Chapter 4

Seaplane Operations - Preflight and Takeoffs

PREFLIGHT INSPECTION

Begin the preflight inspection with a thorough review of the existing local weather, destination weather, and water conditions. This weather evaluation should include the direction and speed of the wind to determine their effects on takeoffs, landings, and other water operations.

The preflight inspection of a seaplane is somewhat different from that of a landplane. Inspecting a seaplane on the water is complicated by the need to reposition the seaplane to gain access to all parts of the airframe. On the other hand, preflighting a seaplane on land may create certain challenges because the wings and tail surfaces may be out of reach and difficult to inspect when standing on the ground.

The following preflight description omits many items that are identical in landplanes and seaplanes in order to emphasize the differences between the two procedures. The process and the equipment to be checked vary from airplane to airplane, but the following description provides a general idea of the preflight inspection for a typical high wing, single-engine floatplane. As always, follow the procedures recommended in the Airplane Flight Manual (AFM) or Pilot's Operating Handbook (POH).

If the seaplane is in the water during the preflight, take a good look at how it sits on the surface. This can provide vital clues to the presence of water in the floats, as well as to the position of the center of gravity. Is the seaplane lower in the water than it should be, given its load? Is one wing lower than the other, or is one float riding noticeably lower in the water than the other? Are the sterns of the floats low in the water? If any of these signs are present, suspect a flooded float compartment or an improperly loaded seaplane. At more than 8 pounds per gallon, even a relatively small amount of water in a float compartment can seriously affect both useful load and center of gravity (CG).

In the cockpit, verify that the throttle is closed, the mixture control is full lean, and the magnetos and master switch are turned off. Lower the water rudders and check for any stiffness or binding in the action of the cables. Check that necessary marine and safety equipment, such as life vests, lines (ropes), anchors, and paddles are present, in good condition, and stowed correctly. Obtain the bilge pump and fuel sample cup.

Standing on the front of the float, inspect the propeller, forward fuselage, and wing. Check the usual items, working from the nose toward the tail. Water spray damage to the propeller looks similar to gravel damage, and must be corrected by a mechanic. Check the oil and fuel levels and sample the fuel, ensuring that it is the proper grade and free of contaminants. Naturally, the most likely contaminant in seaplane fuel tanks is water. Pay extra attention to the lubrication of all hinges. Not only does lubrication make movement easier, but a good coating of the proper lubricant keeps water out and prevents corrosion. Look for any blistering or bubbling of the paint, which may indicate corrosion of the metal underneath. Check the security of the float struts and their attachment fittings. Be careful moving along the float, and pay attention to wing struts, mooring lines, and other obstacles. If the seaplane is on land, do not stand on the floats aft of the step or the seaplane may tip back.

Next, inspect the float itself. Water forces can create very high loads and lead to cumulative damage. Look carefully for signs of stress, such as distortion or buckling of the skin, dents, or loose rivets. The chines should form a continuous smooth curve from front to back, and there should be no bends or kinks along the flange. If the floats are made of fiberglass or composite materials, look carefully for surface cracks, abrasions, or signs of delamination. Check the spreader bars between the floats, and look at the bracing wires and their fittings. Any sign of movement, loose fasteners, broken welds, or a bracing wire that is noticeably tighter or looser than the others is cause for concern. Check for signs of corrosion, especially if the seaplane has been operated in salt water. Although corrosion is

less of an issue with composite floats, be sure to check metal fittings and fasteners. [Figure 4-1]

Figure 4-1. A preflight inspection with the seaplane on land provides an opportunity to thoroughly examine the floats below the waterline. Note the spray rail on the inboard chine of the far float in this photo.

Use the bilge pump to remove any accumulated water from each watertight compartment. The high dynamic water pressure and the physical stresses of takeoffs and landings can momentarily open tiny gaps between float components, allowing small amounts of water to enter. Conversely, sitting idle in the water also results in a small amount of seepage and condensation. While it is normal to pump a modest amount of water from each compartment, more than a quart or so may indicate a problem that should be checked by a qualified aircraft mechanic experienced in working on floats. Normal is a relative term, and experience will indicate how much water is too much. [Figure 4-2]

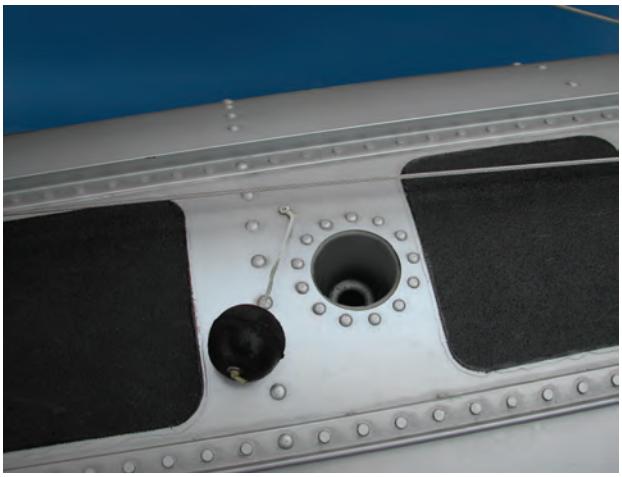

Figure 4-2. Bilge pump openings are closed with a soft rubber ball.

If pumping does not remove any water from a compartment, the tube running from the bilge pump opening to the bottom of the compartment may be damaged or loose. If this is the case, there could be a significant amount of water in the compartment, but the pump is unable to pull it up. [Figure 4-3] Be sure to replace the plugs firmly in each bilge pump opening.

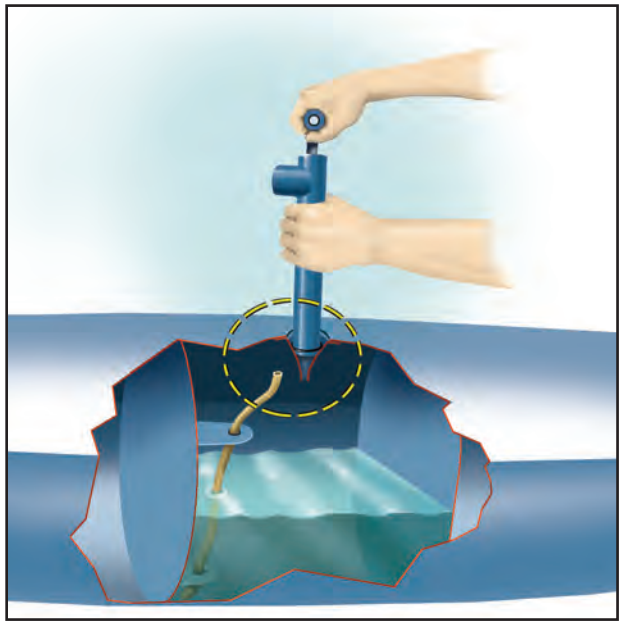

Figure 4-3. Be suspicious if pumping does not remove a small amount of water. If the bilge pump tube is damaged, there may be water in the compartment that the pump cannot remove.

At the stern of the float, check the aft bulkhead, or transom. This area is susceptible to damage from the water rudder moving beyond its normal range of travel. Carefully check the skin for any pinholes or signs of damage from contact with the water rudder or hinge hardware. Inspect the water rudder retraction and steering mechanism and look over the water rudder for any damage. Remove any water weeds or other debris lodged in the water rudder assembly. Check the water rudder cables that run from the float to the fuselage. [Figure 4-4]

Figure 4-4. Inspect the water rudders, cables, springs, and pulleys for proper operation.

To check the empennage area, untie the seaplane, gently push it away from the dock, and turn it 90° so the tail extends over the dock. Take care not to let the water rudders contact the dock. In addition to the normal empennage inspection, check the cables that connect the water rudders to the air rudder. With the air rudder centered, look at the back of the floats to see that the water rudders are also centered. (On some systems, retracting the water rudders disengages them from the air rudder.) If the seaplane has a ventral fin to improve directional stability, this is the time to check it. Spray frequently douses the rear portion of the seaplane, so be particularly alert for signs of corrosion in this area.

With the empennage inspection complete, continue turning the seaplane to bring the other float against the dock, and tie it to the dock. Inspect the fuselage, wing, and float on this side. If the seaplane has a door on only one side, turn the seaplane so the door is adjacent to the dock when the inspection is complete.

When air temperatures drop toward freezing, ice becomes a matter for concern. Inspect the float compartments and water rudders for ice, and consider the possibility of airframe icing during takeoff due to freezing spray. Water expands as it freezes, and this expansion can cause serious damage to floats. A large amount of water expanding inside a float could cause seams to burst, but even a tiny amount of water freezing and expanding inside a seam can cause severe leakage problems. Many operators who remove their floats for the winter store them upside down with the compartment covers off to allow thorough drainage. When the time comes to reinstall the floats, it's a good idea to look for any bugs or small animals that might have made a home in the floats.

STARTING THE ENGINE

Compared to a landplane, a seaplane's starting procedures are somewhat different. Before starting the engine, the seaplane usually needs to be pushed away from the dock, and quite often, it is the pilot who pushes off. Therefore, the pilot should perform as many of the items on the starting checklist as possible prior to shoving off. This includes briefing passengers and seeing that they have fastened their seatbelts. The passenger briefing should include procedures for evacuation, the use of flotation gear, and the location and operation of regular and emergency exits. All passengers are required to be familiar with the operation of seatbelts and shoulder harnesses (if installed). When the engine is primed and ready to start, the pilot leaves the cockpit, shoves off, returns to the pilot's seat, quickly turns on the master switch and magnetos, verifies that the propeller area is clear, and starts the engine. With oil pressure checked, idle r.p.m. set, and the seaplane taxiing in the desired direction, the pilot then fastens the seatbelt and shoulder harness, secures the door, and continues preparing for takeoff.

When a qualified person is available to help launch the seaplane, the pilot can strap in, close the door, and start the engine while the helper holds the seaplane. In most situations, the helper should position the seaplane so it is facing outward, perpendicular to the dock. It is very important that the helper have experience in the proper handling of seaplanes, otherwise an innocent mistake could cause serious damage to the seaplane or to nearby boats, structures, or other seaplanes.

TAXIING AND SAILING

One major difference between taxiing a landplane and taxiing a seaplane is that the seaplane is virtually always in motion, and there are no brakes. When idling, a landplane usually remains motionless, and when moving, brakes can be used to control its speed or bring it to a stop. But once untied, the seaplane floats freely along the water surface and constantly moves due to the forces of wind, water currents, propeller thrust, and inertia. It is important that the seaplane pilot be familiar with the existing wind and water conditions, plan an effective course of action, and mentally stay ahead of the seaplane.

There are three basic positions or attitudes used in moving a seaplane on the water, differentiated by the position of the floats and the speed of the seaplane through the water. They are the idling or displacement position, the plowing position, and the planing or step position.

IDLING POSITION

In the **idling position** or **displacement position**, the buoyancy of the floats supports the entire weight of the seaplane and it remains in an attitude similar to being at rest on the water. Engine r.p.m. is kept as low as possible to control speed, to keep the engine from overheating, and to minimize spray. In almost all circumstances, the elevator control should be held all the way back to keep the nose as high as possible and minimize spray damage to the propeller. This also improves maneuverability by keeping more of the water rudder underwater. The exception is when a strong tailwind component or heavy swells could allow the wind to lift the tail and possibly flip the seaplane over. In such conditions, hold the elevator control forward enough to keep the tail down. [Figure 4-5 on next page]

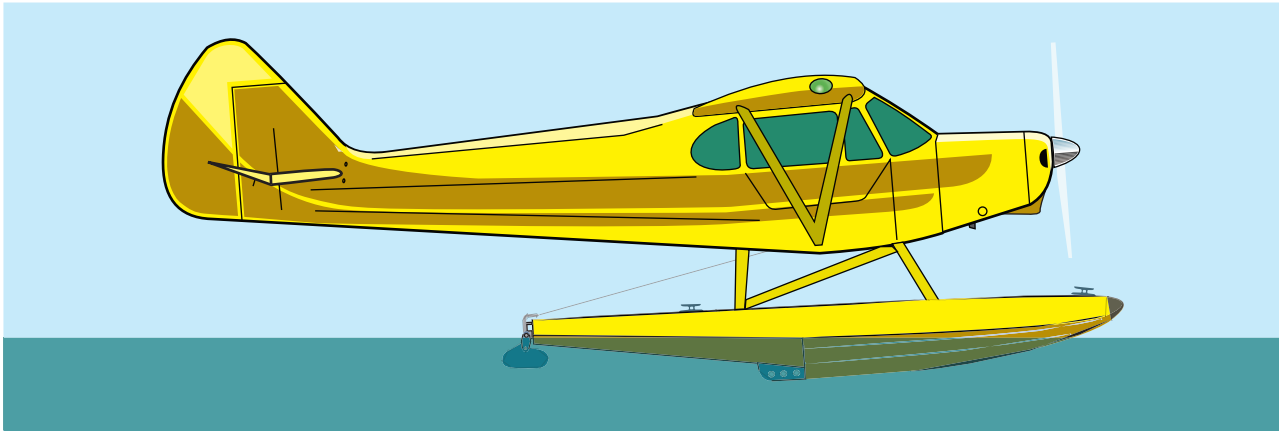

Figure 4-5. Idling position. The engine is at idle r.p.m., the seaplane moves slowly, the attitude is nearly level, and buoyancy supports the seaplane.

Use the idling or displacement position for most taxiing operations, and keep speeds below 6-7 knots to minimize spray getting to the propeller. It is especially important to taxi at low speed in congested or confined areas because inertia forces at higher speeds allow the seaplane to coast farther and serious damage can result from even minor collisions. Cross boat wakes or swells at a 45° angle, if possible, to minimize pitching or rolling and the possibility of an upset.

PLOWING POSITION

Applying power causes the center of buoyancy to shift back, due to increased hydrodynamic pressure on the bottoms of the floats. This places more of the seaplane's weight behind the step, and because the floats are narrower toward the rear, the sterns sink farther into the water. Holding the elevator full up also helps push the tail down due to the increased airflow from the propeller. The **plowing position** creates high drag, requiring a relatively large amount of power for a modest gain in speed. Because of the higher r.p.m., the propeller may pick up spray even though the nose is high. The higher engine power combined with low cooling airflow creates a danger of heat buildup in the engine. Monitor engine temperature carefully to avoid overheating. Taxiing in the plowing position is not recommended. It is usually just the transitional phase between idle taxi and planing. [Figure 4-6]

PLANING OR STEP POSITION

In the **planing position**, most of the seaplane's weight is supported by hydrodynamic lift rather than the buoyancy of the floats. (Because of the wing's speed through the air, aerodynamic lift may also be supporting some of the weight of the seaplane.) Hydrodynamic lift depends on movement through the water, like a water ski. As the float moves faster through the water, it becomes possible to change the pitch attitude to raise the rear portions of the floats clear of the water. This greatly reduces water drag, allowing the seaplane to accelerate to lift-off speed. This position is most often called **on the step**. [Figure 4-7]

There is one pitch attitude that produces the minimum amount of drag when the seaplane is on the step. An experienced seaplane pilot can easily find this "sweet spot" or "slick spot" by the feel of the floats on the water, but the beginning seaplane pilot usually needs to rely on gauging the position of the nose on the horizon. If the nose is considerably high, the rear portions of the floats contact the water, drag increases, and the

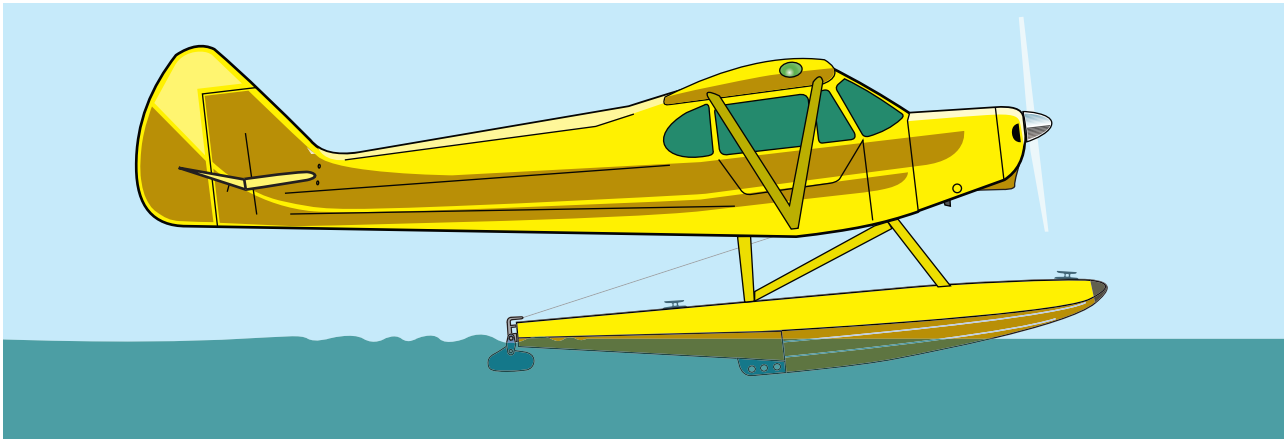

Figure 4-6. Plowing position.

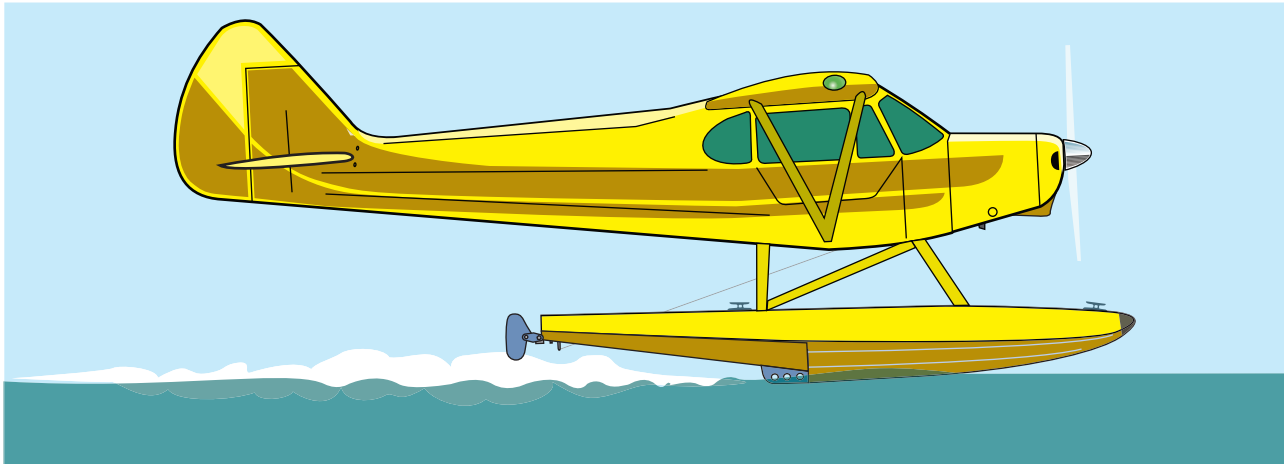

Figure 4-7. On the step. The attitude is nearly level, and the weight of the seaplane is supported mostly by hydrodynamic lift. Behind the step, the floats are essentially clear of the water.

seaplane tends to start settling back into more of a plowing position. If the nose is held only slightly higher than the ideal planing attitude, the seaplane may remain on the step but take much longer to accelerate to rotation speed. On the other hand, if the nose is too low, more of the front portion of the float contacts the water, creating more drag. This condition is called dragging, and as the nose pulls down and the seaplane begins to slow, it can sometimes feel similar to applying the brakes in a landplane.

To continue to taxi on the step instead of taking off, reduce the power as the seaplane is eased over onto the step. More power is required to taxi with a heavy load. However, 65 to 70 percent of maximum power is a good starting point.

Taxiing on the step is a useful technique for covering long distances on the water. Carefully reducing power as the seaplane comes onto the step stops acceleration so that the seaplane maintains a high speed across the water, but remains well below flying speed. At these speeds, the water rudders must be retracted to prevent damage, but there is plenty of airflow for the air rudder. With the seaplane on the step, gentle turns can be made by using the air rudder and the ailerons, always maintaining a precise planing attitude with elevator. The ailerons are positioned into the turn, except when aileron into the wind is needed to keep the upwind wing from lifting.

Step taxiing should only be attempted in areas where the pilot is confident there is sufficient water depth, no floating debris, no hidden obstructions, and no other water traffic nearby. It can be difficult to spot floating hazards at high speeds, and an encounter with a floating log or other obstruction could tear open a float. Your seaplane is not as maneuverable as craft that were designed for the water, so avoiding other vessels is much more difficult. Besides the obvious danger of collision, other water traffic creates dangerous wakes, which are a much more frequent cause of damage. If you see that you are going to cross a wake, reduce power to idle and idle taxi across it, preferably at an angle. Never try to step taxi in shallow water. If the floats touch bottom at high speed, the sudden drag is likely to flip the seaplane.

From either the plowing or the step position, when power is reduced to idle, the seaplane decelerates quite rapidly and eventually assumes the displacement or idle position. Be careful to use proper flight control pressures during the deceleration phase because as weight is transferred toward the front of the floats and drag increases, some seaplanes have a tendency to nose over. Control this with proper use of the elevator.

TURNS

At low speeds and in light winds, make turns using the water rudders, which move in conjunction with the air rudder. As with a landplane, the ailerons should be positioned to minimize the possibility of the wind lifting a wing. In most airplanes, left turns are somewhat easier and can be made tighter than right turns because of torque. If water rudders have the proper amount of movement, most seaplanes can be turned within a radius less than the span of the wing in calm conditions or a light breeze. Water rudders are usually more effective at slow speeds because they are acting in comparatively undisturbed water. At higher speeds, the stern of the float churns the adjacent water, causing the water rudder to become less effective. The dynamic pressure of the water at high speeds may tend to force the water rudders to swing up or retract, and the pounding can cause damage. For these reasons, water rudders should be retracted whenever the seaplane is moving at high speed.

The weathervaning tendency is more evident in seaplanes, and the taxiing seaplane pilot must be constantly aware of the wind's effect on the ability to maneuver. In stronger winds, weathervaning forces may make it difficult to turn

downwind. Often a short burst of power provides sufficient air over the rudder to overcome weathervaning. Since the elevator is held all the way up, the airflow also forces the tail down, making the water rudders more effective. Short bursts of power are preferable to a longer, continuous power application. With continuous power, the seaplane accelerates, increasing the turn radius. The churning of the water in the wake of the floats also makes the water rudders less effective. At the same time, low cooling airflow may cause the engine to heat up.

During a high speed taxiing turn, centrifugal force tends to tip the seaplane toward the outside of the turn. When turning from an upwind heading to a downwind heading, the wind force acts in opposition to centrifugal force, helping stabilize the seaplane. On the other hand, when turning from downwind to upwind, the wind force against the fuselage and the underside of the wing increases the tendency for the seaplane to lean to the outside of the turn, forcing the downwind float deeper into the water. In a tight turn or in strong winds, the combination of these two forces may be sufficient to tip the seaplane to the extent that the downwind float submerges or the outside wing drags in the water, and may even flip the seaplane onto its back. The further the seaplane tips, the greater the effect of the crosswind, as the wing presents more vertical area to the wind force. [Figure 4-8]

When making a turn into the wind from a crosswind condition, often all that is necessary to complete the turn is to neutralize the air rudder and allow the seaplane to weathervane into the wind. If taxiing directly downwind, use the air rudder momentarily to get the turn started, then let the wind complete the turn. Sometimes opposite rudder may be needed to control the rate of turn.

Stronger winds may make turns from upwind to downwind more difficult. The plow turn is one technique for turning downwind when other methods are inadequate, but this maneuver is only effective in certain seaplanes. It takes advantage of the same factor that reduces a floatplane's yaw stability in flight: the large vertical area of the floats forward of the center of gravity. In the plowing attitude, the front portion of each float comes out of the water, presenting a large vertical surface for the wind to act upon. This tends to neutralize the weathervaning force, allowing the turn to proceed. At the same time, the center of buoyancy shifts back. Since this is the axis around which the seaplane pivots while

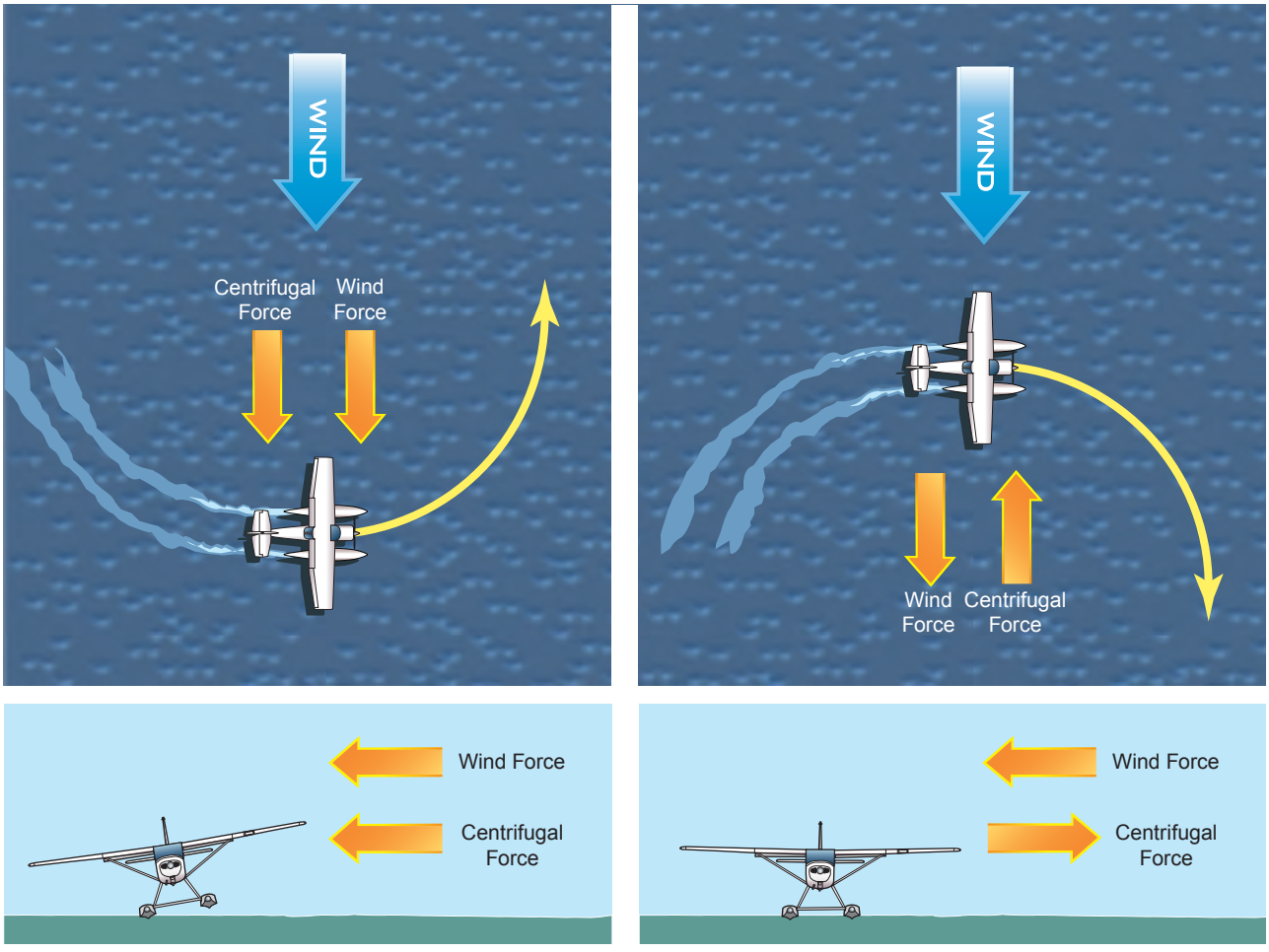

Figure 4-8. Wind effects in turns. When the wind and centrifugal force act in the same direction, the downwind float can be forced underwater. When the wind is countered by centrifugal force, the seaplane is more stable.

on the water, more of the fuselage is now forward of the axis and less is behind, further decreasing the weathervaning tendency. In some seaplanes, this change is so pronounced in the plowing attitude that they experience reverse weathervaning, and tend to turn downwind rather than into the wind. Experienced seaplane pilots can sometimes use the throttle as a turning device in high wind conditions by increasing power to cause a nose-up position when turning downwind, and decreasing power to allow the seaplane to weathervane into the wind. [Figure 4-9]

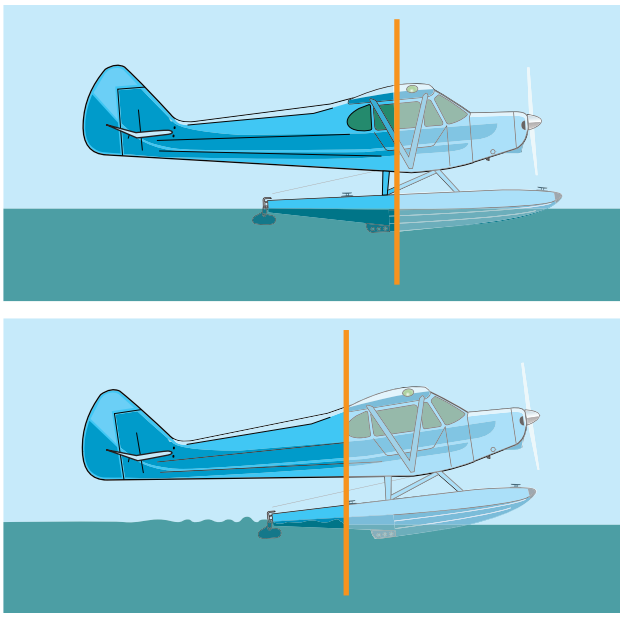

Figure 4-9. In the plowing position, the exposed area at the front of the floats, combined with the rearward shift of the center of buoyancy, can help to counteract the weathervaning tendency.

To execute a plow turn, begin with a turn to the right, then use the weathervaning force combined with full left rudder to turn back to the left. As the seaplane passes its original upwind heading, add enough power to place it into the plow position, continuing the turn with the rudder. As the seaplane comes to the downwind heading, reduce power and return to an idle taxi. From above, the path of the turn looks like a question mark. [Figure 4-10]

Plow turns are useful only in very limited situations because they expose the pilot to a number of potential dangers. They should not be attempted in rough water or gusty conditions. Floatplanes are least stable when in the plowing attitude, and are very susceptible to capsizing. In spite of the nose-high attitude, the high power setting often results in spray damage to the propeller. In most windy situations, it is much safer to sail the seaplane backward (as explained in the next section) rather than attempt a plow turn.

When the seaplane is on the step, turns involve careful balancing of several competing forces. As the rate of turn increases, the floats are being forced to move somewhat sideways through the water, and they resist this sideways motion with drag, much like an airplane fuselage in a skidding turn. More power is required to overcome this drag and maintain planing speed. This skidding force also tends to roll the seaplane toward the outside of the turn, driving the outside float deeper into the water and adding more drag on that side. To prevent this, use aileron into the turn to keep the outside wing from dropping. Once full aileron into the step turn is applied, any further roll to the outside can only be stopped by reducing the rate of turn, so pay careful attention to the angle of the wings and the feel of the water drag on the floats to catch any indication that the outside float is starting to submerge. When stopping a step turn, always return to a straight path before reducing power.

At step taxi speeds, the centrifugal force in a turn is far greater than at idle taxi speed, so the forces involved in turning from downwind to upwind are proportionately more dangerous, especially in strong winds. Chances are, by the time a pilot discovers that the outside float is going under, the accident is almost inevitable. However, immediate full rudder out of the turn and power reduction may save the situation by reversing

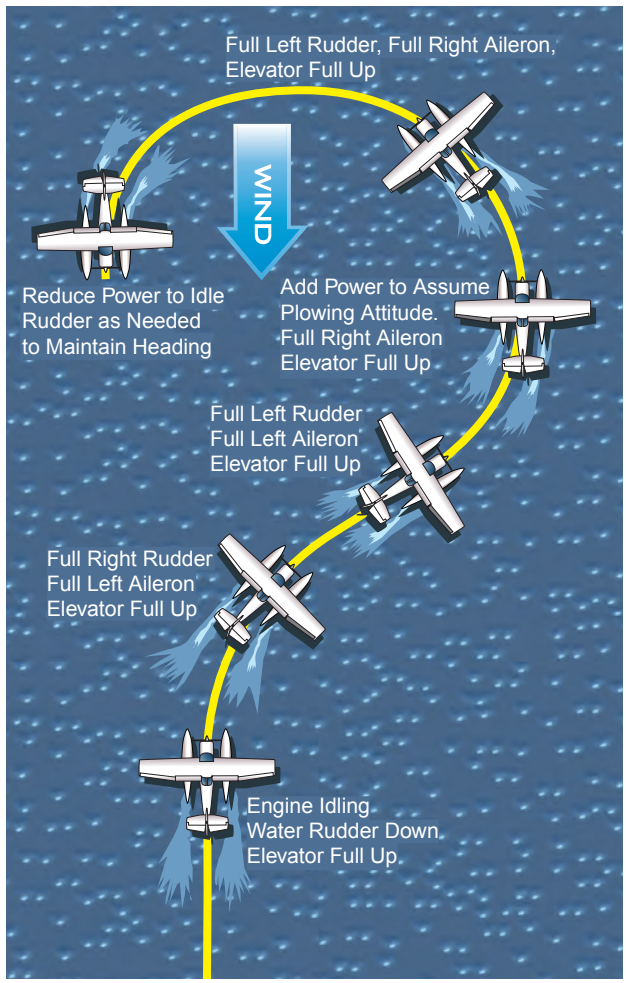

Figure 4-10. Plow turn from upwind to downwind.

the centrifugal force and allowing the buried float to come up.

SAILING

Landplane pilots are accustomed to taxiing by pointing the nose of the airplane in the desired direction and rolling forward. In seaplane operations, there are often occasions when it is easier and safer to move the seaplane backward or to one side because wind, water conditions, or limited space make it impractical to attempt a turn. If there is a significant wind, a seaplane can be guided into a space that might seem extremely cramped to an inexperienced pilot. **Sailing** is a method of guiding the seaplane on the water using the wind as the main motive force. It is a useful technique for maneuvering in situations where conventional taxiing is undesirable or impossible. Since the seaplane automatically aligns itself so the nose points into the wind, sailing in a seaplane usually means moving backward.

In light wind conditions with the engine idling or off, a seaplane naturally weathervanes into the wind. If the pilot uses the air rudder to swing the tail a few degrees, the seaplane sails backward in the direction the tail is pointed. This is due to the keel effect of the floats, which tends to push the seaplane in the direction the sterns of the floats are pointing. In this situation, lift the water rudders, since their action is counter to what is desired. When sailing like this, the sterns of the floats have become the front, as far as the water is concerned, but the rear portions of the floats are smaller and therefore not as buoyant. If the wind is strong and speed starts to build up, the sterns of the floats could start to submerge and dig into the water. Combined with the lifting force of the wind over the wings, the seaplane could conceivably flip over backward, so use full forward elevator to keep the sterns of the floats up and the seaplane's nose down. Adding power can also help keep the floats from submerging.

If enough engine power is used to exactly cancel the backward motion caused by the wind, the seaplane is not moving relative to the water, so keel effect disappears. However, turning the fuselage a few degrees left or right provides a surface for the wind to push against, so the wind will drive the seaplane sideways in the direction the nose is pointed. Combining these techniques, a skilled pilot can sail a seaplane around obstacles and into confined docking spaces. [Figure 4-11]

Figure 4-12 shows how to position the controls for the desired direction of motion in light or strong winds. With the engine off, lowering the wing flaps and opening the cabin doors increases the air resistance and thus adds to the effect of the wind. This increases sailing speed but may reduce the effect of the air rudder. If sailing with the engine off results in too much motion downwind, but an idling engine produces too much thrust, adding carburetor heat or turning off one magneto can reduce the engine power slightly. Avoid using carburetor heat or running on one magneto for extended periods. Instead, start the engine briefly to slow down.

Where currents are a factor, such as in strong tidal flows or a fast flowing river, sailing techniques must

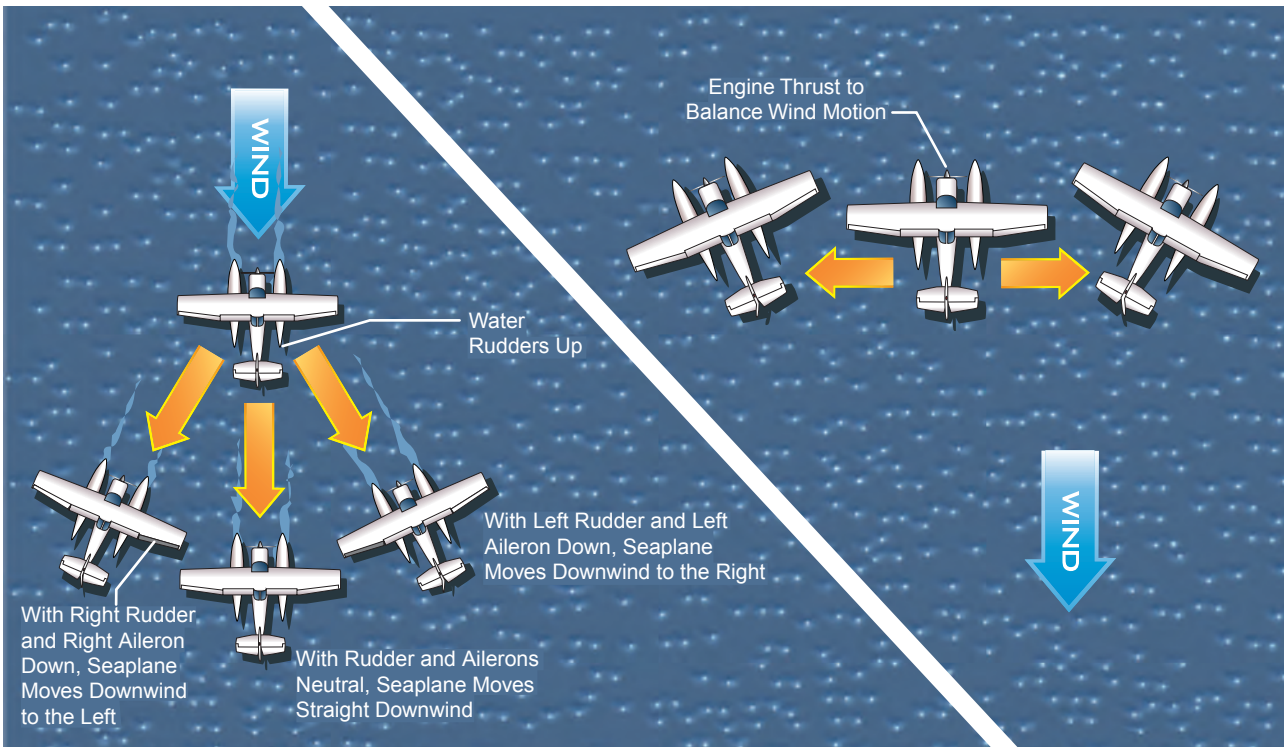

Figure 4-11. When the seaplane moves through the water, keel effect drives it in the direction the tail is pointed. With no motion through the water, the wind pressure on the fuselage pushes the seaplane toward the side the nose is pointed.

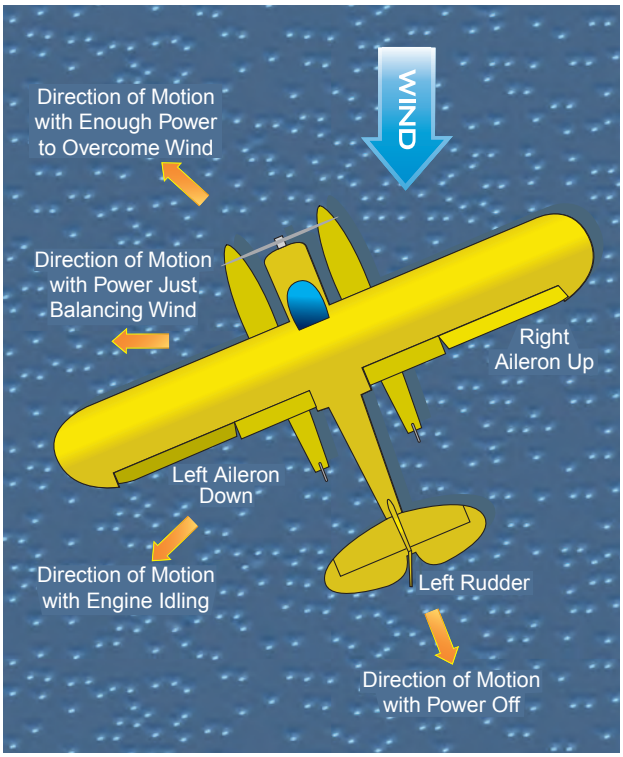

Figure 4-12. By balancing wind force and engine thrust, it is possible to sail sideways or diagonally forward. Of course, reversing the control positions from those illustrated permits the pilot to sail to the opposite side.

incorporate the movement of the water along with the wind. The current may be a help or a hindrance, or change from a help to a hindrance when the pilot attempts to change direction. The keel effect only works when the floats are moving through the water. If the current is moving the seaplane, there may be little or no motion relative to the water, even though the seaplane is moving relative to the shore. Using wind, current, and thrust to track the desired course requires careful planning and a thorough understanding of the various forces at work.

With the engine shut down, most flying boats sail backward and toward whichever side the nose is pointed, regardless of wind velocity, because the hull does not provide as much keel effect as floats in proportion to the side area of the seaplane above the waterline. To sail directly backward in a flying boat, release the controls and let the wind steer. Sailing is an essential part of seaplane operation. Since each type of seaplane has its own peculiarities, practice sailing until thoroughly familiar with that particular type. Practice in large bodies of water such as lakes or bays, but sufficiently close to a prominent object in order to evaluate performance.

Before taxiing into a confined area, carefully evaluate the effects of the wind and current, otherwise the seaplane may be driven into obstructions. With a seaplane of average size and power at idle, a water current of 5 knots can offset a wind velocity of 25 knots in the opposite direction. This means that a 5 knot current will carry the seaplane against a 25 knot wind. Differential power can be used to aid steering in multiengine seaplanes.

PORPOISING

Porpoising is a rhythmic pitching motion caused by dynamic instability in forces along the float bottoms while on the step. An incorrect planing attitude sets off a cyclic oscillation that steadily increases in amplitude unless the proper pitch attitude is reestablished. [Figure 4-13]

A seaplane travels smoothly across the water on the step only if the floats or hull remain within a moderately tolerant range of pitch angles. If the nose is held too low during planing, water pressure in the form of a small crest or wall builds up under the bows of the floats. Eventually, the crest becomes large enough that the fronts of the floats ride up over the crest, pitching the bows upward. As the step passes over the crest, the floats tip forward abruptly, digging the bows a little deeper into the water. This builds a new crest in front of the floats, resulting in another oscillation. Each oscillation becomes increasingly severe, and if not corrected, will cause the seaplane to nose into the water, resulting in extensive damage or possible capsizing. A second type of porpoising can occur if the nose is held too high while on the step. Porpoising can also cause a premature lift-off with an extremely high angle of attack, which can result in a stall and a subsequent nose-down drop into the water. Porpoising occurs during the takeoff run if the planing angle is not properly controlled with elevator pressure just after passing through the “hump” speed. The pitching created when the seaplane encounters a swell system while on the step can also initiate porpoising. Usually, porpoising does not start until the seaplane has passed a degree or two beyond the acceptable planing angle range, and

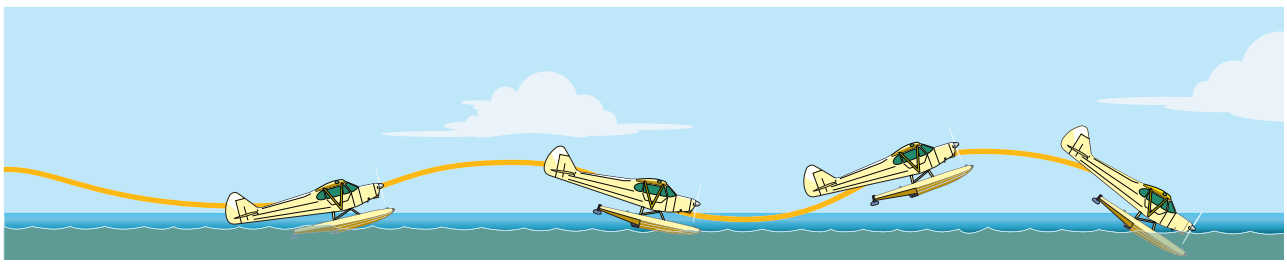

Figure 4-13. Porpoising increases in amplitude if not corrected promptly.

does not cease until after the seaplane has passed out of the critical range by a degree or two.

If porpoising occurs due to a nose-low planing attitude, stop it by applying timely back pressure on the elevator control to prevent the bows of the floats from digging into the water. The back pressure must be applied and maintained until porpoising stops. If porpoising does not stop by the time the second oscillation occurs, reduce the power to idle and hold the elevator control back firmly so the seaplane settles onto the water with no further instability. Never try to "chase" the oscillations, as this usually makes them worse and results in an accident.

Pilots must learn and practice the correct pitch attitudes for takeoff, planing, and landing for each type of seaplane until there is no doubt as to the proper angles for the various maneuvers. The upper and lower limits of these pitch angles are established by the design of the seaplane; however, changing the seaplane's gross weight, wing flap position, or center of gravity location also changes these limits. Increased weight increases the displacement of the floats or hull and raises the lower limit considerably. Extending the wing flaps frequently trims the seaplane to the lower limit at lower speeds, and may lower the upper limit at high speeds. A forward center of gravity increases the possibility of high angle porpoising, especially during landing.

SKIPPING

Skipping is a form of instability that may occur when landing at excessive speed with the nose at too high a pitch angle. This nose-up attitude places the seaplane at the upper trim limit of stability and causes the seaplane to enter a cyclic oscillation when touching the water, which results in the seaplane skipping across the surface. This action is similar to skipping flat stones across the water. Skipping can also occur by crossing a boat wake while taxiing on the step or during a takeoff. Sometimes the new seaplane pilot confuses a skip with a porpoise, but the pilot's body sensations can quickly distinguish between the two. A skip gives the body vertical "G" forces, similar to bouncing a landplane. Porpoising is a rocking chair type forward and aft motion feeling.

To correct for skipping, first increase back pressure on the elevator control and add sufficient power to prevent the floats from contacting the water. Then establish the proper pitch attitude and reduce the power gradually to allow the seaplane to settle gently onto the water. Skipping oscillations do not tend to increase in amplitude, as in porpoising, but they do subject the floats and airframe to unnecessary pounding and can lead to porpoising.

TAKEOFFS

A seaplane takeoff may be divided into four distinct phases: (1) The displacement phase, (2) the hump or plowing phase, (3) the planing or on the step phase, and (4) the lift-off.

The displacement phase should be familiar from the taxiing discussion. During idle taxi, the displacement of water supports nearly all of the seaplane's weight. The weight of the seaplane forces the floats down into the water until a volume that weighs exactly as much as the seaplane has been displaced. The surface area of the float below the waterline is called the wetted area, and it varies depending on the seaplane's weight. An empty seaplane has less wetted area than when it is fully loaded. Wetted area is a major factor in the creation of drag as the seaplane moves through the water.

As power is applied, the floats move faster through the water. The water resists this motion, creating drag. The forward portion of the float is shaped to transform the horizontal movement through the water into an upward lifting force by diverting the water downward. Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction, and in this case, pushing water downward results in an upward force known as hydrodynamic lift.

In the plowing phase, hydrodynamic lift begins pushing up the front of the floats, raising the seaplane's nose and moving the center of buoyancy aft. This, combined with the downward pressure on the tail generated by holding the elevator control all the way back, forces the rear part of the floats deeper into the water. This creates more wetted area and consequently more drag, and explains why the seaplane accelerates so slowly during this part of the takeoff.

This resistance typically reaches its peak just before the floats are placed into a planing attitude. Figure 4-14 shows a graph of the drag forces at work during a seaplane takeoff run. The area of greatest resistance is referred to as the hump because of the shape of the water drag curve. During the plowing phase, the increasing water speed generates more and more hydrodynamic lift. With more of the weight supported by hydrodynamic lift, proportionately less is supported by displacement and the floats are able to rise in the water. As they do, there is less wetted area to cause drag, which allows more acceleration, which in turn increases hydrodynamic lift. There is a limit to how far this cycle can go, however, because as speed builds, so does the amount of drag on the remaining wetted area. Drag increases as the square of speed, and eventually drag forces would balance the power output of the engine and the seaplane would continue along the surface without further acceleration.

Seaplanes have been built with sufficient power to accelerate to takeoff speed this way, but fortunately the step was invented, and it makes further acceleration possible without additional power. After passing over the hump, the seaplane is traveling fast enough that its weight can be supported entirely by hydrodynamic lift. Relaxing the back pressure on the elevator control allows the float to rock up onto the step, and lifts the

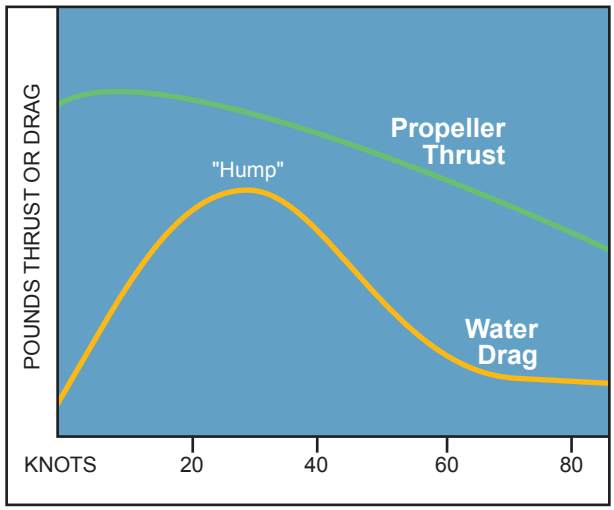

Figure 4-14. This graph shows water drag and propeller thrust during a takeoff run.

rear portions of the floats clear of the water. This eliminates all of the wetted area aft of the step, along with the associated drag.

As further acceleration takes place, the flight controls become more responsive, just as in a landplane. Elevator deflection is gradually reduced to hold the required planing attitude. As the seaplane continues to accelerate, more and more weight is being supported by the aerodynamic lift of the wings and water resistance continues to decrease. When all of the weight is transferred to the wings, the seaplane becomes airborne.

Several factors greatly increase the water drag or resistance, such as heavy loading of the seaplane or glassy water conditions. In extreme cases, the drag may exceed the available thrust and prevent the seaplane from becoming airborne. This is particularly true when operating in areas with high density altitudes (high elevations/high temperatures) where the engine cannot develop full rated power. For this reason the pilot should practice takeoffs using only partial power to simulate the longer takeoff runs needed when operating where the density altitude is high and/or the seaplane is heavily loaded. This practice should be conducted under the supervision of an experienced seaplane instructor, and in accordance with any cautions or limitations in the AFM/POH. Plan for the additional takeoff area required, as well as the flatter angle of climb after takeoff, and allow plenty of room for error.

Use all of the available cues to verify the wind direction. Besides reading the water, pick up clues to the wind's direction from wind indicators and streamers on the masts of moored boats, flags on flagpoles, or rising smoke. A boat moored to a buoy points into the wind, but be aware that it may have a stern anchor as well, preventing it from pointing into the wind. Waterfowl almost always align themselves facing into the wind.

Naturally, be sure you have enough room for takeoff. The landing distance of a seaplane is much shorter than that required for takeoff, and many pilots have landed in areas that have turned out to be too short for takeoff. If you suspect that the available distance may be inadequate, consider reducing weight by leaving some of your load behind or wait for more favorable weather conditions. A takeoff that would be dangerous on a hot, still afternoon might be accomplished safely on the following morning, with cooler temperatures and a brisk wind.

In addition to wind, consider the effects of the current when choosing the direction for takeoff. Keep in mind that when taxiing in the same direction as the current, directional control may be reduced because the seaplane is not moving as quickly through the water. In rivers or tidal flows, make crosswind or calm wind takeoffs in the same direction as the current. This reduces the water forces on the floats. Suppose the seaplane lifts off at 50 knots and the current is 3 knots. If winds are calm, the seaplane needs a water speed of 47 knots to take off downstream, but must accelerate to a water speed of 53 knots to become airborne against the current. This difference of 6 knots requires a longer time on the water and generates more stress on the floats. The situation becomes more complex when wind is a factor. If the wind is blowing against the current, its speed can help the wings develop lift sooner, but will raise higher waves on the surface. If the wind is in the same direction as the current, at what point does the speed of the wind make it more worthwhile to take off against the current? In the previous example, a wind velocity of 3 knots would exactly cancel the benefit of the current, since the air and water would be moving at the same speed. In most situations, take off into the wind if the speed of the wind is greater than the current.

Unlike landplane operations at airports, many other activities are permitted in waters where seaplane operations are conducted. Seaplane pilots encounter a variety of objects on the water, some of which are nearly submerged and difficult to see. These include items that are stationary, such as pilings and buoys, and those that are mobile, like logs, swimmers, water skiers, and a variety of watercraft. Before beginning the takeoff, it is a good practice to taxi along the intended takeoff path to check for any hazardous objects or obstructions.

Make absolutely sure the takeoff path ahead is free of boats, swimmers, and other water traffic, and be sure it will remain so for the duration of the takeoff run. Powerboats, wind-surfers, and jet-skis can move quickly and change direction abruptly. As the

seaplane's nose comes up with the application of full power, the view ahead may be completely blocked by the cowling. Check to the sides and behind the seaplane as well as straight ahead, since many watercraft move much faster than the normal taxi speed and may be passing the seaplane from behind. In addition to the vessels themselves, also scan for their wakes and try to anticipate where the wakes will be during takeoff. Operators of motorboats and other watercraft often do not realize the hazard caused by moving their vessels across the takeoff path of a seaplane. It is usually better to delay takeoff and wait for the swells to pass rather than encountering them at high speed. Even small swells can cause dangerous pitching or rolling for a seaplane, so taxi across them at an angle rather than head-on. Remember to check for other air traffic and make any appropriate radio calls.

Be sure to use the pre-takeoff checklist on every takeoff. All checks are performed as the seaplane taxies, including the engine runup. Hold the elevator control all the way back throughout the runup to minimize spray around the propeller. If there is significant wind, let the seaplane turn into the wind for the runup. As r.p.m. increases, the nose rises into the plowing position and the seaplane begins to accelerate. Since this is a relatively unstable position, performing the runup into the wind minimizes the possibility of crosswinds, rough water, or gusts upsetting the seaplane. Waste no time during the runup checks, but be thorough and precise. Taxi speed will drop as soon as the power is reduced.

Water rudders are normally retracted before applying takeoff power. The buffeting and dynamic water pressure during a takeoff can cause serious damage if the water rudders are left down.

As full power is applied during takeoff in most seaplanes, torque and P-factor tend to force the left float down into the water. Right rudder pressure helps to maintain a straight takeoff path. In some cases, left aileron may also help to counter the tendency to turn left at low speeds, by increasing drag on the right side of the seaplane.

Density altitude is particularly important in seaplane flying. High, hot, and humid conditions reduce engine power and propeller efficiency, and the seaplane must also attain a higher water speed in order to generate the lift required for takeoff. This increase in water speed means overcoming additional water drag. All of these factors combine to increase takeoff distances and decrease climb performance. In high density altitude conditions, consider not only the length of the water run, but the room required for a safe climbout as well.

The land area around a body of water is invariably somewhat higher than the water surface. Tall trees are common along shorelines, and in many areas, steep or mountainous terrain rises from the water's edge. Be certain the departure path allows sufficient room for safe terrain clearance or for a wide climbing turn back over the water.

There are specific takeoff techniques for different wind and water situations. Large water areas almost always allow a takeoff into the wind, but there are occasionally circumstances where a crosswind or downwind takeoff may be more appropriate. Over the years, techniques have evolved for handling rough water or a glassy smooth surface. Knowing and practicing these techniques not only keep skills polished so they are available when needed, they also increase overall proficiency and add to the enjoyment of seaplane flying.

NORMAL TAKEOFFS

Make normal takeoffs into the wind. Once the wind direction is determined and the takeoff path chosen, configure the seaplane and perform all of the pre-takeoff checks while taxiing to the takeoff position. Verify that the takeoff will not interfere with other traffic, either on the water's surface or in the air.

Hold the elevator control all the way back and apply full power smoothly and quickly, maintaining directional control with the rudder. When the nose reaches its highest point, ease the back pressure to allow the seaplane to come up on the step. Establish the optimum planing attitude and allow the seaplane to accelerate to lift-off speed. In most cases, the seaplane lifts off as it reaches flying speed. Occasionally it may be necessary to gently help the floats unstick by either using some aileron to lift one float out of the water or by adding a small amount of back pressure on the elevator control. Once off the water, the seaplane accelerates more quickly. When a safe airspeed is achieved, establish the pitch attitude for the best rate of climb (V_Y) and complete the climb checklist. Turn as necessary to avoid overflying noise-sensitive areas, and reduce power as appropriate to minimize noise.

CROSSWIND TAKEOFFS

In restricted or limited areas such as canals or narrow rivers, it is not always possible to take off or land directly into the wind. Therefore, acquiring skill in crosswind techniques enhances the safety of seaplane operation. Crosswinds present special difficulties for seaplane pilots. The same force that acts to lift the upwind wing also increases weight on the downwind float, forcing it deeper into the water and increasing drag on that side. Keep in mind that the allowable crosswind component for a floatplane may be significantly less than for the equivalent landplane.

A crosswind has the same effect on a seaplane during takeoff as on a landplane, that is, it tends to push the seaplane sideways across the takeoff path, which imposes side loads on the landing gear. In addition, wind pressure on the vertical tail causes the seaplane to try to weathervane into the wind.

At the beginning of the takeoff roll in a landplane, drift and weathervaning tendencies are resisted by the friction of the tires against the runway, usually assisted by nosewheel steering, or in some cases even differential braking. The objective in a crosswind takeoff is the same in landplanes and seaplanes: to counteract drift and minimize the side loads on the landing gear.

The sideways drifting force, acting through the seaplane's center of gravity, is opposed by the resistance of the water against the side area of the floats. This creates a force that tends to tip the seaplane sideways, pushing the downwind float deeper into the water and lifting the upwind wing. The partly submerged float has even more resistance to sideways motion, and the upwind wing displays more vertical surface area to the wind, intensifying the problem. Without intervention by the pilot, this tipping could continue until the seaplane capsizes.

During a takeoff in stiff crosswinds, weathervaning forces can cause an uncontrolled turn to begin. As the turn develops, the addition of centrifugal force acting outward from the turn aggravates the problem. The keels of the floats resist the sideways force, and the upwind wing tends to lift. If strong enough, the combination of the wind and centrifugal force may tip the seaplane to the point where the downwind float submerges and subsequently the wingtip may strike the water. This is known as a waterloop, and the dynamics are similar to a groundloop on land. Although some damage occurs when the wingtip hits the ground during a groundloop, the consequences of plunging a wingtip underwater in a seaplane can be disastrous. In a fully developed waterloop, the seaplane may be severely damaged or may capsize. Despite these dire possibilities, crosswind takeoffs can be accomplished safely by exercising good judgment and proper piloting technique.

Since there are no clear reference lines for directional guidance, such as those on airport runways, it can be difficult to quickly detect side drift on water. Waves may make it appear that the water is moving sideways, but remember that although the wind moves the waves, the water remains nearly stationary. The waves are simply an up-and-down motion of the water surface—the water itself is not moving sideways. To maintain a straight path through the water, pick a spot on the shore as an aim point for the takeoff run. On the other hand, some crosswind techniques involve describing a curved path through the water. Experience will help determine which technique is most appropriate for a given situation.

CONTROLLED WEATHERVANING

In light winds, it is easy to counteract the weathervaning tendency during the early part of the takeoff run by creating an allowance for it from the beginning. Prior to adding takeoff power, use the water rudders to set up a heading somewhat downwind of the aim point. The angle will depend on the speed of the wind—the higher

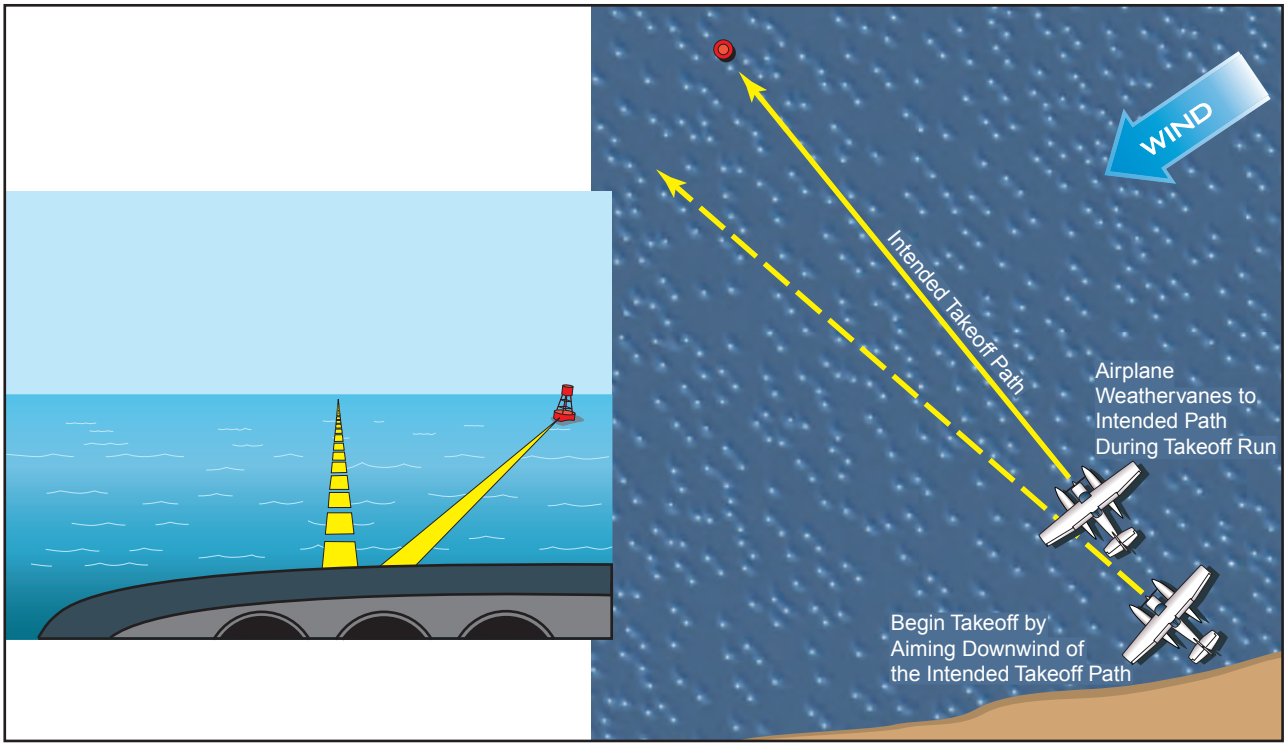

Figure 4-15. Anticipate weathervaning by leading the aim point, setting up a somewhat downwind heading prior to starting the takeoff. Choose an aim point that does not move, such as a buoy or a point on the far shore.

the wind, the greater the lead angle. Create just enough of a lead angle so that when the water rudders are raised and power is applied, the seaplane weathervanes to the desired heading during the time it gains enough speed to make the air rudder and ailerons effective. As the seaplane transitions to the plowing attitude, the weathervaning tendency decreases as the fronts of the floats come out of the water, adding vertical surface area at the front of the seaplane. Use full aileron into the wind as the takeoff run begins, and maintain enough aileron to keep the upwind wing from lifting as airspeed builds. [Figure 4-15 on previous page]

USING WATER RUDDERS

Another technique for maintaining a straight takeoff path involves leaving the water rudders down to assist with steering. Using the water rudders provides added directional control until the aerodynamic controls become effective.

To use this technique, align the seaplane with the aim point on the shore, hold full aileron into the wind, and apply takeoff power. As the seaplane accelerates, use enough aileron pressure to keep the upwind wing down. The downwind float should lift free of the water first. After lift-off, make a coordinated turn to establish the proper crab angle for the climb, and retract the water rudders.

This takeoff technique subjects the water rudders to high dynamic water pressures and could cause damage. Be sure to comply with the advice of the float manufacturer. [Figure 4-16]

DOWNWIND ARC

The other crosswind takeoff technique results in a curved path across the water, starting somewhat into the wind and turning gradually downwind during the takeoff run. This reduces the actual crosswind component at the beginning of the takeoff, when the seaplane is most susceptible to weathervaning. As the aerodynamic controls become more effective, the pilot balances the side loads imposed by the wind with the skidding force of an intentional turn, as always, holding the upwind wing down with the ailerons. [Figure 4-17]

The pilot plans a curved path and follows this arc to produce sufficient centrifugal force so that the seaplane tends to lean outward against the wind force. During the run, the pilot can adjust the rate of turn by varying rudder pressure, thereby increasing or decreasing the centrifugal force to compensate for a changing wind force. In practice, it is quite simple to plan sufficient curvature of the takeoff path to cancel out strong crosswinds, even on very narrow rivers. Note that the tightest part of the downwind arc is when the seaplane is traveling at slower speeds.

The last portion of a crosswind takeoff is somewhat similar to a landplane. Use ailerons to lift the downwind wing, providing a sideways component of lift to counter the effect of the crosswind. This means that the downwind float lifts off first. Be careful not to drop the upwind wing so far that it touches the water. When using a straight takeoff path, keep the nose on the aim point with opposite rudder and maintain the proper step attitude until the other float lifts off. Unlike a landplane, there is usually no advantage in holding the seaplane on the water past normal lift-off speed, and doing so may expose the floats to unnecessary pounding as they splash through the waves. Once airborne, make a coordinated turn to the crab angle that results in a straight track toward the aim point, and pitch to obtain the desired climb airspeed.

Again, experience plays an important part in successful operation during crosswinds. It is essential that all seaplane pilots have thorough knowledge and skill in these maneuvers.

DOWNWIND TAKEOFFS

Downwind takeoffs in a seaplane present a somewhat different set of concerns. If the winds are light, the water is smooth, and there is plenty of room, a downwind takeoff may be more convenient than a long downwind taxi to a position that would allow a takeoff into the wind. In any airplane, the wing needs to attain a specific airspeed in order to fly, and that indicated airspeed is the same regardless of wind direction.

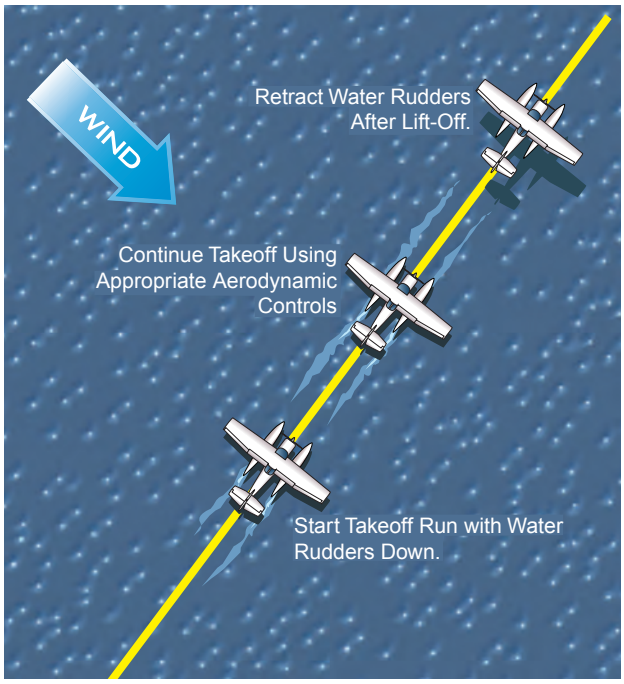

Figure 4-16. Remember to retract the water rudders after takeoff to avoid damage during the next landing.

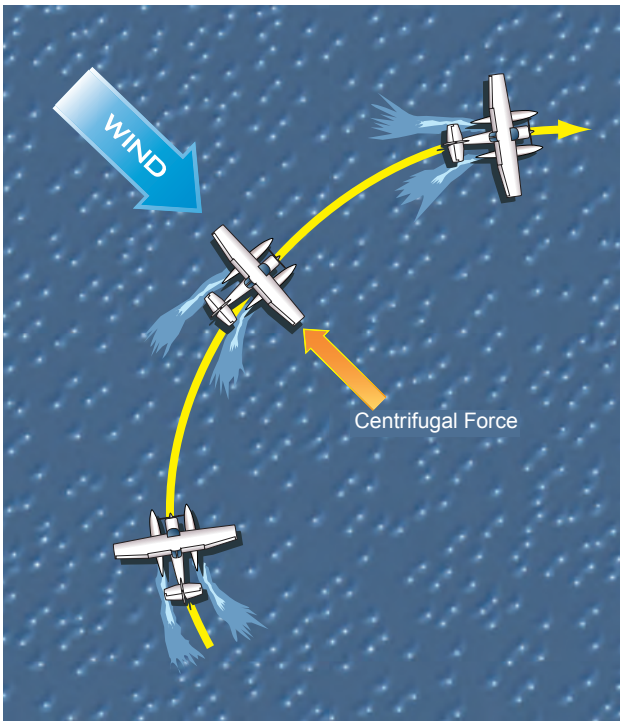

Figure 4-17. The downwind arc balances wind force with centrifugal force.

However, when taking off downwind, obtaining the airspeed means accelerating to a proportionately higher groundspeed. Naturally, the takeoff run is longer because the wings must first be accelerated to the speed of the wind, then accelerated to the correct airspeed to generate the lift required for takeoff. So far, this is identical to what occurs with a landplane during a downwind takeoff. But in addition, a downwind takeoff run in a seaplane is further lengthened by the factor of float drag. The speed of the floats in the water corresponds to the higher groundspeed required in a landplane, but the drag of the floats increases as the square of their speed. This increase in drag is much greater than the increase in rolling resistance of tires and wheel bearings in a landplane. A tailwind may lengthen the seaplane's takeoff distance much more dramatically than the same tailwind in a landplane.

Nevertheless, there are situations in which a downwind takeoff may be more favorable than taking off into the wind. If there is a long lake with mountains at the upwind end and a clear departure path at the other, a downwind takeoff might be warranted. Likewise, noise considerations and thoughtfulness might prompt a downwind takeoff away from a populated shore area if plenty of water area is available. In areas where the current favors a downwind takeoff, the advantage gained from the movement of the water can more than compensate for the wind penalty. Keep in mind that overcoming the current creates far more drag than accelerating a few extra knots downwind with the current. In all cases, safety requires a thorough knowledge of the takeoff performance of the seaplane.

GLASSY WATER TAKEOFFS

Glassy water makes takeoff more difficult in two ways. The smoothness of the surface has the effect of increasing drag, making acceleration and lift-off more difficult. This can feel as if there is suction between the water and the floats. A little surface roughness actually helps break the contact between the floats and the water by introducing turbulence and air bubbles between water and the float bottoms. The intermittent contact between floats and water at the moment of lift-off cuts drag and allows the seaplane to accelerate while still obtaining some hydrodynamic lift, but glassy water maintains a continuous drag force. Once airborne, the lack of visual cues to the seaplane's height above the water can create a potentially dangerous situation unless a positive rate of climb is maintained.

The takeoff technique is identical to a normal takeoff until the seaplane is on the step and nearly at flying speed. At this point, the water drag may prevent the seaplane from accelerating the last few knots to lift-off speed. To reduce float drag and break the grip of the water, the pilot applies enough aileron pressure to lift one float just out of the water and allows the seaplane to continue to accelerate on the step of the other float until lift-off. By allowing the seaplane to turn slightly in the direction the aileron is being held rather than holding opposite rudder to maintain a straight course, considerable aerodynamic drag is eliminated, aiding acceleration and lift-off. When using this technique, be careful not to lift the wing so much that the opposite wing contacts the water. Obviously, this would have serious consequences. Once the seaplane lifts off, establish a positive rate of climb to prevent inadvertently flying back into the water.

Another technique that aids glassy water takeoffs entails roughening the surface a little. By taxiing around in a circle, the wake of the seaplane spreads and reflects from shorelines, creating a slightly rougher surface that can provide some visual depth and help the floats break free during takeoff.

Occasionally a pilot may have difficulty getting the seaplane onto the step during a glassy water takeoff, particularly if the seaplane is loaded to its maximum authorized weight. The floats support additional weight by displacing more water; they sink deeper into the water when at rest. Naturally, this wets more surface area, which equates to increased water drag when the seaplane begins moving, compared to a lightly loaded situation. Under these conditions the seaplane may assume a plowing position when full power is applied, but may not develop sufficient hydrodynamic lift to get on the step due to the additional water drag. The careful seaplane pilot always plans ahead and considers the possibility of aborting the takeoff.

Nonetheless, if these conditions are not too excessive, the takeoff often can be accomplished using the following technique.

After the nose rises to the highest point in the plowing position with full back elevator pressure, decrease back pressure somewhat. The nose will drop if the seaplane has attained enough speed to be on the verge of attaining the step position. After a few seconds, the nose will rise again. At the instant it starts to rise, reinforce the rise by again applying firm back pressure. As soon as the nose reaches its maximum height, repeat the entire routine. After several repetitions, the nose attains greater height and speed increases. If the elevator control is then pushed well forward and held there, the seaplane will slowly flatten out on the step and the controls may then be eased back to the neutral position. Once on the step, the remainder of the takeoff run follows the usual glassy water procedure.

ROUGH WATER TAKEOFFS

The objective in a rough water takeoff is similar to that of a rough or soft field takeoff in a landplane: to transfer the weight of the airplane to the wings as soon as possible, get airborne at a minimum airspeed, accelerate in ground effect to a safe climb speed, and climb out.

In most cases an experienced seaplane pilot can safely take off in rough water, but a beginner should not attempt to take off if the waves are too high. Using the proper procedure during rough water operation lessens the abuse of the floats, as well as the entire seaplane.

During rough water takeoffs, open the throttle to takeoff power just as the floats begin rising on a wave. This prevents the float bows from digging into the water and helps keep the spray away from the propeller. Apply a little more back elevator pressure than on a smooth water takeoff. This raises the nose to a higher angle and helps keep the float bows clear of the water.

Once on the step, the seaplane can begin to bounce from one wave crest to the next, raising its nose higher with each bounce, so each successive wave is struck with increasing severity. To correct this situation and to prevent a stall, smooth elevator pressures should be used to set up a fairly constant pitch attitude that allows the seaplane to skim across each successive wave as speed increases. Maintain control pressure to prevent the float bows from being pushed under the water surface, and to keep the seaplane from being thrown into the air at a high pitch angle and low airspeed. Fortunately, a takeoff in rough water is generally accomplished within a short time because if there is sufficient wind to make water rough, the wind is also strong enough to produce aerodynamic lift earlier and enable the seaplane to become airborne quickly.

The relationship of the spacing of the waves to the length of the floats is very important. If the wavelength is less than half the length of the floats, the seaplane is always supported by at least two waves at a time. If the wavelength is longer than the floats, only one wave at a time supports the seaplane. This creates dangerous pitching motions, and takeoff should not be attempted in this situation.

With respect to water roughness, consider the effect of a strong water current flowing against the wind. If the current is moving at 10 knots and the wind is blowing the opposite direction at 15 knots, the relative velocity between the water and the wind is 25 knots, and the waves will be as high as those produced in still water by a wind of 25 knots.

The advisability of canceling a proposed flight because of rough water depends on the size of the seaplane, wing loading, power loading, and, most importantly, the pilot's ability. As a general rule, if the height of the waves from trough to crest is more than half the height of the floats from keel to deck, takeoffs should not be attempted except by expert seaplane pilots. Chapter 8, Emergency Open Sea Operations, contains more information on rough water operations.

CONFINED AREA TAKEOFFS

If operating from a small body of water, an acceptable technique may be to begin the takeoff run while headed downwind, and then turning to complete the takeoff into the wind. This may be done by putting the seaplane on the step while on a downwind heading, then making a step turn into the wind to complete the takeoff. Exercise caution when using this technique since wind and centrifugal force are acting in the same direction and could result in the seaplane tipping over. The water area must be large enough to permit a wide step turn, and winds should be light.

In some cases, the water area may be adequate but surrounding high terrain creates a confined area. The terrain may also block winds, resulting in a glassy water situation as well. Such conditions may lead to a dangerous situation, especially when combined with a high density altitude. Even though landing was not difficult, careful planning is necessary for the takeoff. If the departure path leads over high terrain, consider circling back over the water after takeoff to gain altitude. If air temperatures have increased since landing, make the proper allowance for reduced takeoff performance due to the change in density altitude. Think about spending the night to take advantage of cooler temperatures the next morning. Although the decision may be difficult, consider leaving some cargo or passengers behind if takeoff safety is in question. It is far better to make a second trip to pick them up than to end your takeoff in the trees along the shore.

PERFORMANCE CONSIDERATIONS FOR TAKEOFF, CLIMB, CRUISE, AND LANDING

Since many pilots are accustomed to a certain level of performance from a specific make and model of land airplane, the changes in performance when that same airplane is equipped with floats can lead to trouble for a careless or complacent pilot. Floats weigh somewhat more than the wheeled landing gear they replace, but floats are designed to produce aerodynamic lift to offset some of the weight penalty. Generating lift inevitably creates induced drag, which imposes a small reduction in overall performance. By far the greatest impact on performance comes from the parasitic drag of the floats.

TAKEOFF

In a landplane, takeoff distance increases with additional takeoff weight for two reasons: it takes longer for the engine and propeller to accelerate the greater mass to lift-off speed, and the lift-off speed itself is higher because the wings must move faster to produce the extra lift required. For seaplanes, there are two more factors, both due to water drag. As seaplane weight increases, the floats sink deeper into the water, creating more drag during initial acceleration. As with the landplane, the seaplane must also accelerate to a higher airspeed to generate more lift, but the seaplane must overcome significantly more water drag force as speed increases. This extra drag reduces the rate of acceleration and results in a longer takeoff run.

Naturally, the location of the additional weight within the seaplane affects center of gravity (CG) location. Because of the way the floats respond to weight, the CG location affects the seaplane's handling characteristics on the water. If the CG is too far aft, it may be impossible to put the seaplane on the step. If the CG is located to one side of the centerline, one float will be pushed deeper into the water, resulting in more water drag on that side. Be sure to balance the fuel load between left and right wing tanks, and pay attention to how baggage or cargo is secured, so that the weight is distributed somewhat evenly from side to side. [Figure 5-1]

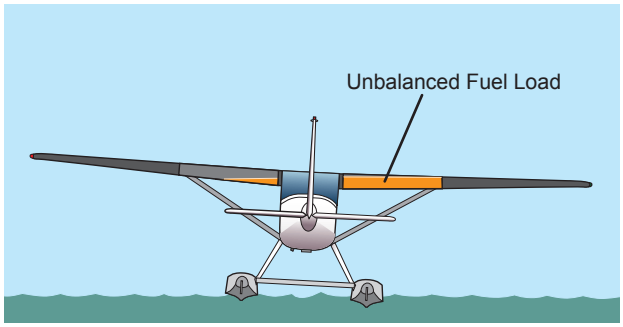

Figure 5-1. The location of the CG can affect seaplane handling.

The importance to weight and balance of pumping out the float compartments should be obvious. Water weighs 8.34 pounds per gallon, or a little over 62 pounds per cubic foot. Performance decreases whenever the wings and engine have to lift and carry useless water in a float compartment. Even a relatively small amount of water in one of the front or rear float compartments could place the airplane well outside of CG limits and seriously affect stability and control. Naturally, water also moves around in response to changes in attitude, and the sloshing of water in the floats can create substantial CG changes as the seaplane is brought onto the step or rotated into a climb attitude.

Some pilots use float compartments near the CG to stow iced fish or game from hunting expeditions. It is imperative to adhere to the manufacturer's weight and balance limitations and to include the weight and moment of float compartment contents in weight and balance calculations.

Density altitude is a very important factor in seaplane takeoff performance. High altitudes, high temperatures, high humidity, and even low barometric pressure can combine to rob the engine and propeller of thrust and the wings of lift. Seaplane pilots are encouraged to occasionally simulate high density altitude by using a reduced power setting for takeoff. This exercise should only be attempted where there is plenty of water area, as the takeoff run will be much longer. An experienced seaplane instructor can assist with choosing an appropriate power setting and demonstrating proper technique.

CLIMB AND CRUISE

When comparing the performance of an airplane with wheels to the same airplane equipped with floats, the drag and weight penalty of the floats usually results in a reduced climb rate for any given weight. Likewise, cruise speeds will usually be a little lower for a particular power setting. This in turn means increased fuel consumption and reduced range. Unless the airplane was originally configured as a seaplane, the performance and flight planning information for a landplane converted to floats will typically be found in the Supplements section rather than the Performance section of the Airplane Flight Manual (AFM) or Pilot's Operating Handbook (POH).

In addition to working within the limits of the seaplane's range, the pilot planning a cross-country flight must also consider the relative scarcity of refueling facilities for seaplanes. Amphibians have access to land airports, of course, but seaplanes without wheels need to find water landing facilities that also sell aviation fuel. While planning the trip, it is wise to call ahead to verify that the facilities have fuel and will be open at the intended arrival times. The Seaplane Pilots Association publishes a Water Landing Directory that is very helpful in planning cross-country flights.

In flight, the seaplane handles very much like the corresponding landplane. On many floatplanes, the floats decrease directional stability to some extent. The floats typically have more vertical surface area ahead of the airplane's CG than behind it. If the floats remain aligned with the airflow, this causes no problems, but if the airplane begins to yaw or skid, this vertical area acts somewhat like a large control surface that tends to increase the yaw, making the skid worse. [Figure 5-2] Additional vertical surface well behind the CG can counteract the yaw force created by the front of the floats, so many floatplanes have an auxiliary fin attached to the bottom of the tail, or small vertical surfaces added to the horizontal stabilizer. [Figure 5-3]

LANDING

Landplane pilots are trained to stay on the lookout for good places to land in an emergency, and to be able to plan a glide to a safe touchdown should the engine(s) fail. An airplane equipped with floats will usually have a steeper power-off glide than the same airplane with wheels. This means a higher rate of descent and a diminished glide range in the event of an engine failure, so the pilot should keep this in mind when spotting potential landing areas during cruising flight.

Seaplanes often permit more options in the event of an unplanned landing, since land can be used as well as water. While a water landing may seem like the only choice for a non-amphibious seaplane, a smooth landing on grass, dirt, or even a hard-surface runway usually causes very little damage to the floats or hull, and may frequently be the safer alternative.

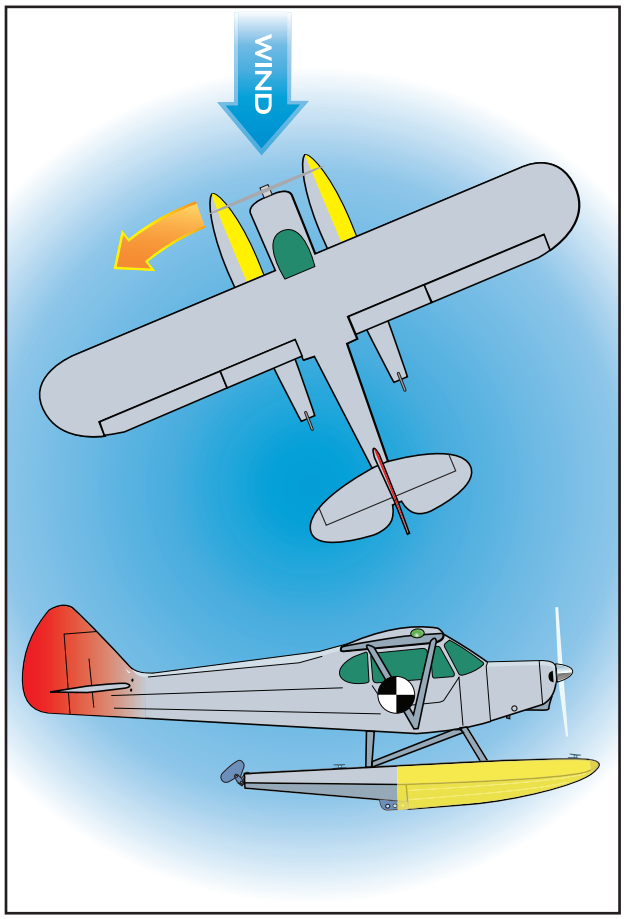

Figure 5-2. The side area of the floats can decrease directional stability.

Figure 5-3. Vertical surfaces added to the tail help restore directional stability.

FLIGHT CHARACTERISTICS OF SEAPLANES WITH HIGH THRUST LINES

Many of the most common flying boat designs have the engine and propeller mounted well above the airframe's CG. This results in some unique handling characteristics. The piloting techniques necessary to fly these airplanes safely are not intuitive and must be learned. Any pilot transitioning to such an airplane is strongly urged to obtain additional training specific to that model of seaplane.

Designing a seaplane with the engine and propeller high above the water offers some important advantages. The propeller is out of the spray during takeoffs and landings, and more of the fuselage volume can be used for passengers and cargo. The pilot usually sits well forward of the wing, and enjoys an excellent view in almost every direction.

Pilots who fly typical light twins are familiar with what happens when one engine is producing power and the other is not. The airplane tends to yaw toward the dead engine. This happens because the thrust line is located some distance from the airplane's CG. In some respects, this situation is similar to the single-engine seaplane with a high thrust line, except that the seaplane flies on one engine all the time. When power is applied, the thrust tends to pitch the nose down, and as power is reduced, the nose tends to rise. [Figure 5-4] This is exactly the opposite of what most pilots are accustomed to. In typical airplanes, including most floatplanes, applying power raises the nose and initiates a climb.

Naturally the magnitude of these pitch forces is proportional to how quickly power is applied or reduced. The most extreme pitch force logically results from a sudden engine failure, when the full thrust of the engine and its associated downward pitching force are suddenly removed. Forward thrust is replaced by the drag of a windmilling propeller, which adds a new upward pitching force. Since the seaplane is already trimmed with a considerable elevator force to counteract the downward pitch force of the engine, the nose pitches up abruptly. If this scenario occurs just after takeoff, when the engine has been producing maximum power, airspeed is low, and there is little altitude, the pilot must react instantly to overpower the upward pitching forces and push the nose down to avoid a stall.

The reversal of typical pitch forces also comes into play if porpoising should begin during a takeoff. As discussed in Chapter 4, Seaplane Operations - Preflight and Takeoffs, porpoising usually occurs when the planing angle is held too low by the pilot, forcing the front portion of the floats to drag until a wave builds up and travels back along the float. The same thing can happen with the hull of a flying boat, and the nose-down force of a high thrust line can make porpoising more likely. Once porpoising develops, the standard solution is to reduce power and let the airplane settle back into the water. But if power is reduced too quickly in a seaplane with a high-mounted engine, the sudden upward pitching force can combine with the porpoising to throw the seaplane into the air with inadequate airspeed for flight, decreasing thrust, and inadequate altitude for recovery.

Depending on how far the engine is from the airplane's CG, the mass of the engine can have detrimental effects on roll stability. Some seaplanes have the engine mounted within the upper fuselage, while oth-

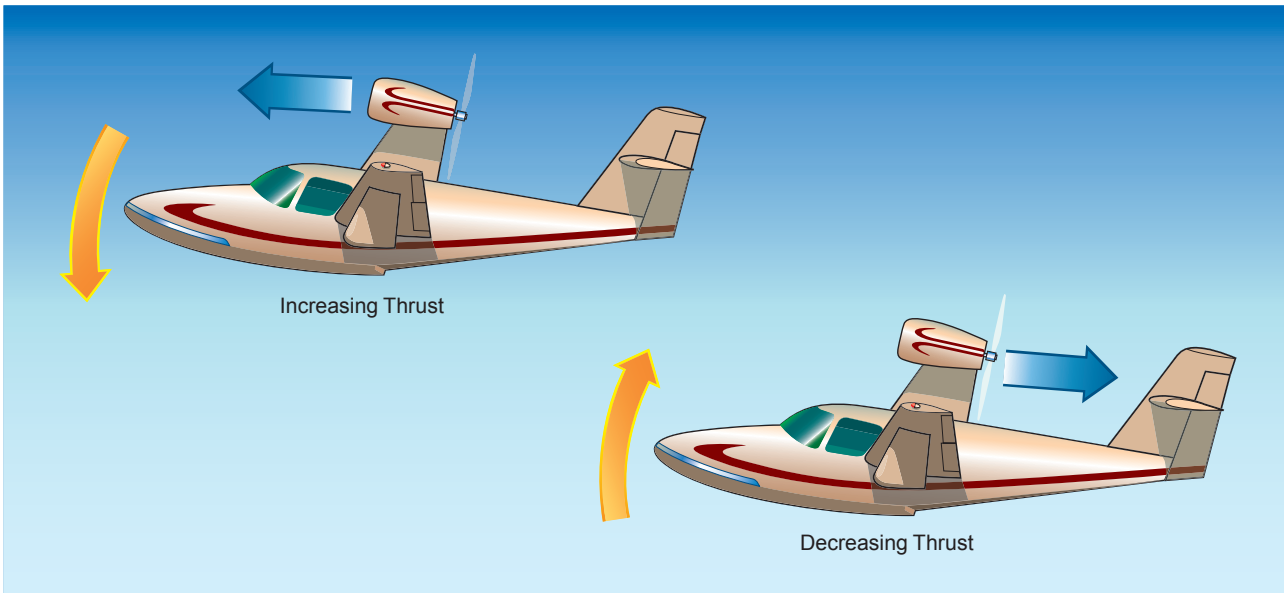

Figure 5-4. Pitching forces in seaplanes with a high thrust line.

ers have engines mounted on a pylon well above the main fuselage. If it is far from the CG, the engine can act like a weight at the end of a lever, and once started in motion it tends to continue in motion. Imagine balancing a hammer upright with the handle on the palm of the hand. [Figure 5-5]

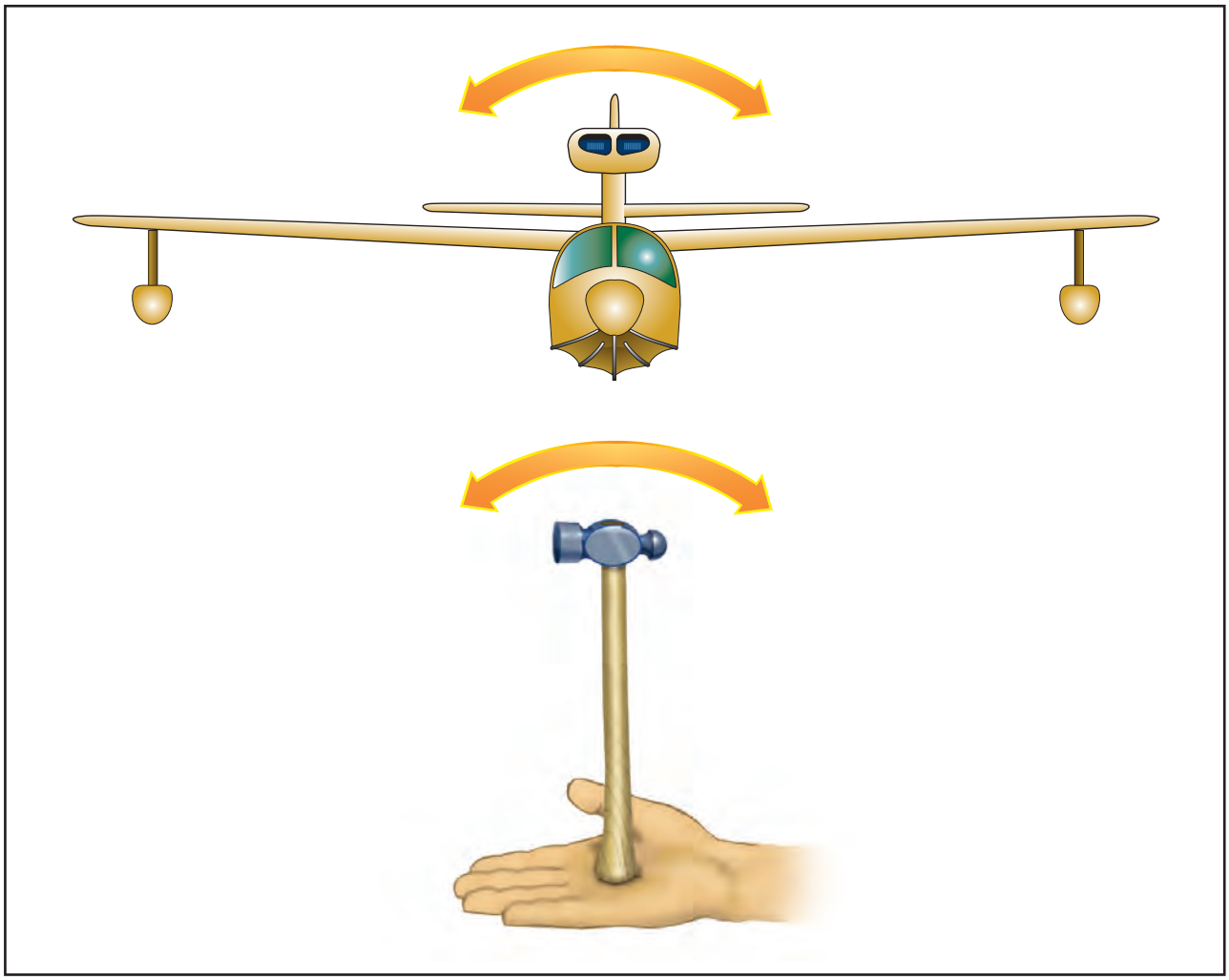

Figure 5-5. Roll instability with a high-mounted engine.

Finally, seaplanes with high-mounted engines may have unusual spin characteristics and recovery techniques. These factors reinforce the point that pilots need to obtain thorough training from a qualified instructor in order to operate this type of seaplane safely.

MULTIENGINE SEAPLANES

A rating to fly single-engine seaplanes does not entitle a pilot to fly seaplanes with two or more engines. The addition of a multiengine sea rating to a pilot certificate requires considerable additional training. Dealing with engine failures and issues of asymmetrical thrust are important aspects in the operation of multiengine seaplanes.

LANDING AREA RECONNAISSANCE AND PLANNING

When a landplane makes an approach at a towered airport, the pilot can expect that the runway surface will be flat and free of obstructions. Wind information and landing direction are provided by the tower. In water operations, the pilot must make a number of judgments about the safety and suitability of the landing area, evaluate the characteristics of the water surface, determine wind direction and speed, and choose a landing direction. It is rare for active airport runways to be used by other vehicles, but common for seaplane pilots to share their landing areas with boats, ships, swimmers, jet-skis, wind-surfers, or barges, as well as other seaplanes.

It is usually a good practice to circle the area of intended landing and examine it thoroughly for obstructions such as pilings or floating debris, and to note the direction of movement of any boats that may be in or moving toward the intended landing site. Even if the boats themselves will remain clear of the landing area, look for wakes that could create hazardous swells if they move into the touchdown zone. This is also the time to look for indications of currents in moving water. Note the position of any buoys marking preferred channels, hidden dangers, or off-limits areas such as no-wake zones or swimming beaches. Just as it is a good idea in a landplane to get a mental picture of the taxiway arrangement at an unfamiliar airport prior to landing, the seaplane pilot should plan a taxi route that will lead safely and efficiently from the intended touchdown area to the dock or mooring spot. This is especially important if there is a significant wind that could make turns difficult while taxiing or necessitate sailing backward or sideways to the dock. If the water is clear, and there is not much wind, it is possible to see areas of waterweeds or obstructions lying below the surface. Noting their position before landing can prevent fouling the water rudders with weeds while taxiing, or puncturing a float on a submerged snag. In confined areas, it is essential to verify before landing that there is sufficient room for a safe takeoff under the conditions that are likely to prevail at the intended departure time. While obstruction heights are regulated in the vicinity of land airports and tall structures are usually well marked, this is not the case with most water landing areas. Be alert for towers, cranes, powerlines, and the masts of ships and boats on the approach path. Finally, plan a safe, conservative path for a go-around should the landing need to be aborted.

Most established seaplane bases have a windsock, but if one is not visible, there are many other cues to gauge the wind direction and speed prior to landing. If there are no strong tides or water currents, boats lying at anchor weathervane and automatically point into the wind. Be aware that some boats also set a stern anchor, and thus do not move with changes in wind direction. There is usually a glassy band of calm water on the upwind shore of a lake. Sea gulls and other waterfowl usually land into the wind and typically head into the wind while swimming on the surface. Smoke, flags, and the set of sails on sailboats also provide the pilot with a fair approximation of the wind direction. If there is an appreciable wind velocity, wind streaks parallel to the wind form on the water. In light winds, they appear as long, narrow, straight streaks of smooth water through the wavelets. In winds of approximately 10 knots or more, foam accents the streaks, forming distinct white lines. Although wind streaks show direction very accurately, the pilot must still determine which end of the wind streak is upwind. For example, an east-west wind streak could mean a wind from the east or the west—it is up to the pilot to determine which. [Figure 6-1]

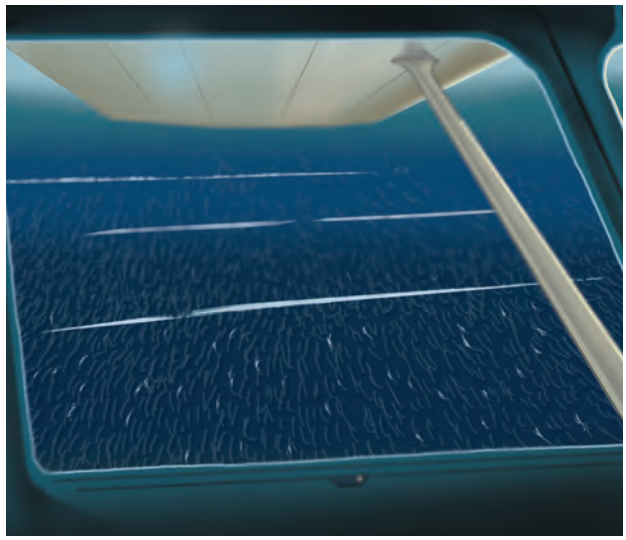

Figure 6-1. Wind streaks show wind direction accurately, but the pilot must determine which end of the streak is upwind.

If there are whitecaps or foam on top of the waves, the foam appears to move into the wind. This illusion is caused by the motion of the waves, which move more quickly than the foam. As the waves pass under the foam, the foam appears to move in the opposite direction. The shape of shorelines and hills influences wind direction, and may cause significant variations from one area to another. Do not assume that because the wind is from a certain direction on this side of the lake that it is from the same direction on the other side.

Except for glassy water, it is usually best to plan to land on the smoothest water available. When a swell system is superimposed on a second swell system, some of the waves may reinforce each other, resulting in higher waves, while other waves cancel each other out, leaving smoother areas. Often it is possible to avoid the larger waves and land on the smooth areas.

In seaplanes equipped with retractable landing gear (amphibians), it is extremely important to make certain that the wheels are retracted when landing on water. Wherever possible, make a visual check of the wheels themselves, in addition to checking the landing gear position indicators. A wheels-down landing on water is almost certain to capsize the seaplane, and is far more serious than landing the seaplane on land with the wheels up. Many experienced seaplane pilots make a point of saying out loud to themselves before every water landing, "This is a **water** landing, so the wheels should be **up**." Then they confirm that each wheel is up using externally mounted mirrors and other visual indicators. Likewise, they verbally confirm that the wheels are down before every landing on land. The water rudders are also retracted for landings.

When planning the landing approach, be aware that the seaplane has a higher sink rate than its landplane counterpart at the same airspeed and power setting. With some practice, it becomes easy to land accurately on a predetermined spot. Landing near unfamiliar shorelines increases the possibility of encountering submerged objects and debris.

Besides being safe, it is also very important for seaplane pilots to make a conscious effort to avoid inflicting unnecessary noise on other people in the area. Being considerate of others can often mean the difference between a warm welcome and the banning of future seaplane activity in a particular location. The actions of one pilot can result in the closing of a desirable landing spot to all pilots. People with houses along the shore of a lake usually include the quiet as one of the reasons they chose to live there. Sometimes high terrain around a lake or the local topography of a shoreline can reflect and amplify sound, so that a seaplane sounds louder than it would otherwise. A good practice is to cross populated shorelines no lower than 1,000 feet AGL whenever feasible. To the extent possible consistent with safety, avoid overflying houses during the landing approach. If making a go-around, turn back over the water for the climbout, and reduce power slightly after attaining a safe altitude and airspeed. A reduction of 200 r.p.m. makes a significant difference in the amount of sound that reaches the ground.

LANDING

In water landings, the major objectives are to touch down at the lowest speed possible, in the correct pitch attitude, without side drift, and with full control throughout the approach, landing, and transition to taxiing.

The correct pitch attitude at touchdown in a landplane varies between wide limits. For example, wheel landings in an airplane with conventional-gear, require a nearly flat pitch attitude, with virtually zero angle of attack, while a full-stall landing on a short field might call for a nose-high attitude. The touchdown attitude for a seaplane typically is very close to the attitude for taxiing on the step. The nose may be a few degrees higher. The objective is to touch down on the steps,

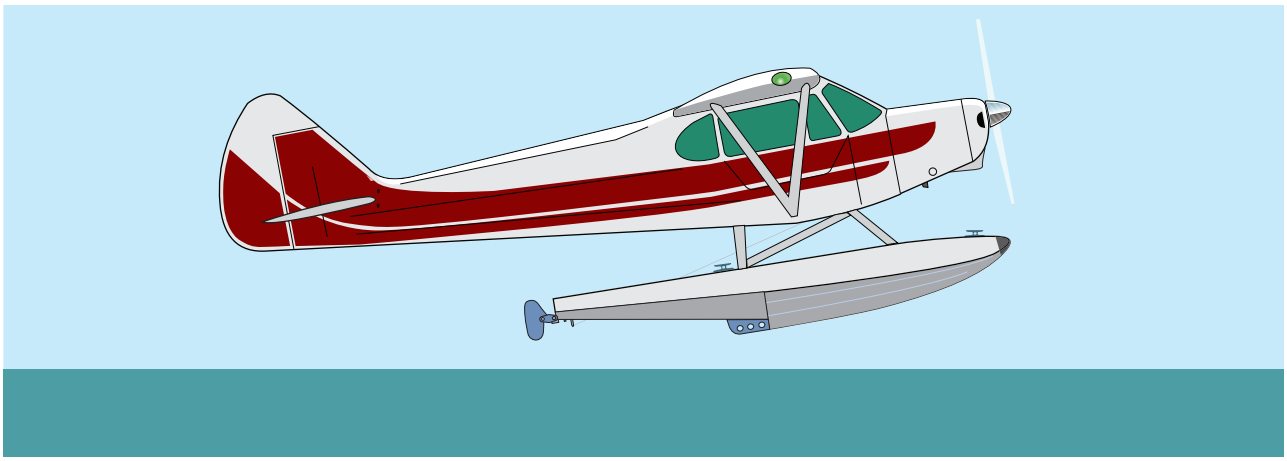

Figure 6-2. The touchdown attitude for most seaplanes is almost the same as for taxiing on the step.

with the sterns of the floats near or touching the water at the same time. [Figure 6-2] If the nose is much higher or lower, the excessive water drag puts unnecessary stress on the floats and struts, and can cause the nose to pitch down, allowing the bows of the floats to dig into the water. Touching down on the step keeps water drag forces to a minimum and allows energy to dissipate more gradually.

NORMAL LANDING

Make normal landings directly into the wind. Seaplanes can be landed either power-off or power-on, but power-on landings are generally preferred because they give the pilot more positive control of the rate of sink and the touchdown spot. To touch down at the slowest possible speed, extend the flaps fully. Use flaps, throttle, and pitch to control the glidepath and establish a stabilized approach at the recommended approach airspeed. The techniques for glidepath control are similar to those used in a landplane.

As the seaplane approaches the water's surface, smoothly raise the nose to the appropriate pitch attitude for touchdown. As the floats contact the water, use gentle back pressure on the elevator control to compensate for any tendency of the nose to drop. When the seaplane is definitely on the water, close the throttle and maintain the touchdown attitude until the seaplane begins to come off the step. Once it begins to settle into the plowing attitude, apply full up elevator to keep the nose as high as possible and minimize spray hitting the propeller.

As the seaplane slows to taxi speed, lower the water rudders to provide better directional control. Raise the flaps and perform the after-landing checklist.

The greater the speed difference between the seaplane and the water, the greater the drag at touchdown, and the greater the tendency for the nose to pitch down. This is why the touchdown is made at the lowest possible speed for the conditions. Many landplane pilots transitioning to seaplanes are surprised at the shortness of the landing run, in terms of both time and distance. It is not uncommon for the landing run from touchdown to idle taxi to take as little as 5 or 6 seconds.

Sometimes the pilot chooses to remain on the step after touchdown. To do so, merely add sufficient power and maintain the planing attitude immediately after touchdown. It is important to add enough power to prevent the seaplane from coming off the step, but not so much that the seaplane is close to flying speed. With too much taxi speed, a wave or swell could throw the seaplane into the air without enough speed to make a controlled landing. In that situation, the seaplane may stall and contact the water in a nose-down attitude, driving the float bows underwater and capsizing the seaplane. Raising the flaps can help keep the seaplane firmly on the water. To end the step taxi, close the throttle and gradually apply full up elevator as the seaplane slows.

CROSSWIND LANDING

Landing directly into the wind might not be practical due to water traffic in the area, obstructions on or under the water, or a confined landing area, such as a river or canal. In landing a seaplane with any degree of crosswind component, the objectives are the same as when landing a landplane: to minimize sideways drift during touchdown and maintain directional control afterward. Because floats have so much more side area than wheels, even a small amount of drift at touchdown can create large sideways forces. This is important because enough side force can lead to capsizing. Also, the float hardware is primarily designed to take vertical and fore-and-aft loads rather than side loads.

If the seaplane touches down while drifting sideways, the sudden resistance as the floats contact the water creates a skidding force that tends to push the downwind float deeper into the water. The combination of the skidding force, wind, and weathervaning as the seaplane slows down can lead to a loss of directional control and a waterloop. If the downwind float submerges and the wingtip contacts the water when the seaplane is moving at a significant speed, the seaplane could flip over. [Figure 6-3 on next page]

Floatplanes frequently have less crosswind component capability than their landplane counterparts. Directional control can be more difficult on water because the surface is more yielding, there is less surface friction than on land, and seaplanes lack brakes. These factors increase the seaplane's tendency to weathervane into the wind.

One technique sometimes used to compensate for crosswinds during water operations is the same as that used on land; that is, by lowering the upwind wing while holding a straight course with rudder. This creates a slip into the wind to offset the drifting tendency. The apparent movement of the water's surface during the landing approach can be deceiving. Wave motion may make it appear that the water is moving sideways, but although the wind moves the waves, the water itself remains virtually stationary. Waves are simply an up-and-down motion of the water surface—the water itself is not moving sideways. To detect side drift over water and maintain a straight path during landing, pick a spot on the shore or a stationary buoy as an aim point. Lower the upwind wing just enough to stop any drift, and use rudder to maintain a straight

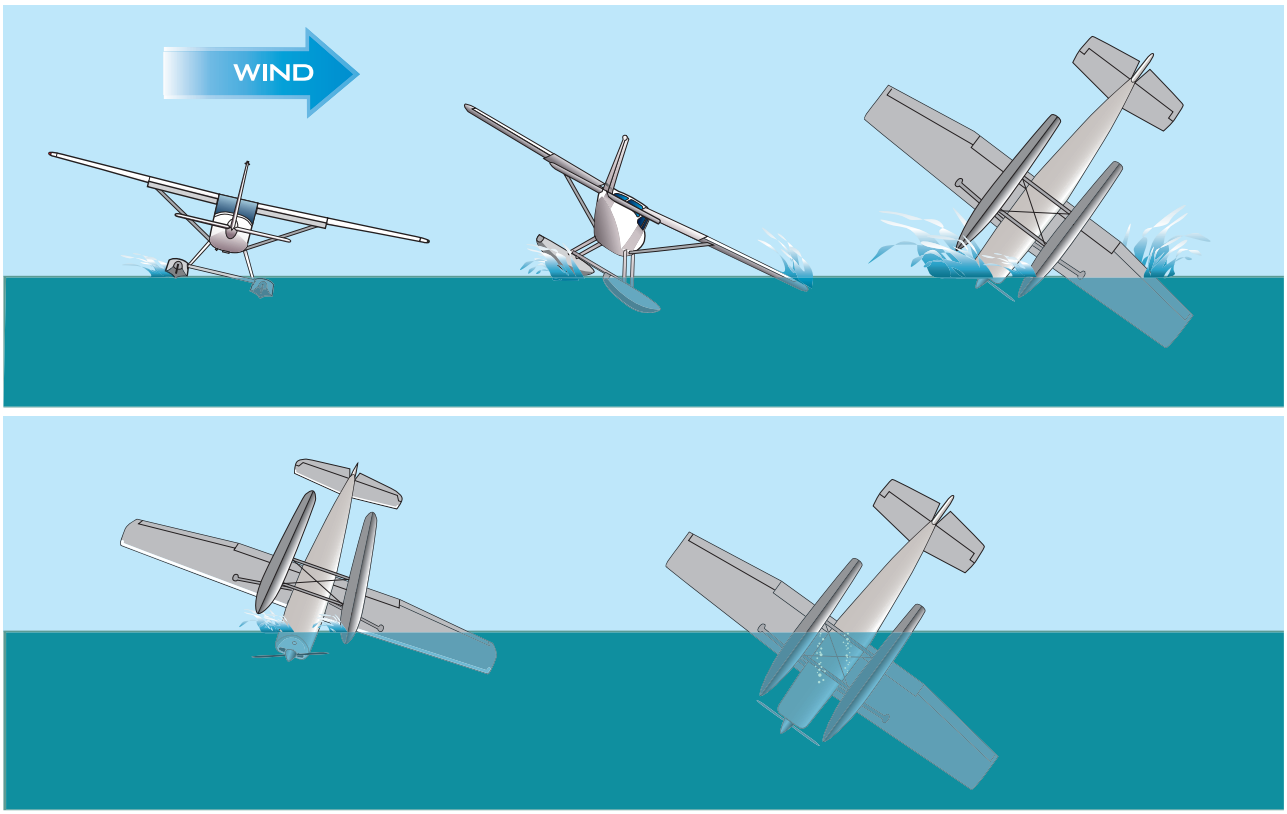

Figure 6-3. Improper technique or excessive crosswind forces can result in an accident.

path. As the seaplane touches down on the upwind float, the water drag will quickly slow the seaplane and the other float will touch down as aerodynamic lift decreases. Close the throttle, and as the seaplane's speed dissipates, increase aileron to hold the upwind wing down. The seaplane is most unstable as it is coming off the step and transitioning through the plowing phase. Be ready for the seaplane to weathervane into the wind as the air rudder becomes less effective. Many pilots make a turn to the downwind side after landing to minimize weathervaning until the seaplane has slowed to taxi speed. Since the seaplane will weathervane sooner or later, this technique reduces the centrifugal force on the seaplane by postponing weathervaning until speed has dissipated. Once the seaplane settles into the displacement attitude, lower the water rudders for better directional control. [Figure 6-4]

Another technique used to compensate for crosswinds (preferred by many seaplane pilots) is the downwind arc method. Seaplanes need not follow a straight path during landing, and by choosing a curved path, the pilot can create a sideward force (centrifugal force) to offset the crosswind force. This is done by steering the seaplane in a downwind arc as shown in figure 6-5. During the approach, the pilot merely plans a curved landing path and follows this path to produce sufficient centrifugal force to counter the wind force. During the landing run, the pilot can adjust the amount of centrifugal force by varying rudder pressure to increase or decrease the rate of turn. This technique allows the pilot to compensate for a changing wind force during the water run.

Figure 6-5 shows that the tightest curve of the downwind arc is during the time the seaplane is traveling at low speed. Faster speeds reduce the crosswind effect, and at very slow speeds the seaplane can weathervane into the wind without imposing large side loads or stresses. Again, experience plays an important part in successful operation during crosswinds. It is essential that all seaplane pilots have thorough knowledge and skill in these maneuvers.

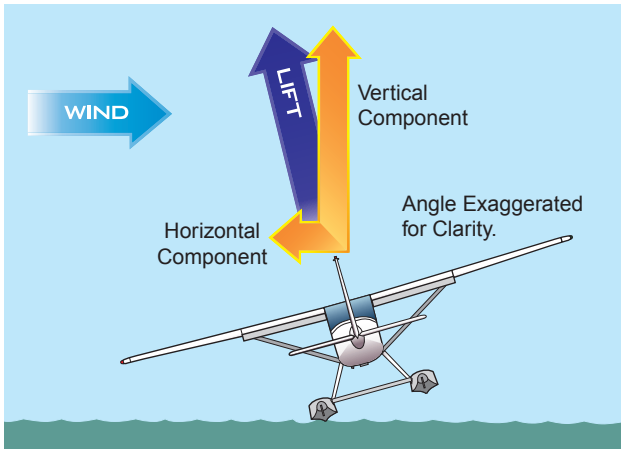

Figure 6-4. Dropping the upwind wing uses a horizontal component of lift to counter the drift of a crosswind.

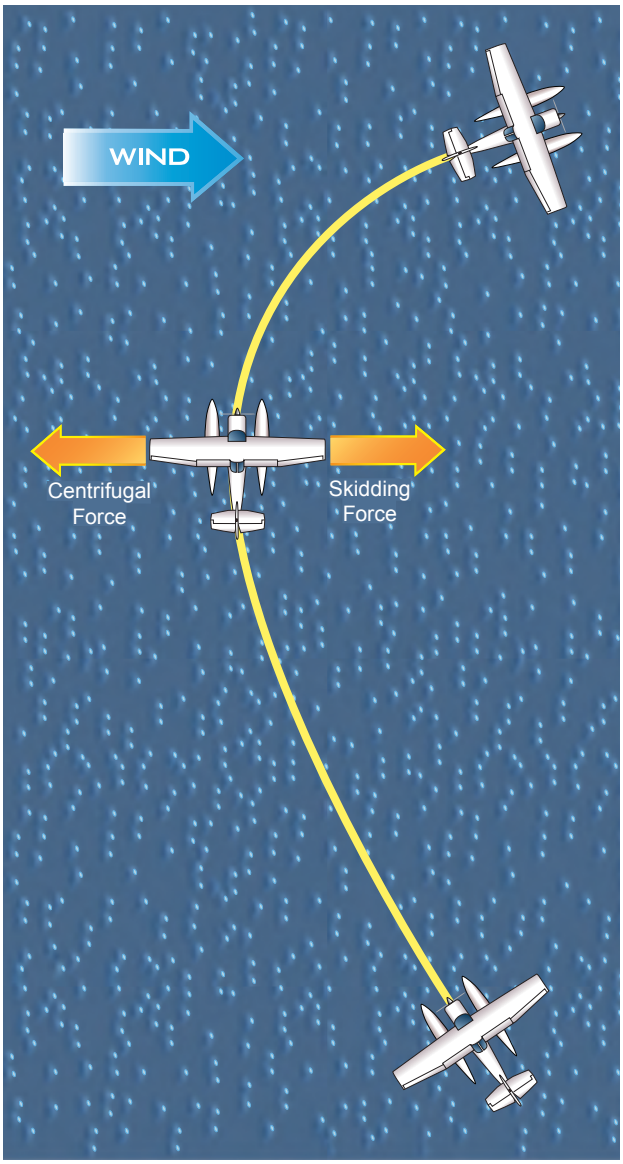

Figure 6-5. A downwind arc is one way to compensate for a crosswind.

DOWNWIND LANDING

Although downwind landings often require significantly more water area, there are occasions when they are more convenient or even safer than landing into the wind. Sometimes landing upwind would mean a long, slow taxi back along the landing path to get to the dock or mooring area. If winds are less than 5 knots and there is ample room, landing downwind could save taxi time. Unless the winds are light, a downwind landing is seldom necessary. Before deciding to land downwind, the pilot needs a thorough knowledge of the landing characteristics of the seaplane as well as the environmental factors in the landing area.

As with a downwind landing in a landplane, the main concern for a seaplane is the additional groundspeed added by the wind to the normal approach speed. The airspeed, of course, is the same whether landing upwind or downwind, but the wind decreases groundspeed in upwind landings and increases groundspeed in downwind landings. While a landplane pilot seldom thinks about the additional force placed on the landing gear by a higher groundspeed at touchdown, it is a serious concern for the seaplane pilot. A small increase in water speed translates into greatly increased water drag as the seaplane touches down, increasing the tendency of the seaplane to nose over. In light winds, this usually presents little problem if the pilot is familiar with how the seaplane handles when touching down at higher speeds, and is anticipating the increased drag forces. In higher winds, the nose-down force may exceed the ability of the pilot or the flight controls to compensate, and the seaplane will flip over at high speed. If the water's surface is rough, the higher touchdown speed also subjects the floats and airframe to additional pounding.

If there is a strong current, the direction of water flow is a major factor in choosing a landing direction. The speed of the current, a confined landing area, or the surface state of the water may influence the choice of landing direction more than the direction of the wind. In calm or light winds, takeoffs usually are made in the same direction as the flow of the current, but landings may be made either with or against the flow of the current, depending on a variety of factors. For example, on a narrow river with a relatively fast current, the speed of the current is often more significant than wind direction, and the need to maintain control of the seaplane at taxi speed after the landing run may present more challenges than the landing itself. It is imperative that even an experienced seaplane pilot obtain detailed information about such operations before attempting them for the first time. Often the best source of information is local pilots with comprehensive knowledge of the techniques that work best in specific locations and conditions.

GLASSY WATER LANDING

Flat, calm, glassy water certainly looks inviting and may give the pilot a false sense of safety. By its nature, glassy water indicates no wind, so there are no concerns about which direction to land, no crosswind to consider, no weathervaning, and obviously no rough water. Unfortunately, both the visual and the physical characteristics of glassy water hold potential hazards for complacent pilots. Consequently, this surface condition is frequently more dangerous than it appears for a landing seaplane.

The visual aspects of glassy water make it difficult to judge the seaplane's height above the water. The lack of surface features can make accurate depth perception very difficult, even for experienced seaplane pilots. Without adequate knowledge of the seaplane's

height above the surface, the pilot may flare too high or too low. Either case can lead to an upset. If the seaplane flares too high and stalls, it will pitch down, very likely hitting the water with the bows of the floats and flipping over. If the pilot flares too late or not at all, the seaplane may fly into the water at relatively high speed, landing on the float bows, driving them underwater and flipping the seaplane. [Figure 6-6]

Besides the lack of surface features, the smooth, reflecting surface can lead to confusing illusions as clouds or shore features are reproduced in stunning detail and full color. When the water is crystal clear and glassy, the surface itself is invisible, and pilots may inadvertently judge height by using the bottom of the lake as a reference, rather than the water surface.

The lack of surface texture also presents a physical characteristic that adds slightly to the risk of glassy water landings. A nice smooth touchdown can result in faster deceleration than expected, for the same reason that the floats seem to stick to the surface during glassy water takeoffs: there is less turbulence and fewer air bubbles between the float bottoms and the water, which effectively increases the wetted surface area of the floats and causes higher drag forces. Naturally, this sudden extra drag at touchdown tends to pull the nose down, but if the pilot is expecting it and maintains the planing attitude with appropriate back pressure, the tendency is easily controlled and presents no problem.

There are some simple ways to overcome the visual illusions and increase safety during glassy water landings. Perhaps the simplest is to land near the shoreline, using the features along the shore to gauge altitude. Be certain that the water is sufficiently deep and free of obstructions by performing a careful inspection from a safe altitude. Another technique is to make the final approach over land, crossing the shoreline at the lowest possible safe altitude so that a reliable height reference is maintained to within a few feet of the water surface.

When adequate visual references are not available, make glassy water landings by establishing a stable descent in the landing attitude at a rate that will provide a positive, but not excessive, contact with the water. Recognize the need for this type of landing in ample time to set up the proper final approach. Always perform glassy water landings with power. Perform a normal approach, but prepare as though intending to land at an altitude well above the surface. For example, in a situation where a current altimeter setting is not available and there are few visual cues, this altitude might be 200 feet above the surface. Landing preparation includes completion of the landing checklist and extension of flaps as recommended by the manufacturer. The objective is to have the seaplane ready to contact the water soon after it reaches the target altitude, so at approximately 200 feet above the surface, raise the nose to the attitude normally used for touchdown, and adjust the power to provide a constant descent rate of no more than 150 feet per minute (f.p.m.) at an airspeed approximately 10 knots above stall speed. Maintain this attitude, airspeed, and rate of descent until the seaplane contacts the water. Once the landing attitude and power setting are established, the airspeed and descent rate should remain the same without further adjustment, and the pilot should closely monitor the instruments to maintain this stable glide. Power should only be changed if the airspeed or rate of descent deviate from the desired values. Do not flare, but let the seaplane fly onto the water in the landing attitude. [Figure 6-7]

Upon touchdown, apply gentle back pressure to the elevator control to maintain the same pitch attitude. Close the throttle only after the seaplane is firmly on the water. Three cues provide verification through three different senses—vision, hearing, and body sensation. The pilot sees a slight nose-down pitch at touchdown and perhaps spray thrown to the sides by the floats, hears the sound of the water against the floats, and feels the deceleration force. Accidents have resulted from cutting the power suddenly after the initial touchdown. To the pilot's surprise, a skip had taken place and as the throttle closed, the seaplane was 10 to 15 feet in the air and not on the water, resulting in a stall and substantial damage. Be sure all of the cues

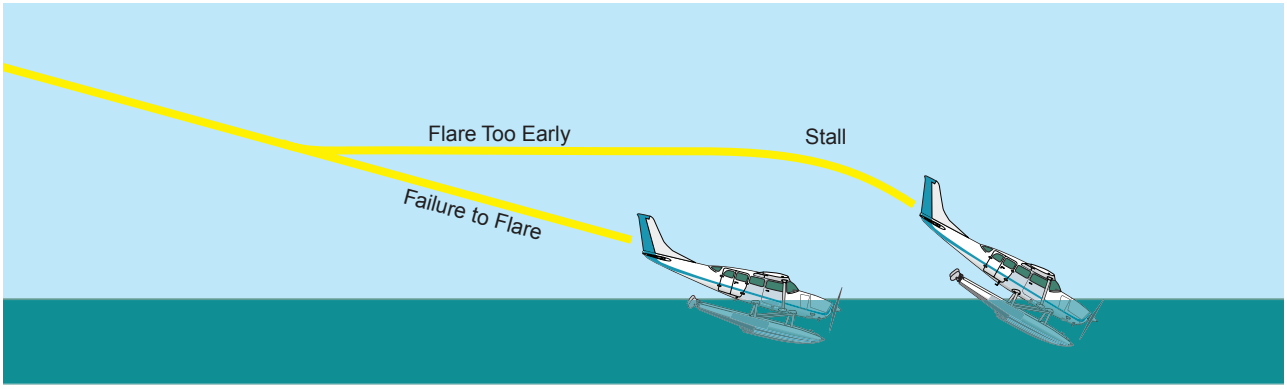

Figure 6-6. The consequences of misjudging altitude over glassy water can be catastrophic.

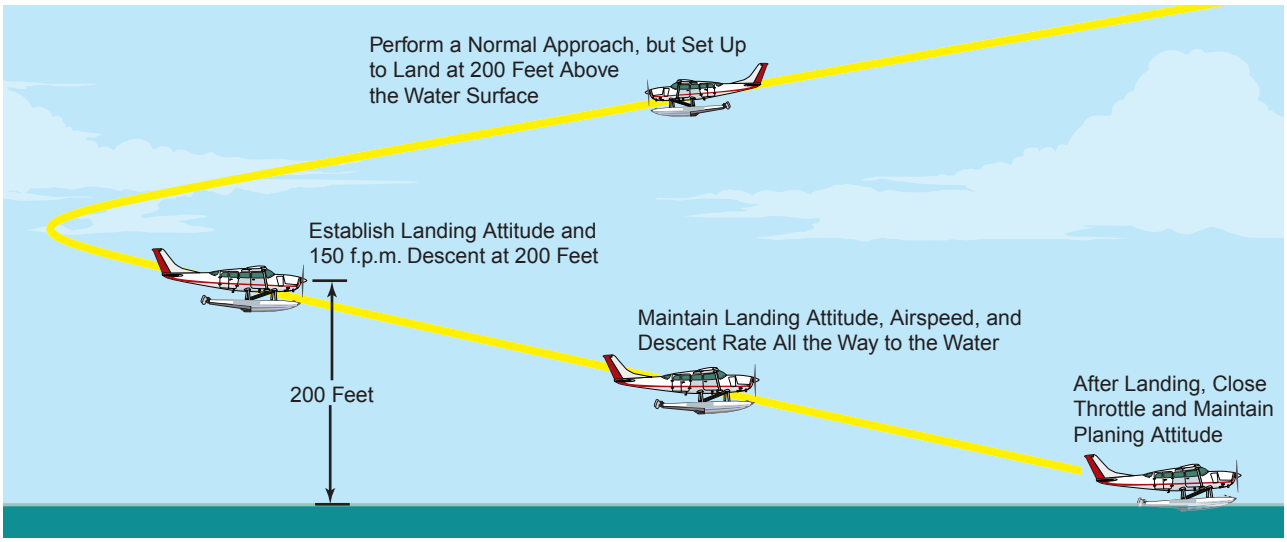

Figure 6-7. Hold the landing attitude, airspeed, and 150 f.p.m. rate of descent all the way to the surface.

indicate that the seaplane is staying on the water before closing the throttle. After the seaplane settles into a displacement taxi, complete the after-landing checklist and lower the water rudders.

An accurately set altimeter may allow the pilot to set up for the touchdown at an altitude somewhat closer to the surface. If the pilot can be certain that the landing configuration and 150 f.p.m. descent will be established well above the water's surface, starting the final glide nearer the surface shortens the descent time and overall landing length.

This technique usually produces a safe, comfortable landing, but the long, shallow glide consumes considerable landing distance. Be certain there is sufficient room for the glide, touchdown, and water run.

ROUGH WATER LANDING

Rough is a very subjective and relative term. Water conditions that cause no difficulty for small boats can be too rough for a seaplane. Likewise, water that poses no challenge to a large seaplane or an experienced pilot may be very dangerous for a smaller seaplane or a less experienced pilot.

Describing a typical or ideal rough water landing procedure is impractical because of the many variables that affect the water's surface. Wind direction and speed must be weighed along with the surface conditions of the water. In most instances, though, make the approach the same as for any other water landing. It may be better, however, to level off just above the water surface and increase the power sufficiently to maintain a rather flat attitude until conditions appear more acceptable, and then reduce the power to touch down. If severe bounces occur, add power and lift off to search for a smoother landing spot.

In general, make the touchdown at a somewhat flatter pitch attitude than usual. This prevents the seaplane from being tossed back into the air at a dangerously low airspeed, and helps the floats to slice through the tops of the waves rather than slamming hard against them. Reduce power as the seaplane settles into the water, and apply back pressure as it comes off the step to keep the float bows from digging into a wave face. If a particularly large wave throws the seaplane into the air before coming off the step, be ready to apply full power to go around.

Avoid downwind landings on rough water or in strong winds. Rough water is usually an indication of strong winds, and vice versa. Although the airspeed for landing is the same, wind velocity added to the seaplane's normal landing speed can result in a much higher groundspeed, imposing excessive stress on the floats, increasing the nose-down tendency at touchdown, and prolonging the water run, since more kinetic energy must be dissipated. As the seaplane slows, the tendency to weathervane may combine with the motion created by the rough surface to create an unstable situation. In strong winds, an upwind landing means a much lower touchdown speed, a shorter water run, and subsequently much less pounding of the floats and airframe.

Likewise, crosswind landings on rough water or in strong winds can leave the seaplane vulnerable to capsizing. The pitching and rolling produced by the water motion increases the likelihood of the wind lifting a wing and flipping the seaplane.

There is additional information on rough water landings in Chapter 8, Emergency Open Sea Operations.

CONFINED AREA LANDING

One of the first concerns when considering a landing in a confined area is whether it is possible to get out

again. For most seaplanes, the takeoff run is usually much longer than the landing run. Before landing, the pilot should also consider the wind and surface conditions expected when it is time to leave. If the seaplane lands into a stiff breeze on water with small waves, it might be more difficult to leave the next morning when winds are calm and the water is glassy. Conversely, if the seaplane lands in the morning when the air temperature is low, departure in the hot afternoon might mean a significant loss in takeoff performance due to the density altitude.

It is especially important to carefully inspect the landing area for shallow areas, obstructions, or other hazards. After touchdown is not the time to discover factors that make a confined landing area even smaller or less usable than originally supposed. Evaluation of the landing area should include approach and departure paths. Terrain that rises faster than the seaplane can climb is an obvious consideration, both for the eventual takeoff as well as in case of a go-around during landing. If climbout over the terrain is not easily within the seaplane's capabilities, be certain there is sufficient room to make a gentle turn back over the water for climb.

GO-AROUND

Whenever landing conditions are not satisfactory, execute a go-around. Potential conflicts with other aircraft, surface vessels or swimmers in the landing area, recognition of a hazard on the water, wind shear, wake turbulence, water surface conditions, mechanical failure, or an unstabilized landing approach are a few of the reasons to discontinue a landing attempt. Climb to a safe altitude while executing the go-around checklist, then evaluate the situation, and make another approach under more favorable conditions. Remember that it is often best to make a gentle climbing turn back over the water to gain altitude, rather than climbing out over a shoreline with rising terrain or noise-sensitive areas. The go-around is a normal maneuver that must be practiced and perfected like any other maneuver.

EMERGENCY LANDING

Emergency situations occurring within gliding distance of water usually present no landing difficulty. Although there is some leeway in landing attitude, it is important to select the correct type of landing for the water conditions. If the landing was due to an engine failure, an anchor and paddle are useful after the landing is completed.

Should the emergency occur over land, it is usually possible to land a floatplane with minimal damage in a smooth field. Snow covered ground is ideal if there are no obstructions. The landing should be at a slightly flatter attitude than normal, a bit fast, and directly into the wind. If engine power is available, landing with a small amount of power helps maintain the flatter attitude. Just before skidding to a stop, the tail will begin to rise, but the long front portions of the floats stop the rise and keep the seaplane from flipping over.

A night water landing should generally be considered only in an emergency. They can be extremely dangerous due to the difficulty of seeing objects in the water, judging surface conditions, and avoiding large waves or swell. If it becomes necessary to land at night in a seaplane, seriously consider landing at a lighted airport. An emergency landing can be made on a runway in seaplanes with little or no damage to the floats or hull. Touchdown is made with the keel of the floats or hull as nearly parallel to the surface as possible. After touchdown, apply full back elevator and additional power to lessen the rapid deceleration and nose-over tendency. Do not worry about getting stopped with additional power applied after touchdown. It will stop! The reason for applying power is to provide additional airflow over the elevator to help keep the tail down.

In any emergency landing on water, be as prepared as possible well before the landing. Passengers and crew should put on their flotation gear and adjust it properly. People sitting near doors should hold the liferafts or other emergency equipment in their laps, so no one will need to try to locate or pick it up in the scramble to exit the seaplane. Unlatch all the doors prior to touchdown, so they do not become jammed due to distortion of the airframe. Brief the passengers thoroughly on what to do during and after the landing. These instructions should include how to exit the seaplane even if they cannot see, how to get to the surface, and how to use any rescue aids.

POSTFLIGHT PROCEDURES

After landing, lower the water rudders and complete the after-landing checklist. The flaps are usually raised after landing, both to provide better visibility and to reduce the effects of wind while taxiing. It is a good practice to remain at least 50 feet from any other vessel during the taxi.

After landing, secure the seaplane to allow safe unloading, as well as to keep winds and currents from moving it around. Knowing a few basic terms makes the following discussions easier to understand. Anchoring uses a heavy hook connected to the seaplane by a line or cable. This **anchor** digs into the bottom due to tension on the line, and keeps the seaplane from drifting. **Mooring** means to tie the seaplane to a fixed structure on the surface. The seaplane may be moored to a floating buoy, or to a pier, or to a floating raft. For this discussion, **docking** means securing the seaplane to a permanent structure fixed to the shore. To **beach** a seaplane means to pull it up onto a suitable shore surface, so that its weight is supported by relatively dry ground

rather than water. **Ramping** is defined as using a ramp to get the seaplane out of the water and onto the shore.

ANCHORING

Anchoring is the easiest way to secure a seaplane on the water surface. The area selected should be out of the way of moving vessels, and in water deep enough that the seaplane will not be left aground during low tide. The holding characteristics of the bottom are important in selecting an appropriate anchorage. The length of the anchor line should be about seven times the depth of the water. After dropping the anchor with the seaplane headed into the wind, allow the seaplane to drift backward to set the anchor. To be sure the anchor is holding, watch two fixed points somewhere to the side of the seaplane, one farther away than the other, that are aligned with each other, such as a tree on the shore and a mountain in the distance. If they do not remain aligned, it means that the seaplane is drifting and dragging its anchor along the bottom. The nautical term for when two objects appear directly in line, one behind the other, is "in range" and the two objects are called a range.

When choosing a place to anchor, think about what will happen if the wind shifts. Allow enough room so that the seaplane can swing around the anchor without striking nearby obstacles or other anchored vessels. Be certain the water rudders are retracted, as they can interfere with the seaplane's ability to respond to wind shifts.

If anchoring the seaplane overnight or for longer periods of time, use a heavier anchor and be sure to comply with maritime regulations for showing an anchor light or daytime visual signals when required. [Figure 6-8]

When leaving the seaplane anchored for any length of time, it is a good idea to secure the controls with the elevator down and rudder neutral. Since the seaplane can rotate so that it always faces into the wind, this forces the nose down and reduces the angle of attack, keeping lift and wind resistance at a minimum.

MOORING

Mooring a seaplane eliminates the problem of the anchor dragging. A permanent mooring installation consists of a heavy weight on the bottom connected by a chain or cable to a floating buoy with provisions for securing mooring lines. Approach a mooring at a very low speed and straight into the wind. To keep from overrunning the mooring, shut down the engine early and let the seaplane coast to the mooring. If necessary, the engine can be started again for better positioning.

Never straddle a buoy with a twin-float installation. Always approach while keeping the buoy to the outside of the float to avoid damage to the propeller and underside of the fuselage. Initial contact with the buoy is usually made with a boat hook or a person standing on the deck of one float.

While approaching the mooring, have the person on the float secure one end of a short line to the bottom of a float strut, if one is not there already. Then taxi the seaplane right or left of the mooring so that the float on which the person is standing comes directly alongside the buoy. The free end of the line can then be secured to the mooring.

Exercise extreme caution whenever a person is assisting in securing the seaplane. There have been many instances of helpers being struck by the propeller. On

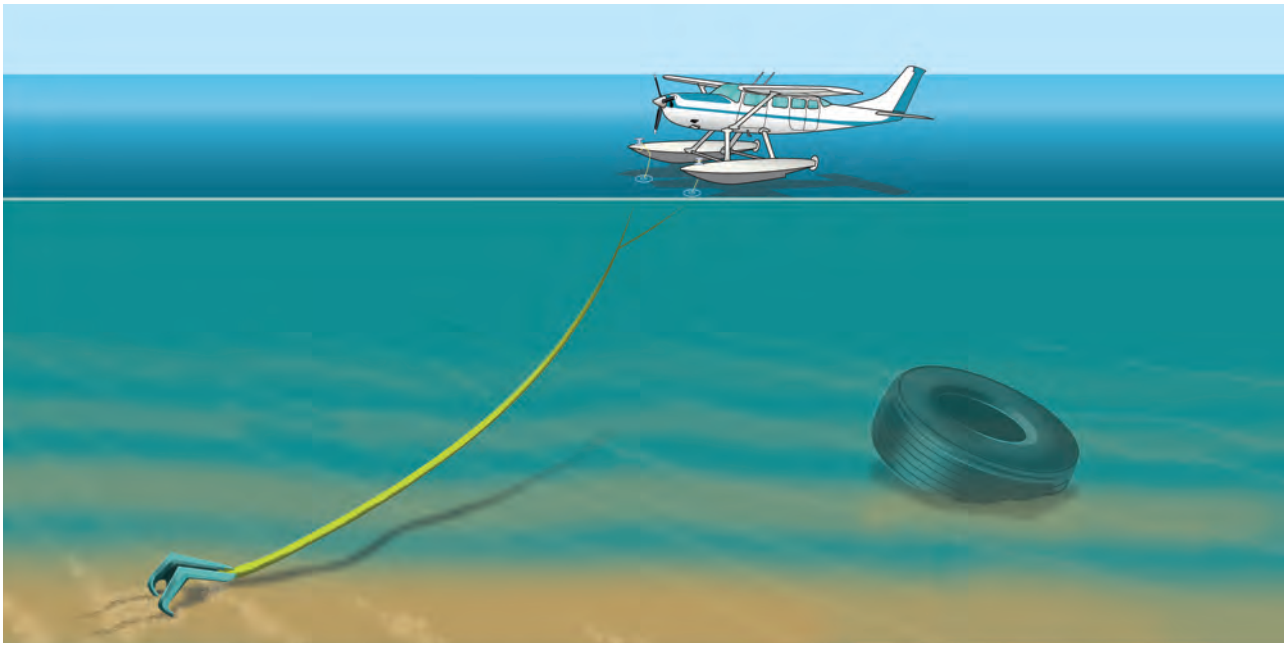

Figure 6-8. Anchoring.

most floatplanes, the floats extend well in front of the propeller arc. Eager to do a good job, an inexperienced helper might forget the spinning propeller while walking forward along the float.

DOCKING

The procedure for docking is essentially the same as for mooring, except that approaching directly into the wind may not be an option. The keys to successful docking are proper planning of the approach to the dock, compensating for the existing environmental conditions, and skill in handling the seaplane in congested areas. Bear in mind that a seaplane is fragile and hitting an obstruction can result in extensive damage.

Plan the approach to the dock so as to keep the wind on the seaplane's nose as much as possible. While still well clear of the dock area, check the responsiveness of the water rudders and be sure the seaplane will be able to maneuver in the existing wind and current. If control seems marginal, turn away and plan an alternative method of reaching the dock. While approaching the dock, the person who will be jumping out to secure the seaplane should take off seatbelts and unlatch the door. When it is clear that the seaplane will just make it to the dock, shut down the engine and let the seaplane coast the remaining distance to encounter the dock as gently as possible. The person securing the seaplane should step out onto the float, pick up the mooring line attached to the rear float strut, and step onto the dock as the seaplane stops. The line should be secured to a mooring cleat on the dock. Use additional mooring lines if the seaplane will be left unattended. Be sure to complete any remaining items on the checklist, and to double-check that the mixture, magnetos, and master switch are in the off positions.

BEACHING

Success in beaching depends primarily on the type and firmness of the shoreline. Inspect the beach carefully before using it. If this is impossible, approach the beach at an oblique angle so the seaplane can be turned out into deeper water if the beach is unsatisfactory. The hardest packed sand is usually near the water's edge and becomes softer where it is dry, further from the water's edge. Rocky shorelines are likely to damage the floats, especially if significant waves are rolling in. Mud bottoms are usually not desirable for beaching.

To protect them from damage, water rudders should be up before entering the shallow water near a beach. Sand is abrasive and erodes any protective coatings on the bottoms of the floats. If possible, beach the seaplane by sailing backward with the water rudders up. The aft bottoms of the floats do not dig into the sand as deeply as the forward bottoms, so backing onto a beach is not as hard on the floats as going in nose-first.

Do not leave the seaplane unattended unless at least a tail line is fastened to some solid object ashore. Moderate action of the water rapidly washes away the sand under the floats and lets the seaplane drift. An incoming tide can float a beached seaplane in just a few minutes. Likewise, a receding tide may leave a seaplane stranded 30 or 40 feet from the water in a few hours. Even small waves may alternately pick up and drop the seaplane, potentially causing serious damage, unless the seaplane is beached well out of their reach. Flying boat pilots should be sure to clear the main gear wells of any sand or debris that may have accumulated before departing.

If the seaplane is beached overnight or higher winds are expected, use portable tiedowns or stakes driven into firm ground and tie it down like a landplane. If severe winds are expected, the compartments of the floats can be filled with water. This holds the seaplane in very high winds, but it is a lot of work to pump out the floats afterward.

RAMPING

For the purpose of this discussion, a ramp is a sloping platform extending well under the surface of the water. If the ramp is wood, the seaplane can be slid up or down it on the keels of the floats, provided the surface of the ramp above the water is wet. Concrete boat ramps are generally not suitable for seaplanes. Water rudders should be down for directional control while approaching the ramp, but raised after the seaplane hits the ramp.

If the wind is blowing directly toward the shore, it is possible to approach the ramp downwind with enough speed to maintain control. Continue this speed until the seaplane actually contacts the ramp and slides up it. Many inexperienced pilots make the mistake of cutting the power before reaching the ramp for fear of hitting it too hard. This is more likely to result in problems, since the seaplane may weathervane and hit the ramp sideways or backward, or at least need to be taxied out for another try. When approaching at the right speed, the bow wave of the float cushions the impact with the ramp, but if the seaplane is too slow or decelerating, the bow wave moves farther back along the float and the impact with the ramp may be harder. Many pilots apply a little power just prior to hitting the ramp, which raises the fronts of the floats and creates more of a cushioning bow wave. Be sure to hold the elevator control all the way back throughout the ramping. [Figure 6-9]

When the seaplane stops moving, shut down the engine and complete the appropriate checklist. Ideally, the seaplane should be far enough up the ramp that waves or swells will not lift the floats and work the seaplane

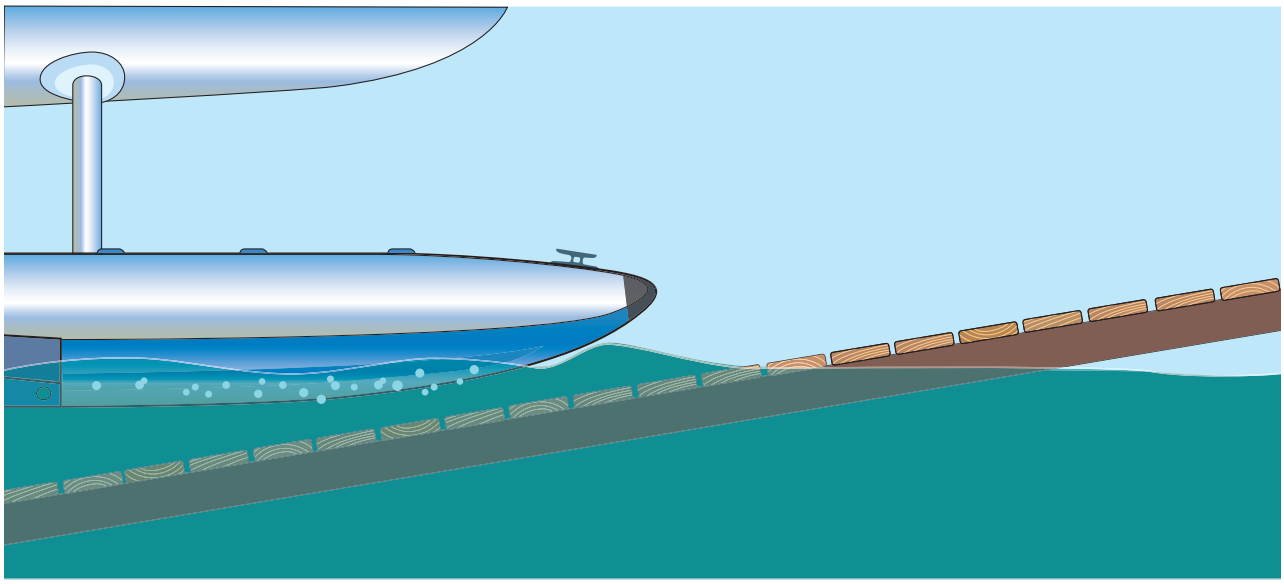

Figure 6-9. The bow wave cushions the contact with the ramp.

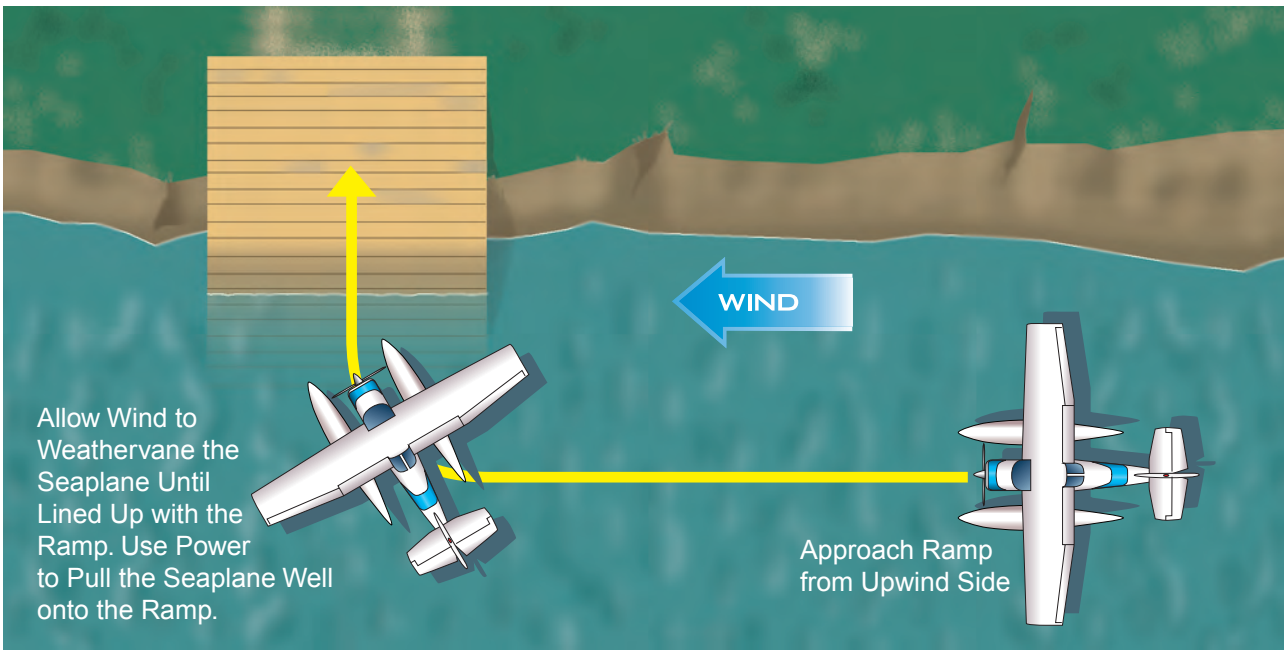

Figure 6-10. Crosswind approach to a ramp.

back into the water, but not so far up the ramp that shoving off is difficult. Ramps are usually quite slippery, so pilot and passengers must be very cautious of their footing when walking on the ramp.

The most difficult approach is when the wind is blowing parallel to the shore, and strong enough to make control marginal. If the approach is made into the wind, it may not be possible to turn the seaplane crosswind toward the ramp without excessive speed. In most cases, the best procedure is to taxi directly downwind until near the ramp, then close the throttle at the right point to allow weathervaning to place the seaplane on the ramp in the proper position. Then apply power to pull the seaplane up the ramp and clear of the water. This should not be attempted if the winds are high or the ramp is too slippery, since the seaplane could be blown sideways off the leeward side of the ramp. [Figure 6-10]

Experience and proficiency are necessary for ramping in strong winds. In many instances, the safest procedure is to taxi upwind to the ramp and near enough for a helper to attach a line to the floats. The seaplane may then be left floating, or pushed and pulled into a position where a vehicle can haul it up the ramp.

SALT WATER

Any time the seaplane has been operated in salt water, be sure to flush the entire seaplane with plenty of fresh water to minimize corrosion.