

Materials Needed (Prices Approximate)

1. (1) 7" section of 1/2" schedule 40 PVC pipe, cut into (1) 5" length and (2) 1" lengths (40¢)
2. (2) 1.5" sections of 2" PVC pipe, with a 1" section cut out (35¢)
3. (1)- 1/2" PVC "T" (45¢)
4. (2)- 1/2" PVC couplings (85¢)
5. (2)- 1/2" PVC plugs (85¢)
6. (1)- 2" diameter Fishing bobber (75¢)
7. (1)- 3/4" long pan-head screw (25¢)
8. Approx. 12" 16 ga. galvanized steel tie wire (2¢)
9. (2) standard 100 ml E. coli sampling bottles (85¢)
10. (2) 2" aluminum carabiners (45¢)
11. 26 feet (8 M) braided nylon line (\$1.45)
12. (1) outrigger clip (\$12.00) (Optional)
13. (2) 1" chrome-plated key rings (20¢)
14. (4) 8"X1/2" velcro straps (if desired) (20¢)

Total do-it-yourself price: \$19.07 with outrigger clip

\$7.07 using breakaway ring(s)

Price if purchased ready to assemble from the Verde River Institute: \$25.00 each w/o outrigger clip

This drone sampling rig is designed to allow the use of sterile sampling bottles with low risk of cross-contamination from previous uses of the rig, since the bottles are separated laterally from the rig, and drip lines are kept away from the samples. This means it should not normally be necessary to sterilize the rig between samples. It holds two identical 100 ml E. coli sterile sample bottles pre-loaded with sodium thiosulphate.

It is lightweight, yet strong and durable. Weight is minimized to allow the use of standard "prosumer" drones.

The primary parts are made using standard "schedule 40" 1/2" PVC piping and fittings, available at any hardware store. The collars that hold the sample bottles are made from a 1.5" length of 2" PVC pipe, with a 1" section removed, to allow the collar to flex. Bottles may be secured in the collars using 8"X1/2" Velcro straps.

PVC is used for several reasons: it is strong, light, waterproof and durable; it has a specific gravity of about 1.4, so it will sink in the water; the parts are all easily obtained and are very economical; it can be assembled without gluing*, so parts are easily interchanged; it can be milled, drilled and cut using standard household tools; it has a high melting point (over 140°C), so it can be sterilized, if necessary, in a steamer.

The float at the top is a standard 2" fishing bobber, available at any sporting goods store. The function of the bobber is to keep the center rod afloat just long enough for the sample bottles to fill. With the bobber in place, typically the rig hits the water, the center rod falls over and lies horizontally on the surface, such that the bottles' mouths are partially submerged, and the bottles sink the rig as they fill. Without the bobber, the rig can flip upside-down as soon as it hits the water, the bottles fail to fill, and instead will float the entire rig, necessitating some additional maneuvering of the drone to fill the bottles.

The holes drilled in the sides of the "T" help the rig fill with water so it will sink and also drain the rig as it's extracted from the water, thus reducing the load on the drone.

The line used is bright green "Micro 90 Cord , M90, Nylon Paracord" with a tensile strength of about 90 lb. It's available on Amazon.com or at Paracord Planet. It's very strong, won't unravel, is resistant to abrasion, is easy to see in the drone's monitor, and doesn't tangle as easily as some cords. Use a match, lighter, or torch to cut the line and seal the ends at the same time. The carabiners attaching the rig to the drone at both ends of the line are inexpensive aluminum 2" carabiners.

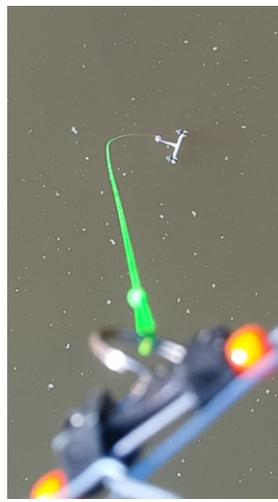
*If the parts do not fit together tightly enough to prevent them from easily separating, place a small length of Teflon tape across the female fitting's opening, then press the male end into it. This should tighten the fit.



The Collection Rig



Rig in the Air



Rig having just hit the surface



Outrigger Clip (optional)

The rig is attached to the drone using a 25' (7.6 M) line. The line has chrome-plated 1" key rings and a 2" aluminum carabiner at each end to facilitate attachment to and detachment from the drone. Both ends of the line need a "breakaway ring" made of 16 ga. galvanized steel tie wire. These rings are essential, because they are designed to release the payload if it becomes entangled in rocks, trees, etc. See page 3 for construction of these rings. Alternatively, you can use an outrigger clip, available at marine fishing supplies or on-line. The clips have an adjustable release force, and must be adjusted to hold the payload firmly, yet release when a 2-3-pound (or so) force is applied. Breakaway rings will stretch out and allow the payload to separate from the drone. You do not want your drone tethered to a tree! You also don't want to lose rigs due to insufficient release force. Be sure to follow the directions on page 3 precisely!

Your rig will weigh about 10.5 oz. (300 g) empty and about 19.6 oz. (556 g) when the bottles are full. Drones like the DJI Phantom 4 can lift about 2lb, 8 oz. max. Be sure you attach the outrigger clip or breakaway rings to the rig, so only the rig is lost in a hang-up.

The Procedure

Once you have the line attached to the drone, and the other end of the line attached to the sampling rig, you're ready to gather a sample. The following procedure is one that works well for us, but certainly your experience and needs may vary. One thing is very important: practice using the drone and attached rig over dry land many times until you are comfortable with placing the rig on a target on the ground. Get used to the way the rig oscillates, how it looks in your monitor, etc.. After that, practice over water several times, until you are comfortable lowering the rig to the water surface, making sure it sinks, etc. Don't expect to get it all right the first time out!

You must have a way to attach the rig to the landing gear of the drone. We do this with a length of tie wire strung diagonally between the front and back corners of the landing gear. In the middle of the wire, form a loop that will be used to clip the line's carabiner and outrigger clip. Be sure the wire doesn't interfere with the camera or gimbal. If you have a "gimbal guard" below the camera, you may be able to use it as an attachment point.

Fly the drone slowly until you are above the target water. Make sure that your camera is pointed straight down (check this more than once, it's critical!). Once the camera is set, lower the drone slowly until you see the rig touch the surface of the water (sometimes you can see the rig's shadow or the drone's prop wash on the surface just before it hits). When 10 feet or so above the water, switch to "tripod mode", if your drone has it. This will facilitate fine movements. As you lower the rig, and just before it hits the water, fly the drone very slowly upstream. This will get the bottles' mouths to face upstream when they fall over. Now let the rig drop about 6-8" into the water. Once you're sure it has sunk, slowly retract it from the water and return to the launch site. **Make all speed and altitude changes slowly and smoothly, to avoid large pendulum swings and to prevent sudden g-forces that may cause the breakaway ring or outrigger clip to release the rig!**

If your rig does start to swing, and you feel it's necessary to stop or slow it, just wait until the swing is fully forward, then "bump" the drone once in a forward direction. That will dampen the oscillation. Descending rapidly can also dampen swinging rigs.

If your rig gets tangled in a tree or other obstruction, drop the drone down a foot or so, then fly straight up at full throttle. This will pop a breakaway ring or outrigger clip and release the payload.

If you want to set a depth of your sample, do this by attaching a colored marker at the desired distance above the rig on the rig line. When you see the marker hit the water, the rig is at the set depth.

In high winds, be especially cautious, both to avoid snagging the rig in streamside vegetation and to reduce oscillation, but also to reduce stresses on the drone and the breakaway device.

You may find it advantageous to shoot a few stills or even a short video with each collection. Photos can be invaluable in establishing the site conditions and collection criteria for future documentation. Also, each video or still will have metadata that help document the collection.

This sheet is in no way intended to be a complete reference for sampling using a drone. It will get you started, but experience and practice will hone your skills



Wrap the wire tightly around the ½" PVC pipe.



Then cut the rings with a small overlap of ¼" to ½"



Attach the ring to the top of the bobber

How to Make Breakaway Rings

Breakaway rings are constructed using 16 gauge galvanized steel tie wire, available at any hardware store. **It's very important that you use the correct gauge and type of wire.**

1. Drill a 1/16" hole about ½" from the end of a short (12" or so) length of ½" PVC pipe. Insert the 16 ga. wire into the hole just a short way, then begin wrapping the wire neatly around the pipe, so as to form a long coil of wire (see illustration above). After wrapping the wire 10 or more times around the pipe, clip the wire where it enters the hole in the pipe with a pair of diagonal snips. Then clip the wire at the source end. You now have a coil of wire that looks like a spring.

2. Clip the "spring" into rings that have an overlap of the end of about ¼" to ½" (see illustration). **This is critical, as the ring will fail to release the payload if the overlap is too great.**

3. Place one breakaway clip in the top of the bobber attached to the sampling rig. Place another at the drone end of the line, so if the line gets tangled in something above the rig, it will still break away. This will ensure that all you will lose in the event of a snag is the rig.

4. The breakaway ring forms the "weak link" in the entire rig, and if constructed properly, will release the payload when it should and won't break when it shouldn't! The ring is designed to stretch out and release whatever is hung from it, at about 3-4 pounds of pull.

5. Since most "prosumer" drones can only lift about 2-2.5 pounds, the ring will not stretch out at maximum **smooth** thrust. It will, however, stretch if the payload is "snapped" up suddenly. If you get hung up, lower the drone a foot or two, then fly it upward suddenly at maximum thrust, so as to snap the rig loose. This may take more than one attempt, but as long as the rings are constructed properly, it will work.

IMPORTANT!

Try the breakaway ring on a rig with full water bottles. Fly around a safe area with the rig hung from the drone, using erratic (g-causing) maneuvers until you are comfortable that the rig will not release prematurely. Then, with the rig attached to the drone, hold the rig and pull **smoothly** on it with the drone at full power. This should demonstrate that the ring will not release with smooth flight maneuvers. Finally, hold the rig and fly the drone up until it has taken up all but about a foot of the line, then suddenly fly it upward at full power while you continue to hold the rig. The ring should separate and release the rig. If these do not behave as stated, make sure the rings are made properly and that they have the correct amount of overlap.

Before each flight, visually check the breakaway ring(s) to be sure they have not been stretched in a previous flight. If they have, just bend them back into shape so they have the appropriate amount of overlap.