2. TOMORROW RIVER FIELD TRIP

80 Points

The purpose of this field experience is to collect field data to test a variety of hypotheses relating stream hydraulics, bed texture, and channel morphology. From our field data we will draw scale diagrams of the channel geometry and calculate cross-sectional area, the wetted perimeter, and the hydraulic radius. From our hydraulic data, we will calculate average flow velocity, stream discharge, the Reynolds number, the Froude number, bed shear stress, and unit stream power. We will sieve our sediment samples in the laboratory in order to calculate the grain size distribution and a representative grain size for each cross-section. We will then use our calculated results to test a variety of hypotheses, some specified by you and some specified by me. Everyone should be involved in some aspect of collecting field data.

YOU SHOULD BE ABLE TO:

- Properly set up and use field equipment such as current meters and measuring rods to measure stream channel width, depth, flow velocity, and bed gradient for the purpose of calculating and analyzing stream geometric and hydraulic characteristics; and
- Collect samples of stream bed sediment to characterize the stream bed texture for the purpose of correlating bed texture to stream geometric and hydraulic characteristics.

FIELD SAFETY

Regardless of the type of field work undertaken in geomorphology, safety is always a prime concern. For this exercise, we will take a variety of measurements in the stream itself. Since stream wading often entails getting wet, it is very important that you **wear appropriate clothing!!** Hypothermia is a concern if the weather is cold. Jeans or other cotton clothing is miserable if you get wet and the weather is cold. Cotton provides little insulation and takes forever to dry. Clothes made of nylon, polyester, wool, or other synthetic fabrics that either dry fast or keep you warm when wet are much more appropriate. Since there is a VERY good chance that several of you will get wet, wearing clothes that will dry fast and clothes that provide insulation when wet is important. Everyone should bring a spare set of dry clothes; every year at least one person (sometimes more) falls in the river! Dress in layers that you can either remove if you get too warm or that you can add to if you start feeling cold. If the weather is really cold, gloves with the fingertips cut off are good to have, as is a wool hat. If it's raining, be absolutely sure to bring a rain coat with a hood or a rain hat.

The water is very cold, and although it's great for a swim on a hot summer day, standing in cold water for several hours is a different story (even on a hot summer day). Chest waders or hip-boots will be provided for those who don't have their own. Chest waders are great for staying dry and warm but do not overtop the waders – pay attention to the water depth. Chest waders full of water can spell serious trouble. Our chest-waders are neoprene which will provide a source of floatation should you fall in. In addition to watching water depth, solid footing is important. The section of river bed where we will be wading is uneven and contains large rocks and boulders. Most often people who fall in do so because they tripped over a submerged rock. Walk slowly and carefully.

In places, the water flow is fast. Again, walk slowly and carefully, maintaining your balance and bracing yourself against the flow. If you are uncomfortable wading your section of river, please ask for help or for a new location that is easier to wade. Please ask for help at any point in time if you're unsure how best to do something. Ask your team-mates for help and ask me for help. Personal floatation devices (life jackets) will be available; you need to wear them!

There is poison ivy along the Tomorrow River. If you are allergic to poison ivy, wear long pants and a long sleeved shirt. After returning from the field, wash your field clothes in hot water and take a shower using a soap which neutralizes the oils in poison ivy (e.g. Tecnu or Zanfels).

EXPERIMENTS IN GEOMORPHOLOGY

Because it is nearly impossible to test geomorphological hypotheses in a completely controlled situation or in a laboratory setting that realistically represents the complexity of the real world, it is imperative that we all follow appropriate field and laboratory procedures. It is vital that each group collect their field data in an identical fashion to every other group. If each group follows the outlined field procedures strictly, we can compare measurements and calculations from one group to those of another group with confidence, and we can compare the overall results of our experiments to the results of other studies found in the literature. The field procedures outlined below are standard field procedures in fluvial geomorphology – field procedures that have been widely used and found to produce accurate results (see reference list at the end of the introduction).

Numerous factors affect the success of experiments in geomorphology. These factors start in the field. What type of equipment was used to collect data? Was the equipment accurate? Was it the same type of equipment other scientists have used? Did the field workers know how to use the equipment properly? Was information recorded correctly in the field? Were measurements taken in the correct way, in appropriate places, and at appropriate times? Were all the measurements taken that needed to be taken? Not all scientists have access to identical equipment and not all measurements are equally accurate. Use of field procedures and instruments that are different from the procedures and instruments used by others does not invalidate field work; it just means that you need to account for these differences when you analyze and interpret your data.

TAKE LOTS AND LOTS OF NOTES IN THE FIELD. As you're writing notes in the field, ask yourself this: if I handed my notes to someone else, would they understand what my notes mean? Every year, when we get back and start analyzing our field notes, someone always asks me what their field notes mean. And every year my answer is the same: "I don't know." Write clear, detailed notes that state what you did, where you did it and how you did it. Write down where each measurement was taken. Make it clear what it is you are measuring. Clearly and fully label all your samples. Since you'll be working in teams, you may not be the one analyzing the notes you wrote; one of your team-mates may be doing that. Make their work easy. Write clear, detailed notes.

TAKE ALL YOUR NOTES IN PENCIL, NOT PEN. If your data sheets get wet, pencil will not run but ink will. There's nothing worse than have a full sheet of data measurements only to drop it in the river and have all the ink run – and lose several hours of work.

PROCEDURE

Do not designate one person as "data recorder" and thereby deprive that person of actually doing any of the actual data measurements. Each person should have the opportunity to be involved in different aspects of collecting field data. Take turns. One of our learning outcomes involves knowing how to use equipment properly and watching someone else use the equipment is not the same as using the equipment yourself.

Each group is responsible for the following: 1) taking cross-sectional area measurements at their transects, 2) taking flow velocity measurements at their transects, and 3) collecting sediment samples at their transects. Two or three individuals, designated once in the field, will take water temperature and stream bed slope measurements.

In the following instructions, **river right** is always the right shore of the stream when you are **facing downstream.** Always try to walk on the downstream side of your transect so you disturb the river bed along the transect line as little as possible.

1. Setting Up Your Transect

Each team will be assigned an approximate location for their transect. You may need to make slight adjustments based on your ability to safely wade across the river and to find suitable locations for your end stakes. You may attach your tape measure to the end stakes provided, or you may attach them to existing trees. Be sure to pound the stakes sufficiently deep so they don't come out when you tug on the tape measure.

1. Place your first stake on the river right bank beyond the water's edge and attach your tape measure to it.

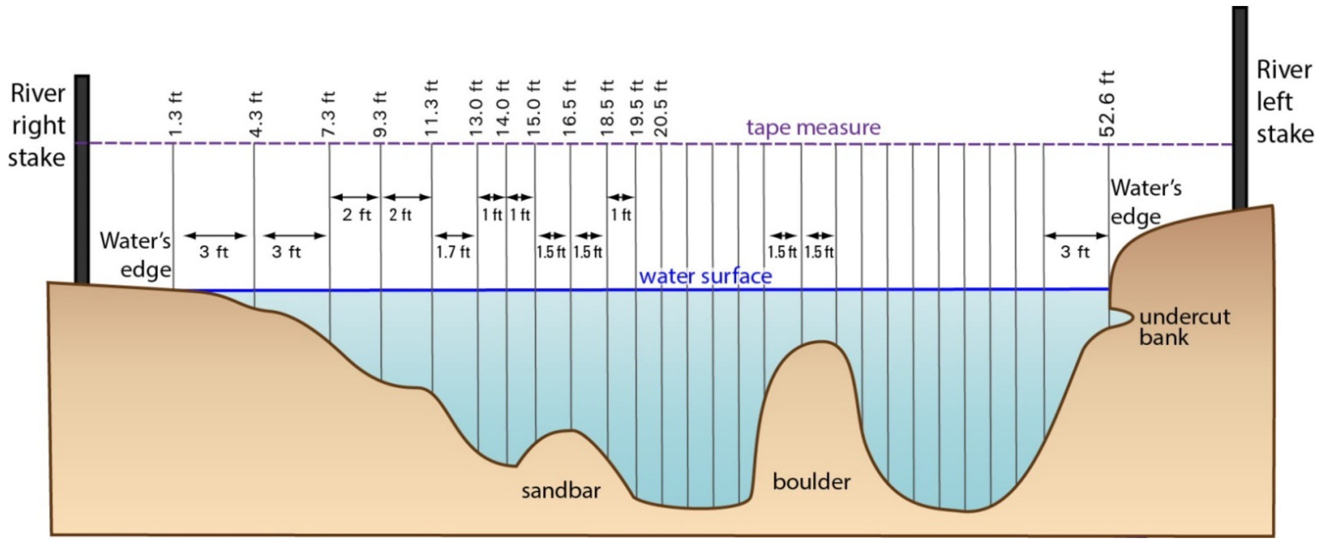
2. Walk across the stream and position your second stake on the river left bank beyond the water's edge, insuring that the tape measure is perpendicular to the flow direction (Harrelson et al. 1994, Nolan and Shields 2000, Pleuss 1999, Rantz 1982, Turnipseed and Sauer 2010, WMO 2008).

3. Attach the tape measure to the second stake (wind it around the stake several times), stretching the tape measure as tight as possible. There will be some sag in the tape measure, but keep the sag as small as possible (Pleus 1999, Rantz 1982). It does not matter how far above the water surface the tape measure is, but try to keep the tape measure horizontal (an equal distance above the water surface).

4. Determine the location of the water's edge on river right and river left from the tape measure and record that information in Table 2.1. For example, water's edge on river right might fall at the 1.3 foot mark on the tape measure and water's edge on river left might fall at the 52.6 foot mark (see Figure 2.1).

5. Calculate the total width of the stream (e.g. 52.6 – 1.3 = 51.3 ft).

FIGURE 2.1 View of a Transect Looking Upstream Showing Verticals and Sections of Variable Width



6. Ideally, for an accurate measurement of discharge, you want no more than 5% of the total flow in any one section, but absolutely no more than 10%. To achieve this goal, you need about 30 sections in your transect (Harrelson et al. 1994, Pleus 1999, Rantz 1982, Shedd 2011, Turnipseed and Sauer 2010, WMO 2008), so divide the total width by 30. This will tell you the average width of each section (e.g. 51.3/30=1.7). Establish the location of the verticals where you will take measurements. Sections should be wider where the flow is slower or the water shallower, and narrower where the flow is faster or the water deeper (see Figure 2.1) (Nolan and Shields 2000, Rantz 1982, WMO 2008). Wade across the channel to assess the flow conditions, and determine your section widths and the location of your verticals insuring you end up with approximately 30 measurements. Record the locations of the verticals in Table 2.1.

II. Depth and Flow Velocity Measurements Using a Swoffer Digital Current Meter

1. Handle the current meter with care – it is very expensive! **Always assemble the current meter out of and away from the water.** DO NOT assemble the meter while standing in or over the water. If you drop a part in the water, you will lose it, and then you have a problem! I suggest assembling the meter over the meter case so any dropped parts fall into the case. Make sure the meter is working properly before you walk into the water. Take turns using the current meter so everyone understands how it works.

2. Assembly:

   a. Attach the round base to the lowest section of rod (Figure 2.2). The wider part of the base is the bottom. Tighten the screw by hand; you will have to unscrew it by hand later on.

   b. Attach the second section of rod to the first section of rod.

   c. Put the slider (Figure 2.3) on the rod with the long narrow indentation facing up. Use the screw at the end to loosen/tighten the slider when you want to reposition the propeller.

   d. Screw the top cap (Figure 2.4) to the top of the second rod section. If you are in deep water, put the pointer in position for use, otherwise you can leave the pointer in storage.

   e. Slide the propeller with the attached cable into the slider so the cable comes out the top of the long indentation in the top of the slider (Figure 2.5). There is an Allen wrench in the top cap or in your meter case. Use this Allen wrench to tighten the screw that holds the propeller in place. Tighten the screw *just enough* so the propeller won't come out. If you tighten it too much, you will damage the propeller mechanism. Be sure to put the Allen wrench back in its storage spot so you don't lose it.

   f. Attach the cable to the meter.

   g. Put the meter strap around your neck so you don't drop the current meter in the water. You can stuff the excess cable running from the propeller to the meter in your wader pocket or else hold the cable; do not allow the cable to float freely in the stream. It may become snagged on a rock or tangled in your feet.

FIGURE 2.2 Rod and Base

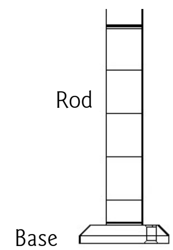


FIGURE 2.3 Slider

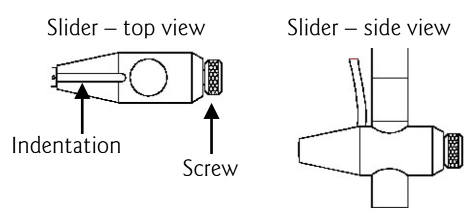
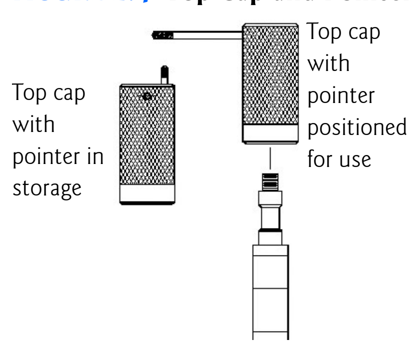


FIGURE 2.4 Top Cap and Pointer



3. Insure the current meter is working properly.

   a. Rotate the selector switch to CALIBRATE (Figure 2.6). Each meter has its own calibration number, which is written on a paper slip in the meter case. Make sure the calibration numbers match; if they don't you may need to replace the battery.

   b. Rotate the selector switch to the COUNT position. Spin the propeller to confirm that the indicator reads increasing counts as the propeller spins. Do a spin test by blowing hard on the propeller and hitting the reset button as soon as you stop blowing. The spin test number should equal or exceed the value written on a paper slip in the meter case.

   c. Rotate the selector switch to the *maximum* update time (maximum display averaging). . Standard procedures recommend averaging the flow velocity over a 40-60 second interval (Nolan and Shields 2000, Rantz 1982, Shedd 2011). The Swoffer meters have three selections for averaging stream velocity before providing a reading – 10 seconds, 20 seconds, and 90 seconds. Since our field site has highly turbulent flow, a longer time interval is more appropriate, so we will average velocity over 90 seconds (maximum display averaging in Figure 2.6). This means that the average velocity will be displayed once every 90 seconds.

FIGURE 2.5 Position of Propeller and Cable

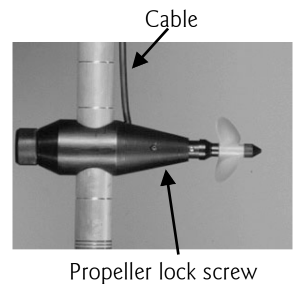


FIGURE 2.6 Meter Functions

4. You are now ready to start taking velocity measurements. When taking velocity measurements, always stand downstream of your transect and downstream of and to the side of the current meter (Harrelson et al. 1994, Nolan and Shields 2000, Rantz 1982); do not stand in front of the meter or in a position that blocks any water flow past the meter!

5. Measure the water depth at each vertical (Harrelson et al. 1994, Nolan and Shields 2000, Rantz 1982) in decimal feet using the current meter rod and record this depth in Table 2.1. You can estimate depth to the nearest 0.05 feet. For example, you could measure a depth of 0.8 feet or 0.85 feet or 0.9 feet. You should *not* measure a depth of 0.875 feet or 0.88 feet; our rods are only precise enough to refine our measurements to within 0.05 feet. Remember that water may pile up on the upstream side of the rod, so the true depth will be slightly less than indicated by the piled up water (WMO 2010).

6. Measure flow velocity at each vertical and record these velocities in Table 2.1. If the water is 2.5 feet deep or less, take one velocity reading at six-tenths the depth down from the surface (or four-tenths up from the bed) (Harrelson et al. 1994, Nolan and Shields 2000, Rantz 1982, Turnipseed and Sauer 2010, Shedd 2011). For example, if the water is 2 feet deep, you would take one velocity measurement at 0.6×2=1.2 feet *down from the surface*, or 0.4×2=0.8 feet *up from the bed*. If the water is more than 2.5 feet deep, take two velocity readings, one at two-tenths and one at eight-tenths the depth (Harrelson et al. 1994, Nolan and Shields 2000, Shedd 2011, Rantz 1984). Table 2.2 tells you where to place the propeller based on the depth so that it is six tenths of the depth down from the surface. The propeller placements are measurements up from the bed, so if the table says to take a reading at 0.8, set the propeller at the 0.8 mark on the rod. Tables 2.3 and 2.4

tell you where to place the propeller based on the depth so that it is two tenths and eight tenths of the depth. Again, the propeller positions are distances up from the bed.

Get in position to take a velocity reading. Adjust the propeller to the appropriate depth and align the propeller with the pointer. If you can't see the propeller, the pointer indicates which way the propeller is pointing. Orient the propeller *perpendicular to the transect* even if water flows through the transect at an angle, ***unless*** the angle appears greater than 45º (Rantz 1982, WMO 2010). If the angle is greater than 45º, make a note on Table 2.1 and point the propeller directly into the current (Rantz 1982, WMO 2010). Keep the rod vertical while measuring velocity (WMO 2010).

Once the propeller is in position, press the reset button. You must press the reset button each time you take a measurement. Press reset only after the meter is in its proper position. The display will zero out. 90 seconds later the average flow velocity will appear. This number will remain on the screen until another 90 seconds has passed or until you press the reset button again. Record your velocities in Table 2.1. Always remember to press the reset button once the propeller is in place.

There is a limit to the Swoffer meter's ability to measure very slow flow. As a result, if the meter is in the water but the flow is too slow for the meter to detect, it will display a velocity of zero; however, do not record a zero on your data sheet unless the meter is out of the water. ***If the meter is IN the water and the meter displays a velocity of zero, record a velocity of 0.05 ft/s.***

III. Sampling Bed Material

In order to assess the bed texture for the purpose of analyzing channel roughness and the likelihood of sediment transport, each group will collect four samples of bed material along their transects.

1. Each sample must be collected at a vertical (location where depth and velocity was measured). In order to determine whether stream bed texture correlates with flow hydraulics, we need to know exactly where each sample came from. Record the location of the sample on the sample container lid along with your team number. Make a note on Table 2.1 indicating the verticals where sediment was collected.
2. Collect sufficient material to fill the sample containers. We will sieve these samples in the lab to analyze particle size, and if there is insufficient material, we cannot get an accurate assessment of bed texture. Although there are some large boulders along the channel bed, we are interested in material the river is capable of moving. These boulders were left by glaciers and the river erodes, transports, and deposits sediment around these boulders; the river doesn't move the boulders.
3. Use a scoop to scrape sediment from the surface of the channel bed and pour the sediment into your sample container. Some of the finer material will be washed away; there is no good way to get around this. As you pour sediment into your container, you will also end up pouring water into the container. Drain the water from the container and continue filling the container with sediment until it is full.
4. If the texture of the bed material is fairly consistent along your transect, then collect samples at approximately equal intervals across the channel. If there are significant changes in the texture of the bed material along your transect, collect samples that represent the different textures present. For example, say three-quarters of the channel bed contains gravel and one quarter of the bed contains fine sand. In that case, collect three samples of gravel and one sample of fine sand. In total, the four samples should be representative of the textures present.

IV. Measurement of Channel Slope and Water Temperature

We need to measure the channel slope in order to calculate bed shear stress and unit stream power. A minimum of two people is needed for this task; 4 is better. Depending on which group finishes first, only a few people will record slope measurements for the entire class. We will use two ranging poles, a tape measure and a level to determine the slope. We also need to know the water temperature in order to determine the density and viscosity of the water. A thermometer will be available for this.

V. Field Notes

Detailed field notes are very important for several reasons. First, each team must draw a scale diagram of their transect and the field sketch and notes will help you draw an accurate diagram. Second, obstacles to flow such as boulders or fallen trees may impact the accuracy of our velocity and discharge measurements. When we test our hypotheses, we need to know about sources of error in our measurements. Without all these field notes, we can't assess how serious some of these inaccuracies are (and there are always some inaccuracies) and thus we can't assess how much confidence we should have in the results of our hypothesis tests. In addition, our results may not meet our expectations or they may not match the results of past studies. A detailed knowledge of the study site may provide an explanation for why our expectations are not met, or why our results differ from the results of other studies.

- Channel bed

  As you work your way across the stream recording water depths and velocities, take notes describing the channel bed. For example, in some areas the stream bed may be very soft and the current meter may sink into the sediment. This will result in inaccurate depth measurements, which will then result in improper placement of the propeller. If the meters sinks a small amount (e.g. 0.1 ft), make a note of that, but don't adjust your depth measurement or the propeller placement. If the meter sinks more than that, estimate how much it sinks and adjust your water depth and the propeller position accordingly. Any time you do this, write a note in Table 2.1 indicating how much you adjusted the depth reading and propeller position.

  You should take notes on how the bed texture changes as you work your way across the stream (e.g. mucky, soft sand, gravelly sand, cobbles), and on the location of sandbars and boulders or large rocks, particularly if the boulders or rocks obstruct flow and impede the propeller. If there are logs or down trees, make note of that. All these notes should be added to Table 2.1. Draw a field sketch to accompany your notes.

- Channel banks (right and left)

  If there is undercutting along the bank, use the meter rod to estimate how deep the undercutting goes (move the propeller out of the way first) and record this information in Table 2.1. Take notes on the bank composition, condition, and slope at your transect, and up- and downstream of your transect.

- Vegetation

  Describe the type and density of vegetation on the channel banks, particularly if the vegetation appears to impact the location or shape of the bank. Note the type and density of vegetation in the entire area surrounding our sample site up- and downstream of your transect.

- Channel planform or path

  Take notes on the path of the river, noting whether the channel is straight or meandering and where any meander bends are located relative to your transect. Note the location of islands in the channel as well.

- Channel morphology
  Take notes on the location of pools, riffles, constrictions or changes in width, hydraulic drops and hydraulic jumps, the presence of boulders, large woody debris and other obstructions to flow.
- Nature of the stream flow
  Take notes on the presence of eddies and turbulence at your transect and up- and downstream of your transect. What is the flow direction in the eddies? How strong are the eddies? Are any eddies correlated with boulders or obstructions or sand bars?
- Landuse
- Surrounding topography

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SEDIMENT SAMPLES

We will eventually sieve the sediment samples to determine the particle size distribution for each transect. The sediment must be completely dry before we can sieve it. As a result, all sediment samples must be put in the oven for drying. Do not put the field sediment containers in the oven; use the glass beakers provided. In order to allow air circulation, do not pack the sediment into the beakers, just dump it loosely into the beakers. Do not fill the beakers to the top; fill them about half-way to allow more air circulation. You will need to divide each sediment sample into several beakers. All the beakers are numbered. Record which beakers contain your first sample, which beakers contain your second sample, etc. in the space below. Dry your entire sample.

	Beaker Numbers	Location on Tape Measure	Point Depth	Point Velocity
Upstream sample 1	______	______	______	______
Upstream sample 2	______	______	______	______
Upstream sample 3	______	______	______	______
Upstream sample 4	______	______	______	______
Downstream sample 1	______	______	______	______
Downstream sample 2	______	______	______	______
Downstream sample 3	______	______	______	______
Downstream sample 4	______	______	______	______

TABLE 2.1 Depth and Velocity Measurements (Decimal Feet *NOT FEET & INCHES!*)

Date ____________________ Personnel ____

Location of water's edge RR ____________________ Location of water's edge RL ____________________

Total channel width ___________________ Average section width _______________

Distance on tape measure (decimal ft)	Water Depth (decimal ft)	Velocity (ft/s)	Comments

Distance on tape measure (decimal ft)	**Water Depth (decimal ft)**	**Velocity (ft/s)**	**Comments**

TABLE 2.2 Propeller Position – 0.6 Depth

Water Depth (ft)	Propeller Position (up from bottom)
0.10	0.04
0.15	0.06
0.20	0.08
0.25	0.10
0.30	0.12
0.35	0.14
0.40	0.16
0.45	0.18
0.50	0.20
0.55	0.22
0.60	0.24
0.65	0.26
0.70	0.28
0.75	0.30
0.80	0.32
0.85	0.34
0.90	0.36
0.95	0.38
1.00	0.40
1.05	0.42
1.10	0.44
1.15	0.46
1.20	0.48
1.25	0.50
1.30	0.52
1.35	0.54
1.40	0.56
1.45	0.58
1.50	0.60
1.55	0.62
1.60	0.64
1.65	0.66
1.70	0.68
1.75	0.70

Water Depth (ft)	Propeller Position (up from bottom)
1.80	0.72
1.85	0.74
1.90	0.76
1.95	0.78
2.00	0.80
2.05	0.82
2.10	0.84
2.15	0.86
2.20	0.88
2.25	0.90
2.30	0.92
2.35	0.94
2.40	0.96
2.45	0.98
2.50	1.00
2.55	1.02
2.60	1.04
2.65	1.06
2.70	1.08
2.75	1.10
2.80	1.12
2.85	1.14
2.90	1.16
2.95	1.18
3.00	1.20
3.05	1.22
3.10	1.24
3.15	1.26
3.20	1.28
3.25	1.30
3.30	1.32
3.35	1.34
3.40	1.36
3.45	1.38

Water Depth (ft)	Propeller Position (up from bottom)
3.50	1.40
3.55	1.42
3.60	1.44
3.65	1.46
3.70	1.48
3.75	1.50
3.80	1.52
3.85	1.54
3.90	1.56
3.95	1.58
4.00	1.60
4.05	1.62
4.10	1.64
4.15	1.66
4.20	1.68
4.25	1.70
4.30	1.72
4.35	1.74
4.40	1.76
4.45	1.78
4.50	1.80
4.55	1.82
4.60	1.84
4.65	1.86
4.70	1.88
4.75	1.90
4.80	1.92
4.85	1.94
4.90	1.96
4.95	1.98
5.00	2.00
5.05	2.02
5.10	2.04
5.15	2.06

TABLE 2.3 Propeller Position – 0.2 Depth

Water Depth (ft)	Propeller Position (up from bottom)	Water Depth (ft)	Propeller Position (up from bottom)	Water Depth (ft)	Propeller Position (up from bottom)
0.10	0.02	1.80	0.36	3.50	0.70
0.15	0.03	1.85	0.37	3.55	0.71
0.20	0.04	1.90	0.38	3.60	0.72
0.25	0.05	1.95	0.39	3.65	0.73
0.30	0.06	2.00	0.40	3.70	0.74
0.35	0.07	2.05	0.41	3.75	0.75
0.40	0.08	2.10	0.42	3.80	0.76
0.45	0.09	2.15	0.43	3.85	0.77
0.50	0.10	2.20	0.44	3.90	0.78
0.55	0.11	2.25	0.45	3.95	0.79
0.60	0.12	2.30	0.46	4.00	0.80
0.65	0.13	2.35	0.47	4.05	0.81
0.70	0.14	2.40	0.48	4.10	0.82
0.75	0.15	2.45	0.49	4.15	0.83
0.80	0.16	2.50	0.50	4.20	0.84
0.85	0.17	2.55	0.51	4.25	0.85
0.90	0.18	2.60	0.52	4.30	0.86
0.95	0.19	2.65	0.53	4.35	0.87
1.00	0.20	2.70	0.54	4.40	0.88
1.05	0.21	2.75	0.55	4.45	0.89
1.10	0.22	2.80	0.56	4.50	0.90
1.15	0.23	2.85	0.57	4.55	0.91
1.20	0.24	2.90	0.58	4.60	0.92
1.25	0.25	2.95	0.59	4.65	0.93
1.30	0.26	3.00	0.60	4.70	0.94
1.35	0.27	3.05	0.61	4.75	0.95
1.40	0.28	3.10	0.62	4.80	0.96
1.45	0.29	3.15	0.63	4.85	0.97
1.50	0.30	3.20	0.64	4.90	0.98
1.55	0.31	3.25	0.65	4.95	0.99
1.60	0.32	3.30	0.66	5.00	1.00
1.65	0.33	3.35	0.67	5.05	1.01
1.70	0.34	3.40	0.68	5.10	1.02
1.75	0.35	3.45	0.69	5.15	1.03

TABLE 2.4 Propeller Position – 0.8 Depth

Water Depth (ft)	Propeller Position (up from bottom)
0.10	0.08
0.15	0.12
0.20	0.16
0.25	0.20
0.30	0.24
0.35	0.28
0.40	0.32
0.45	0.36
0.50	0.40
0.55	0.44
0.60	0.48
0.65	0.52
0.70	0.56
0.75	0.60
0.80	0.64
0.85	0.68
0.90	0.72
0.95	0.76
1.00	0.80
1.05	0.84
1.10	0.88
1.15	0.92
1.20	0.96
1.25	1.00
1.30	1.04
1.35	1.08
1.40	1.12
1.45	1.16
1.50	1.20
1.55	1.24
1.60	1.28
1.65	1.32
1.70	1.36
1.75	1.40

Water Depth (ft)	Propeller Position (up from bottom)
1.80	1.44
1.85	1.48
1.90	1.52
1.95	1.56
2.00	1.60
2.05	1.64
2.10	1.68
2.15	1.72
2.20	1.76
2.25	1.80
2.30	1.84
2.35	1.88
2.40	1.92
2.45	1.96
2.50	2.00
2.55	2.04
2.60	2.08
2.65	2.12
2.70	2.16
2.75	2.20
2.80	2.24
2.85	2.28
2.90	2.32
2.95	2.36
3.00	2.40
3.05	2.44
3.10	2.48
3.15	2.52
3.20	2.56
3.25	2.60
3.30	2.64
3.35	2.68
3.40	2.72
3.45	2.76

Water Depth (ft)	Propeller Position (up from bottom)
3.50	2.80
3.55	2.84
3.60	2.88
3.65	2.92
3.70	2.96
3.75	3.00
3.80	3.04
3.85	3.08
3.90	3.12
3.95	3.16
4.00	3.20
4.05	3.24
4.10	3.28
4.15	3.32
4.20	3.36
4.25	3.40
4.30	3.44
4.35	3.48
4.40	3.52
4.45	3.56
4.50	3.60
4.55	3.64
4.60	3.68
4.65	3.72
4.70	3.76
4.75	3.80
4.80	3.84
4.85	3.88
4.90	3.92
4.95	3.96
5.00	4.00
5.05	4.04
5.10	4.08
5.15	4.12

ADDITIONAL FIELD NOTES AND SKETCHES