

## **Manual Monitoring of Farm Water Tables <sup>1</sup>**

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Water table monitoring can improve irrigation and drainage management for agricultural production in the high water table areas of Florida. A large portion of Florida's agricultural land, notably the Everglades Agricultural Area (EAA) and surrounding sandlands, is irrigated and drained using water table management (including forms of seepage and sub-irrigation). In water table management, a target water table level is selected and water is either added to or removed from the field or farm according to whether the existing water table is lower or higher than the target, respectively. The water table depth and the amount it is allowed to deviate from the target level are dependent on soil properties, crop characteristics, pumping capacities, and the level of protection from flood or drought conditions desired by the grower. It is evident that water table depth is one of the most important physical features of a cropped field, and that its measurement is vital for optimum management.

Current public interest is directed towards achieving optimum water management for water supply and quality enhancement. Agricultural demands on water supplies and the negative effects of

agricultural drainage water on the environment could decrease appreciably through better control of target water levels, permissible fluctuations, and pumping rates and durations. To achieve this, however, it is necessary to accurately track water tables both during and between pumping activities. Water table monitoring is vital to any management or research program that addresses farm water supply and quality issues in Florida's shallow water-table areas.

Water table monitoring, and its effective incorporation into a farm water management program, requires that four distinct activities be carried out. First, observation wells must be constructed and installed at strategic locations in the area to be monitored. Second, water levels in the wells must be accurately read and recorded on a regular basis. Third, the resulting data must be analyzed and put into a readily useful form for the front line water managers. Finally, the resulting information must be incorporated into scheduling and managing irrigation and drainage events. Adherence to this program should enable a grower to optimize his water usage with water table management irrigation and drainage systems.

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Presently, irrigation and drainage decisions are often made based on rainfall amounts and drive-by scanning of water levels in ditches (ditch-riding). Pumping decisions are then made according to past experience. This method seems inexact, but can be quite satisfactory, depending on the experience of the water manager. However using this method, there are as many ways to manage water tables as there are front line managers. A water management policy maker can convey his expectations to his ditch riders, but what transpires during interpretation and implementation of those expectations may be unique to each ditch rider. To obtain some consistency and uniformity in making pumping decisions, water table levels should be measured and used in the decision making process. An additional benefit in the form of enhanced, documented knowledge of the farm water system and of localized and system-wide responses to pumping can be obtained through the use of simple, inexpensive water table level sensing instruments and a notebook.

The objective of this publication is to provide information on the characteristics of water table management and to describe the currently available methods of manual water table monitoring.

### **Advantages and Disadvantages of Manual Monitoring**

Manual monitoring and recording methods generate useful information upon which to base irrigation and drainage decisions. The data can be used directly when a decision is needed. Direct or immediate use of the measurement can be made without the recording of values. A manager simply checks the water table level prior to making the decision to irrigate or drain. Alternatively, the manager can implement a data collection and analysis program which would enable him to calibrate pumping amounts with ditch water levels and field water table behavior under various rainfall, irrigation, evapotranspiration, and drainage conditions. This program requires additional monitoring before and after the event, as well as regular monitoring between events, for optimum utility. Whatever level of monitoring sophistication is desired, manual water table measurements can remove much of the present guesswork involved in making pumping decisions.

Measurement tools for manual water table monitoring are inexpensive and can be constructed easily out of off-the-shelf components. Data management techniques are simple and effective, as long as the limitations of the methods are understood when the technique is selected.

It must be emphasized that manual monitoring methods have less utility than continuous recordings of water table levels. In-depth use of manual methods also requires more time commitment than present decision making processes. In addition, continual care by a conscientious operator is needed when taking measurements.

The water manager must determine the objectives of the monitoring program prior to system selection. A commitment of time and resources to data management and interpretation must be made while considering system alternatives. For instance, if monitoring the water table level is only a substitute for estimating ditch water levels, the simplest monitoring program would be adequate. However, if relationships between pumping, rainfall, irrigation, drainage, ditch water levels, and water tables are desired, more sophisticated monitoring programs will be required.

### **Observation Wells and Initialization**

The construction, location, and installation of observation wells are presented by Izuno et al. (1988) in IFAS Extension Bulletin 251, Water Table Monitoring. These well specifications also apply to the construction of wells used for manual monitoring of water tables.

After the well is constructed, initialization, or establishment of a datum or reference measuring point on the well casing, is required. The vertical distance from the measuring point to the ground surface must be determined. Guidelines for performing this activity are also presented in IFAS Extension Bulletin 251. For convenience, the initialization procedures applicable to manual measurements are summarized here.

When a water table measurement is taken, it must be reported as a depth above or below a selected point of interest. For field and farm monitoring, the

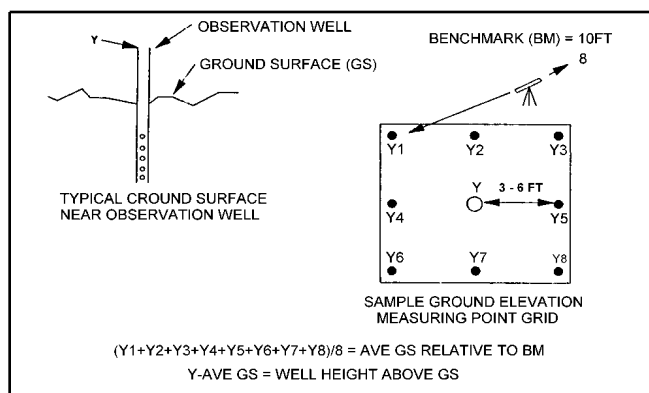
ideal point of interest is the ground surface. However, the ground surface is extremely variable, and changes throughout the cropping season. A single point on the ground surface may not be representative of the average field elevation. In fact, a measurement from a point on the ground surface cannot be considered to be anything more than the depth to the water table at that point. Therefore, it is necessary to establish a permanent datum, or reference point, from which all water table depths will be measured during the monitoring period. Obviously, the datum will then have to be related to the ground surface.

For convenience, the reference point is often chosen to be the top of the observation well casing. The tops of the well casings frequently are not parallel to the ground surface. Hence, it is advisable to mark the exact location using an indelible marker or by notching the top edge of the casing. Any future manual measurements should be read relative to the same location by holding the measuring device against the mark or notch. It is essential that the well casing be secured firmly in place so that the measurement reference point will not move during the monitoring period.

Relating the datum to the ground surface is more complicated. This can be done by simply determining the distance of the marked point above ground at the base of the well casing. However, this may not be entirely correct, especially since the soil around the casing was disturbed during well installation. The proper method of datum establishment is to survey the area around the observation well. If several wells around the farm will be monitored and data compared, their elevations should be measured with respect to a common benchmark.

Several ground elevations should be measured in a grid pattern around each observation well (Figure 1). Care must be taken to place the surveying rod lightly on the ground in order to avoid erroneous readings due to the rod penetrating the ground surface. The readings should be taken without any attempt to smooth the ground surface before placement of the surveying rod.

For bedded crops, the ground surface elevation should be taken at the top of the bed. Additional rod readings may be desired in the furrows between beds



**Figure 1.** Determination of average ground surface elevation and height of top of well casing above ground surface.

to track the consistency of bed height. For sugarcane and other non-bedded crops, the ground surface should be the average of the ridges and furrows formed during field planting and disking operations. Small grid spacings will ensure that both ridges and furrows will be included in the readings.

It is unnecessary that the rod readings be true elevations with respect to sea level. Any arbitrary value can be assigned to the common benchmark. Ten feet or 10 meters is often used as the benchmark elevation for this type of differential leveling.

The elevations at each point on the grid are measured and then averaged around each well location. The resulting value is the average ground surface elevation for that well. If the same procedure is used around all the other wells in the field or on the farm, the average ground elevations at each site can be related to each other.

While measuring ground surface elevations relative to the benchmark, a sighting should also be taken on the measurement point marked on the top of the well casing. The elevation of the measurement point relative to the benchmark, minus the elevation of the average ground surface relative to the same benchmark, yields the height of the measurement point above the average ground surface.

The above procedure may not always be feasible. The lack of surveying equipment may preclude such measurements. If such is the case, the ground around the observation well can be smoothed and a surface representative of the average ground surface can be estimated. When using this procedure, it should be

remembered that the water table depths measured at any two sites cannot be compared. The water table readings will represent the water table depth only at the point measured. An assumption is then made that there is a certain area over which that ground elevation and water table depth is applicable. The limitations of this method are obvious. However, if the purpose of the water table measurement is to obtain a gross estimate of the water table in the general area, and if the resultant measurement will be used only in immediate decision making, the technique is acceptable.

## Manual Measurement Instruments

In this section, the construction, installation, and use of several common water table depth measuring instruments will be discussed. The reader is directed to other IFAS publications for detailed discussions on basic monitoring principles, observation well construction and location, initiation procedures, mechanical and electronic continuous recording devices, and detailed data management procedures. The methods of water table monitoring discussed herein require that a person visit the well site and manually measure the water table level. The instruments described are tools that can be used to actually sense the position of the water table. The means of recording data and data sheet formats are left to the discretion of the user.

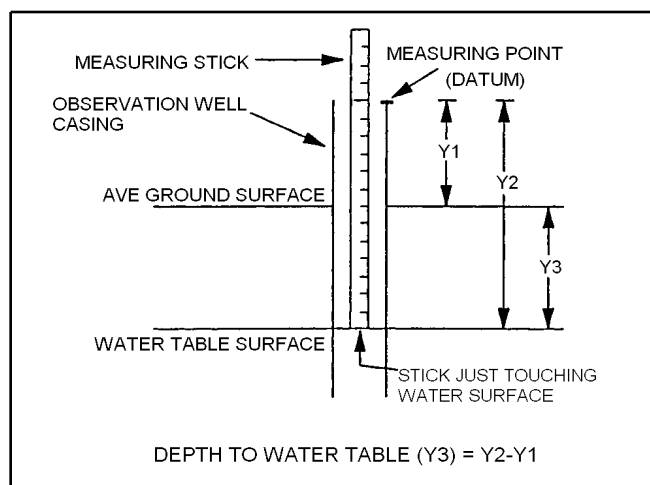
There are many ways to manually measure the depth of a shallow water table. Virtually any item that is rigid, such as yardsticks or folding rulers, can be lowered into an observation well until it makes contact with the water surface in the well. Depth from the datum can be read directly if the tool is graduated. Alternatively, the tool can be marked, removed from the well, and laid against a measuring instrument to determine depth. As an alternative to the rigid tool, a flexible string or tape can be used in the same manner as long as it does not deform greatly when stretched to eliminate kinks.

The manual instruments discussed are tools that ease the process of water table measurement or sensing. It is not difficult to dip yardsticks, folding rulers, or tape measures into observation wells. Although such activities can suffice, the procedure

becomes tedious and time-consuming, discouraging rigid adherence to a monitoring program. Some of the instruments suggested were designed to reduce the strain of determining when a stick or tape makes contact with the water surface in the observation well. Others were developed to reduce the time and effort needed for obtaining water table depths when quick estimates are needed for immediate decision making. All methods were developed with the intention of increasing the accuracy of judging water table depths in fields and around farms.

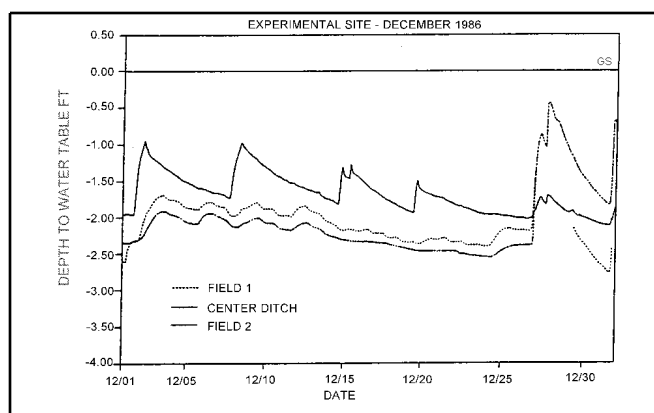
## Measuring Sticks

The simplest instruments used for water table depth measurements are measuring sticks. This category includes ungraduated laths of wood, lengths of rigid PVC pipe, or metal rods with or without graduations marked on them, yardsticks, folding carpenter's rules, surveying rods, etc. All require an individual visit the well site on a regular basis, or whenever readings are desired. The measuring sticks are simply lowered into the shallow observation well until the lower end just touches the water surface. The device is then read adjacent to the measuring point marked on the top of the well casing. The depth of the measuring point above ground surface, determined during initialization, is then subtracted from the reading. The resulting value is the depth of the water table below ground surface. The process is illustrated in Figure 2 .



**Figure 2.** Calculation of the depth to water table from the ground surface.

When using measuring sticks, it is important to ensure that they are as nearly vertical as possible so the readings will not be distorted. A carpenter's rule, for example, tends to bow when extended. Additionally, the water table must be shallow enough, and the well diameter large enough, so that the operator can see the stick making contact with the water. Obviously, this method is time consuming, labor intensive, and greatly depends on operator care for accuracy. However, the method is still more desirable than estimating ditch water levels and assuming the field water table level to be identical because ditch water levels and field water table levels do not generally coincide (Figure 3).



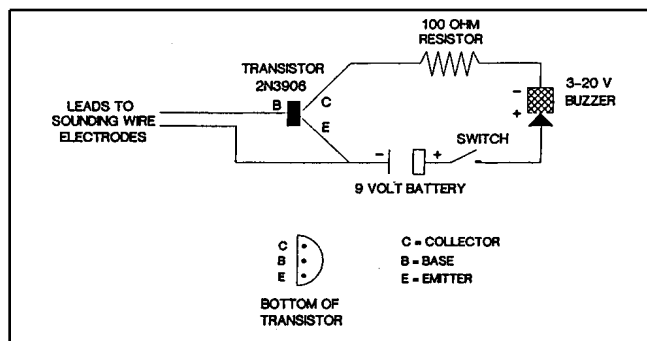
**Figure 3.** Differences that can occur between ditch levels and field water tables.

Another related method makes use of a tape measure or other length of flexible material. Standard metal tape measures can be used but are subject to many of the same limitations of the rigid sticks. It is recommended that a nylon or Fiberglass tape be used. These types of tape measures can be purchased in open reel configurations which will be useful during transport between well sites. An ordinary piece of string is not recommended because of its tendency to stretch and kink. At the end of the tape measure, a small lead weight, or series of weights, should be attached to the metal anchoring piece found on most of these devices. Lead sinkers available in any fishing supply store are ideal. The weights will ensure that the tape hangs vertically. The tape is then lowered into the well until contact with water is made. Water table depth calculations are the same as for the above methods.

The above methods of measuring water table depths are the most basic ones. Obviously, they are better than using no monitoring device at all. The methods are all inexpensive, with the cost of a tape measure being the most significant expense. A single measuring device can be used for all wells. The methods, however, are tedious and time-consuming, and accuracy depends greatly on the diligence of the operator. The process of discerning instrument contact with the water level in the observation well can be difficult and can cause operator strain when large numbers of wells need to be read.

### Well Sounders

A simple well-sounding device can be used to ease the strain of determining instrument-water surface contact and to improve accuracy of measurements when using measuring sticks or tapes. The sounder is a set of electrical lead wires that indicate the water table by a visible light or audible tone when the electrical circuit is completed by submersion of the lead wires.



**Figure 4.** Well sounder circuit schematic.

Graduations on the lead wires allow accurate measurement of the depth to the water table. These tools are available commercially. However, they are generally used for deep well applications such as determining depths of water in pumped wells. Hence graduations may not be as closely spaced as desired and the accuracy may be insufficient for shallow water table monitoring. Additionally, the user must buy the units capable of measuring 20 or more times the depth required for shallow water table applications. The unit consists of a paired set of graduated wires, a reel, and electronic circuits for driving the water contact indicator.

A simple well sounder can be assembled with off-the-shelf parts for less than \$30. The assembly of a unit for deep wells was discussed in depth by Smajstrla et al. (1984) in IFAS Agricultural Engineering Fact Sheet AE-46. Slight modifications in the design can be made during construction to enhance its utility for shallow water table measurement.

The electronic circuitry consists of lengths of light gauge wire (22 or higher), a 9 volt battery, with snap-on leads and clamp, a transistor (2N3906), a Single Pole-Single Throw (SPST) switch, a 100 ohm resistor, a perforated circuit board with approximate dimensions of 2 in x 3 in, a Light Emitting Diode (LED) or buzzer, and a small plastic project box available at any electronic hobby store. The electronic circuitry is redrawn from Agricultural Engineering Fact Sheet AE-46 in Figures 4-5. Figure 4 shows the circuit schematic and the correct orientation of the transistor. It is highly recommended that the LED be replaced by a buzzer. In brightly lit situations, such as those encountered in the field, an audible tone is much more appropriate than an LED. A PC Board Mount Piezo-Electric Buzzer with an operating range of 3 to 20 volts DC is an ideal replacement that requires few circuit adaptations. Also, the resistor should be changed to alter the tone and loudness of the buzzer. For maximum loudness without the sound becoming too shrill, a resistor in the 1000 to 2200 ohm range is effective. Alternatively 9 or 12 volt MiniBuzzers, also available at electronic hobby stores, can be used. The buzzers cost no more than \$2.50 each. Figure 5 illustrates the circuit diagram as recommended by Smajstrla et al. (1984), with appropriate modifications. The circuit should be enclosed in the plastic box to protect it from the weather and abuse during handling.

A folding carpenter's rule or other rigid graduated device can be used to lower the sensing device to the water table surface. The design shown in Figure 6 is recommended. Two wires should be run the length of the stick. The ends of the wires must be stripped and separated so that they do not come into contact with each other or with a common wetted piece of the assembly during measurement. If such contact is made, the buzzer will sound continuously

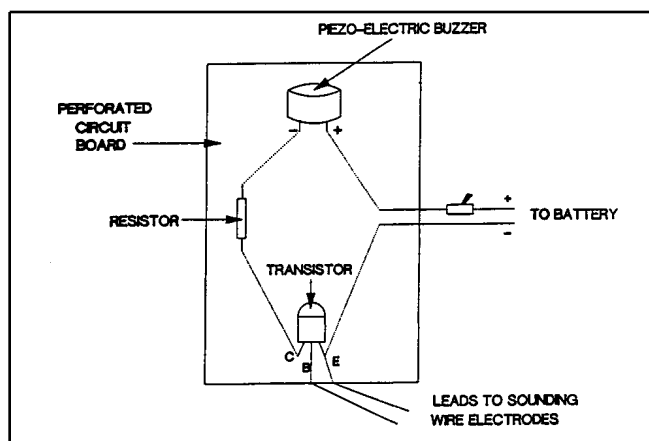


Figure 5. Well sounder circuit diagram.

when the unit is switched on. For example, if the lead wires in Figure 6 were both touching the carpenter's rule, water adhering to the stick may complete the circuit. The unit will then have to be dried out between readings.

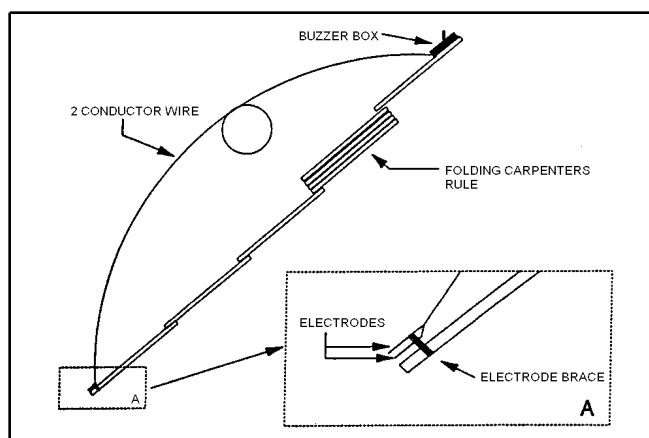
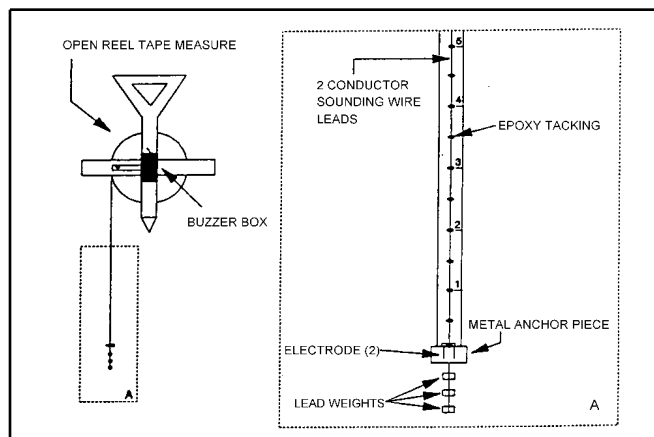


Figure 6. Well sounder constructed out of a carpenter's rule.

The rigid stick and carpenter's rule can present problems during use. The carpenter's rule is flexible and may deform when lowered into the well. Additionally, when stored, it is folded up, causing kinking of the wire leads. The leads do not have to be attached to the rule, but tangles may occur when separate. The rigid yardstick or graduated PVC pipe configuration can be inconvenient when transporting the device through fields. It should be remembered that the total length of the device must be at least as long as the greatest depth from measuring point to water table surface expected. The ideal configuration is to use a nylon or Fiberglass open reel tape measure. The circuit housing can be attached to the reel using screws. For best results, the plastic box should be

attached to the winding crank, and the wires passed through a hole drilled in the crank and reel hub. In this configuration, the buzzer box and all wires will turn with the spool of tape thus avoiding kinking of the wires. These tape measures are available in 25 ft lengths and greater. The 25 ft length is more than adequate for most applications. The 50 ft tapes may be a simple matter to remove the tape and cut it to the desired length. In many cases, 10 ft will be adequate.

While the tape is disassembled for cutting, it should be stretched out on a flat surface. Lead weights should be attached to the metal anchoring assembly at the end of the tape measure. The lead wires from the electronic circuitry can then be tacked to the tape with epoxy or PVC cement as shown in Figure 7. The ends of the lead wires (the electrodes) should be set up as shown in Figure 7. When dry, the tape can be re-installed in the reel. It will probably be desirable to attach the lead wires to the tape prior to their connection to the buzzer unit. In this event, simply add connectors between the electrode wires and the buzzer lead wires. The connectors will facilitate servicing the unit since it can be readily broken down into two separate items.



**Figure 7.** Well sounder constructed using an open reel tape measure.

The type of wire used with these reel tape measures is extremely important. The wire must be thin and flexible enough so that it will roll up on the reel and unwind without creating permanent kinks that prohibit the straightening of the tape. Weights added to the end of the measuring tape will help prevent kinking. Keep in mind that the longer the tape length that will actually be used (deeper water tables), the more weight will be needed to ensure a

straight tape. Multi-stranded telecommunications wire or ES-232 ribbon cable are two types of wire that work well for this application. The ribbon cable commonly comes in rolls of 25 ft with 25 conductors. Shorter lengths are equally common. When using this wire, two strands can easily be separated from the roll. It is not recommended that the two wires used be separated from each other. Care must be taken so that the insulation around the wires remains intact. In the field, the weighted end of the tape is lowered into the observation well until the buzzer sounds. The tape is then carefully raised until the buzzer stops. Following that, the tape should be slowly lowered until the buzzer sounds again. It is advisable that the tape be raised and lowered slightly once contact is made in order to determine the precise water table elevation. The point at which the buzzer first begins to sound indicates the water table location. The piezoelectric buzzer may continue to sound when not in contact with the water table. However, there is an audible difference in tone and intensity when the electrodes come in direct contact with water.

The tape measure should be read relative to the measuring datum point when contact is made. Performing the appropriate subtraction will again yield the depth of the water table below ground surface.

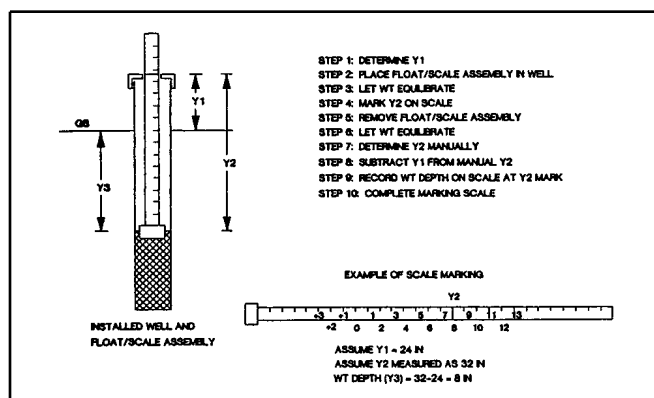
This method of locating the water table considerably eases the strain of determining when a measuring device contacts the water table surface. Measurement becomes a simple matter of lowering a tape measure into the well, listening for the tone, and reading the depth. The tape is easily retracted from the well and can be transported without difficulty. This method of manually reading water tables is especially recommended when accurate readings are desired. The device is also extremely useful in initializing continuous type recorders.

### Float Poles

When the intent of monitoring water tables is solely to obtain an approximate reading for immediate decision making, a different method may be preferable. A water manager may simply want to know how deep the water table is, without expending much more energy, time, or resources than in his present ditch-riding activities. In most cases, the data

will not be recorded and no relationships will be drawn between different locations or between ditch water levels, rainfall events, drainage and irrigation responses, and field water tables.

The method makes use of a float device placed in the observation well. The device moves up and down with the movement of the water table. Attached to the float is a rigid graduated scale which moves with the position of the water table. The graduations on the scale can be marked so that the device registers actual water table position.

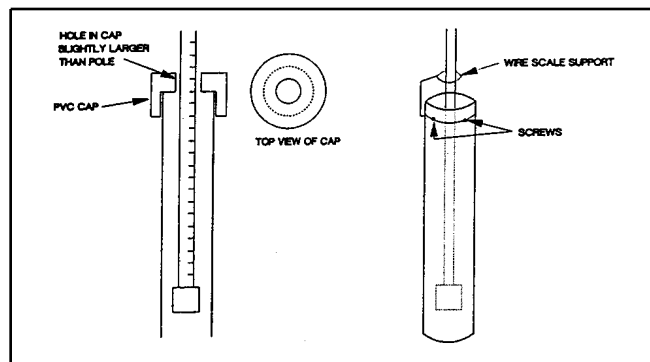


**Figure 8.** Marking graduations on float/scale or float pole.

The scale should be marked following similar procedures to those used to initialize the other manual devices. The distance above ground of the measuring point on the well casing is measured. Next, the depth to water table from ground surface is determined using one of the previously presented methods. The float device with scale attachment is lowered into the well. The point on the rod adjacent to the measuring point is then marked and the depth noted as the measured depth minus the height of the measuring point above ground. From the marked point on the rod, use a measuring tape or yardstick to mark graduations above and below the initial reading. As the float rises, the depth to water table decreases. Hence, the scale numbers marked as shown in Figure 8, should decrease as graduations continue down towards the float. A zero water table mark will be encountered. Marks below this point should be marked with a plus sign, or differently, to indicate pounding on the surface. As shown in Figure 8, the numbers below the zero point should increase. Markings above the initial reading should continue with the scale increasing. Simply measuring distances and marking the scale relative to the bottom of the

float will result in incorrect measurements since the float will settle in the well until buoyant forces equal the weight of the float-scale assembly, much as a boat settles in water.

The float assembly is then placed in the well. The scale must be supported at the top of the well in order to keep it vertical. A metal supporting brace can be fashioned out of a wire coat hanger as shown in Figure 9. Alternatively, a hole slightly larger than the scale rod can be cut in a PVC cap (Figure 9). The cap should then be placed over the rod scale and secured to the well casing. In this case, the distance of the top of the cap above the well casing measure point must be measured and added to the original measuring point to ground surface height. Alternatively, surveying readings should be taken on top of the cap when placed firmly over the well casing.

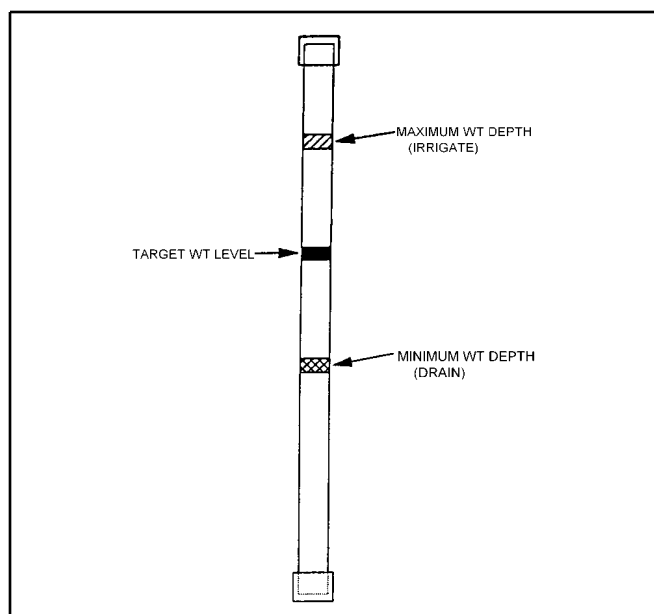


**Figure 9.** Two suggestions for constructing float/scale or float pole guides/supports.

As an alternative to having a float and rod assembly, the entire unit can be constructed out of PVC pipe as shown in Figure 10.

A length of PVC pipe, smaller in outside diameter than the well casing inside diameter should be used. Both ends of the pipe should be capped. It is important that the bottom cap be fastened securely using PVC cement or another weatherproof adhesive. It is recommended that the seal not be formed with silicone caulking since caulking will eventually deteriorate and separate from the PVC, resulting in possible water entry into the assembly. Sealing the upper cap is not as critical as long as it is clearly marked. Possible confusion could otherwise occur during marking of graduations, resulting in the lesser sealed end being placed in the well. The cap on top of the float pole is necessary to prevent precipitation





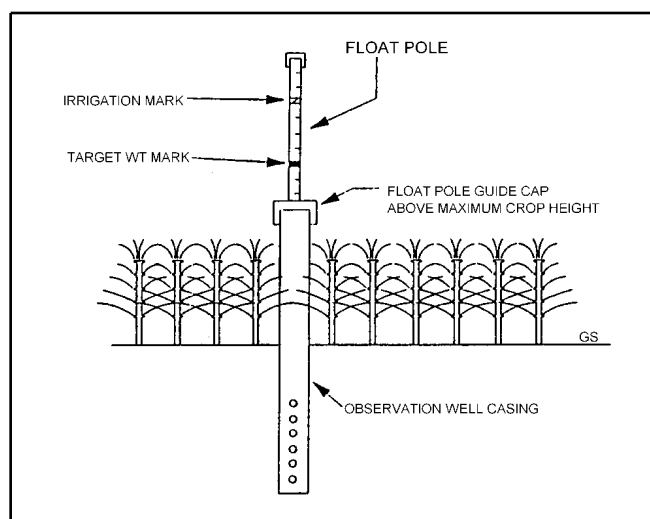
**Figure 10.** PVC float pole marked with target and critical water table levels.

from filling the float. This assembly acts as the float and scale of the system. A hole slightly larger than the outside diameter of the float pole should be drilled in the PVC cap on top of the well casing. The float pole should then be marked with graduations as was done for the previously discussed float scale assembly. The float pipe is then inserted into the well cap which is then secured to the casing. It is recommended that the well casing cap not be cemented to the casing so that removal of the unit is possible if maintenance of the well or float is necessary.

Several methods of enhancing the readability of the above mechanisms are available. As it is, the user must get within close proximity of the well to read the numbers. Color schemes can be used to facilitate readings from a distance. For example, alternate colors that will stand out against expected background colors can be used for every other 1 ft or 6 in increment. Sighting on the poles can be further enhanced by using a pair of binoculars. The critical water table elevations for signifying when an irrigation or drainage event should occur can be marked on the pole as shown in Figure 11.

Any other critical points of interest can also be marked accordingly. If this is done, the well/monitoring assembly can yield much information with little more equipment and work than is presently necessary. This system also enables the

policy makers to set water table fluctuation levels that are easily communicated to, and carried out by, front line managers. This system will work well for short-height crops. When crops such as corn or sugar cane are involved, the method may not work or may be difficult to implement because of the height of the crop. Naturally, the reading point on the well casing cap must be higher than the maximum crop height or readings will be impossible (Figure 11).



**Figure 11.** Float pole water table monitoring instrument indicating that water table is above target.

If crops are tall, problems may occur. For example, if the well casing needs to be 10 ft above ground surface, and the well depth is only 4 ft, the well casing may tend to tip over unless braced. The other problem occurs in initialization. This problem, too, can be overcome by measuring the distance from the top of the casing cap to a marked point on the casing, whose elevation can be surveyed once the unit is installed. That fixed amount must also be accounted for in marking the scale.

Another problem that might occur, especially in the PVC float assembly, is restriction of the float travel. For example, if the observation well top is only 1 ft above ground, and water fluctuations range from flooded to 4 or 5 ft, it is likely that the float will get hung up at high water table levels. When a large length of PVC float is out of the well, the float will tend to lean. If the lean is not prevented by the well casing, the sides of the hole in the casing cap will impede the movement of the float. This problem can be remedied by increasing the height of the observation well above ground, using a larger

diameter float pole, or increasing the size of the guide hole in the well casing cap. The float pole method of water table monitoring can be a valuable tool for systems that continue to use ditch-riding techniques. Rather than estimating ditch levels and assuming they are indicative of field water levels, the ditch rider can now note critical water table elevations in the field centers. Additionally, the manager can terminate an irrigation or drainage event based on actual water tables in fields rather than having to wait until ditch levels and field water tables equilibrate to make a judgment. The user can also enhance his management of water tables by gaining a more quantitative feel for water table responses to pumping and rainfall.

### **Other Methods**

Other methods of manually reading water tables exist. In fact, the only limiting factor is one's imagination. Some methods make use of electronic items such as potentiometers and pressure transducers. These can be mounted on a well and be read manually with a simple multi-meter whenever a reading is desired. Additionally, strip chart recorders can be placed in an observation well and read only when data is desired. It is assumed, though, that if these devices are to be installed, the user will have intentions for data uses above what is discussed here because of their costs and calibration and initialization processes.

### **Monitoring Schedules**

Monitoring schedules depend on the desires of the operator. The techniques discussed can offer valuable data without exceeding the present level of effort expended in ditch-riding activities. It may, however, be possible to keep tighter controls on water tables by taking daily readings. The readings should be taken at the same time each day for maximum accuracy since water tables tend to drop during the day and recover over night (Izuno et al., 1988).

If the user intends to apply the data to determining relationships between rainfall, drainage, irrigation, ditch water levels and field water tables, daily readings are virtually mandatory. However, recording data need not be done daily unless desired. Measurements and recordings should occur more

frequently before and after rainfall, or before, during, and after irrigation and drainage. The time interval between readings is left to the discretion of the grower, and will depend on his desire to draw meaningful relationships. Obviously, more measurements yield more data upon which to base relationships. Yet collecting more data is a waste of time and resources unless the user has a well-defined use for it.

Recording measurements on multi-day or weekly intervals has little meaning unless constant water tables are being maintained by automated pump stations. In this case again, it will be beneficial to take more readings around pumping and rainfall events.

### **Servicing Wells and Instruments**

The observation wells should be checked regularly to ensure that they are functional. Common problems encountered are filling in of the well casing with soil, insect nests in the casing impeding float travel, and destruction of the well by farm machinery.

The rigid measuring instruments should be checked for deformations. Electronic sounders are easily checked by dipping the electrodes in water. A multi-meter may be useful to determine which circuit component needs replacement if the unit is not operating. Float poles should be checked to ensure that the marked scales have not rubbed off. It is also necessary to check the float scale guide to ensure that it is supporting the float scale in a vertical position. Manual methods require very little maintenance, and when maintenance is needed, remedies are simple.

### **Summary**

Simple and inexpensive methods of monitoring water tables in a field or on a farm were presented. The discussion included principles of operation, construction, and applications of manual measuring techniques. The utility of the resulting data was also indicated.

Manual methods of water table monitoring generally should be practiced by users who desire only limited water table data. Ideally, the methods should be used to determine water tables prior to

making pump start or stop decisions. Attempts to collect further data for increased analyses could very easily become too time consuming and tedious, while resulting in less than optimum data.

## References

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