Drain Gauge

Model G3

Operator's Manual

Version 0

DECAGON DEVICES

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1. Introduction

Thank you for purchasing the Drain Gauge G3. The Drain Gauge G3 is designed for long-term monitoring of soil water drainage, with an estimated minimum 10-year lifetime. The Drain Gauge G3 also has a collection system that allows for rapid sampling of drainage waters. This innovative device will enable you to monitor soil water movement and chemical leaching accurately and affordably.

Customer Service and Tech Support

When contacting us via fax or email, include the following information: Your G3's serial number, your name, address, phone and fax number, and a description of your problem.

Phone:

Call Monday - Friday, between 8 a.m. and 5 p.m. PST.
US and Canada (toll-free): **1-800-755-2751**
Outside of the US and Canada: **(509) 332-2756**

Fax:

(509) 332-5158

E-mail:

support@decagon.com.

NOTE: *If you purchased your G3 through a distributor, please contact them for assistance.*

Warranty

The Drain Gauge G3 has a one year warranty on parts and labor. It is activated upon the arrival of the instrument at your location.

Seller's Liability

Seller warrants new equipment of its own manufacture against defective workmanship and materials for a period of one year from date of receipt of equipment (the results of ordinary wear and tear, neglect, misuse, accident and excessive deterioration due to corrosion from any cause are not to be considered a defect); but Seller's liability for defective parts shall in no event exceed the furnishing of replacement parts F.O.B. the factory where originally manufactured. Material and equipment covered hereby which is not manufactured by Seller shall be covered only by the warranty of its manufacturer. Seller shall not be liable to Buyer for loss, damage or injuries to persons (including death), or to property or things of whatsoever kind (including, but not without limitation, loss of anticipated profits), occasioned by or arising out of the installation, operation, use, misuse, nonuse, repair, or replacement of said material and equipment, or out of the use of any method or process for which the same may be employed. The use of this equipment constitutes Buyer's acceptance of the terms set forth in this warranty. There are no understandings, representations, or warranties of any kind, express, implied, statutory or otherwise (including, but without limitation, the implied warranties of merchantability and fitness for a particular purpose), not expressly set forth herein.

Specifications

Suction at intake: 110 cm (11 kPa)
Solution collection capacity: 3.1L (6.1 cm of drainage) to bottom of wick. Additional 5.1L (10 cm of drainage) of reserve capacity in wick chamber.
Solution collection surface area: 507 cm^2 (25.4 cm inside diameter)
Solution extraction: Maximum extraction depth approximately 8m.
Wetted Materials
DCT (standard): 304 stainless steel 11 gauge
DCT (optional inert material): PVC
Wick: dry fired fiberglass
Root inhibitor: Treflan (BioBarrier ™), removable
Sample evacuation tube: Polyethylene
Hydraulic bridge material: Diatomaceous Earth (DE)
All other parts: PVC
Dimensions:
Total length: 147 cm
DCT length: 63.5 cm
DCT (outside) diameter: 26.4 cm
Reservoir length: 81.3 cm
Reservoir (outside) diameter: 11.5 cm
Access tube length: 180 cm standard, customizable
Access tube, outside diameter: 6.0 cm (2" schedule 40 PVC)
Sample evacuation tube: 1.27 cm OD X 0.79 cm ID X 5m length (standard)
Mass: 20 kg with Stainless Steel DCT, 14 kg with PVC DCT

2. How the G3 Works

The Drain Gauge G3 is installed below the root zone. Water infiltrates down through the soil and enters the divergence control tube (DCT). It then flows down through a fiberglass wick into a reservoir (see Fig. 1). The water is stored in a measurement reservoir until a sample can be removed. The volume of the removed sample can be used to calculate the total drainage since the last date the reservoir was emptied. Chemical analysis can also be performed on the sample. If the drainage rate and chemical concentration in the drainage water are both known, the flux of chemical through the soil can be calculated.

Theory

A soil water balance takes into consideration the inputs, losses and storage of water in a soil profile. An important component of the water balance is the water that drains from the bottom of the soil profile, often referred to as "deep drainage" or "deep percolation." This is water that has gone sufficiently far below the root zone that it cannot be removed from the soil by transpiration or evaporation. The other components of the water balance can be measured, but the deep drainage typically has been computed as the residual when the other components were measured and accounted for. Because of uncertainties in the measurements of the other water balance components, deep drainage estimates were subject to large errors.

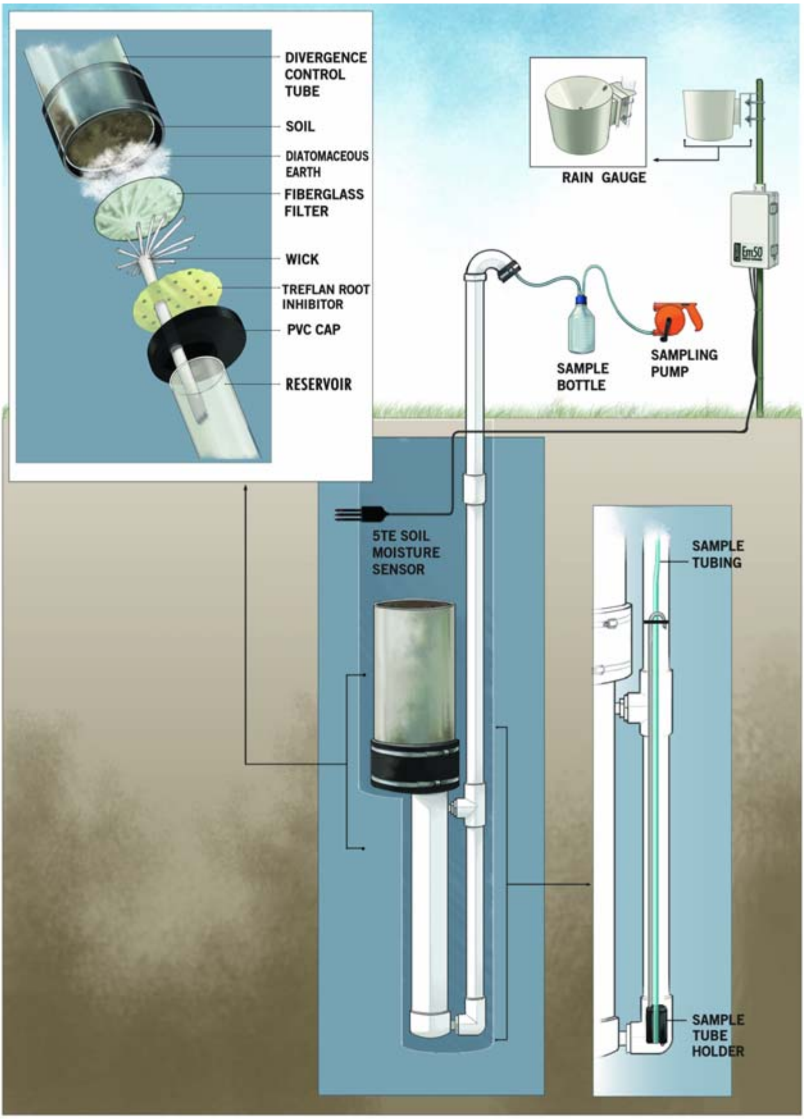


Figure 1. Components of the Drain Gauge G3

The Drain Gauge G3 allows direct measurement of the deep drainage component of the water balance. This is accomplished by intercepting and collecting a representative sample of the water that moves below the root zone. The Drain Gauge G3 is sometimes referred to as a passive wick lysimeter. It has a specially treated fiberglass wick which maintains tension on the water at the bottom of the soil profile where it is extracting water. Without this tension, water would "pile up" at the outflow boundary, and force the water in the soil above to move around the Drain Gauge G3, rather than into it. The divergence control tube (DCT) on the top of the Drain Gauge G3 is also for the purpose of maintaining vertical flow above the Gauge so that the Drain Gauge G3 intercepts a representative sample.

Both the amount of sample and its chemical composition need to be representative of deep drainage in the area where the Drain Gauge G3 is installed. Whether or not this is true is determined largely by the installation. The main issues are:

- Depth of installation and root incursion
- Soil water divergence/convergence
- Soil disturbance above the Drain Gauge G3.
- Contact between the wick and the soil profile.

Following are some general comments related to these issues. Specific installation procedures are then outlined in the next chapter.

Depth of Installation/Root Incursion

In any soil profile, there is a zone of recharge and seasonal depletion extending to the bottom of the root zone. The Drain Gauge

G3 should be placed with the union between the DCT and the wick section below the root zone of the cover vegetation. If the union between the DCT and the wick section is placed in the root zone, the Drain Gauge G3 can intercept water that normally would be transpired from the soil by the vegetative cover, thus overestimating the amount of drainage. There have also been cases of roots growing down through the wick and impeding flow through the wick as well as pulling water from the reservoir, thereby reducing the amount of measured drainage substantially. A patch of Biobarrier™ root inhibitor fabric is included with each Drain Gauge G3. This fabric has beads impregnated with trifluralin which prevents root tip cell division and thereby acts as a root elongation inhibitor with 20+ years of effective lifetime. This fabric has been shown to effectively keep roots from penetrating the Drain Gauge G3 wick section. In some situations where trifluralin or trifluralin breakdown products might compromise specialized chemical analysis of drainage water, the Biobarrier fabric can be removed from the Drain Gauge G3 assembly. Contact Decagon for instructions on removing the Biobarrier fabric without compromising the effectiveness of the capillary wick system. In cases where the Biobarrier fabric is removed, it is especially critical to get the Drain Gauge G3 buried below the root zone.

Since root density decreases with depth, the bottom of this zone may be difficult to locate. In annual crops it is typically around 1 m (3 ft.), but can be much deeper in perennials. There is, of course, a practical limit to how deep the Drain Gauge G3 can be installed. With shallow-rooted crops this is not an issue, but with deep-rooted plants, one may need to strike a compromise between getting below all roots and installing the Drain Gauge G3 at a practical depth. Even when roots go quite deep, the amount of water taken up by these roots may be small, so installing the Drain Gauge G3 within the lower root zone will result in minimal error. However, if the Drain Gauge G3 is installed in the root zone it is essential that the Biobarrier root inhibitor be included to prevent root incursion into the wick.

It is standard practice that the upper section of the DCT be placed in the root zone as long as vegetation is re-established above the Drain Gauge G3 and normal root growth is present in the DCT. In some instances where the root zone is nonexistent or shallow (e.g. bare soil, turfgrass), it is possible to install the Drain Gauge G3 with the DCT extending all the way to the surface. This type of installation has the advantage of preventing flow divergence or convergence. However, it can be difficult to re-establish natural surface conditions and surface vegetation if the DCT is extended to the surface.

Divergence/Convergence of Soil Water

Water in the soil flows in response to differences in soil suction, which is the same as water potential, but with the opposite sign. The two components of soil suction that are important in the water balance are the matric suction, which arises from the attraction between water and soil particle surfaces, and the gravitational suction which arises from gravitational forces pulling on the soil water. The important thing to understand is that water always flows from low suction (high water potential) to high suction (low water potential). Suction in the soil generally ranges from 0 (saturation) to 100,000 kPa (air dry). The suction at which there is no longer enough water in the soil to allow significant gravitational drainage is generally between 10 kPa and 33 kPa, and is known as field capacity.

For water to enter a lysimeter, the suction at the intake must be equal to or greater than the suction in the surrounding soil. With traditional pan lysimeters, there is a zero suction boundary, which means that water will preferentially flow around the lysimeter intake (flux divergence) unless the soil suction is very close to zero (saturation). This results in significant underestimation of drainage rates with pan lysimeters. The Drain Gauge G3 uses a fiberglass wick to form a hanging water column which pulls continuous suction at the intake. In a perfect system, this suction would vary to match the matric suction of the surrounding soil allowing water to flow into the Drain Gauge G3 in exactly the same manner as it flows through the soil. However, the wick system is only able to pull a constant suction. The suction at the top of the DCT is approximately 11 kPa (50 cm wick plus 60 cm soil column in DCT). If the soil is drier than 11 kPa, water will preferentially diverge around the Drain Gauge G3. Conversely, if the soil is wetter than 11 kPa, water will preferentially flow into the Drain Gauge G3 (flux convergence). The chosen suction value of 11 kPa is an intermediate value between saturation and field capacity, which define the range of suctions where a significant amount of water will drain through the soil. During very wet periods, the Drain Gauge G3 may experience flux convergence, and during periods between 11 and 33 kPa of suction, it may experience flux divergence, but the overall integrated flux measurement should be close to the actual drainage.

In addition to the fiberglass wick, the Drain Gauge G3 makes use of an innovative divergence control tube (DCT) that serves to minimize flux divergence and convergence and optimize collection efficiency of the Drain Gauge G3. Numerical and laboratory simulations performed by Gee et al. (2009) have demonstrated the effectiveness of DCT in preventing flux divergence and convergence around the collection point. Figure 2 shows the modeled collection efficiency of the passive wick lysimeters such as the Drain Gauge G3 as a function of DCT height for six different flux rates in four different soils (note that the Drain Gauge G3 DCT is 60 cm long). It is apparent that in coarse textured or structured soils, reasonable collection efficiency is achieved with the standard 60 cm DCT even at low drainage flux rates. It is also apparent that in non-structured, fine textured soils, the standard 60 cm DCT will only result in reasonable collection efficiencies at high drainage flux rates. However, it should be noted that the simulations were conducted with steady state drainage fluxes, which would seldom (if ever) occur in nature. Typically, drainage is associated with pulsed infiltration events (e.g. rainfall, irrigation, snow melt) where the drainage fluxes are relatively high, thus increasing the overall integrated collection efficiency of the Drain Gauge G3.

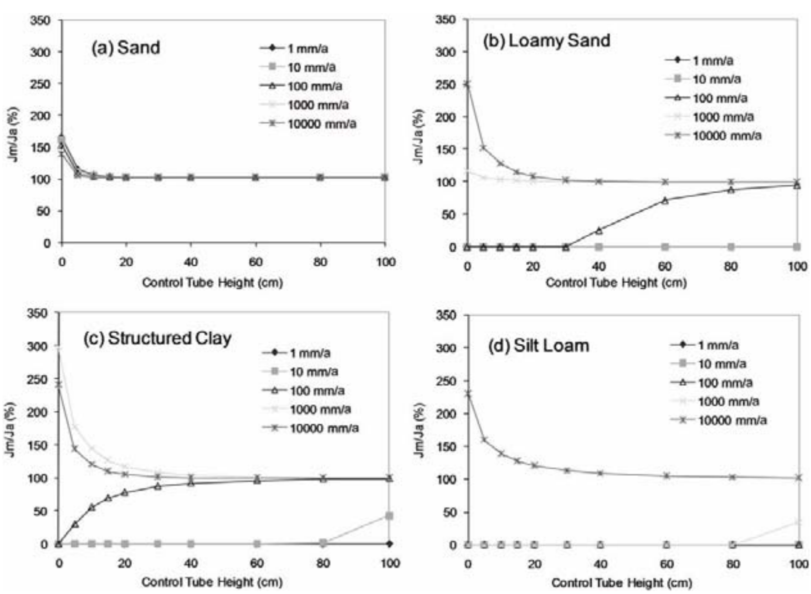


Figure 2: Simulated collection efficiency as a percentage (Jm/Ja = 100X measured/actual) for passive wick lysimeters with 60 cm long wicks in selected soils under a variety of steady state flux conditions and DCT heights. Figures from Gee et al. (2009).

Soil Disturbance

It is impossible to install the Drain Gauge G3 without disturbing the soil. The goal is to install it in such a way that the disturbance has minimal impact on the Gauge's ability to measure deep drainage accurately. In some cases, it may be necessary to install the Drain Gauge G3 beneath an undisturbed core of soil. In all cases it will be necessary to allow time for roots to grow back into disturbed soil. If the soil surface is tilled, there is no point in trying to keep that part of the soil undisturbed, since it is already disturbed. The following chapter on installing the Drain Gauge G3 has some specific tips on how to minimize soil disturbance during installation.

Soil-Wick Contact

In order for the bottom of the soil profile to be under the proper suction, the suction in the wick must be transferred to the bottom of the soil column. There must therefore be good capillary continuity between the soil column and the wick. If the Drain Gauge G3 is installed by backfilling with soil, the contact is likely to be good without further effort. If an undisturbed core is installed, capillary continuity is established by placing a layer of diatomaceous earth over the wick. The diatomaceous earth conforms to the irregularities of the soil and wick to provide continuity.

3. Installing the G3

Location Selection

The location that is chosen for Drain Gauge G3 installation must match the objectives of the particular drainage study. For many studies, an estimate of the average groundwater recharge from the study site is desired. In this case, it is important to choose installation location(s) that are representative of the study site as a whole, and several characteristics of the study site must be accounted for:

1. **Vegetation**: Once water has percolated more than a few centimeters into the soil, the main mechanism by which water is transported from the soil to the atmosphere is through vegetative transpiration. It is desirable that the Drain Gauge G3 be installed at a location with vegetative cover that it representative of the whole area of interest. It is also particularly critical that vegetation be re-established above the Drain Gauge G3 after installation.
2. **Topography**: It is best to avoid low areas where runoff collection can cause uncharacteristically high drainage rates. Typically, most accurate drainage results are measured at locations with a level surface, although installations on slopes can yield good results if the installation location is properly restored to natural conditions.
3. **Location Disturbance**: For most accurate drainage measurement, it is critical to re-establish natural conditions above the Drain Gauge G3 after installation and is therefore best to

disturb the location as little as possible during installation. With the Drain Gauge G3, significant location disturbance is inevitable, but there are strategies to minimize location disturbance. We suggest that you select one location for your installation, but select a second location nearby that you will use to collect an intact soil monolith in the DCT. The monolith location should be close enough to the installation location that soil properties are similar between the two locations, but far enough away that excavation activities at the monolith location don't impact the installation location. This method allows you to use whatever methods are most convenient to fill the DCT with an intact monolith (i.e. heavy equipment), while still minimizing disturbance at your installation site. Typically, the site where the monolith is collected and the installation site are on the order of 10 m apart.

Installation Depth

The depth of the Drain Gauge G3 installation depends on the depth of the root zone. The objective of the installation is to place the union between the DCT and the wick section below the root zone of the cover vegetation. If the union between the DCT and the wick section is placed in the root zone, then the Drain Gauge G3 can intercept water that normally would be transpired from the soil by the vegetative cover, thus overestimating the amount of drainage. It is acceptable and expected that the upper section of the DCT be placed in the root zone as long as vegetation is re-established above the Drain Gauge G3 and normal root growth is present in the DCT.

Because the installation depth is determined by vegetative rooting depth, the depth of installation will vary from location to location. In some instances where the root zone is nonexistent or shallow (e.g. bare soil, turfgrass), it is possible to install the Drain Gauge G3 with the DCT extending all the way to the surface. This type of installation has the advantage of preventing flow divergence or convergence. However, it can be difficult to re-establish natural surface conditions and surface vegetation if the DCT is extended to the surface.

Collecting an Intact Soil Monolith in the DCT

(Stainless Steel DCT only)

1. If you do not wish to collect an intact soil core (monolith) in the DCT and would rather use a disturbed soil sample, skip this section and go straight to the Assembling the Drain Gauge G3 section below.

2. Select the location where you will collect the intact monolith. We recommend that you collect your monolith at a separate (but nearby) location from where you will install the Drain Gauge G3 (see the comments in the Location Selection section above).

3. Excavate to the level that you have determined to be optimal for the top of the DCT. See the Installation depth section above for help determining how deep the Drain Gauge G3 should be installed.

4. Place the DCT on the exposed soil in the hole that you have just excavated.

5. Press or pound the DCT into the soil. The most convenient method for inserting the DCT into the soil is to use heavy equipment (e.g. backhoe or front end loader) to apply the downward force. However, it is possible to pound the DCT into the soil with a heavy sledgehammer. With either method

it is critical to distribute the insertion force to avoid damaging the top edge of the DCT. This is commonly accomplished by placing one or more 4" X 4" wood boards on the top edge of the DCT before pushing or pounding it in. The amount of force needed to insert the DCT is reduced considerably by removing the soil around the portion of the DCT that has already been inserted. In other words, push or pound the DCT in for a few inches, dig down around the outside of the DCT and remove the soil to the depth of the cutting edge of the DCT, then repeat. In some situations (e.g. stony soil), it may not be possible to push or pound the DCT into the soil to collect an intact monolith. In this case, a re-packed monolith is the only option. See instructions for filling the DCT with soil in the Installing the apparatus section below for more information on this option.

6. Once the DCT has been fully inserted into the soil, dig a large enough hole around it to access the bottom edge of the DCT. Use a flat blade or other utensil to cut the soil at the bottom edge of the DCT, resulting in a flat soil face at the lower boundary of the DCT.
7. Lift the DCT with intact monolith out of the hole.

Assembling the Drain Gauge G3

Once the installation depth has been chosen and the intact monolith has been collected in the DCT (if desired), you are ready to assemble the Drain Gauge G3.

1. Add a layer of diatomaceous earth (DE) on top of the fiberglass fabric on the top of the wick section or on the bottom of the DCT with the intact monolith. The DE ensures good hydraulic contact between the soil in the DCT and the wick,

and also filters fine particulates from the drainage water, keeping the Drain Gauge G3 from accumulating soil or "silting up" over time.

2. Attach the DCT to the wick section. Loosen the screw on the hose clamp at the top of the rubber union sleeve until the hose clamp is visibly loose.

   a. Insert the DCT into the rubber union sleeve until the soil column at the bottom of the DCT seats snugly against the layer of DE. If the DCT does not contain an intact soil monolith, simply seat the bottom of the DCT against the fiberglass fabric. If you are having trouble getting the DCT into the rubber union sleeve, you can use a screwdriver or other thin object to work the rubber union sleeve out and around the DCT.

   b. Tighten the hose clamp until the rubber union sleeve is sealed to the DCT.

3. Extend the access tube to desired length. The desired length will be determined by the depth of the Drain Gauge G3 installation. Typically, the top of the access tube will be 1-3 feet above the ground surface. To extend the access tube, simply add the two enclosed sections of 2 inch schedule-40 PVC tubing connected by the slip coupling. The overall length of the access tube can be customized by cutting the second PVC section to the desired length, or by adding additional PVC tubing. In areas where a high water table is present it is recommended that the PVC connections be glued to prevent water from entering the access tube/sampling chamber.

Making the Installation Hole

1. Select a location for your installation (allow plenty of room to move around the hole) and lay a tarp nearby that can be used to hold the vegetation and soil that will be removed from the site.

2. Remove the surface vegetation and place it on the tarp. Try to preserve as much of the root mass as possible. Also, it is important to organize the vegetation you remove so that it can be replaced as closely as possible to its original location(Figure 3)

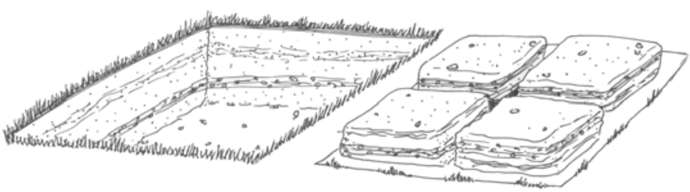


Figure 3: Initial excavation for Drain Gauge G3 Installation.

3. Make a vertical hole at least 16 inches (41 cm) in diameter to the level of the junction between the DCT and the reservoir section (25 inches, 635 cm below the top of the DCT).

4. Method #1 (offset holes). Starting at the floor of the 16 inch diameter hole, make a 10 inch (25.4 cm) diameter vertical hole to the depth of the bottom of the reservoir section (approximately 33 inches, 84 cm below the junction between the bottom of the 16 inch hole) to accommodate the reservoir section. The center of the 10 inch hole should be offset from the center of the 16 inch hole by 3 inches. In other words, the outer edge of the 10 inch hole should be flush

with the outer edge of the 16 in hole. With the offset hole configuration, the shelf formed at the end of the 16 inch hole helps to support the weight of the Drain Gauge G3 during installation and minimizes the amount of backfilling necessary.

5. Method #2 (straight hole). Continue the 16 inch vertical hole from #3 above to the depth of the bottom of the reservoir section (approximately 58 inches, 147 cm below the top of the DCT). This method is easier to accomplish in practice, but requires more significant backfilling of soil around the reservoir section of the Drain Gauge G3.

Installing the Apparatus

1. Loop a length of heavy rope or strap below the fitting connecting the reservoir section to the access tube immediately below the junction between the DCT and reservoir section (See figure 4 below).

Caution: If you are using an intact monolith, when turning the Drain Gauge G3 upright it is important to not lift the drain gauge up using the bottom part of the sampling chamber as a lift point. Doing this could result in a break around PVC fittings or the seal around the wick section.

2. Carefully lower the Drain Gauge G3 into the installation hole with one person holding the Drain Gauge G3 level and guiding it into the installation hole while another person(s) slowly lowers it into the hole using the loop of rope or strap (this job typically take 2 to 3 people slowly lower the Drain Gauge G3 into the hole). Do not drop the Drain Gauge G3 into the hole or it could be permanently damaged.

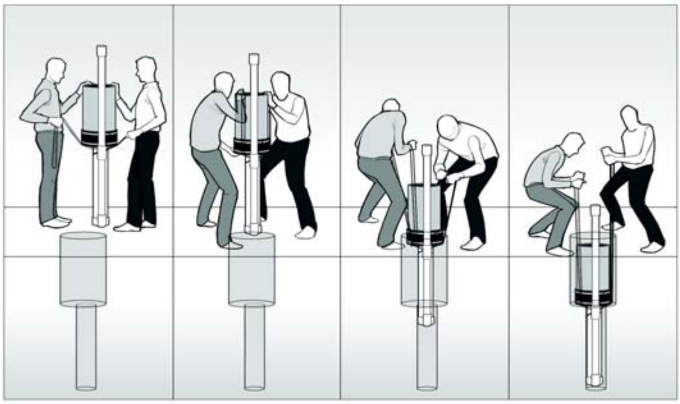


Figure 4: How to safely lower the Drain Gauge into the installation hole.

3. Filling the DCT with a disturbed sample (ignore this section if you collected an intact monolith in the DCT). If you did not collect an intact monolith it is important to re-pack the disturbed soil in the DCT as similarly as possible to the natural soil conditions.

   a. Bulk density: When backfilling the DCT, it is important to pack the soil back to the natural bulk density. Try to avoid large variations in bulk density between layers as these will act to retard flow and can cause flux divergence.

   b. Horizonation: Try to pack the soil back into the DCT in layers that correspond to the horizons in the surrounding soil.

3. Carefully backfill soil into the hole around the reservoir section. The more soil you are able to backfill into this section

the better, as the Drain Gauge G3 is less likely to settle over time if this section is full of soil.

4. Backfill soil around the DCT. Try to achieve a similar bulk density to the surrounding soil.

5. Carefully replace the soil above the DCT and vegetation that were removed as described at the beginning of making the installation hole section. Be careful to re-pack the soil above the DCT to the same bulk density as the surrounding soil and to re-create any layering that is present in the natural soil. Also be careful not to leave a mound or depression of soil above the Drain Gauge G3, as this could significantly affect infiltration of water in the area of the Drain Gauge G3.

6. If there is vegetative cover above the Drain Gauge G3, it may be desirable to "water in" the disturbed vegetation to help it re-establish as soon as possible.

Aboveground Tubing Terminations

1. Now that the Drain Gauge G3 is installed in the ground the sampling tube coming out of the access tube needs to be run through the "U" connector. Then connect the "U" connector to the top of the access tube.

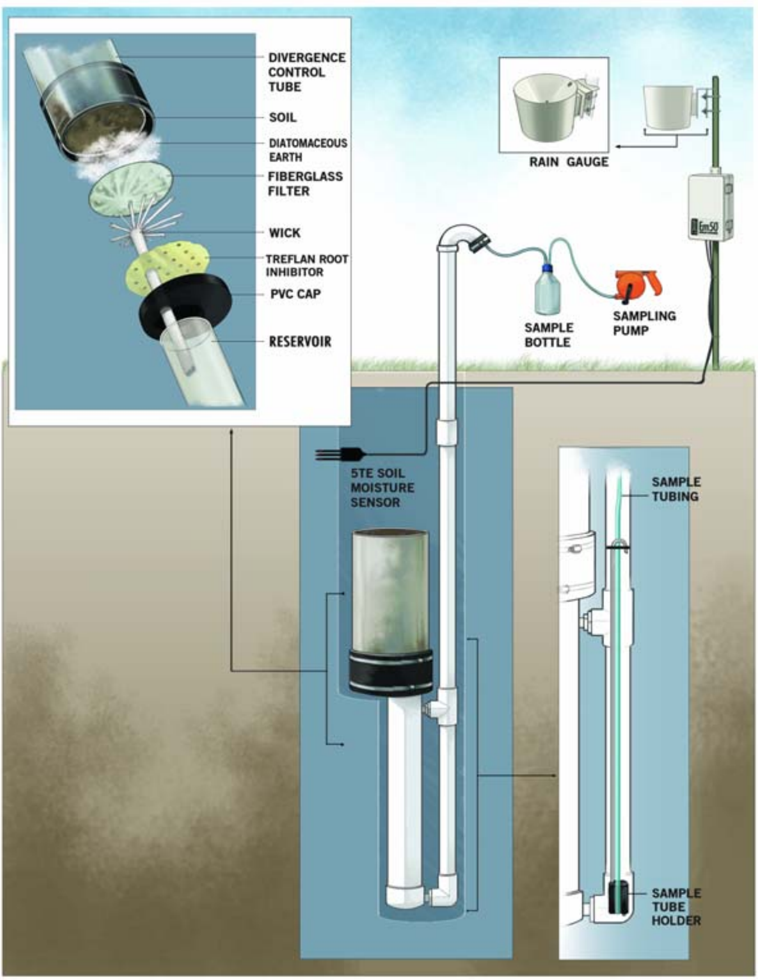
2. After connecting the "U" connector to the access tube run the sampling tube through the pre-cut slit in the rubber end cap. Pull the sampling tube through the end cap until the end cap meets up with the end of the "U" connector. Be sure not to pull the sampling tube too tight, because doing so could cause the end of the sampling tube to be pulled up higher in the access tube. Connect the end cap with the end of the "U" connector and tighten the hose clamp with a flat head screwdriver.

Figure 5: PVC "U" connector assembly on top of access tube.

Water Balance

It is often useful to install ECH2O soil moisture sensors near the Drain Gauge G3 to observe how the water content changes with depth over time in the soil profile. Some users will also install ECH_2O sensors in the DCT, to make sure that the soil moisture dynamics in the DCT are similar to those in the undisturbed soil surrounding the Drain Gauge G3. If you install ECH_2O sensors in the DCT, you must take care so they are not touching any part of the DCT, as this will adversely affect the readings. A good rule is to locate them as close to the center of the DCT as possible. Installing a rain gauge near the installation site is also useful for measuring incoming water values for water balance calculations.

4. Using the Drain Gauge G3



Overview

The Drain Gauge G3 measures the total drainage by accumulating a representative drainage sample in the reservoir section. If the volume of water accumulated in the reservoir section is divided by the cross sectional surface area of the intake of the DCT, the total drainage can be calculated with units of m^3 drainage/m^2 soil surface are, or more commonly simply cm of drainage.

The water in the reservoir section is easily accessed by the sample tube, and can be removed using the pump included with the Drain Gauge G3 for chemical analysis in the laboratory. If the concentration of the constituent of interest is measured, it can be multiplied by the drainage flux density to yield the flux density of the constituent through the soil.

Collecting Water

Supplied with the Drain Gauge G3 is a peristaltic pump and a 1 L sampling bottle. The cap for the sampling bottle has two connectors for hoses. Connect the sample evacuation tube coming out of the drain gauge to one of the ports. Then connect supplied second hose from the other port in the sampling bottle to the inlet port of the peristaltic pump. Begin rotating the handle on the pump counterclockwise continuously. This will create a vacuum inside of the sampling bottle pulling the collected drainage water out of the Drain Gauge G3's sampling reservoir and into the sampling bottle. Because the reservoir has a higher capacity than the sampling bottle, you may need to stop pumping if the sampling bottle becomes full and empty the solution into a secondary bottle. Continue this process until water stops flowing into the sampling bottle. The reservoir should now be empty.

The total volume of sample that was pulled will be used to calculate drainage and contaminant flux rates.

In order to prevent cross contamination between samples and across different locations it is important to rinse out the sampling bottle and associated parts before pulling another sample. Take apart the cap and bottle assembly and rinse all of the parts that came into contact with the sampled water using distilled water 3 times. The pump does not need to be rinsed out since it does not come into contact with any of the sampled water.

NOTE: If the pump becomes hard to turn you may open the pump and apply lubricating grease to the internal apparatus.

Calculating Drainage

The inner diameter of the DCT is 25.4 cm (10.0 inches), which yields a cross sectional surface area of 506.7 cm^2 (78.5 in^2) at the intake of the Drain Gauge G3. The amount of drainage can easily be calculated by the change in volume of water accumulated in the reservoir section. Simply divide the volume of water removed (cm^3) by the cross sectional surface area of the DCT intake (506.7 cm^2), yielding the total accumulated drainage in units of cm.

Priming the Drain Gauge G3

The end of the Drain Gauge G3 sample tube is situated slightly above the floor of the access tube. This is also slightly above the level of the floor of the reservoir section. This creates a "dead volume" of 47 mL of accumulated drainage water that cannot be removed using the sample tube. When the Drain Gauge G3 is first installed into the soil, this volume does not contain water, so a total of 47 mL of drainage water will need to be accumulated before the Drain Gauge G3 will begin to record drainage. We recommend that you prime the Drain Gauge G3 after installation by adding 250 mL or more of water through the access tube. Then, you should remove all possible water by evacuating from the sample tube with the included pump. This will effectively fill the dead volume and ensure that any subsequent drainage is recorded accurately.

Calculating Concentration

Collected drainage water can be easily and quickly removed from the Drain Gauge G3 through the sample tube using the included pump and sampling bottle. The concentration of the constituent(s) of interest can then be determined through laboratory analysis.

The end of the Drain Gauge G3 sample tube is situated slightly above the floor of the access tube. If all possible water is removed to the level of the end of the sample tube, 47 mL of drainage water will remain in the lowest portion of the access tube and in the lowest portion of the reservoir section. This drainage water will mix with any new soil solution that is collected by the Drain Gauge G3. The chemical concentration of a sample that is subsequently removed for analysis will then represent a weighted average of the chemical concentration of the remnant drainage water and the newly accumulated drainage water. For many applications, this is acceptable, but for some, only the chemical concentration of the newly accumulated drainage water is desired. This can be calculated by:

$$C_{new} = \frac{C_{mix}[(V_{new} + V_{old}) - (C_{old} \cdot V_{old})]}{V_{new}}$$

Where C is constituent concentration, V is volume of drainage water, and the subscripts new, old, and mix indicate newly accumulated drainage water, drainage water remaining in the reservoir chamber after the previous extraction, and the mixture of the two types of drainage water respectively.

An example calculation follows.
The nitrate concentration of drainage water that was removed from a Drain Gauge G3 just prior to fertilization of a corn crop was 30 mg/L. When the water was extracted a few weeks following application of urea, 500 mL of drainage water was extracted with a nitrate concentration of 45 mg/L.

C_{mix} = 45 mg/L
V_{new} = 500mL
V_{old} = 47 mL
C_{old} = 30 mg/L

$$C_{new} = \frac{45\frac{mg}{L} \cdot (0.500L + 0.047L) - 30\frac{mg}{L} \cdot 0.047L}{0.500L} = 46.4\frac{mg}{L}$$

For this calculation to be valid, the reservoir must be fully emptied to the level of the bottom of the sample tube during the evacuation previous to the analysis and during the evacuation used for the analysis.

NOTE: **Because the Drain Gauge G3 is a completely sealed system and does not have an overflow tube, it will need to be emptied periodically to prevent the water level from reaching the bottom of the wick. If the water level reaches the wick it will change the tension that the wick is applying as it continues to rise above the bottom of the wick. This will not cause damage to the Drain Gauge G3 but it may reduce your collection efficiencies.**

Further Reading

Gee, G. W., B. D. Newman, S. R. Green, R. Meissner, H. Rupp, Z. F. Zhang, J. M. Keller, W. J. Waugh, M. van der Velde, and J. Salazar (2009), Passive wick fluxmeters: Design considerations and field applications, Water Resour. Res., 45, W04420, doi:10.1029/2008WR007088

Declaration of Conformity

Application of Council Directive:	89/336/EEC
Standards to which Conformity is Declared:	EN61326: 1998 EN55022: 1998
Manufacturer's Name:	Decagon Devices, Inc. 2365 NE Hopkins Court Pullman, WA 99163 USA
Type of Equipment:	Gee Passive Capillary Lysimeter Drain Gauge.
Model Number:	G3
Year of First Manufacture:	2010

This is to certify that the Drain Gauge G3, manufactured by Decagon Devices, Inc., a corporation based in Pullman, Washington, USA meets or exceeds the standards for CE compliance as per the Council Directives noted above. All instruments are built at the factory at Decagon and pertinent testing documentation is freely available for verification.

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