

Walton

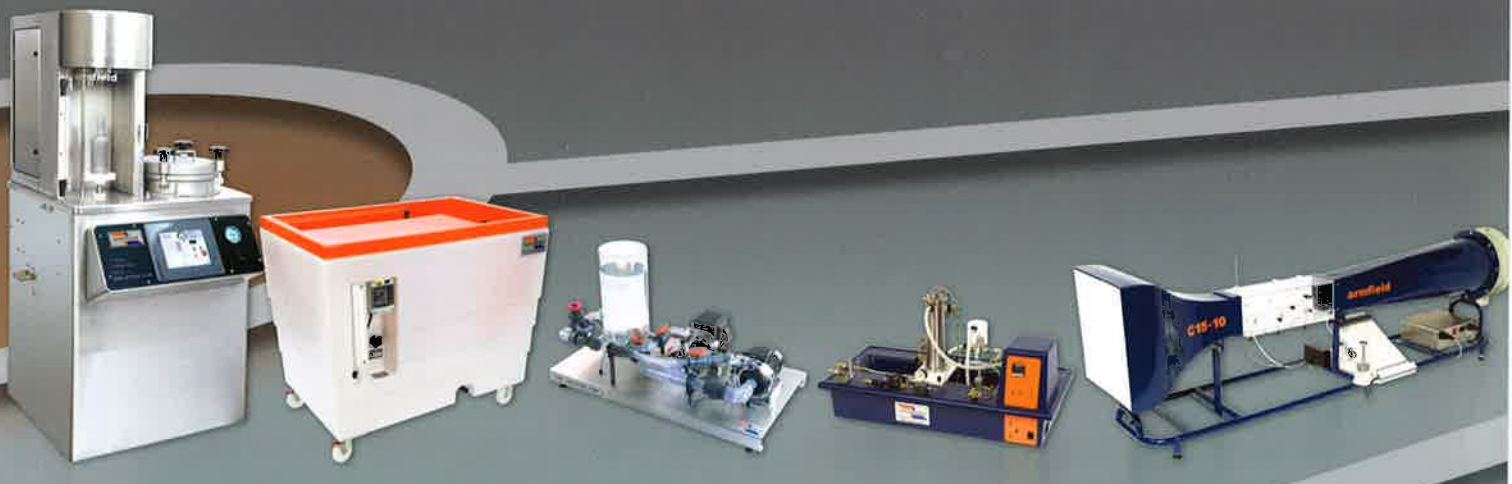
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## Engineering Teaching & Research Equipment

S11

INSTRUCTION MANUAL



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# INSTRUCTION MANUAL

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**S11**  
**ISSUE 8**

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## **Ground Water Flow and Well Abstraction Unit**

022616



## IMPORTANT SAFETY INFORMATION

All practical work areas and laboratories should be covered by local safety regulations **which must be followed at all times.**

It is the responsibility of the owner to ensure that all users are made aware of relevant local regulations, and that the apparatus is operated in accordance with those regulations. If requested then Armfield can supply a typical set of standard laboratory safety rules, but these are guidelines only and should be modified as required. Supervision of users should be provided whenever appropriate.

Your **Ground Water Flow and Well Abstraction Unit** has been designed to be safe in use when installed, operated and maintained in accordance with the instructions in this manual. As with any piece of sophisticated equipment, dangers may exist if the equipment is misused, mishandled or badly maintained.



### Wet Environment

Use of this equipment requires a supply of water. During use it is possible that there will be some spillage and splashing.

- All users should be made aware that they may be splashed while operating the equipment, and should wear appropriate clothing and non-slip footwear.
- 'Wet Floor' warnings should be displayed where appropriate.
- Electrical devices in the vicinity of the equipment must be suitable for use in wet environments or be properly protected from wetting.



### Heavy Equipment

This apparatus is heavy.

- The apparatus should be placed in a location that is sufficiently strong to support its weight, as described in the Installation section of the manual.
- The sand tank should be emptied of water and sand before moving the equipment.
- Where manual lifting is necessary, two or more people will be required for safety, and all should be made aware of safe lifting techniques to avoid strained backs, crushed toes, and similar injuries.
- Safety shoes and/or gloves should be worn when appropriate.



### Water Borne Hazards

The equipment described in this instruction manual involves the use of water, which under certain conditions can create a health hazard due to infection by harmful micro-organisms.

For example, the microscopic bacterium called *Legionella pneumophila* will feed on any scale, rust, algae or sludge in water and will breed rapidly if the temperature of water is between 20 and 45°C. Any water containing this bacterium which is sprayed or splashed creating air-borne droplets can produce a form of pneumonia called Legionnaires Disease which is potentially fatal.

*Legionella* is not the only harmful micro-organism which can infect water, but it serves as a useful example of the need for cleanliness.

Under the COSHH regulations, the following precautions must be observed:-

- Any water contained within the product must not be allowed to stagnate, i.e. the water must be changed regularly.
- Any rust, sludge, scale or algae on which micro-organisms can feed must be removed regularly, i.e. the equipment must be cleaned regularly.
- Where practicable the water should be maintained at a temperature below 20°C. If this is not practicable then the water should be disinfected if it is safe and appropriate to do so. Note that other hazards may exist in the handling of biocides used to disinfect the water.
- A scheme should be prepared for preventing or controlling the risk incorporating all of the actions listed above.

Further details on preventing infection are contained in the publication "The Control of Legionellosis including Legionnaires Disease" - Health and Safety Series booklet HS (G) 70.

# Groundwater Flow/Well Abstraction Unit

## S11

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## 1 Introduction to the Equipment

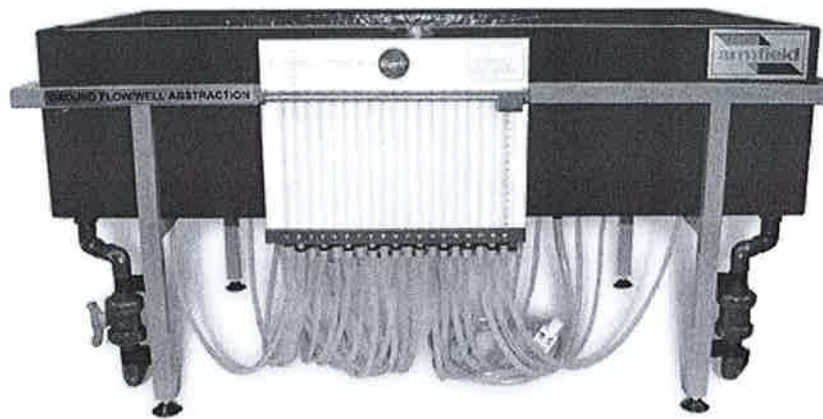
This bench-mounting equipment is capable of demonstrating, on a small scale, the hydrological principles of ground water flow and the applications of these to certain engineering constructions. The demonstrations are of interest to geologists and geographers concerned with sub-surface water flows.

The equipment is valuable in any practical coursework related to water resource engineering. Demonstrations of flood risks associated with land drainage works, the use of wells for water abstraction, de-watering and the drainage of lakes and polders are all readily performed.

The Armfield Ground water flow unit allows simple three dimensional flow situations to be set up quickly and measurements of piezometric levels taken at appropriate positions within the model. The following demonstrations are described in the teaching exercises included in this instruction manual:-

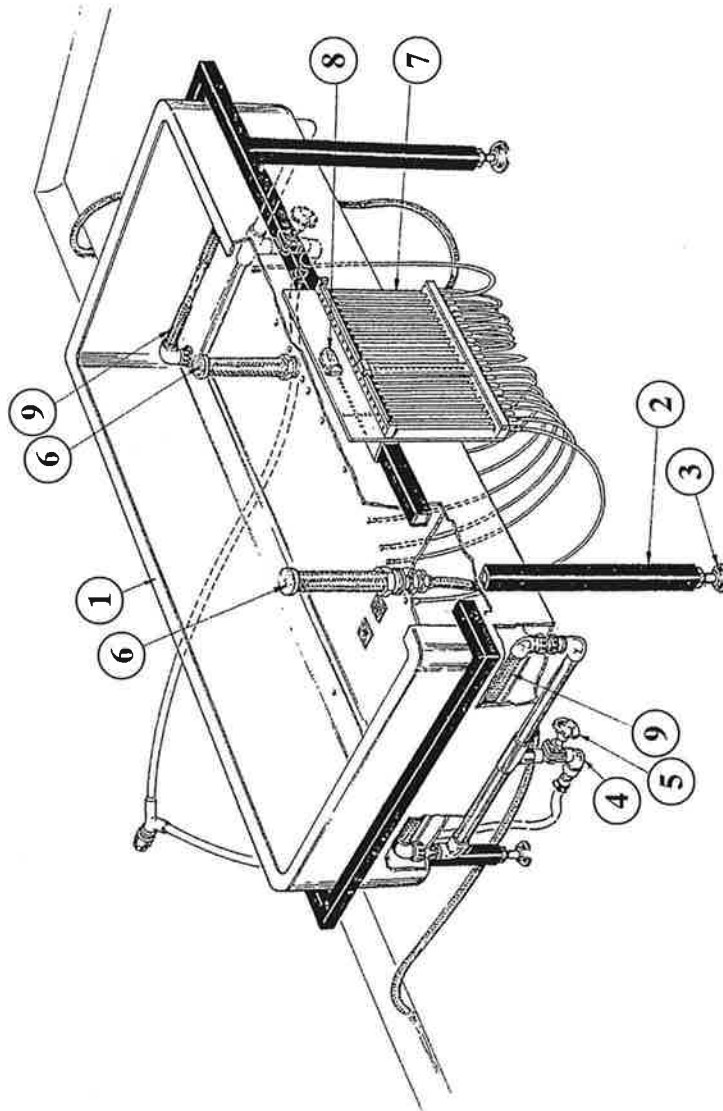
- Hydraulic gradients in ground water flow (Darcy's Law), including the effect of permeability
- Cone of depression for a single well in an unconfined aquifer
- Abstraction from a single well in confined aquifer
- Cone of depression for two adjacent wells, including superposition of two single wells
- Dewatering an excavation site using wells
- Draining a polder or lake using wells

In addition to the above demonstrations, instructors and students of engineering hydrology may readily construct further model situations for study.



*S11 Groundwater Flow and Well Abstraction*

1.1 S11 Diagram



## **2 Description**

Where necessary, refer to the drawing on page 2.

### **2.1 Overview**

The S11 Groundwater Flow/Well Abstraction apparatus consists of a sand tank with water inlets at both ends, two drains for the simulation of well abstraction and tappings in the floor connected to a multi-tube manometer to provide a visual indication of the water level throughout the tank.

### **2.2 Sand Tank**

The sand tank (1) is manufactured from robust glass reinforced plastic for durability. Internal dimensions of the tank are typically:

Length:	990mm
Width:	490mm
Depth:	235mm

### **2.3 Steel Frame**

The sand tank is supported by a mild steel frame (2), which is painted for corrosion protection. Four adjustable feet (3) permit levelling of the equipment. The frame is designed to stand on a suitable bench for convenience when reading water levels on the multi-tube manometer. However, the equipment may be operated at floor level if required.

### **2.4 Water Inlet Ports**

Two independent water inlet ports (4) are situated at each end of the tank. Each port consists of a perforated tube, across the width of the tank to diffuse the flow. The perforated tube is covered with fine woven material to prevent sand from escaping. Each port has a separate flow control valve (5) allowing the flow into the tank to be varied to achieve fixed levels inside the tank. Water can be fed to both ports simultaneously or to one port only while the other port is used as a drain.

### **2.5 Quick Release Fittings**

The flexible tubing connected to both water inlet ports is terminated with a quick release connector to allow a rapid conversion from one configuration to another. A 'Y' connector allows both inlets to be connected to the source of water.

### **2.6 Wells**

Two wells (6) with control taps in the base of the tank allow studies of abstraction. Each well consists of a perforated tube open at the bottom that is covered with fine woven material to prevent sand from escaping. The perforated tube protrudes vertically upwards into the sand tank to provide a large surface area to minimise resistance to flow.

## 2.7 Manometer and Tappings

Nineteen tappings in the base of the tank, arranged in a cruciform configuration, are connected to a multi-tube manometer (7) which is clipped to the side of the frame. The positions of the tappings and dimensions relative to the wells are given on page 8. The manometer is easily removable to assist in the priming of the individual tubes. A sliding cursor on the manometer permits measurement of the level at any tapping position.

Range of manometer:	0 to 155 mm
Calibration:	1 mm intervals

## 2.8 Rectangular and Cylindrical Rings

An open rectangular ring, an open cylindrical ring and a closed cylindrical ring with central floor tapping and sight tube are provided. The use of these is described in the appropriate exercises.

### 3 Operation

Where necessary, refer to the drawing on page 2.

#### 3.1 Level the equipment

Place the equipment in the required location and level the frame by adjusting the feet while referring to the spirit level on the manometer board. Before filling the tank with sand connect the water supply and prime the manometer as described below to check the equipment for leaks.

#### 3.2 Connect the water supply and drain

A suitable mains water supply or equivalent should be connected to the Y-adapter. The Y-adapter connects the two water inlet pipes for the apparatus.

The two well abstraction pipes situated at the base of the sand tank should be led to a suitable drain.

When using one inlet port as a water supply, the other port should be led to drain.

#### 3.3 Prime the multi-tube manometer

A bucket or similar container for water will be required to prime the manometer board.

Close the well taps and open the flow control valves. Switch on the water supply.

Allow the water level in the tank to rise to 100mm.

Remove the manometer board and immerse it in the empty bucket or container at a lower level than the water in the sand tank. When all the tubes are running full of water, replace the manometer board. If the manometer is properly primed then the level in each tube should be the same. If they are not, repeat the process.

Check the tank, connections and manometer for leaks before proceeding to fill the tank with sand.

#### 3.4 Fill the tank with sand

For studying gradients, water table draw-down, well abstraction etc. as described in the teaching exercises, graded sand with sizes varying from 0.6 to 2.0 mm is recommended. The sand should be thoroughly washed to remove all silt and salt present before loading it into the sand tank.

A more uniform bed of sand will result if water is retained in the sand tank when the sand is introduced. A typical depth of 150 mm of sand will suit most demonstrations, requiring approximately 75 litres of sand.

10-30 US size  
272 lbs = 6 bags

#### 3.5 Monitoring the ground water level

Once the manometer bank is primed, the level in each manometer tube will provide a visual indication of the corresponding water level at that tapping point. The nineteen tappings in the floor of the sand tank are arranged in a cruciform pattern and are attached to the multi-tube manometer bank. The position and dimensions of each of the tappings relative to the wells are given on page 8. The manometer tubes are numbered sequentially 1 – 19 from left to right.

## **4 Specifications**

### **4.1 Overall Dimensions**

Height: - 1.115m  
Width - 0.585m  
Depth - 0.530m

### **4.2 Mains Water Supply**

The equipment requires connection to a clean water supply with a minimum pressure of 1 bar and a maximum pressure of 3 bar.

### **4.3 Connection to Drain**

Water exiting the equipment should be directed to a suitable cold water drain.

### **4.4 Sand Required**

For studying the water table drawdown and well abstraction, the size of sand suggested is 0.6 - 2.0 mm. The sand should be thoroughly washed to remove all silt and salt present.

## **5 Routine Maintenance**

To preserve the life and efficient operation of the equipment it is important that the equipment is properly maintained. Regular maintenance of the equipment is the responsibility of the end user and must be performed by qualified personnel who understand the operation of the equipment.

### **5.1 General**

Water should be drained from the equipment when it is not in use.

The sand should be removed if the equipment is not to be used for some time.

### **5.2 Cleaning**

Should the equipment require cleaning, external surfaces may be wiped with a soft, damp, lint-free cloth. A small quantity of mild detergent may be used if needed. Avoid the use of solvents.

In the event of problems with algae or scale, the system should be soaked by removing the sand and then filling the tank, pipework, tubing and manometer bank with a solution of biocide (for algae) or a mild descaler (for scale). Always follow the manufacturer's instructions when using proprietary chemicals, and ensure the equipment is thoroughly rinsed with clean water after treatment.

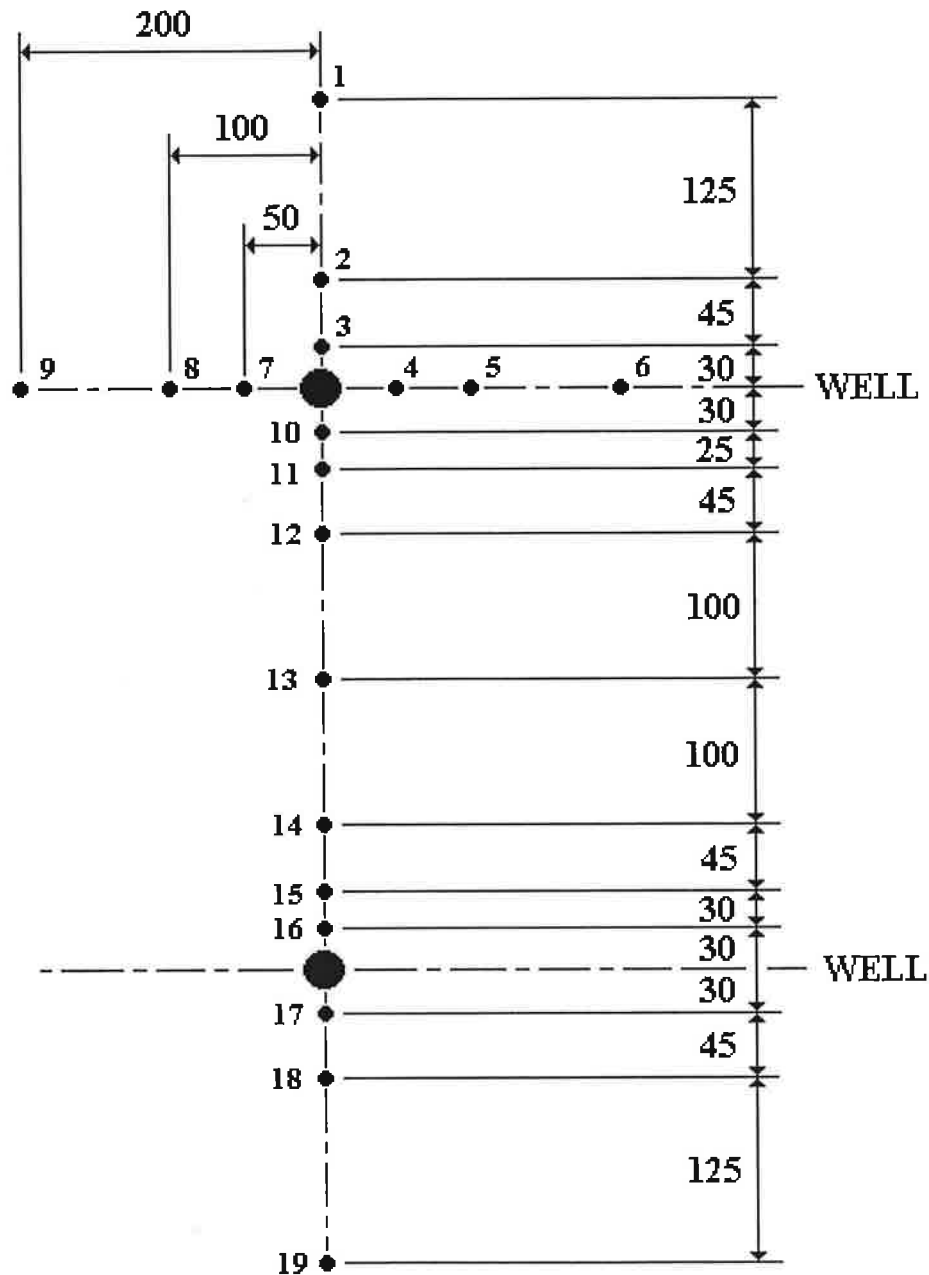
If the sand also requires treatment then it too must be thoroughly rinsed clean of any chemicals used before it is returned to the sand tank.

## 6 Laboratory Teaching Exercises

### 6.1 Piezometer tapping positions

Piezometer positions in cruciform arrangement in base of sand tank.

All dimensions in mm.



## 6.2 Exercise A – Hydraulic gradient associated with ground water flow

### Objective

To demonstrate ground water flow and the resulting hydraulic gradient between two different potentials.

### Equipment Required

S11 groundwater Flow/Well Abstraction Unit

0.1 m<sup>3</sup> of washed well graded coarse sand, range 0.6 – 2.0mm

Stopwatch (not supplied)

Bucket or container for volumetric measurement (not supplied)

### Theory

The linear relationship between head loss  $h$  and flow rate  $Q$ , expressed as approach velocity  $V$  is given by Darcy's Law:

$$V = k \frac{dh}{dL}$$

where  $V$  = Volumetric flow rate per unit cross-sectional area

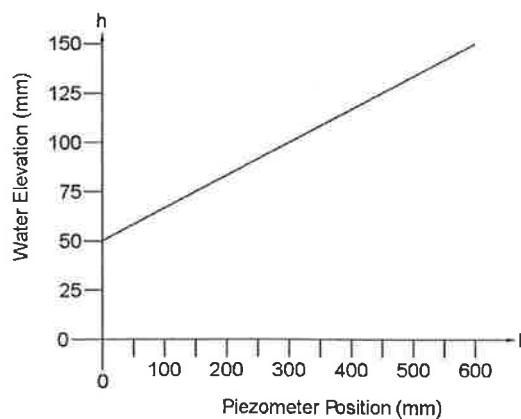
$\frac{dh}{dL}$  = Hydraulic gradient

$k$  = Permeability coefficient

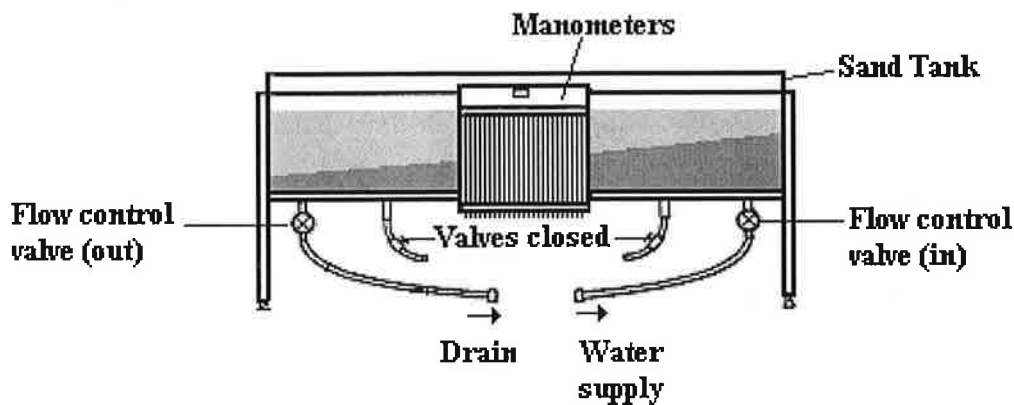
$V$  may also be calculated from the flow rate using the average wetted area of sand (as calculated from the water levels):

$$V = \frac{Q}{A}$$

The coefficient of permeability for the grade of sand recommended is 0.0138mms<sup>-1</sup> (approximately).



## Equipment Set Up



Place the sand in the sand tank and smooth the surface, to give an even depth of 150mm.

Connect the right-hand flow inlet pipe to a suitable water supply (the quick-release fitting may need to be removed to do this).

Direct the left-hand flow inlet pipe to drain. This will be the drainage tube for this experiment.

Fully close the outlet valve on both well abstraction pipes. Direct the pipes to drain as a precaution.

Check that the manometer is primed.

## Procedure

Turn on the water supply.

Open the left hand flow control valve fully.

Adjust the right hand flow control valve until a steady head is maintained. This will be indicated by manometer tube No 13.

Allow conditions to stabilise for several minutes.

Record the manometer levels.

Perform a timed volume collection to measure the flow rate ( $Q$ ) out of the drainage tube.

Repeat the procedure with a different water flowrate by closing the inlet control valve slightly. Allow conditions to stabilise for several minutes then repeat the readings.

Partly close the outlet flow control valve until the water level rises slightly at the left hand side of the tank. Allow the conditions to stabilise for several minutes then repeat the readings.

### Results

Volume Collected \_\_\_\_\_ m<sup>3</sup>

Time to Collect \_\_\_\_\_ s

Flow Rate Q \_\_\_\_\_ m/s

Manometer Tube	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Height (h) mm																			

Draw a graph of water height (h) against piezometer (tapping) distance (L) from well. See page 8 for piezometer positions. The graph obtained should be similar to the graph in the theory section above.

Calculate the wetted cross-sectional area of the sand.

Calculate the hydraulic gradient from the graph.

Calculate the theoretical hydraulic gradient using Darcy's Law and the measured volumetric flow rate:

$$\frac{dh}{dL} = \frac{V}{k}$$

(Use  $k = 0.013\text{mm/s}$ )

### Conclusion

How did the hydraulic gradient obtained from the graph compare to the hydraulic gradient calculated using the measured flow rate? Give reasons for any discrepancies, and suggest changes to the experimental method that might help to reduce such discrepancies. Comment on the effect of  $k$  on the gradient.

### 6.3 Exercise B – Cone of depression for a single well in an unconfined aquifer

#### Objective

To determine the Cone of Depression for a single well in an unconfined aquifer.

#### Equipment Required

S11 groundwater Flow/Well Abstraction Unit

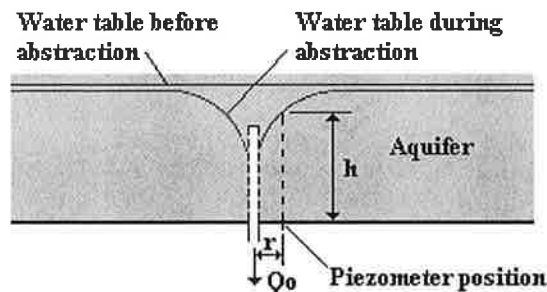
0.1 m<sup>3</sup> of washed well graded coarse sand, range 0.6 – 2.0 mm

Stopwatch (not supplied)

Bucket or container for volumetric measurement (not supplied)

#### Theory

In an unconfined aquifer, the piezometric surface coincides with the upper limit of the saturated zone and this is commonly termed the WATER TABLE.



Ground water abstraction from a well will result in the lowering of the water table and at the same time, a reduction of saturated depth available for the flow of water.

The equation of flow thus becomes:-

Darcy's equation:  $Q = 2\pi rhk \frac{dh}{dr}$

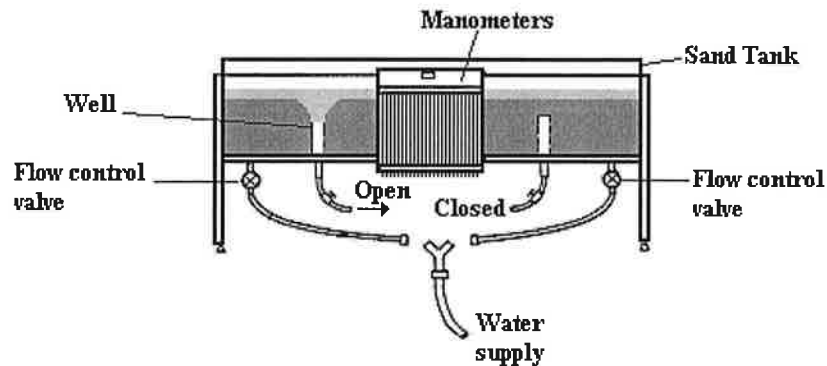
where  $k$  = Coefficient of permeability (Approx 0.013mms<sup>-1</sup> grade of sand recommended).

$r$  = Radius of piezometer (m)

$Q$  = Flow rate (m<sup>3</sup>s<sup>-1</sup>)

$h$  = Height in piezometer tube (m)

### Equipment Set Up



Place the sand in the sand tank and smooth the surface, to give an even depth of 150mm.  
 Connect both inlet pipes to the Y-connector, and the Y-connector a suitable water supply.  
 Fully close the outlet valve on both well abstraction pipes. Direct the pipes to drain.  
 Check that the manometer is primed.

### Procedure

Turn on the water supply.  
 Open the left hand well abstraction pipe valve.  
 Open the left and right flow control valves, and adjust these valves until equal readings are obtained for manometer tubes 1 and 13.  
 Perform a timed volume collection to measure the flow rate (Q) out of the well.  
 Record the manometer levels.

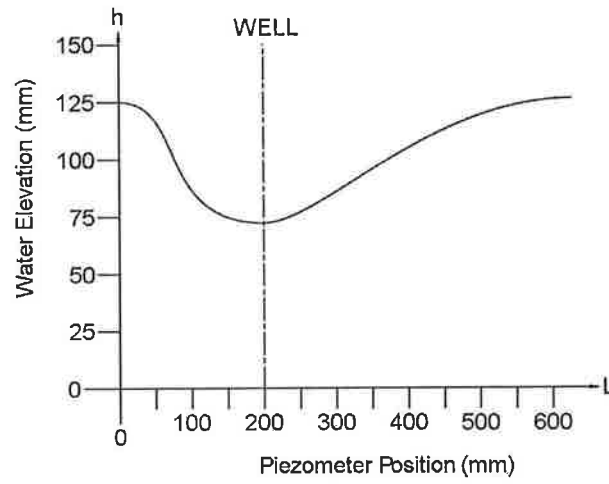
### Results

Volume Collected \_\_\_\_\_ m<sup>3</sup>  
 Time to Collect \_\_\_\_\_ s  
 Flow Rate Q \_\_\_\_\_ m/s

Manometer Tube	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Height (h) mm																			

Draw a graph of water height (h) against piezometer (tapping) distance (L) from well. See page 8 for piezometer positions. Plot the lateral tubes 4-9 on the graph to show the three-dimensional cone of depression.

The graph obtained should be similar to the following:



Calculate  $k$  from  $Q = 2\pi rhk \frac{dh}{dr}$

### Conclusion

Did the results obtained prove Darcy's equation?

## 6.4 Exercise C – Cone of depression for two wells in an unconfined aquifer

### Objective

To determine the Cone of Depression for two wells in an unconfined aquifer.

### Equipment Required

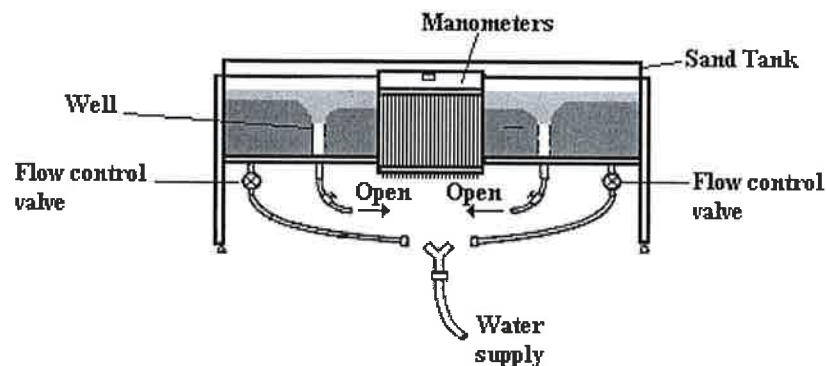
S11 groundwater Flow/Well Abstraction Unit

0.1 m<sup>3</sup> of washed well graded coarse sand, range 0.6 – 2.0 mm

### Theory

The method of superposition allows the prediction of a complex situation by considering it to be made up of a number of simple elements and superimposing their resulting individual effects. In the case of ground water flow in an unconfined aquifer with two adjacent wells, the method of superposition can be used only in its simple linear form if the separate drawdowns are small compared with the saturated thickness of the aquifer.

### Equipment Set Up



Place the sand in the sand tank and smooth the surface, to give an even depth of 150mm.  
Connect both inlet pipes to the Y-connector, and the Y-connector a suitable water supply.  
Direct the well abstraction pipes to drain. Close the outlet valve on both pipes.  
Check that the manometer is primed.

### Procedure

Turn on the water supply.  
Open the left hand well abstraction pipe valve.  
Fully open the left and right flow control valves.  
Allow several minutes for the system to stabilise.

Record the manometer levels.

Open the right hand well abstraction pipe valve. Close the left hand well abstraction pipe valve.

Allow several minutes for the system to stabilise.

Record the manometer levels.

Open the left hand well abstraction pipe valve. Both well pipe valves should now be open.

Allow several minutes for the system to stabilise.

Record the manometer levels.

### Results

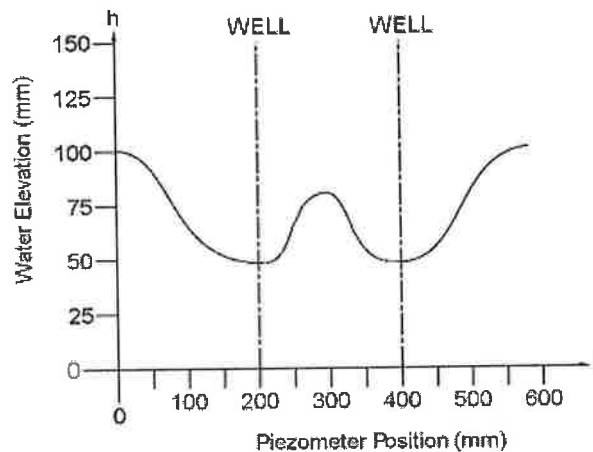
Manometer Tube	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Height (h) mm																				

Draw a graph of water height (h) against piezometer (tapping) distance (L) from well for each of the three sets of data.

Using the highest water level as a datum, calculate the reduction in water level for each piezometric position for each of the single wells. By adding these (negative) values and subtracting the sums from the datum, calculate the superimposed readings and plot a graph of the results.

Compare the graph obtained through superposition to the graph obtained from two wells.

The graph obtained should be similar to the following:



### Conclusion

How similar were the results obtained from two wells and the results obtained through superposition of two single wells?

## 6.5 Exercise D – De-watering an excavation site using wells

### Objective

To demonstrate the de-watering of an excavation site by locally lowering the water table using wells.

### Equipment Required

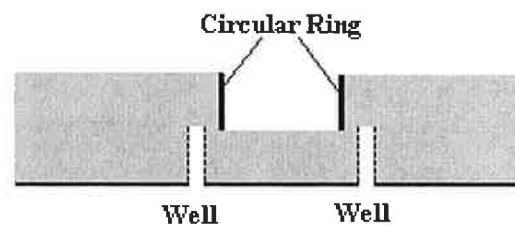
S11 groundwater Flow/Well Abstraction Unit

Rectangular Open Ring (supplied)

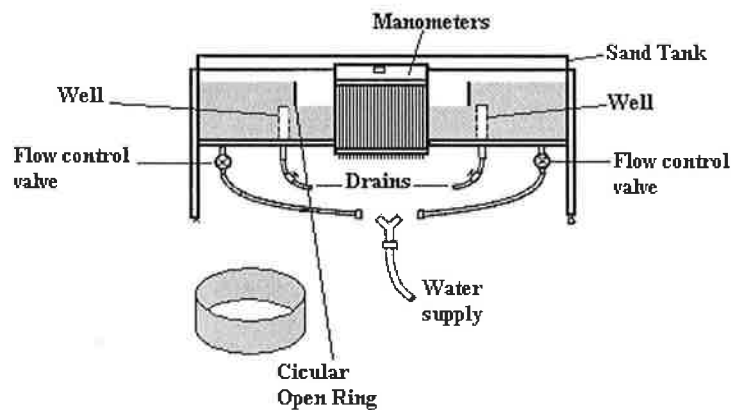
0.1 m<sup>3</sup> of washed well graded coarse sand, range 0.6 – 2.0 mm

### Theory

A deep excavation, for the purposes of foundation construction or other below ground activity, will frequently penetrate below the natural rest level for the water table in that area. If the excavation is in permeable ground, this will constitute an aquifer and the excavation will fill with water to the local water table level due to ground water flow. One method of keeping such an excavation dry is to sink a ring of wells around the outside of the excavation site and to lower the water table locally by pumping the well system. This can be created by sinking the open cylindrical ring into the sand between the wells then removing the sand inside the cylinder, as shown in the diagram below.



### Equipment Set Up



Place the sand in the sand tank and smooth the surface, to give an even depth of 150 mm.

Press the open cylindrical ring vertically down through the sand along the centreline of the tank equidistant between the two wells. Sink the ring until its top edge is level with the surface of the sand.

Remove the sand inside the ring to the lower edge of the ring wall.

Connect both inlet pipes to the Y-connector and the Y-connector a suitable water supply.

Direct the well abstraction pipes to drain. Close the outlet valve on both pipes.

Check that the manometer is primed.

### Procedure

Turn on the water supply.

Open both flow control valves and saturate the sand tank. The excavation site will fill with water.

Open the two well abstraction pipe valves and lower the water level until the excavation dries out.

Record the manometer levels.

If time permits, investigate the effect of using only one well.

### Results

Manometer Tube	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Height (h) mm																			

Draw a graph of water height (h) against piezometer (tapping) distance (L) from well.

Plot a profile along the centreline of the tank showing the position of the water table in relation to the wells and the cross-section of the sand (including the excavation).

### Conclusion

Describe the results obtained.

Comment on the effects of using two wells. If additional data was taken using only one well, compare the difference in the water table levels obtained.

## 6.6 Exercise E – Single well in a confined aquifer with radial symmetry

### Objective

To determine the effect of a single well in a confined aquifer with radial symmetry.

### Equipment Required

S11 groundwater Flow/Well Abstraction Unit

Closed Ring (supplied)

0.1 m<sup>3</sup> of washed well graded coarse sand, range 0.6 – 2.0 mm

Stopwatch (not supplied)

Bucket or container for volumetric measurement (not supplied)

### Theory

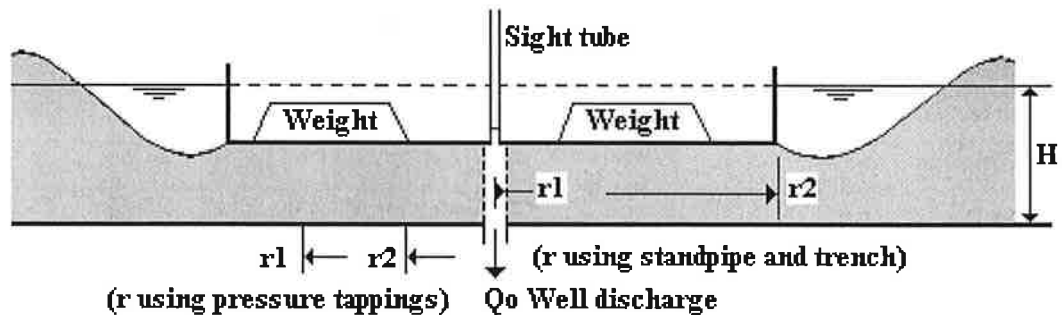
In a confined aquifer, a permeable layer is confined above and below by layers that are impermeable to water. This is simulated in the S11 by using the closed ring to form the upper impermeable stratum, confining the aquifer (sand) between itself and the sand tank bed and so producing the required radial flow distribution.

$$s_1 - s_2 = \frac{Q_0}{2\pi kH} \log_n \frac{r_2}{r_1} \dots (1)$$

where  $s_n$  is the lower of the piezometric surface at point  $r_n$ ,

$H$  is the depth of the aquifer

If values  $r_1$  and  $r_2$ , and  $s_1$  and  $s_2$  are obtained from either the manometer pressure tapplings or the water levels in the peripheral trench and the stand pipe, the value of the coefficient of permeability ( $k$ ) can be found.



### Equipment Set Up

Place the sand in the sand tank and smooth the surface to give an approximate depth of 150mm.

Scoop a shallow depression in the sand above the left hand well tube (adjacent to piezometer tapping 3) until the top of the well tube is exposed.

Around this, prepare a flat sand surface level with the top of the well tube, large enough so that the closed ring accessory can be placed on it.

Place the closed ring onto the prepared surface with the transparent central stand pipe positioned over the well tube.

Scoop a smooth, shallow trench around the outside of the closed ring and smooth the surrounding sand until it is flat and level.

Position weights inside the closed ring, sufficient to prevent it from floating during the experiment. Approximately 10kg will be required. Anything of the correct weight will be suitable providing it will not damage the ring, block the view of the central standpipe, or be susceptible to water.

Connect both inlet pipes to the Y-connector, and the Y-connector a suitable water supply.

Direct the well abstraction pipes to drain and close the outlet valve on both wells.

Check that the manometer is primed.

### Procedure

Switch on the water supply and open the inlet valves. Flood the sand until the water level surrounding the closed ring is just below its rim (if this is not possible, as near as possible).

Open the well abstraction pipe valve for the appropriate well.

Observe the water levels in the manometer bank, adjusting the inlet and well valve settings to give steady water levels with a good variation in water level through the cross-section of the tank.

Record the manometer readings.

Perform a timed volume collection of the outflow through the well pipe to determining the flow rate.

### Results

Volume Collected \_\_\_\_\_ m<sup>3</sup>

Time to Collect \_\_\_\_\_ s

Flow Rate Q \_\_\_\_\_ m/s

Manometer Tube	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Height (h) mm																			

From the manometer readings, plot graphs showing the level of the piezometric surface in sections, one along the axis of the tank and one at right angles to it. From these graphs, prepare a plan showing the piezometric surface contour lines.

### Conclusion

Describe the results obtained. Did the well demonstrate radial symmetry? If not then suggest reasons why it did not.

Comment on the differences between the results obtained for the confined and unconfined aquifers.

## 6.7 Exercise F – Draining a polder or lake using wells

### Objective

To simulate the draining of a man-made polder or natural lake and to investigate the factors involved.

### Equipment Required

S11 groundwater Flow/Well Abstraction Unit

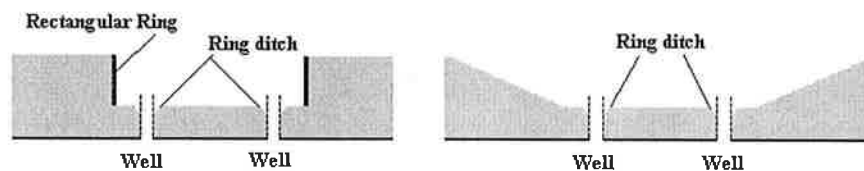
Rectangular Ring (supplied with S11)

0.2 m<sup>3</sup> of washed well graded coarse sand, range 0.6 – 2.0 mm

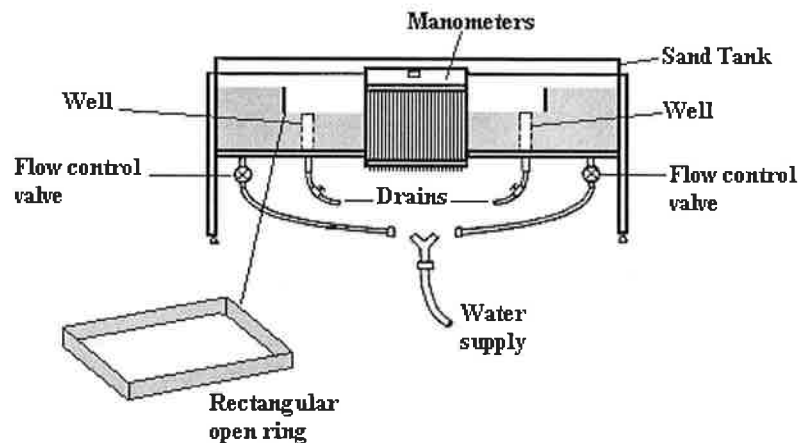
### Theory

In this exercise, ground water flows into the polder / lake, is collected in a ring ditch near the wall and is pumped out from one or more points. This situation differs from the excavation dewatering problem in that the drainage takes place from the floor of the polder. This means that ground water flows into the polder, is collected in a ring ditch near the wall and pumped out from one or more points.

In this exercise the bank of the polder / lake is represented by a large rectangular ring which encloses the two wells. The sand is removed from inside as before and a circumferential ditch (ring ditch) formed in the bottom to link both the wells. It is possible to carry out this experiment without using the ring, by forming a natural bank with the sand at stable slope as shown in the right hand diagram below.



### Equipment Set Up



Place the sand in the sand tank and smooth the surface, to give an even depth of 150 mm.

Press the open rectangular ring vertically down through the sand along the centreline of the tank to surround the two wells. Sink the ring until its top edge is level with the surface of the sand.

Remove the sand inside the ring to the lower edge of the ring wall.

Create a shallow ditch around the circumference of the ring connected to the two wells.

Connect both inlet pipes to the Y-connector and the Y-connector a suitable water supply.

Direct the well abstraction pipes to drain. Close the outlet valve on both pipes.

Check that the manometer is primed.

**Procedure**

Turn on the water supply.

Open both flow control valves and saturate the sand tank. The lake / polder will fill with water.

Open the two well abstraction pipe valves and lower the water level until the lake / polder dries out.

Record the manometer levels.

If time permits, investigate the effect of using only one well.

**Results**

<b>Manometer Tube</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<b>Height (h) mm</b>																			

Draw a graph of water height (h) against piezometer (tapping) distance (L) from well.

Plot a profile along the centreline of the tank showing the position of the water table in relation to the wells and the cross-section of the sand (including the lake / polder).

**Conclusion**

Comment on the profile of the water table.

Compare this profile with the profile obtained in exercise D (Draining of an excavation site).

## 7 Installation Guide

**Before operating the equipment, it must be unpacked, assembled and installed as described in this Installation Guide. Safe use of the equipment depends on following the correct installation procedure.**

The equipment is delivered completely assembled with the exception of the flexible tubes that are used to connect the equipment to a suitable water supply and drain.

A suitable mains water supply or equivalent should be connected to the Y-adapter. The Y-adapter connects the two water inlet pipes to the apparatus.

The two well abstraction pipes situated at the base of the sand tank should be led to a suitable drain.

When using one inlet port as a water supply, the other port should be led to drain.

A bucket or similar container for water will be required to prime the manometer board.

Close the well taps and open the flow control valves. Switch on the water supply.

Allow the water level in the tank to rise to 100mm.

Remove the manometer board and immerse it in the empty bucket or container at a lower level than the water in the sand tank. When all the tubes are running full of water, replace the manometer board. If the manometer is properly primed then the level in each tube should be the same. If they are not, repeat the process.

The water level in the tank may be lowered, ready for filling with sand, once the manometer is primed. A small amount of water retained in the sand tank will ensure that the manometer tappings remain fully primed.

**The basic operation of the S11 Ground Water Flow and Well Abstraction Unit has been confirmed.  
Refer to the Operational Procedures section in the product manual for further information.**

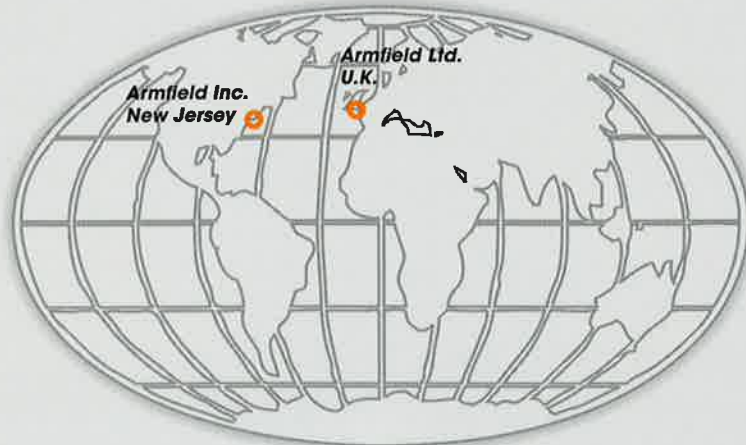
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