In Situ Measurement of Field Saturated Hydraulic Conductivity *Using the ETC Pask Constant Head Well Permeameter*

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Need for accurate infiltration testing

- Tests helpful when soil characteristics unclear.
- Identify influences on permeability due to soil density, grain size sorting/packing or sand sizes.
- Practitioners of varying skill levels can do them.
- Can be part of a conservative, dual sizing approach.
- K values required for large scale drainfield design (eg. groundwater mounding, lateral flow analysis.

Field-Saturated Hydraulic Conductivity as an alternative to Perc Time

- "Field-saturated" hydraulic conductivity, Kfs, measures the permeability of "field-saturated" soil.
- When water is infiltrated into unsaturated soil, some air is entrapped or encapsulated in the pore spaces.
- Field saturated soil is approx. 95% to 98% saturated
  $K_{sat} \approx 2 \times K_{fs}$
- Kfs is largely independent of test conditions.

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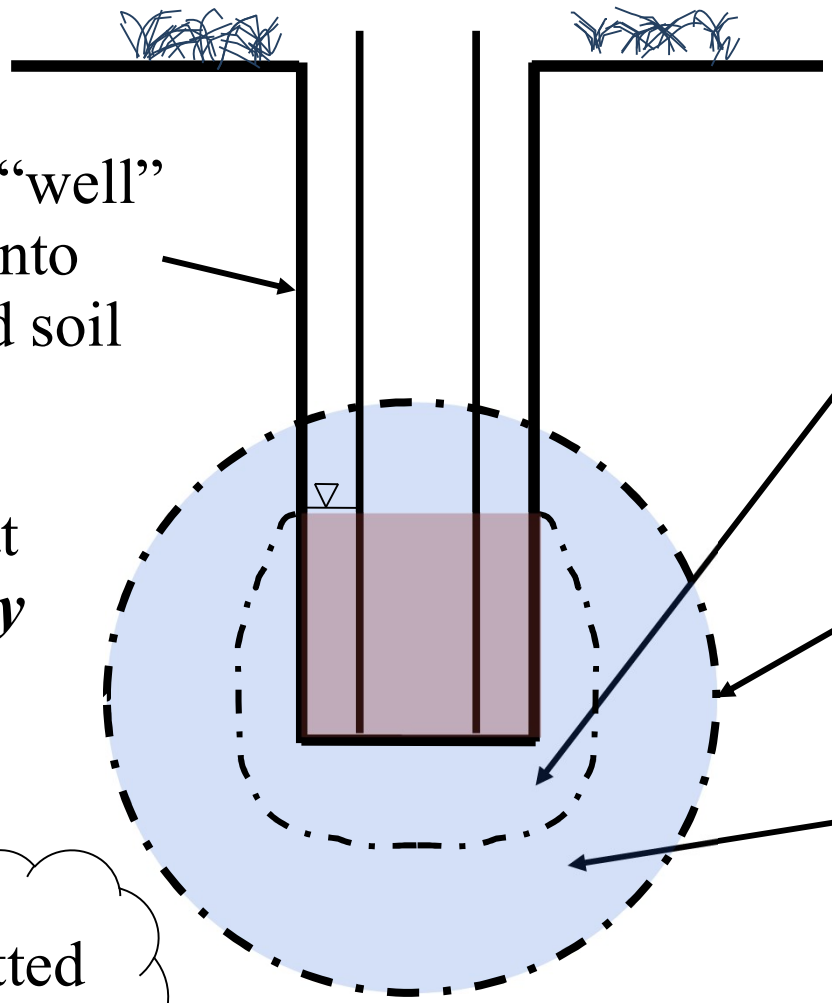
Constant Head Well Permeameter (CHWP) Method For Determining Kfs

- When a constant "head" of water is ponded in a borehole or "well" augered into unsaturated soil, a ***bulb of field saturated soil*** is gradually established around the base of the well.
- As the bulb becomes established, the flow of water out of the well and into the soil approaches a constant rate *(**steady state flow***).

Constant Head Well Permeameter

- Need suitable apparatus for ponding a constant head of water in the well.
- Must also allow measurement of flow into well hole.
- Several different permeameters available each with different features, limitations, cost.

CHW Permeameter - Basics



Borehole or "well" augered into unsaturated soil

soil must initially be at ***field capacity or drier!***

Steady-state ***field saturated bulb*** (does not increase in size)

Wetting front at ***steady state flow***

Wetted but ***unsaturated*** zone (increases in size beyond steady state)

Unwetted zone

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Basics: Soil at Field Capacity or Drier!

Saturated soil has no ***capillarity***.

Field Capacity – Working definition & guidelines:

- Water content in soil once drainage stops after a soaking rain.
- Soil does not compress under foot
- Tends to crumble, rather than remold or smear, when worked in the hand.

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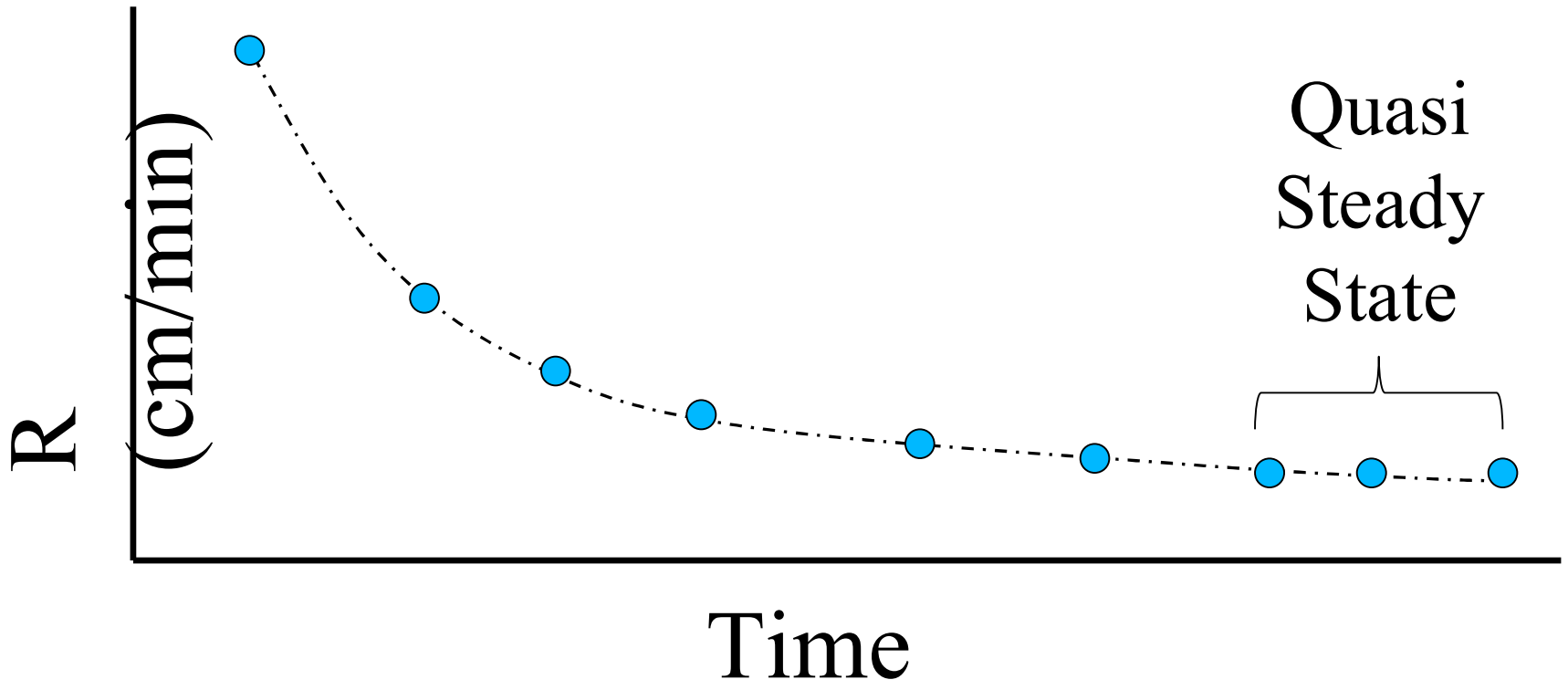
Basics: Steady State (SS) Flow

- No need to "pre-soak" the soil.
- Test is done once a minimum of 3 rates of fall (R) in reservoir water level are the same.
- Time to reach SS: as little as **30 minutes for permeable soils** to **several hours for slowly permeable soils** (Reynolds and Galloway).

Basics: Steady State (SS) Flow

Confirmed once minimum of 3 rates of fall (R) in reservoir water level are the same.



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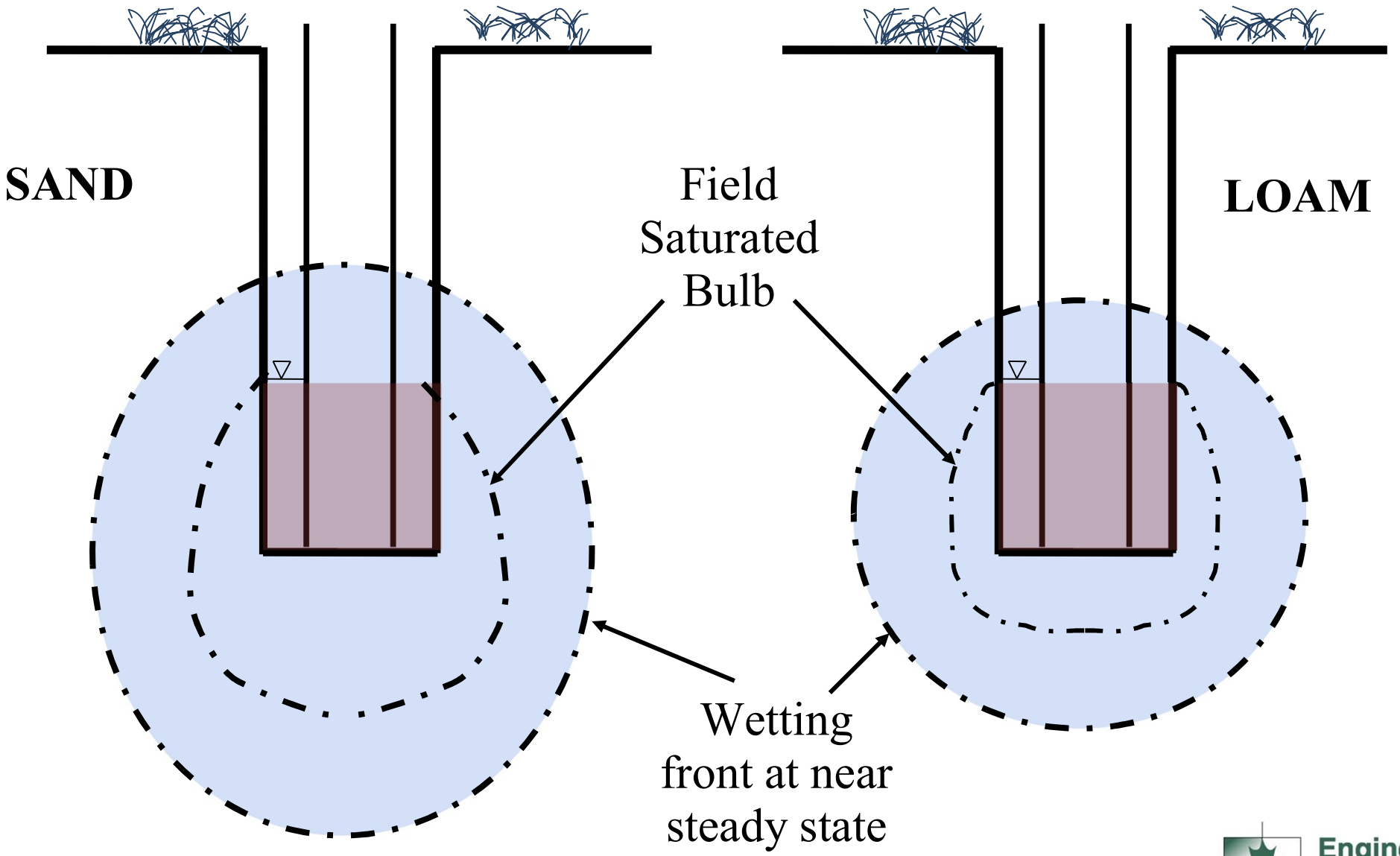
Sample Volume at Steady State



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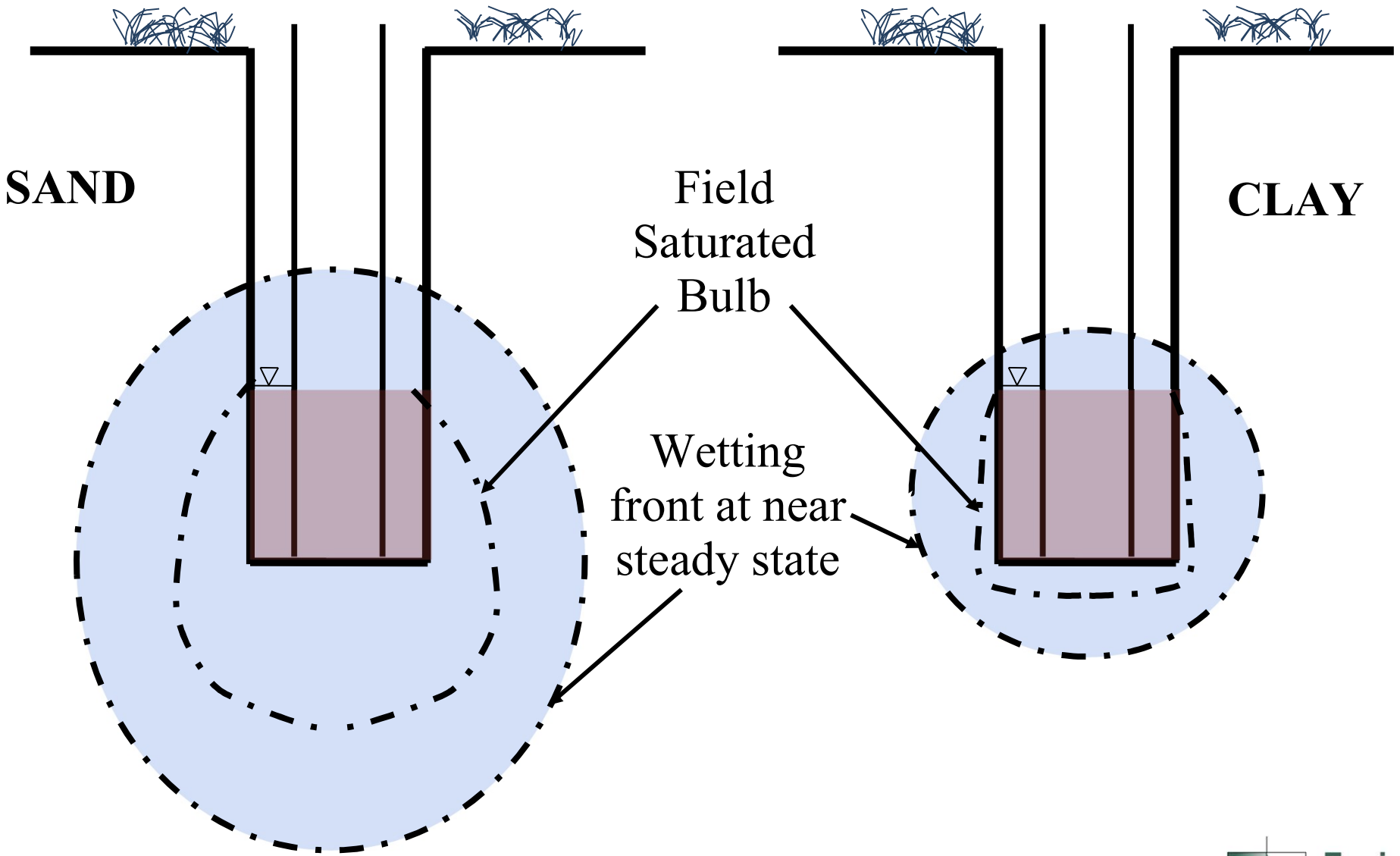
Sample Volume at Steady State



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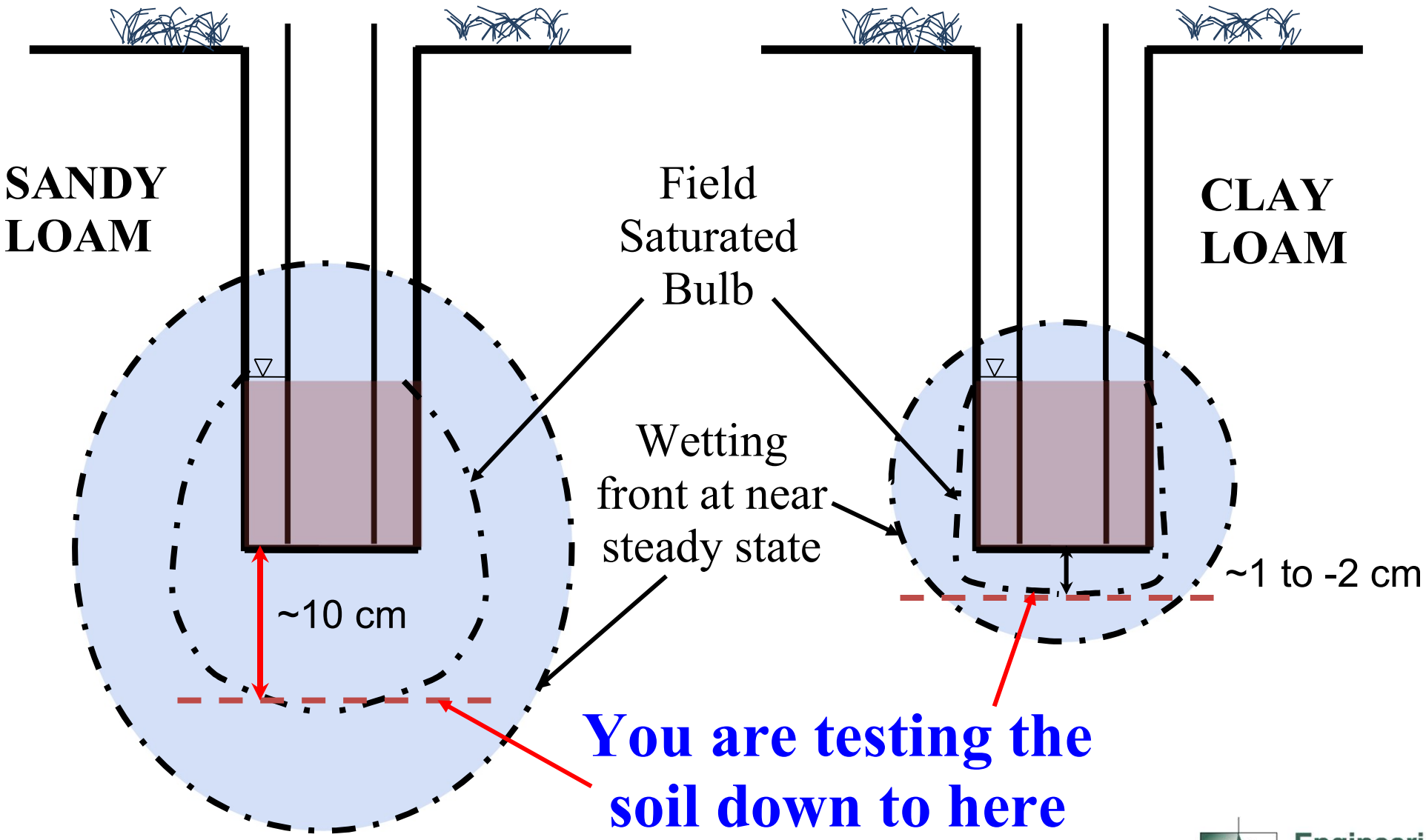
CHW Permeameter – Test Depth

- For moderately permeable soils, the ***bulb of field saturated soil*** typically extends some distance below the bottom of the well hole.
- For PEI Site Assessments, if the soil within 10cm of the bottom of the well hole is moderately permeable and appears to be of a similar texture/structure as the soil at the bottom of the well hole, you can assume that your test is valid to at least 10cm below the bottom of the well hole.

Sample Volume at Steady State



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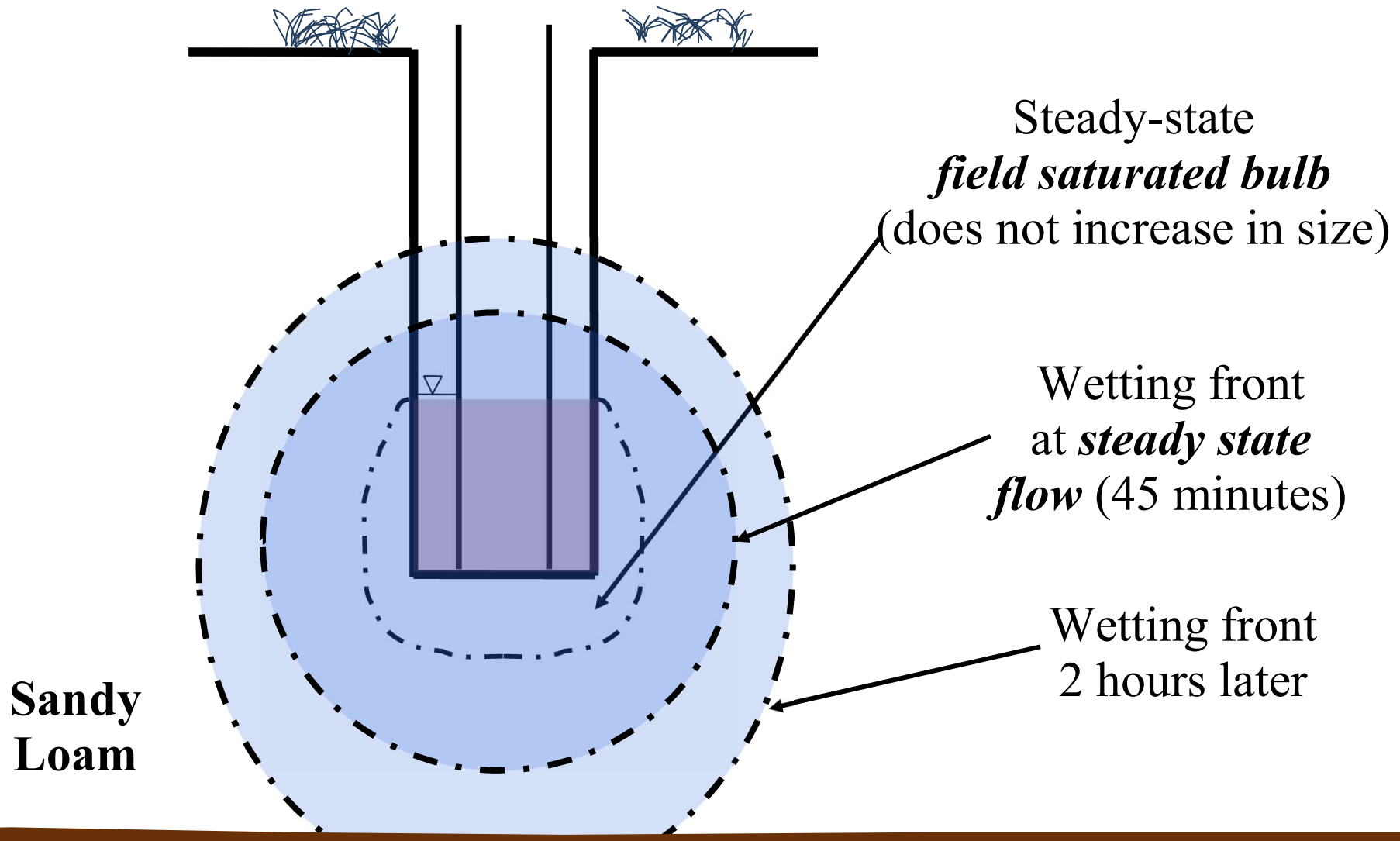
CHWP and Soil Heterogeneity

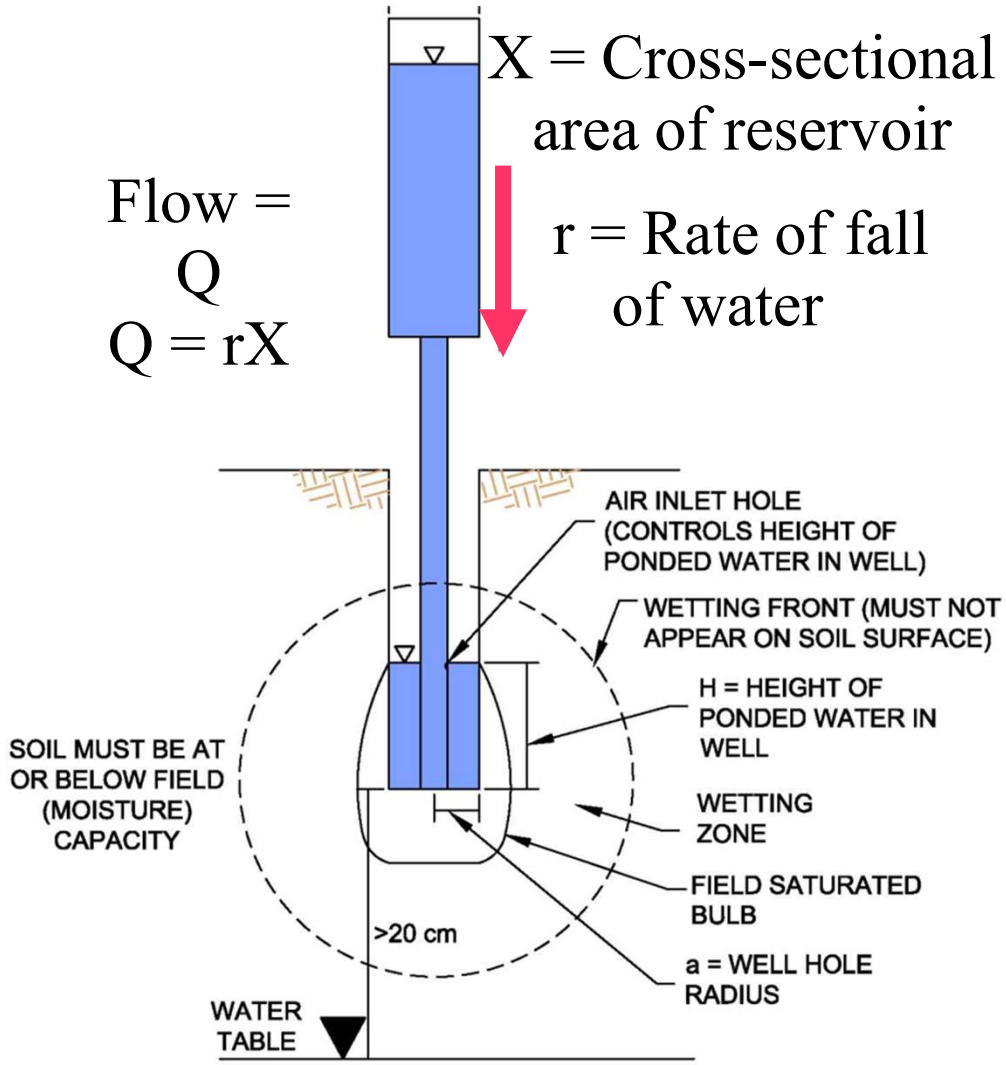


Single-Head CHWP Technique

For soil at ***field capacity or drier.***

Kfs determined from:

- Radius of the well
- Height of ponded water
- Steady state flow rate
- **α*** soil *capillary category*



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Single-Head CHWP Technique

α* soil texture-structure parameter

Texture-Structure Classification	Soil Capillary Category	α* (cm -1)
Coarse sands and highly structured soils	Weak	0.36
Most structured soils and medium sands	Moderate	0.12
Unstructured fine textured soils, fine sands	Strong	0.04
Compacted clays	Very Strong	≤0.01

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The permeability test should be conducted near to a test pit.
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CHWP Formula for calculating Kfs

$$K_{fs} = \frac{CQ_S}{\left[2\pi H^2 + C\pi a^2 + \left(2\pi H / \alpha *\right)\right]}$$

Where:

Qs = Steady state rate of flow into hole

H is the height of water in well

a is the well radius

α* is a visually estimated *soil texture-structure parameter (capillary category)*

C is a shape factor

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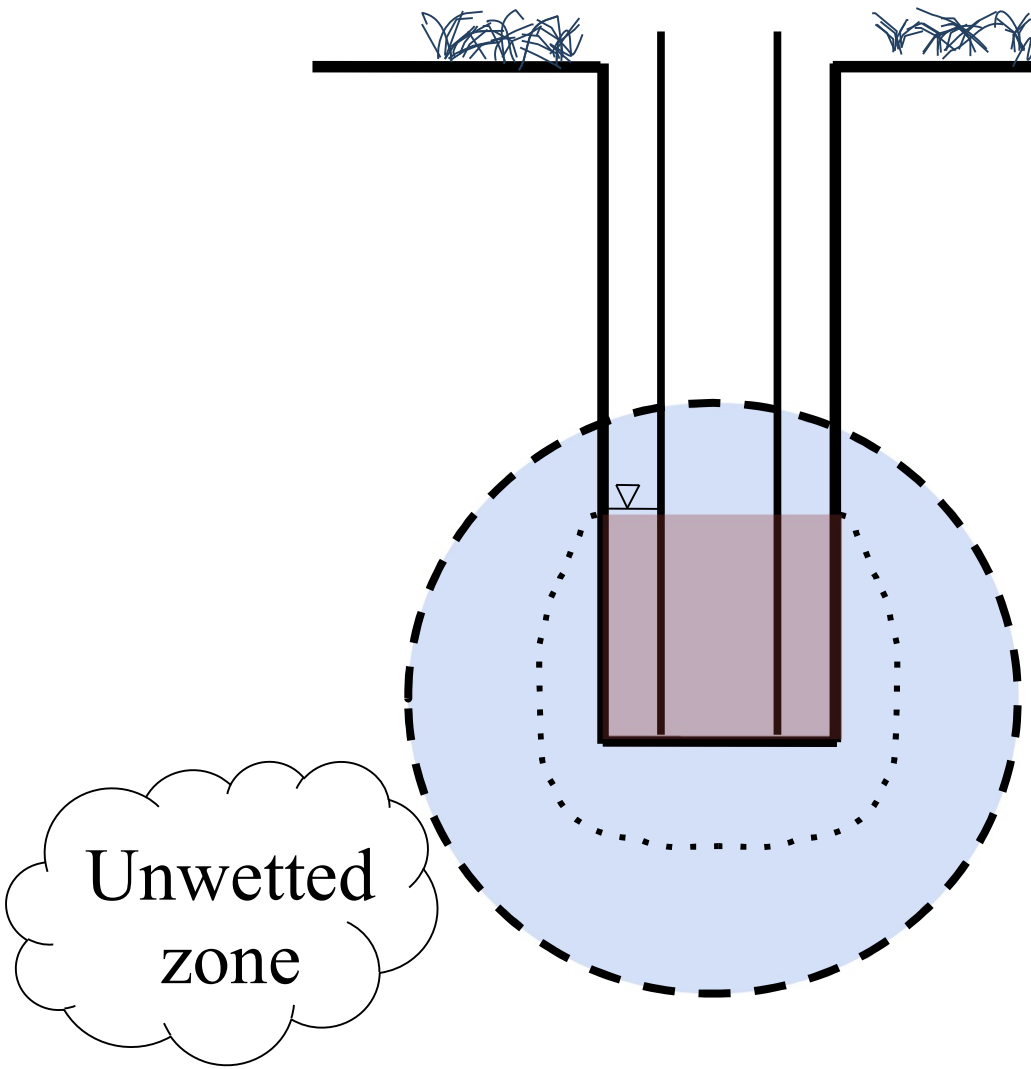
CHWP Formula for calculating Kfs

$$K_{fs} = \frac{CQ_S}{\left[2\pi H^2 + C\pi a^2 + \left(2\pi H / \alpha^*\right)\right]}$$

Model accounts for 3 components of flow:

- ✓ **Hydraulic push** (head of water)
- ✓ **Gravitational pull** through base of well
- ✓ **Capillary suction** from surrounding soil

CHWP Technique
Three Components of Flow



1. Hydraulic push
(head of water)

2. Gravitational pull
through base of well

3. Capillary suction
from surrounding soil

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Toll Free 1-888-747-7645 (SOIL)

ETC STANDARD PASK CONSTANT HEAD WELL PERMEAMETER SINGLE PONDED HEIGHT METHOD

Most structured soils from clays through loams; Also includes unstructured medium and fine sands. The first choice for most soils.

d – well hole diameter (cm)	8.3	α* - sat/unsat flow ratio (cm-1)	0.12
H – height of water in well (cm)	15.0	C – shape factor	1.36

R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs
0.01	5.3E-06	Too Slow	2.7	1.4E-03	Acceptable	21.0	1.1E-02	Too Fast
0.02	1.1E-05	Too Slow	2.8	1.5E-03	Acceptable	22.0	1.2E-02	Too Fast
0.03	1.6E-05	Too Slow	2.9	1.5E-03	Acceptable	23.0	1.2E-02	Too Fast
0.04	2.1E-05	Too Slow	3.0	1.6E-03	Acceptable	24.0	1.3E-02	Too Fast
0.05	2.7E-05	Too Slow	3.1	1.6E-03	Acceptable	25.0	1.3E-02	Too Fast
0.06	3.2E-05	Too Slow	3.2	1.7E-03	Acceptable	26.0	1.4E-02	Too Fast
0.07	3.7E-05	Too Slow	3.3	1.8E-03	Acceptable	27.0	1.4E-02	Too Fast
0.08	4.3E-05	Too Slow	3.4	1.8E-03	Acceptable	28.0	1.5E-02	Too Fast
0.09	4.8E-05	Too Slow	3.5	1.9E-03	Acceptable	29.0	1.5E-02	Too Fast
0.10	5.3E-05	Too Slow	3.6	1.9E-03	Acceptable	30.0	1.6E-02	Too Fast
0.15	8.0E-05	Acceptable	3.7	2.0E-03	Acceptable	31.0	1.6E-02	Too Fast
0.20	1.1E-04	Acceptable	3.8	2.0E-03	Acceptable	32.0	1.7E-02	Too Fast
0.25	1.3E-04	Acceptable	3.9	2.1E-03	Acceptable	33.0	1.8E-02	Too Fast
0.30	1.6E-04	Acceptable	4.0	2.1E-03	Acceptable	34.0	1.8E-02	Too Fast
0.35	1.9E-04	Acceptable	4.1	2.2E-03	Acceptable	35.0	1.9E-02	Too Fast
0.40	2.1E-04	Acceptable	4.2	2.2E-03	Acceptable	36.0	1.9E-02	Too Fast
0.45	2.4E-04	Acceptable	4.3	2.3E-03	Acceptable	37.0	2.0E-02	Too Fast
0.50	2.7E-04	Acceptable	4.4	2.3E-03	Acceptable	38.0	2.0E-02	Too Fast
0.55	2.9E-04	Acceptable	4.5	2.4E-03	Acceptable	39.0	2.1E-02	Too Fast
0.60	3.2E-04	Acceptable	4.6	2.4E-03	Acceptable	40.0	2.1E-02	Too Fast
0.65	3.5E-04	Acceptable	4.7	2.5E-03	Acceptable	41.0	2.2E-02	Too Fast
0.70	3.7E-04	Acceptable	4.8	2.6E-03	Acceptable	42.0	2.2E-02	Too Fast
0.75	4.0E-04	Acceptable	4.9	2.6E-03	Acceptable	43.0	2.3E-02	Too Fast
0.80	4.3E-04	Acceptable	5.0	2.7E-03	Acceptable	44.0	2.3E-02	Too Fast
0.85	4.5E-04	Acceptable	5.5	2.9E-03	Acceptable	45.0	2.4E-02	Too Fast
0.90	4.8E-04	Acceptable	6.0	3.2E-03	Acceptable	46.0	2.4E-02	Too Fast
0.95	5.1E-04	Acceptable	6.5	3.5E-03	Acceptable	47.0	2.5E-02	Too Fast
1.0	5.3E-04	Acceptable	7.0	3.7E-03	Acceptable	48.0	2.6E-02	Too Fast
1.1	5.9E-04	Acceptable	7.5	4.0E-03	Acceptable	49.0	2.6E-02	Too Fast
1.2	6.4E-04	Acceptable	8.0	4.3E-03	Acceptable	50.0	2.7E-02	Too Fast
1.3	6.9E-04	Acceptable	8.5	4.5E-03	Acceptable	52.0	2.8E-02	Too Fast
1.4	7.5E-04	Acceptable	9.0	4.8E-03	Acceptable	54.0	2.9E-02	Too Fast
1.5	8.0E-04	Acceptable	9.5	5.1E-03	Acceptable	56.0	3.0E-02	Too Fast
1.6	8.5E-04	Acceptable	10.0	5.3E-03	Acceptable	58.0	3.1E-02	Too Fast
1.7	9.0E-04	Acceptable	11.0	5.9E-03	Acceptable	60.0	3.2E-02	Too Fast
1.8	9.6E-04	Acceptable	12.0	6.4E-03	Acceptable	62.0	3.3E-02	Too Fast
1.9	1.0E-03	Acceptable	13.0	6.9E-03	Acceptable	64.0	3.4E-02	Too Fast
2.0	1.1E-03	Acceptable	14.0	7.5E-03	Acceptable	66.0	3.5E-02	Too Fast
2.1	1.1E-03	Acceptable	15.0	8.0E-03	Acceptable	68.0	3.6E-02	Too Fast
2.2	1.2E-03	Acceptable	16.0	8.5E-03	Too Fast	70.0	3.7E-02	Too Fast
2.3	1.2E-03	Acceptable	17.0	9.0E-03	Too Fast	72.0	3.8E-02	Too Fast
2.4	1.3E-03	Acceptable	18.0	9.6E-03	Too Fast	74.0	3.9E-02	Too Fast
2.5	1.3E-03	Acceptable	19.0	1.0E-02	Too Fast	76.0	4.0E-02	Too Fast
2.6	1.4E-03	Acceptable	20.0	1.1E-02	Too Fast	78.0	4.2E-02	Too Fast

R – quasi steady-state rate of fall Kfs – field saturated hydraulic conductivity

Caution: These tables were generated based on the dimensions and characteristics of the Standard ETC Pask Permeameter Kit only. They should not be used with other constant head permeameters or when the well hole diameter is significantly different than indicated above. Calculate Kfs from first principles instead.

Quick reference tables have been developed by Dynamic Monitors for their specific permeameter kits.

To get **Kfs,** Just need: rate of fall –**R** and **α***

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Toll Free 1-888-747-7645 (SOIL)

ETC STANDARD PASK CONSTANT HEAD WELL PERMEAMETER SINGLE PONDED HEIGHT METHOD

Coarse and gravelly sands; may also include some highly structured soils with large cracks and/or macropores

d – well hole diameter (cm)	8.3	α* - sat/unsat flow ratio (cm-1)	0.36
H – height of water in well (cm)	15.0	C – shape factor	1.36

R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs
0.01	6.9E-06	Too Slow	2.7	1.9E-03	Acceptable	21.0	1.5E-02	Too Fast
0.02	1.4E-05	Too Slow	2.8	1.9E-03	Acceptable	22.0	1.5E-02	Too Fast
0.03	2.1E-05	Too Slow	2.9	2.0E-03	Acceptable	23.0	1.6E-02	Too Fast
0.04	2.8E-05	Too Slow	3.0	2.1E-03	Acceptable	24.0	1.7E-02	Too Fast
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0.15	1.0E-04	Acceptable	3.7	2.6E-03	Acceptable	31.0	2.1E-02	Too Fast
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0.25	1.7E-04	Acceptable	3.9	2.7E-03	Acceptable	33.0	2.3E-02	Too Fast
0.30	2.1E-04	Acceptable	4.0	2.8E-03	Acceptable	34.0	2.4E-02	Too Fast
0.35	2.4E-04	Acceptable	4.1	2.8E-03	Acceptable	35.0	2.4E-02	Too Fast
0.40	2.8E-04	Acceptable	4.2	2.9E-03	Acceptable	36.0	2.5E-02	Too Fast
0.45	3.1E-04	Acceptable	4.3	3.0E-03	Acceptable	37.0	2.6E-02	Too Fast
0.50	3.5E-04	Acceptable	4.4	3.0E-03	Acceptable	38.0	2.6E-02	Too Fast
0.55	3.8E-04	Acceptable	4.5	3.1E-03	Acceptable	39.0	2.7E-02	Too Fast
0.60	4.1E-04	Acceptable	4.6	3.2E-03	Acceptable	40.0	2.8E-02	Too Fast
0.65	4.5E-04	Acceptable	4.7	3.2E-03	Acceptable	41.0	2.8E-02	Too Fast
0.70	4.8E-04	Acceptable	4.8	3.3E-03	Acceptable	42.0	2.9E-02	Too Fast
0.75	5.2E-04	Acceptable	4.9	3.4E-03	Acceptable	43.0	3.0E-02	Too Fast

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Toll Free 1-888-747-7645 (SOIL)

ETC STANDARD PASK CONSTANT HEAD WELL PERMEAMETER SINGLE PONDED HEIGHT METHOD

Most structured soils from clays through loams;
Also includes unstructured medium and fine sands.
The first choice for most soils.

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0.01	5.3E-06	Too Slow	2.7	1.4E-03	Acceptable	21.0	1.1E-02	Too Fast
0.02	1.1E-05	Too Slow	2.8	1.5E-03	Acceptable	22.0	1.2E-02	Too Fast
0.03	1.6E-05	Too Slow	2.9	1.5E-03	Acceptable	23.0	1.2E-02	Too Fast
0.04	2.1E-05	Too Slow	3.0	1.6E-03	Acceptable	24.0	1.3E-02	Too Fast
0.05	2.7E-05	Too Slow	3.1	1.6E-03	Acceptable	25.0	1.3E-02	Too Fast
0.06	3.2E-05	Too Slow	3.2	1.7E-03	Acceptable	26.0	1.4E-02	Too Fast
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0.08	4.3E-05	Too Slow	3.4	1.8E-03	Acceptable	28.0	1.5E-02	Too Fast
0.09	4.8E-05	Too Slow	3.5	1.9E-03	Acceptable	29.0	1.5E-02	Too Fast
0.10	5.3E-05	Too Slow	3.6	1.9E-03	Acceptable	30.0	1.6E-02	Too Fast
0.15	8.0E-05	Acceptable	3.7	2.0E-03	Acceptable	31.0	1.6E-02	Too Fast
0.20	1.1E-04	Acceptable	3.8	2.0E-03	Acceptable	32.0	1.7E-02	Too Fast
0.25	1.3E-04	Acceptable	3.9	2.1E-03	Acceptable	33.0	1.8E-02	Too Fast
0.30	1.6E-04	Acceptable	4.0	2.1E-03	Acceptable	34.0	1.8E-02	Too Fast
0.35	1.9E-04	Acceptable	4.1	2.2E-03	Acceptable	35.0	1.9E-02	Too Fast
0.40	2.1E-04	Acceptable	4.2	2.2E-03	Acceptable	36.0	1.9E-02	Too Fast
0.45	2.4E-04	Acceptable	4.3	2.3E-03	Acceptable	37.0	2.0E-02	Too Fast
0.50	2.7E-04	Acceptable	4.4	2.3E-03	Acceptable	38.0	2.0E-02	Too Fast
0.55	2.9E-04	Acceptable	4.5	2.4E-03	Acceptable	39.0	2.1E-02	Too Fast
0.60	3.2E-04	Acceptable	4.6	2.4E-03	Acceptable	40.0	2.1E-02	Too Fast
0.65	3.5E-04	Acceptable	4.7	2.5E-03	Acceptable	41.0	2.2E-02	Too Fast
0.70	3.7E-04	Acceptable	4.8	2.6E-03	Acceptable	42.0	2.2E-02	Too Fast
0.75	4.0E-04	Acceptable	4.9	2.6E-03	Acceptable	43.0	2.3E-02	Too Fast

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Toll Free 1-888-747-7645 (SOIL)

ETC STANDARD PASK CONSTANT HEAD WELL PERMEAMETER SINGLE PONDED HEIGHT METHOD

Porous materials that are both fine textured and massive; including unstructured clayey and silty soils, as well as fine structureless sandy materials.

d – well hole diameter (cm)	8.3	α* - sat/unsat flow ratio (cm-1)	0.04
H – height of water in well (cm)	15.0	C – shape factor	1.35

R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs
0.001	3.1E-07	Too Slow	0.95	3.0E-04	Acceptable	5.30	1.7E-03	Acceptable
0.002	6.3E-07	Too Slow	1.00	3.1E-04	Acceptable	5.40	1.7E-03	Acceptable
0.003	9.4E-07	Too Slow	1.10	3.5E-04	Acceptable	5.50	1.7E-03	Acceptable
0.004	1.3E-06	Too Slow	1.20	3.8E-04	Acceptable	5.60	1.8E-03	Acceptable
0.005	1.6E-06	Too Slow	1.30	4.1E-04	Acceptable	5.70	1.8E-03	Acceptable
0.006	1.9E-06	Too Slow	1.40	4.4E-04	Acceptable	5.80	1.8E-03	Acceptable
0.007	2.2E-06	Too Slow	1.50	4.7E-04	Acceptable	5.90	1.9E-03	Acceptable
0.008	2.5E-06	Too Slow	1.60	5.0E-04	Acceptable	6.00	1.9E-03	Acceptable
0.009	2.8E-06	Too Slow	1.70	5.3E-04	Acceptable	6.10	1.9E-03	Acceptable
0.010	3.1E-06	Too Slow	1.80	5.6E-04	Acceptable	6.20	1.9E-03	Acceptable
0.015	4.7E-06	Too Slow	1.90	6.0E-04	Acceptable	6.30	2.0E-03	Acceptable
0.020	6.3E-06	Too Slow	2.00	6.3E-04	Acceptable	6.40	2.0E-03	Acceptable
0.025	7.8E-06	Too Slow	2.10	6.6E-04	Acceptable	6.50	2.0E-03	Acceptable
0.030	9.4E-06	Too Slow	2.20	6.9E-04	Acceptable	6.60	2.1E-03	Acceptable
0.035	1.1E-05	Too Slow	2.30	7.2E-04	Acceptable	6.70	2.1E-03	Acceptable
0.040	1.3E-05	Too Slow	2.40	7.5E-04	Acceptable	6.80	2.1E-03	Acceptable
0.045	1.4E-05	Too Slow	2.50	7.8E-04	Acceptable	6.90	2.2E-03	Acceptable
0.050	1.6E-05	Too Slow	2.60	8.2E-04	Acceptable	7.00	2.2E-03	Acceptable
0.055	1.7E-05	Too Slow	2.70	8.5E-04	Acceptable	7.50	2.4E-03	Acceptable
0.060	1.9E-05	Too Slow	2.80	8.8E-04	Acceptable	8.00	2.5E-03	Acceptable
0.065	2.0E-05	Too Slow	2.90	9.1E-04	Acceptable	8.50	2.7E-03	Acceptable
0.070	2.2E-05	Too Slow	3.00	9.4E-04	Acceptable	9.00	2.8E-03	Acceptable
0.075	2.4E-05	Too Slow	3.10	9.7E-04	Acceptable	9.50	3.0E-03	Acceptable

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Toll Free 1-888-747-7645 (SOIL)

ETC STANDARD PASK CONSTANT HEAD WELL PERMEAMETER SINGLE PONDED HEIGHT METHOD

Most structured soils from clays through loams; Also includes unstructured medium and fine sands. The first choice for most soils.

d – well hole diameter (cm)	8.3	α* - sat/unsat flow ratio (cm-1)	0.12
H – height of water in well (cm)	15.0	C – shape factor	1.36

R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs
0.01	5.3E-06	Too Slow	2.7	1.4E-03	Acceptable	21.0	1.1E-02	Too Fast
0.02	1.1E-05	Too Slow	2.8	1.5E-03	Acceptable	22.0	1.2E-02	Too Fast
0.03	1.6E-05	Too Slow	2.9	1.5E-03	Acceptable	23.0	1.2E-02	Too Fast
0.04	2.1E-05	Too Slow	3.0	1.6E-03	Acceptable	24.0	1.3E-02	Too Fast
0.05	2.7E-05	Too Slow	3.1	1.6E-03	Acceptable	25.0	1.3E-02	Too Fast
0.06	3.2E-05	Too Slow	3.2	1.7E-03	Acceptable	26.0	1.4E-02	Too Fast
0.07	3.7E-05	Too Slow	3.3	1.8E-03	Acceptable	27.0	1.4E-02	Too Fast
0.08	4.3E-05	Too Slow	3.4	1.8E-03	Acceptable	28.0	1.5E-02	Too Fast
0.09	4.8E-05	Too Slow	3.5	1.9E-03	Acceptable	29.0	1.5E-02	Too Fast
0.10	5.3E-05	Too Slow	3.6	1.9E-03	Acceptable	30.0	1.6E-02	Too Fast
0.15	8.0E-05	Acceptable	3.7	2.0E-03	Acceptable	31.0	1.6E-02	Too Fast
0.20	1.1E-04	Acceptable	3.8	2.0E-03	Acceptable	32.0	1.7E-02	Too Fast
0.25	1.3E-04	Acceptable	3.9	2.1E-03	Acceptable	33.0	1.8E-02	Too Fast
0.30	1.6E-04	Acceptable	4.0	2.1E-03	Acceptable	34.0	1.8E-02	Too Fast
0.35	1.9E-04	Acceptable	4.1	2.2E-03	Acceptable	35.0	1.9E-02	Too Fast
0.40	2.1E-04	Acceptable	4.2	2.2E-03	Acceptable	36.0	1.9E-02	Too Fast
0.45	2.4E-04	Acceptable	4.3	2.3E-03	Acceptable	37.0	2.0E-02	Too Fast
0.50	2.7E-04	Acceptable	4.4	2.3E-03	Acceptable	38.0	2.0E-02	Too Fast
0.55	2.9E-04	Acceptable	4.5	2.4E-03	Acceptable	39.0	2.1E-02	Too Fast
0.60	3.2E-04	Acceptable	4.6	2.4E-03	Acceptable	40.0	2.1E-02	Too Fast
0.65	3.5E-04	Acceptable	4.7	2.5E-03	Acceptable	41.0	2.2E-02	Too Fast
0.70	3.7E-04	Acceptable	4.8	2.6E-03	Acceptable	42.0	2.2E-02	Too Fast
0.75	4.0E-04	Acceptable	4.9	2.6E-03	Acceptable	43.0	2.3E-02	Too Fast
0.80	4.3E-04	Acceptable	5.0	2.7E-03	Acceptable	44.0	2.3E-02	Too Fast
0.85	4.5E-04	Acceptable	5.5	2.9E-03	Acceptable	45.0	2.4E-02	Too Fast
0.90	4.8E-04	Acceptable	6.0	3.2E-03	Acceptable	46.0	2.4E-02	Too Fast
0.95	5.1E-04	Acceptable	6.5	3.5E-03	Acceptable	47.0	2.5E-02	Too Fast
1.0	5.3E-04	Acceptable	7.0	3.7E-03	Acceptable	48.0	2.6E-02	Too Fast
1.1	5.9E-04	Acceptable	7.5	4.0E-03	Acceptable	49.0	2.6E-02	Too Fast
1.2	6.4E-04	Acceptable	8.0	4.3E-03	Acceptable	50.0	2.7E-02	Too Fast
1.3	6.9E-04	Acceptable	8.5	4.5E-03	Acceptable	52.0	2.8E-02	Too Fast
1.4	7.5E-04	Acceptable	9.0	4.8E-03	Acceptable	54.0	2.9E-02	Too Fast
1.5	8.0E-04	Acceptable	9.5	5.1E-03	Acceptable	56.0	3.0E-02	Too Fast
1.6	8.5E-04	Acceptable	10.0	5.3E-03	Acceptable	58.0	3.1E-02	Too Fast
1.7	9.0E-04	Acceptable	11.0	5.9E-03	Acceptable	60.0	3.2E-02	Too Fast
1.8	9.6E-04	Acceptable	12.0	6.4E-03	Acceptable	62.0	3.3E-02	Too Fast
1.9	1.0E-03	Acceptable	13.0	6.9E-03	Acceptable	64.0	3.4E-02	Too Fast
2.0	1.1E-03	Acceptable	14.0	7.5E-03	Acceptable	66.0	3.5E-02	Too Fast
2.1	1.1E-03	Acceptable	15.0	8.0E-03	Acceptable	68.0	3.6E-02	Too Fast
2.2	1.2E-03	Acceptable	16.0	8.5E-03	Too Fast	70.0	3.7E-02	Too Fast
2.3	1.2E-03	Acceptable	17.0	9.0E-03	Too Fast	72.0	3.8E-02	Too Fast
2.4	1.3E-03	Acceptable	18.0	9.6E-03	Too Fast	74.0	3.9E-02	Too Fast
2.5	1.3E-03	Acceptable	19.0	1.0E-02	Too Fast	76.0	4.0E-02	Too Fast
2.6	1.4E-03	Acceptable	20.0	1.1E-02	Too Fast	78.0	4.2E-02	Too Fast

R – quasi-steady-state rate of fall Kfs – field saturated hydraulic conductivity

Caution: These tables were generated based on the dimensions and characteristics of the Standard ETC Pask Permeameter Kit only. They should not be used with other constant head permeameters or when the well hole diameter is significantly different than indicated above. Calculate Kfs from first principles instead.

Caution:

Tables are based on the characteristics of the **ETC Pask Permeameter Kit**.

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Calculate Kfs from first principles instead.

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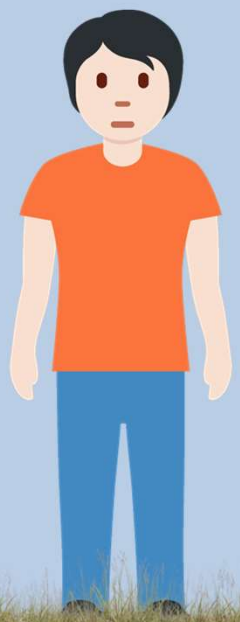
Temperature Correction Factors

- **Temperature affects the ability for water to move through soil** because water viscosity varies with temperature.
- The **borehole soil / water temperature** at the end of the test should be recorded.
- **A temperature correction factor** should be applied to the steady-state flow rate (R), before determining the temperature-corrected, field saturated hydraulic conductivity (Kfs).

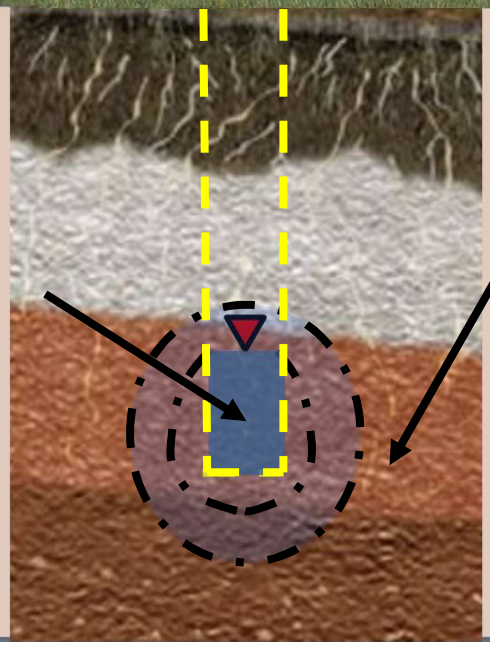


Make sure to use borehole water / soil temperature at the end of the test, not the air temperature!

$T_{air} = 30\ ^{o}C$

<u>TEST</u> TEMP.

$T_{water/soil} = 20\ ^{o}C$



<u>DESIGN</u> TEMP.

$T_{water/soil} = 4\ ^{o}C$

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Temperature Correction as per PEI Construction Standards Handbook

Rate of Fall of Water (cm/min)	Field Saturated Hydraulic Conductivity - Kfs (cm/sec)					Rate of Fall of Water (cm/min)
	Type 1 (Coarse, gravelly, sands) $a^*(cm^{-1})$ = 0.36, C = 1.2			Type 2 (Structured loams & clays) $a^*(cm^{-1})$ = 0.12, C = 1.17		
	Without temp. gradient	With temp gradient	Acceptable Rate of Fall	Without temp. gradient	With temp gradient	
0.010	1.07E-05	6.41E-06	Too Slow	1.48E-05	8.87E-06	0.02
0.020	2.14E-05	1.28E-05		3.70E-05	2.22E-05	0.05
0.050	5.34E-05	3.21E-05		5.54E-05	3.33E-05	0.075
0.075	**8.00E-05**	4.80E-05		7.39E-05	4.43E-05	0.100
0.100	**1.07E-04**	6.41E-05		**8.00E-05**	4.80E-05	0.108
0.125	**1.33E-04**	**8.00E-05**	Acceptable Range	**1.33E-04**	**8.00E-05**	**0.181**
0.200	**2.14E-04**	**1.28E-04**		**1.48E-04**	**8.87E-05**	**0.200**
0.500	**5.34E-04**	**3.21E-04**		**3.70E-04**	**2.22E-04**	**0.500**
1.000	**1.07E-03**	**6.41E-04**		**7.39E-04**	**4.43E-04**	**1.000**
2.000	**2.14E-03**	**1.28E-03**		**1.48E-03**	**8.87E-04**	**2.000**
3.000	**3.21E-03**	**1.92E-03**		**2.22E-03**	**1.33E-03**	**3.000**
4.000	**4.27E-03**	**2.56E-03**		**2.96E-03**	**1.77E-03**	**4.000**
5.000	**5.34E-03**	**3.21E-03**		**3.70E-03**	**2.22E-03**	**5.000**
6.000	**6.41E-03**	**3.85E-03**		**4.43E-03**	**2.66E-03**	**6.000**
7.000	**7.48E-03**	**4.49E-03**		**5.17E-03**	**3.10E-03**	**7.000**
7.490	**8.00E-03**	**4.80E-03**		**5.54E-03**	**3.33E-03**	**7.500**
7.500	8.01E-03	**4.81E-03**		**8.00E-03**	**4.80E-03**	**10.830**
8.000	8.55E-03	**5.13E-03**	Too Fast	1.11E-02	**6.65E-03**	15.000
10.000	1.07E-02	**6.41E-03**		1.33E-02	**8.00E-03**	18.050
12.480	1.33E-02	**8.00E-03**		1.48E-02	8.87E-03	20.000
25.000	2.67E-02	1.60E-02		1.85E-02	1.11E-02	25.000
50.000	5.34E-02	3.21E-02		3.70E-02	2.22E-02	50.000
100.000	1.07E-01	6.41E-02		7.39E-02	4.43E-02	100.000
1000.000	1.07E+00	6.41E-01		7.39E-01	4.43E-01	1000.000

This table is based on the following assumptions:

Internal Reservoir Diameter **D** =	7.6 cm
Well Hole Diameter **d** =	7 cm
Height of Water in Well **H** =	10 cm
Temperature **T** =	20 °C

Temperature Gradient column is based on soil temperature Ts = 4°C and water temperature Tw = 20°C

- Kfs values within the dotted lines are acceptable.
- Assumes the water/soil test temperature is **20C**.
- If using the ETC Pask Permeameter Kit and quick reference tables, more tests may pass after making a temperature correction to account for the actual soil/water test temperature.

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ETC's Temperature Correction Table

- A ***Temperature Correction Factor***, (TCF), is selected from the table based on the borehole water/soil temperature at the end of the test and assumes a septic operating temperature of 4°C.

- Multiply the SS Rate of Fall (R) by the TCF to get the "temp. corrected" Rate of Fall (R_{TC}).

Water/Soil Test Temperature °Celcius	Temperature Correction Factor, TCF
2	1.07
3	1.03
4	1.00
5	0.97
6	0.94
7	0.91
8	0.88
9	0.86
10	0.83
11	0.81
12	0.79
13	0.77
14	0.75
15	0.73
16	0.71
17	0.69
18	0.67
19	0.66
20	0.64
21	0.62
22	0.61
23	0.59
24	0.58
25	0.57

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Temperature Correction Factors- Application Using ETC's Tables

- e.g. You have done a test in **structured loam** soil. **Steady state rate of fall** on the permeameter is **R = 0.20 cm/min,** and the borehole soil / water temperature at the end of the test is **15 ºC**.
- Apply temperature correction to R, then use ETC quick reference table for the **appropriate soil capillary category** to determine Kfs.

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Toll Free 1-888-747-7645 (SOIL)

ETC STANDARD PASK CONSTANT HEAD WELL PERMEAMETER SINGLE PONDED HEIGHT METHOD

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d – well hole diameter (cm)	8.3	α* – sat/unsat flow ratio (cm-1)	0.12
H – height of water in well (cm)	15.0	C – shape factor	1.36

R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs	R(cm/min)	Kfs (cm/sec)	PEI Regs
0.01	5.3E-06	Too Slow	2.7	1.4E-03	Acceptable	21.0	1.1E-02	Too Fast
0.02	1.1E-05	Too Slow	2.8	1.5E-03	Acceptable	22.0	1.2E-02	Too Fast
0.03	1.6E-05	Too Slow	2.9	1.5E-03	Acceptable	23.0	1.2E-02	Too Fast
0.04	2.1E-05	Too Slow	3.0	1.6E-03	Acceptable	24.0	1.3E-02	Too Fast
0.05	2.7E-05	Too Slow	3.1	1.6E-03	Acceptable	25.0	1.3E-02	Too Fast
0.06	3.2E-05	Too Slow						
0.07	3.7E-05	Too Slow						
0.08	4.3E-05	Too Slow						
0.09	4.8E-05	Too Slow						
0.10	5.3E-05	Too Slow						
0.15	8.0E-05	Acceptable						
0.20	1.1E-04	Acceptable						
0.25	1.3E-04	Acceptable						
0.30	1.6E-04	Acceptable						
0.35	1.9E-04	Acceptable						
0.40	2.1E-04	Acceptable						
0.45	2.4E-04	Acceptable						
0.50	2.7E-04	Acceptable						
0.55	2.9E-04	Acceptable						
0.60	3.2E-04	Acceptable						
0.65	3.5E-04	Acceptable	4.7	2.5E-03	Acceptable	41.0	2.2E-02	Too Fast
0.70	3.7E-04	Acceptable	4.8	2.6E-03	Acceptable	42.0	2.2E-02	Too Fast
0.75	4.0E-04	Acceptable	4.9	2.6E-03	Acceptable	43.0	2.3E-02	Too Fast

SS R (uncorrected) = 0.20 cm/min

TCF for 15°C = 0.73

α* = 0.12cm-1

Rtc = 0.20 x 0.73 = 0.15 cm/min

Kfs = **8.0E-05 cm/sec**

Factors Which Can Affect the Accuracy of Tests

- **Not waiting until steady state.** *Wait for at least 3 "rates of fall" to be similar*
- **Smearing, compaction of soil during augering.** *Good augering practice, use stiff brush to remove smear layer.*
- **Well collapse during measurement in unstable soils.** *Use well screen or fine gravel around lower reservoir.*

Factors Which Can Affect the Accuracy of Tests

- **Poor choice of α* category**. Note: Kfs is not overly sensitive to selection of **α***. *Error minimized by using larger "H" and well radius "a".*
- **Sinking of permeameter during test.**

-*Use lightweight permeameter*

-*Support permeameter if soil is soft.*

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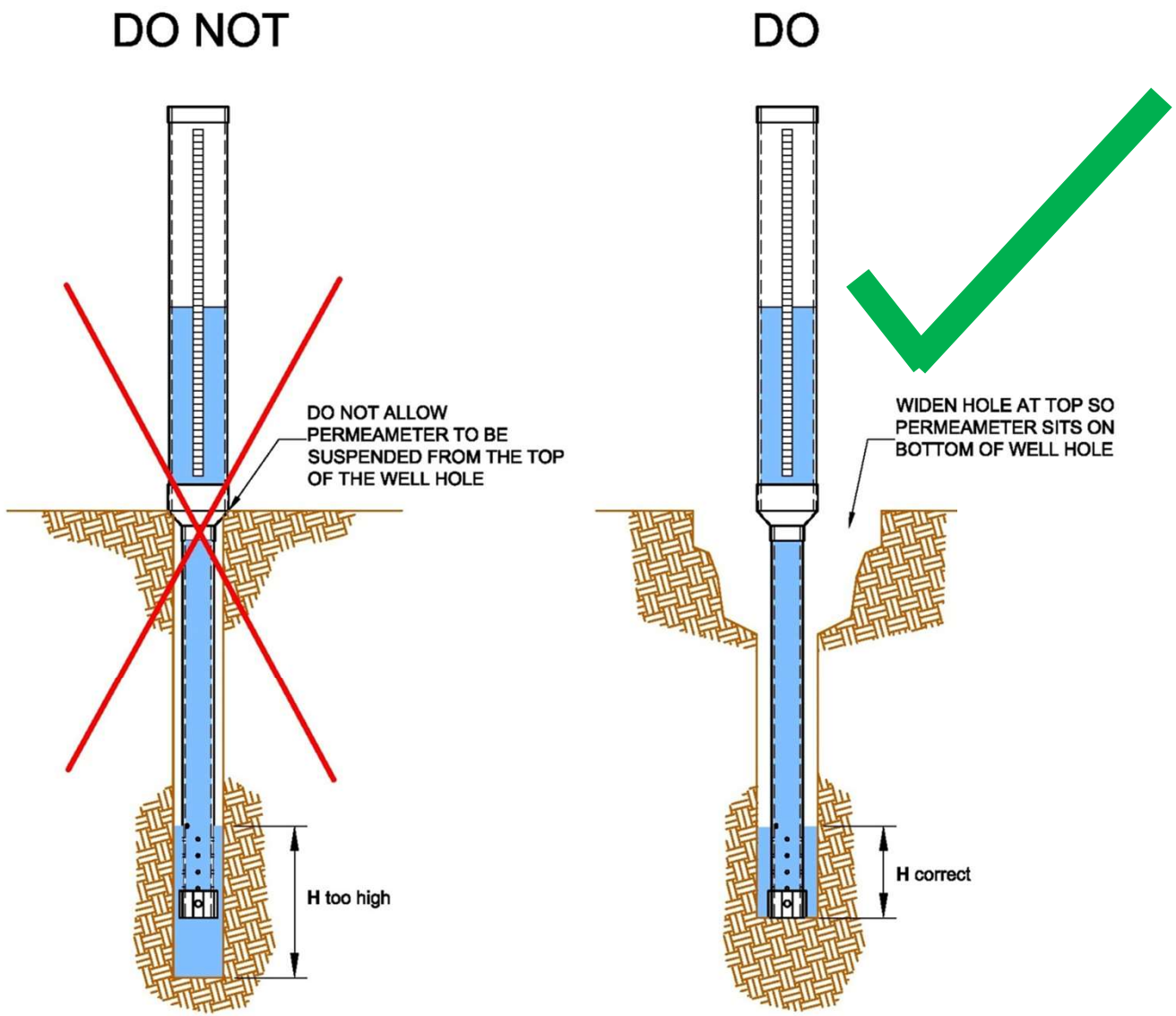
Factors Which Can Affect the Accuracy of Tests

- **Over-augering so the borehole diameter is much larger** than assumed in calculations. -*Know your hole diameter. Note: Kfs is not overly sensitive to small variations in hole diameter.*
- **Significant change in temperature of water during testing. -***Use water close to ambient temperature.*



Ensure permeameter is not hanging from the top of the well hole, otherwise H will be incorrect.

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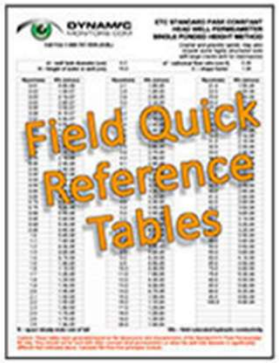

The ETC Pask Permeameter Kit

BEST VALUE
MOST SOILS

Durable, hard-sided carry case

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