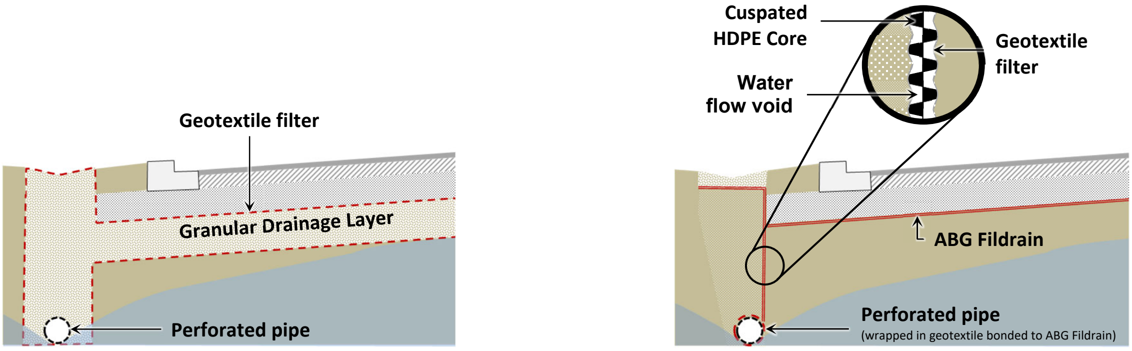
ABG Fildrain vs. Granular Drainage Layers
Drainage performance in Highway Applications

Technical Note

Introduction

In road construction a drainage layer is often provided on flat surfaces and in collection trenches to control water flows. Traditionally, this consists of an approximately 300mm layer of no fines sandy gravel and a geotextile filter to prevent fines migrating into the stone. This note addresses the drainage performance of this traditional method and makes comparison with the performance of **ABG Fildrain**.



Traditional Method **Using ABG Fildrain**

Figure 1: Example of use of Drainage Geocomposites in Road Construction

Background

The practical difficulties and environmental and monetary costs of obtaining and placing granular drainage material are well-known. Recognition of the inadequacies of the traditional methods and the increasing use of geotextiles as filters led to the development of drainage geocomposites. These geocomposites have been an accepted form of drainage in UK Highway works for over 25 years and are now available in a wide variety of forms. ABG drainage geocomposites consist of a cuspated HDPE core bonded to a geotextile filter. They have been developed specifically for use as drainage layers for managing water flow and possess the necessary technical properties – compressive strength, permeability, multi-directional flow, and pore size – for long-term performance. In most cases ABG geocomposites outperform all granular solutions and specialised manufacturers such as ABG, with well-established experience, will provide a manufacturer's statement design life of 120 years.

ABG Fildrain

ABG Fildrain is a geocomposite filter, drainage and separation system designed for road construction applications. It consists of a cuspated polyethylene (HDPE) core with a thermally bonded geotextile to prevent the migration of fine particles into the drainage path. The HDPE core allows for optimum water flow and comes either as single or double cuspated to allow water infiltration from one or both sides. It can be provided with a geotextile 'sock' for direct connection to a perforated pipe. **ABG Fildrain** is CE Marked and has BBA certification. The water flow rates of **ABG Fildrain** are significantly higher than equivalent thicknesses of granular material, as demonstrated below.

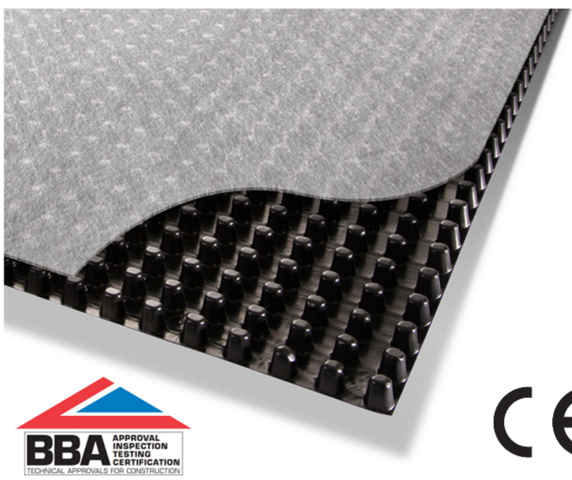


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Figure 2: ABG Fildrain

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Granular Drainage Layer Flow Capacity Assessment

The flow capacity of a granular drainage layer depends on its size (cross sectional area), the hydraulic gradient (slope) that it is installed at, and the permeability of the granular material.

Permeability of Granular Material

The permeability (k) of granular materials is typically measured in a laboratory and is reported as a value in m/s. Typical values of permeability for commonly used drainage gravels are shown in Table 1.

Table 1: Permeability of Typical Drainage Gravel

Name	Description	Permeability, k (m/s)
Type B Filter Stone	Quarried, graded stone in accordance with UK DTp SHW Series 500.	1×10^{-1}
Type A Filter Stone / Class 6C Stone	Quarried, graded stone in accordance with UK DTp SHW Series 500 (Type A Filter Stone), or Series 600 (Class 6C Stone).	5×10^{-2}
Cobbles and boulders	Cobbles and boulders with particle sizes ≥ 65 mm.	10 to 10^{-1}
Coarse, clean gravel	Gravel with particle sizes of 2.0-20mm. Zero fines.	10^{-1} to 10^{-3}
Well graded sandy gravel	Sandy gravel with particle sizes 0.1-20mm. Less than 5% fines.	10^{-3} to 10^{-5}
Well graded sand	Sand with particle sizes 0.06-2.0mm. Less than 10% fines.	10^{-4} to 10^{-6}

Notes:

1. The permeability values have been assessed based on laboratory tests on freshly quarried stone and samples taken from site. They are an estimate of typical values and should not be relied upon for design. Site-specific testing is strongly recommended along with flow-reduction factors to account for crushing of stone during installation and long term clogging risks.

Calculating Flow Capacity

Using Darcy's Law for the movement of water, the flow capacity through a granular material is given by:

$$Q = k \cdot i \cdot A$$

Where
- Q = Water flow (l/s)
- k = Permeability (m/s)
- i = Hydraulic gradient (decimal)
- A = Cross sectional area of flow (mm x m)

Considering a one metre strip of filter stone, of thickness t:

$$Q = k \cdot i \cdot (t \cdot 1)$$
$$= k \cdot i \cdot t \text{ l/m·s (l/s per m width)}$$

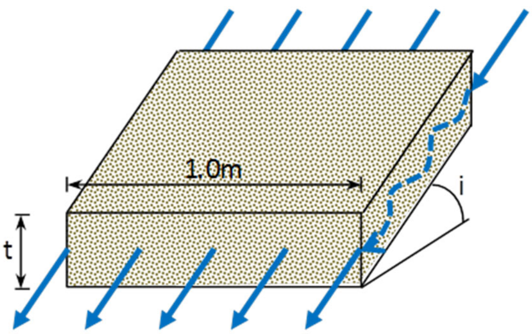

Figure 3: Granular drainage layer layout

The specified permeability of filter stone typically varies from 10^{-1}m/s to 10^{-4}m/s, and roading applications can have hydraulic gradients of 0.01 to 1.0 (equivalent of slopes of 1:100 and vertical applications, respectively). So the ultimate drainage capacity for a typical 300mm thick granular drainage layer can be anywhere in the range of 30 l/m·s to 0.0003 l/m·s. For further information on the permeability of granular drainage layers, contact ABG Technical Department.

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Geocomposite Flow Capacity Measurement

ABG Fildrain comes in several different sized cores in order to provide a range of different drainage rates. From in-plane flow testing in accordance with BS EN ISO 12958, the average tested flow capacities at various compressive stresses and hydraulic gradients are shown in Table 2.

Table 2: ABG Fildrain Average Ultimate Flow Capacities, $q_{ult,Fd}$ (l/m·s)

Application	Pressure	ABG Fildrain Grade					
		4S	6S	7S	7D/7DH	12S	25S/25SH
Vertical (1.0)	20kPa	0.85	1.45	2.40	0.60	4.25	12.15
	100kPa	0.75	1.35	1.95	0.48	3.20	9.40
	200kPa	0.60	1.10	1.45	0.40*	1.80	7.95*
1 : 100 (0.01)	20kPa	0.05	0.12	0.17	0.03	0.30	1.20
	100kPa	0.04	0.08	0.13	0.02	0.18	0.90
	200kPa	0.03	0.05	0.10	0.01*	0.10	0.62*

Notes:
1. The 4, 6, 7, 12 or 25 in the product name refer to the geocomposite's nominal thickness in millimetres.
2. The S or D in the product name refers to Single or Double cuspated products.
3. The flow values given for 7D are flow on one side of the geocomposite only.
4. The H at the end of the product name refers to a High strength core.
5. Flow values with a * are where high strength core is recommended and the flow values are as measured when testing high strength core.

These in-plane flow values have been obtained with soft foam rubber platens to simulate real soil conditions. Other geocomposites, such as geonets, can have water flow impeded by soil intrusion, whereas **ABG Fildrain**'s geotextile spans between the cuspates to resist soil intrusion (see Figure 4). For more information ABG can provide a technical paper on this topic (Bamforth, 2008).

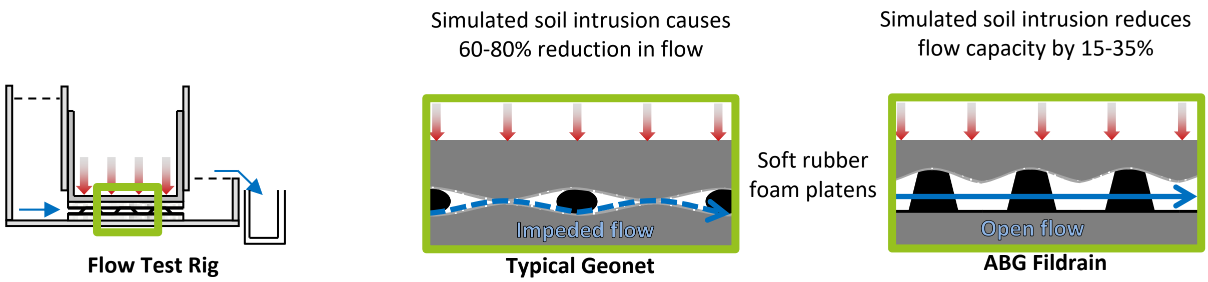

Figure 4: In-plane flow testing simulating soil intrusion in geocomposite drainage products

The pressure on a drainage layer varies widely depending on the application. Hence the in-plane flow testing has been conducted at a range of pressures to determine the flow capacity for typical applications in the range of 20-200 kPa. For higher pressures ABG can provide grades of **Fildrain** suitable for up to 1000 kPa with associated flow test results at these higher pressures.

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Geocomposite Flow Capacity Design

To assess an allowable flow capacity (q_{allow}) in a geocomposite several reduction factors should be considered as outlined below (Koerner, 2012).

$$q_{allow} = \frac{q_{ult}}{RF_{IN} RF_{CR} RF_{PC} RF_{CC} RF_{BC} RF_{ID}}$$

Where q_{ult} = geocomposite flow rate as determined from in-plane flow testing.

Table 3: Flow Reduction Factors

Factor	Description	ABG Fildrain Values
RF_{IN}	**Reduction factor to account for geotextile intrusion into the core** **ABG Fildrain** accounts for this by using soft platens and hence the reduction factor can be taken as 1.0. Without soft platen testing RF_{IN} can be as high as 2.5 to 5.0 as is the case with many geonet products.	RF_{IN} = 1.0
RF_{CR}	**Reduction factor to account for long term creep compression**. For **ABG Fildrain** the long term creep compression depends on the load imposed. For light loading (≤ 20kPa) the creep compression is minimal whereas with high loads (100-200kPa) it can be up to 25% during a 100 year lifespan.	Light Load RF_{CR} = 1.0 Heavy Load RF_{CR} = 1.3
RF_{PC}	**Reduction factor to account for particulate clogging of the core** **ABG Fildrain** has geotextile filter to prevent soil particles from entering the core. A granular drainage layer may have a reduction factor as high as 10 unless it is wrapped in a geotextile.	RF_{PC} = 1.0
RF_{CC} & RF_{BC}	**Reduction factors to account for chemical (RF_{CC}) and biological (RF_{BC}) clogging of the geotextile.** This factor should be applied to both granular and geocomposite drainage layers. For **ABG Fildrain** in typical roading situations, there is relatively little biological activity or chemical effects that could cause clogging of the geotextile.	RF_{CC} = 1.1 RF_{BC} = 1.1
RF_{ID}	**Reduction factor to account for installation damage**. Test results for **ABG Fildrain** indicate that an installation damage reduction factor of 1.07 is appropriate. In granular materials the resistance to abrasion/fragmentation should be understood as any crushing during installation may severely affect the flow capacity of a granular drainage layer.	RF_{ID} = 1.07

When using **ABG Fildrain** in normal roading conditions there are two typical loading situations. The first is light loading situations – such as a findrain at the edge of the carriageway – where soil pressures are unlikely to exceed 20kPa. The second is heavy loading situations – such as below the sub-base of a road pavement – where pressures are unlikely to exceed 100kPa. These situations can be assessed as:

$$q_{allow,light} = \frac{q_{ult,Fd,20kPa}}{1.0 \cdot 1.0 \cdot 1.0 \cdot 1.1 \cdot 1.1 \cdot 1.07} \quad = \quad q_{allow,light} = \frac{q_{ult,Fd,20kPa}}{1.29}$$

$$q_{allow,heavy} = \frac{q_{ult,Fd,100kPa}}{1.0 \cdot 1.3 \cdot 1.0 \cdot 1.1 \cdot 1.1 \cdot 1.07} \quad = \quad q_{allow,heavy} = \frac{q_{ult,Fd,100kPa}}{1.68}$$

Where $q_{ult,Fd,20kPa}$ = flow rate in **ABG Fildrain** at 20kPa pressure as per Table 1.
$q_{ult,Fd,100kPa}$ = flow rate in **ABG Fildrain** at 100kPa pressure as per Table 1.

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In addition to the reduction factors outlined above, a global factor of safety should be applied to both the granular filter flows and geocomposite flows to give the final design flows (Koerner, 2012).

$$FS = \frac{q_{allow}}{q_{reqd}}$$

Where FS = global factor of safety (applied to both granular and geocomposite flows)
q_{allow} = allowable flow rate
q_{reqd} = required flow rate as obtained from the design of the overall system.

Flow Capacity Comparison

As demonstrated above, for a given hydraulic gradient (slope), the flow capacity of a granular drainage layer depends on the thickness of the layer and the permeability of the stone used. For a geocomposite such as **ABG Fildrain**, the dimensions, strength and stiffness of the geocomposite, and the pressure applied, are the governing properties. Shown in Figures 5 and 6 are graphs of granular layer thickness vs. flow for various permeability grades at hydraulic gradients of 1.0 (vertical applications such as a drainage trench) and 0.01 (near horizontal applications such as below a road surface). Superimposed on these graphs is the recommended type of ABG Fildrain to provide equal or better flow.

Note that the flow rates shown in Figures 5 and 6 assume that the granular layer is fully wrapped in a suitable geotextile to prevent fines migrating into the layer and that the granular material is highly resistant to abrasion/fragmentation. The flow rates shown for the granular layer therefore represent best case scenarios.

Notes for Figures 5 & 6:

1. The plotted flow values for granular drainage layers are ultimate flow values (i.e. they do not take account of particulate, chemical, or biological clogging).
2. In order to provide a more accurate comparison, the plotted **ABG Fildrain** flow values also do not include reduction factors for particulate, chemical, or biological clogging (RF_{PC}, RF_{CC} and RF_{BC}) but do include reduction factors for geotextile intrusion (RF_{IN}), creep (RF_{CR}), and installation damage (RF_{ID}). Hence the plotted ABG Fildrain flow values for light loading situations are $q_{allow,light} = q_{ult}/1.07$ (flows measured at 20kPa pressure) and for heavy loading situations $q_{allow,heavy} = q_{ult}/1.39$ (flows measured at 100kPa pressure).

Conclusion

ABG Fildrain provides flow capacity equivalent to that of granular drainage layers with just a fraction of the space required. This allows greater use of on-site materials and reduces the need to acquire and place suitable granular filter material. In addition, a geotextile filter does not need to be added as **ABG Fildrain** is a geocomposite which incorporates a geotextile filter. On sites where suitable granular drainage stone is not readily available this can lead to significant savings both in terms of monetary cost and CO_2 emissions associated with quarrying and delivering stone over long distances.

References

Bamforth, A. (2008) *Role of Platen Hardness on Interpretation and Use of In-Plane Flow Capacity Test Results for Geosynthetics*. Paper presented at the 4th European Geosynthetics Conference, Scotland, 2008.

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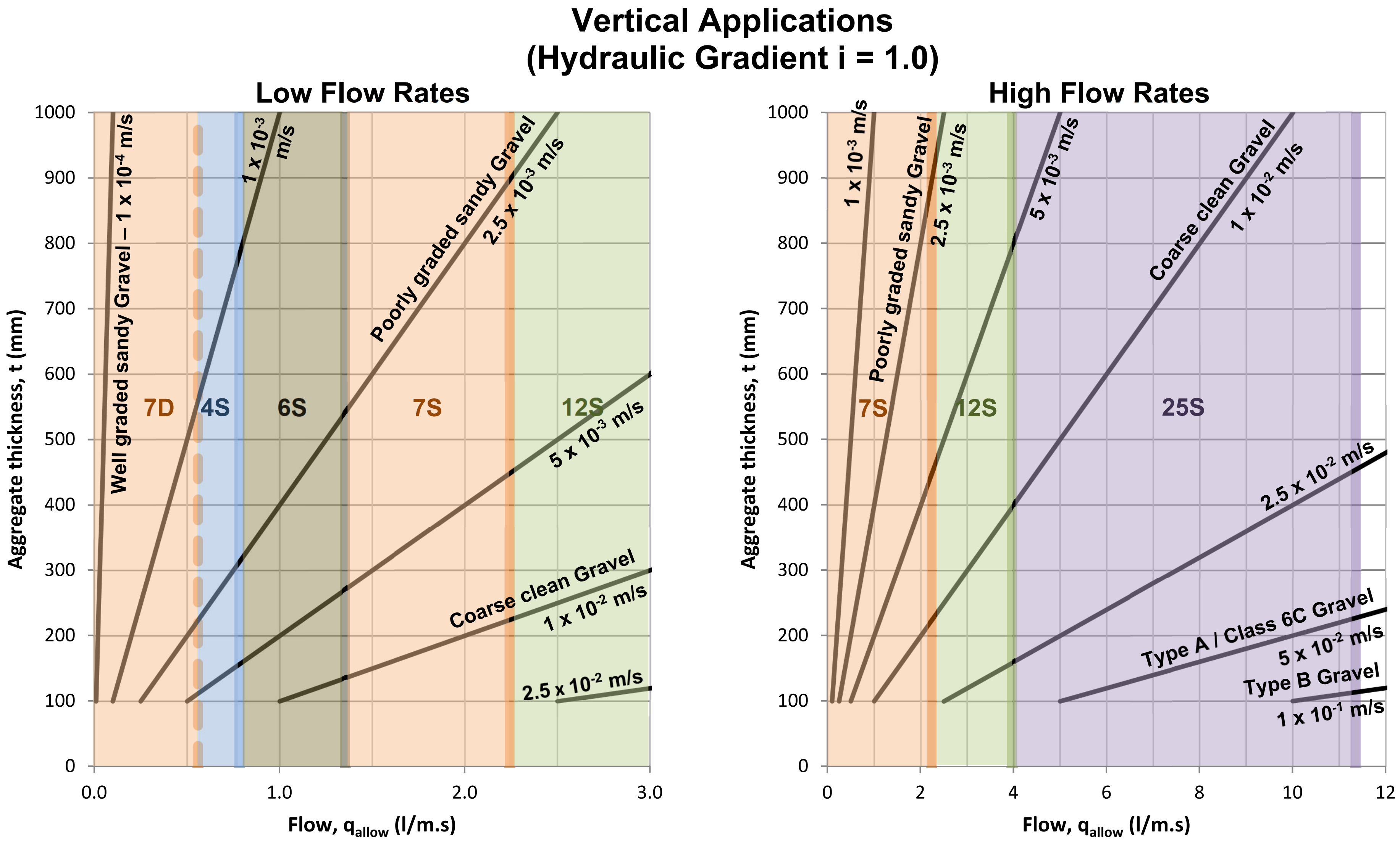

Figure 5: Flow Capacity Equivalence – Vertical Applications (Hydraulic Gradient, i = 1.0)

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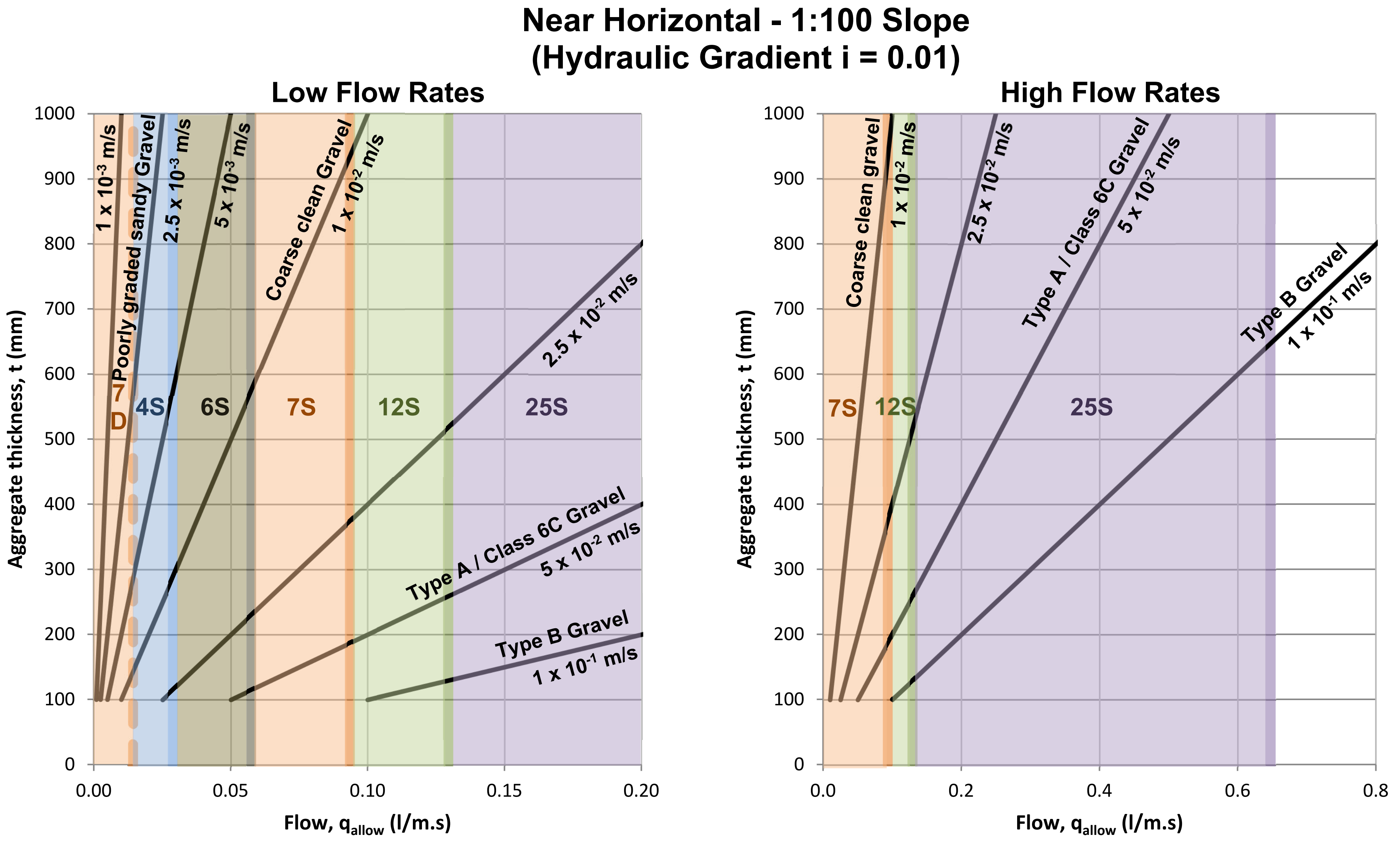

Figure 6: Flow Capacity Equivalence – Near Horizontal - 1:100 Slope (Hydraulic Gradient, i = 0.01)

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