Appendix D: Enhancing pathogen removal using novel antimicrobial media

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Recent research has demonstrated the potential to enhance pathogen removal from stormwater in biofilters using layers of a specially modified media. To date, this novel design approach has only been tested under laboratory conditions. However, field-scale systems trialling this media are currently under construction and performance results will be assessed from these systems. This section summarises the use of antimicrobial media in laboratory trials, and further details can be found in:

Li, Y. L., Deletic, A., Henry, R., Schang, C. & McCarthy, D. T. in preparation. *Pollutant removal from urban stormwater by copper-zeolite integrated biofilters.*

Li, Y. L., Deletic, A. & McCarthy, D. T. 2014a. Removal of E. coli from urban stormwater using antimicrobial-modified filter media. *Journal of Hazardous Materials*, 271, 73-81.

Li, Y. L., McCarthy, D. & Deletic, A. submitted. The removal of E. coli from urban stormwater by biofilters using copper-treated media. *Water Research*.

Li, Y. L., McCarthy, D. T. & Deletic, A. 2014b. Stable copper-zeolite filter media for bacteria removal in stormwater. *Journal of Hazardous Materials*, 273, 222-230.

Detailed laboratory testing has been conducted to develop an antibacterial media that is stable under wide-ranging conditions, and does not contribute to pollutant leaching. While zeolite coated with exchangeable copper (Cu^{2+}) (known as 'ZCu') is effective for the removal of bacteria from stormwater, it is not stable under very saline conditions and copper leaching can be problematic. However, further testing revealed that calcination (a thermal treatment process) and application of a $Cu(OH)_2$ coating significantly reduces copper leaching (Cu leaching of 20mg/L was reduced by 97%, when using a test solution of salinity 250 µS/cm).

Two media designs were identified for optimal bacterial removal. The first uses ZCu coated with $Cu(OH)_2$ and treated at 180°C, which shows effective E. coli removal (1.7-2.7 log reduction in concentration) from various test solutions under a contact time of 22 minutes (known as 'ZuCuCuO180'). The second type of media uses ZCu calcined at 400°C (known as 'ZCu400'), which effectively inactivates retained bacteria across a 24 hour drying period. As a result, layers of both media are recommended in biofilters seeking optimal removal of bacteria, and copper leaching was minimised to 9 µg/L.

A further consideration is the potential for copper toxicity effects on plants within the biofilter. High levels of copper can lead to poor plant growth, possibly death, which will severely restrict biofilter functioning. To prevent this, it is recommended the antimicrobial layers are restricted to relatively thin layers near the surface of the biofilter, laid down a month or two after planting (to allow establishment). In addition, pipe collars can be used to protect plant stems from the antimicrobial media if necessary to further protect plants (Figure 1). However, in publicly accessible areas it may not be deemed safe to have the ZCu layer exposed. While mulch is not recommended in biofilters, in this case a thin layer (e.g. 50 mm) of granite mulch (14 mm diameter) may be laid above the ZCu layers to prevent the risk of contact with the public.

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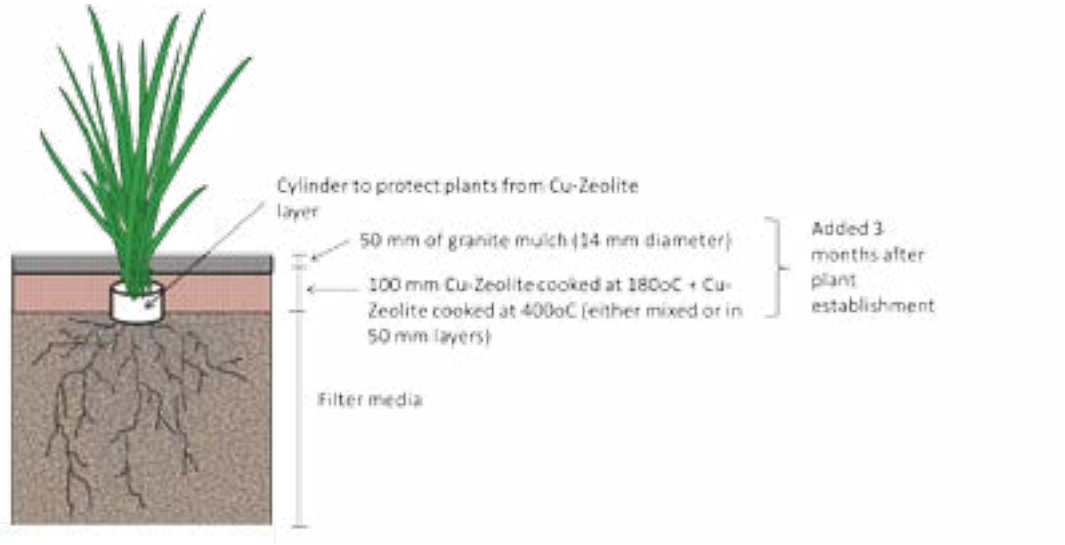

Figure 1. Example layering of Cu-Zeolite antibacterial layers using pipe collar to prevent contact with plant stems and roots

Summary

- It is important to note that, while novel antimicrobial media has been thoroughly tested under laboratory conditions, it is currently undergoing field testing. Hence, it is not as yet recommended for widespread adoption, but guidance will be updated as performance results from the field become available.
- Biofilter designs using antimicrobial media should incorporate:
  - ¬ A layer of ZCu400 at the top of the biofilter to inactivate bacteria during dry periods
  - ¬ A layer of ZCuCuO180 below the ZCu400 to retain and inactivate bacteria that pass through the upper layer during storm events
  - ¬ Plant roots should be protected from potential Cu toxicity but restricting the ZCu layers to the surface of biofilter, with seedlings planted directly into traditional biofilter media and allowed to establish for a month or two before the ZCu layers are placed above. A cut piece of pipe can be used to reduce contact between the plant stem and the ZCu layers. A topping layer of granite mulch (14 mm diameter) may be added above to prevent the risk of contact between the public and the ZCu.

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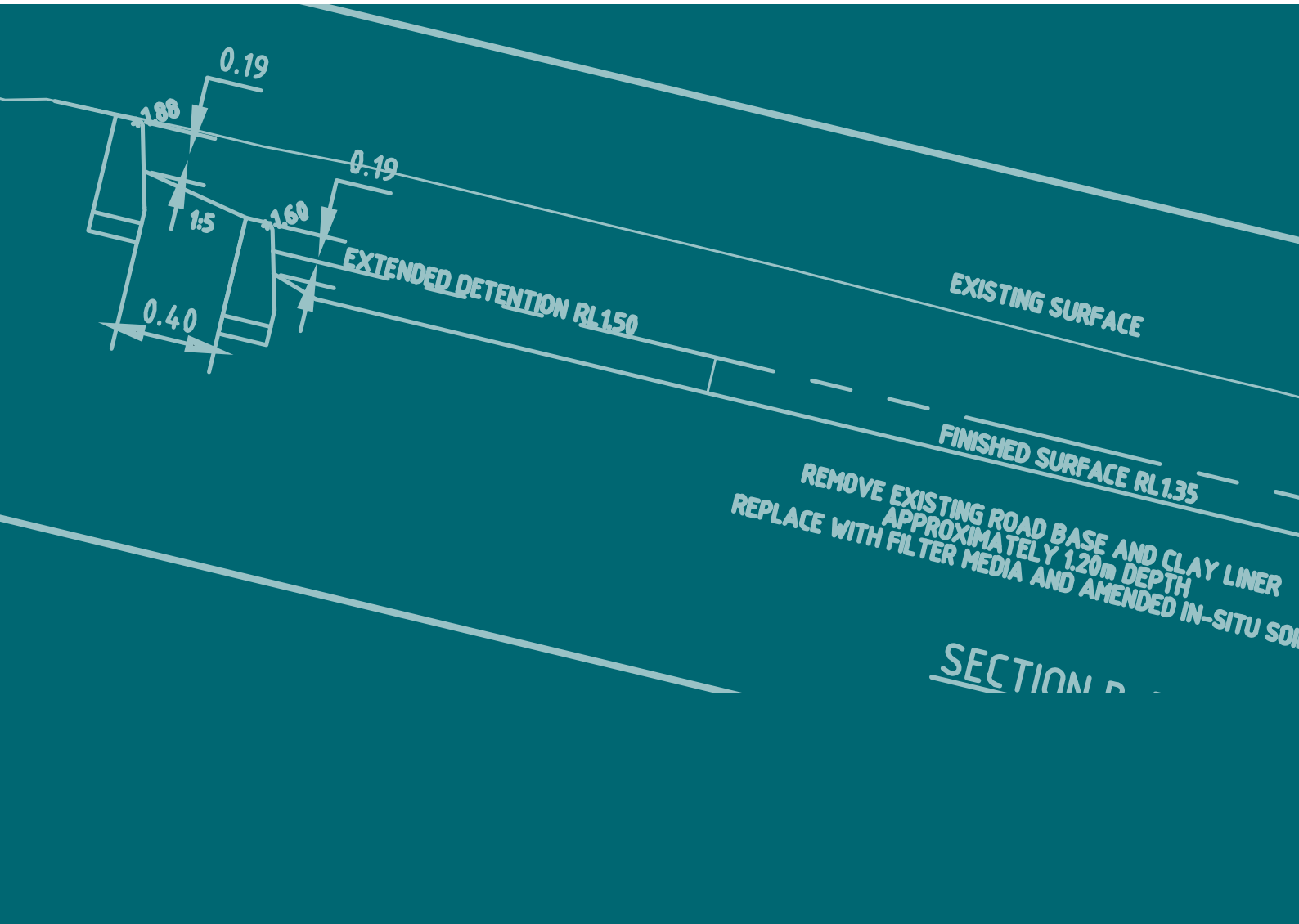
0.19
1.86
0.19
1:5
1.60
EXTENDED DETENTION RL1.50
EXISTING SURFACE
FINISHED SURFACE RL1.35
0.40
REMOVE EXISTING ROAD BASE AND CLAY LINER
APPROXIMATELY 1.20m DEPTH
REPLACE WITH FILTER MEDIA AND AMENDED IN-SITU SOI
SECTION