Potential of Pervious and Macro-Pervious Pavements as Harvesting Systems for Irrigation of Adjacent Lawns and Flower Beds

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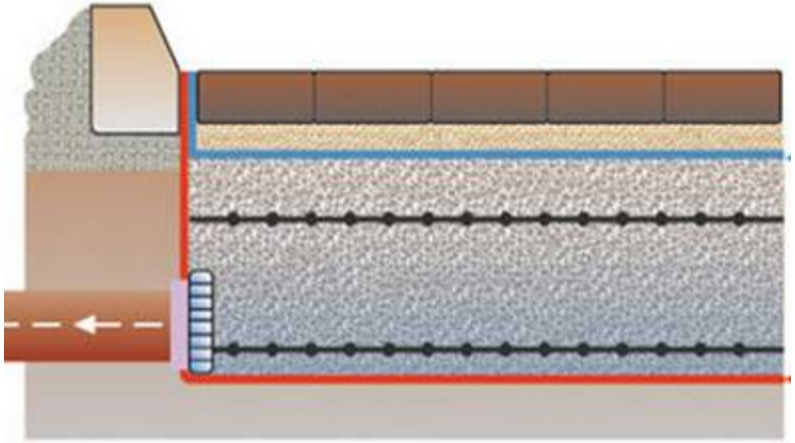
Aims

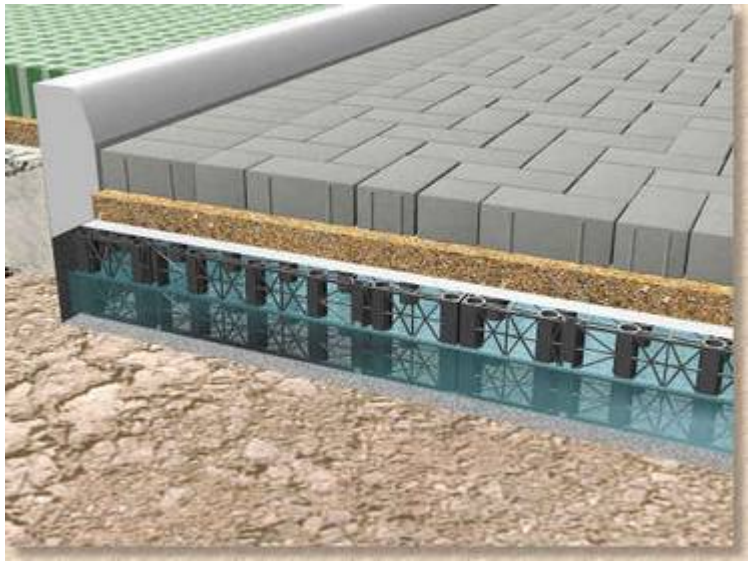
- Report the quality of effluents from 6 year old and 10 year old hard paved macro-pervious and pervious pavement installations.
- Consider the quality of the effluent in terms of potential as a landscape irrigation source as well as a potential water pollutant.
- Provide some base line data for a future pot trial experiment.

Pervious Pavements

Automobile derived pollutants !



Typical PPS cross section



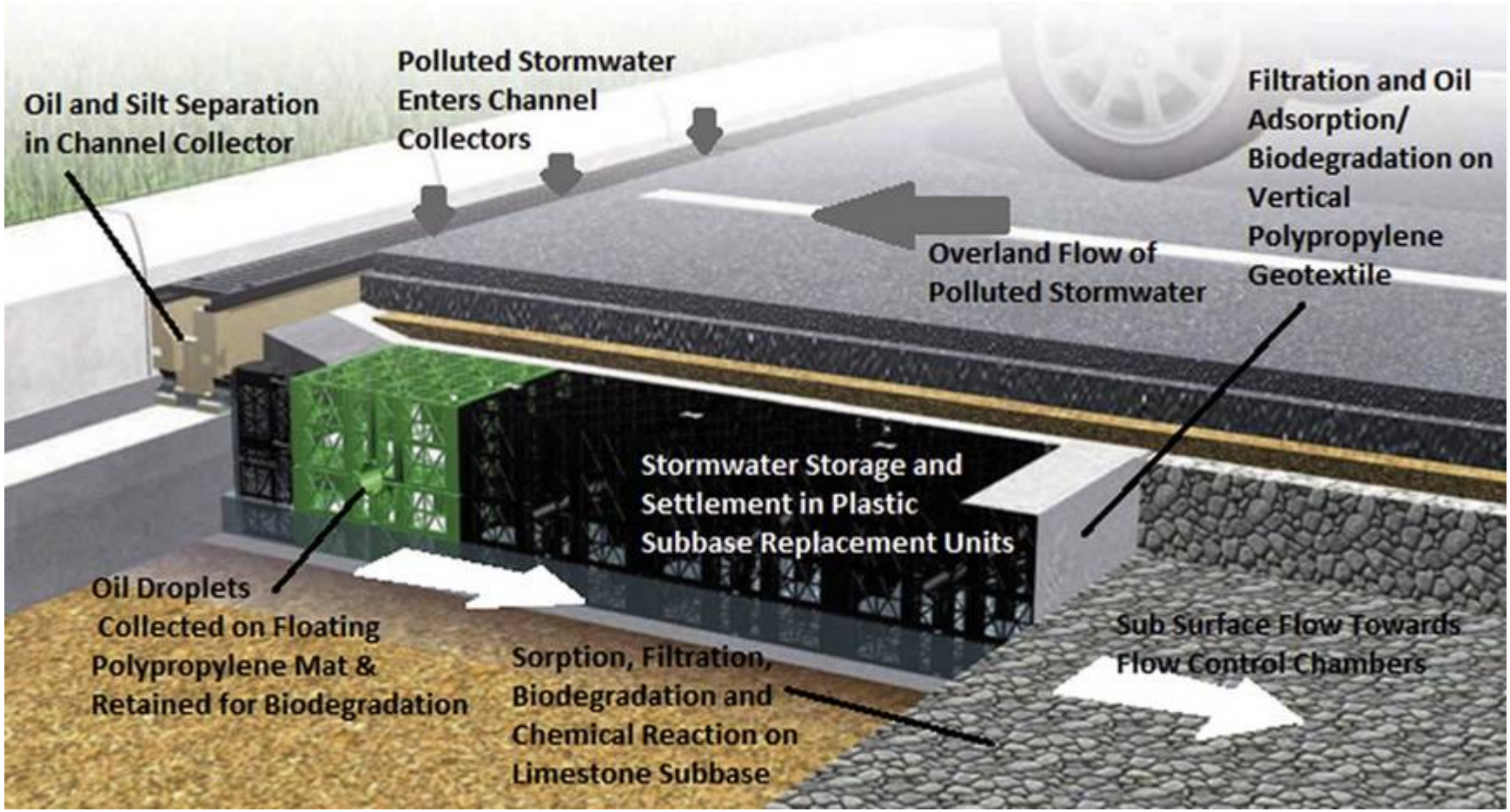
Alternative to aggregate subbase-when shallow installation is preferred

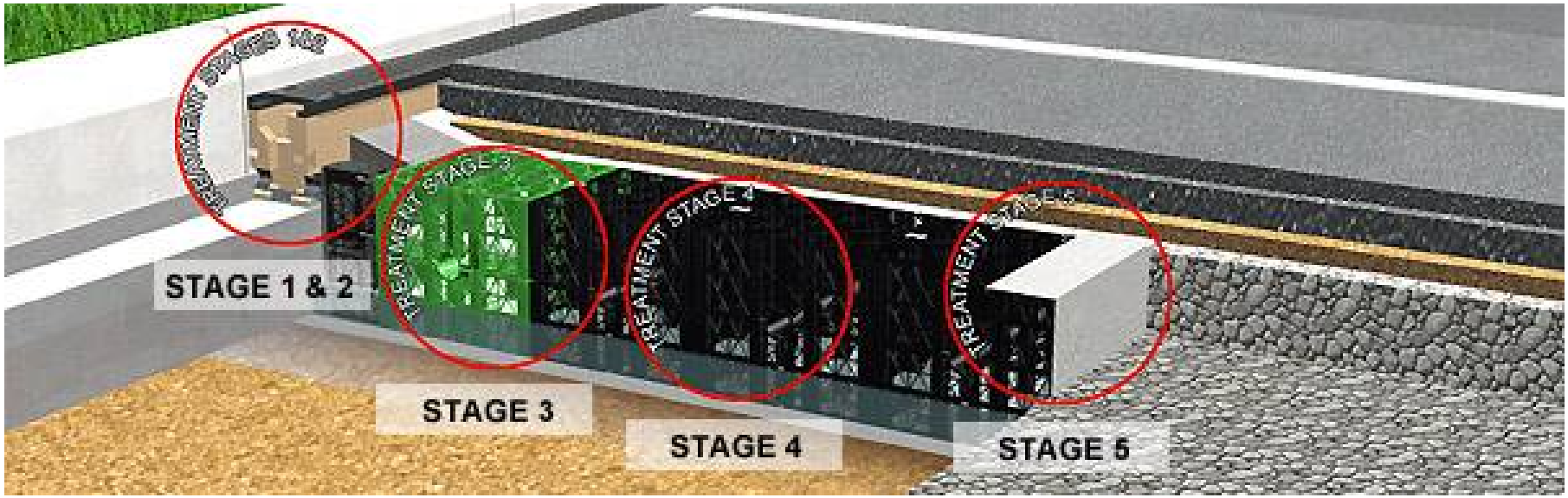
Harvesting of Pavement-Derived Water

Pollutant Removal Mechanisms in Pervious Pavements

- Filtration
- Gravity Separation- temporary gravity separator above upper geotextile
- Adsorption
- Biodegradation
- Chemical Precipitation.
- **All can be provided without a pervious surface-can feed the pervious subbase at distinct infiltration points**

Options For Getting Water Underground in the Macro-pervious Pavement





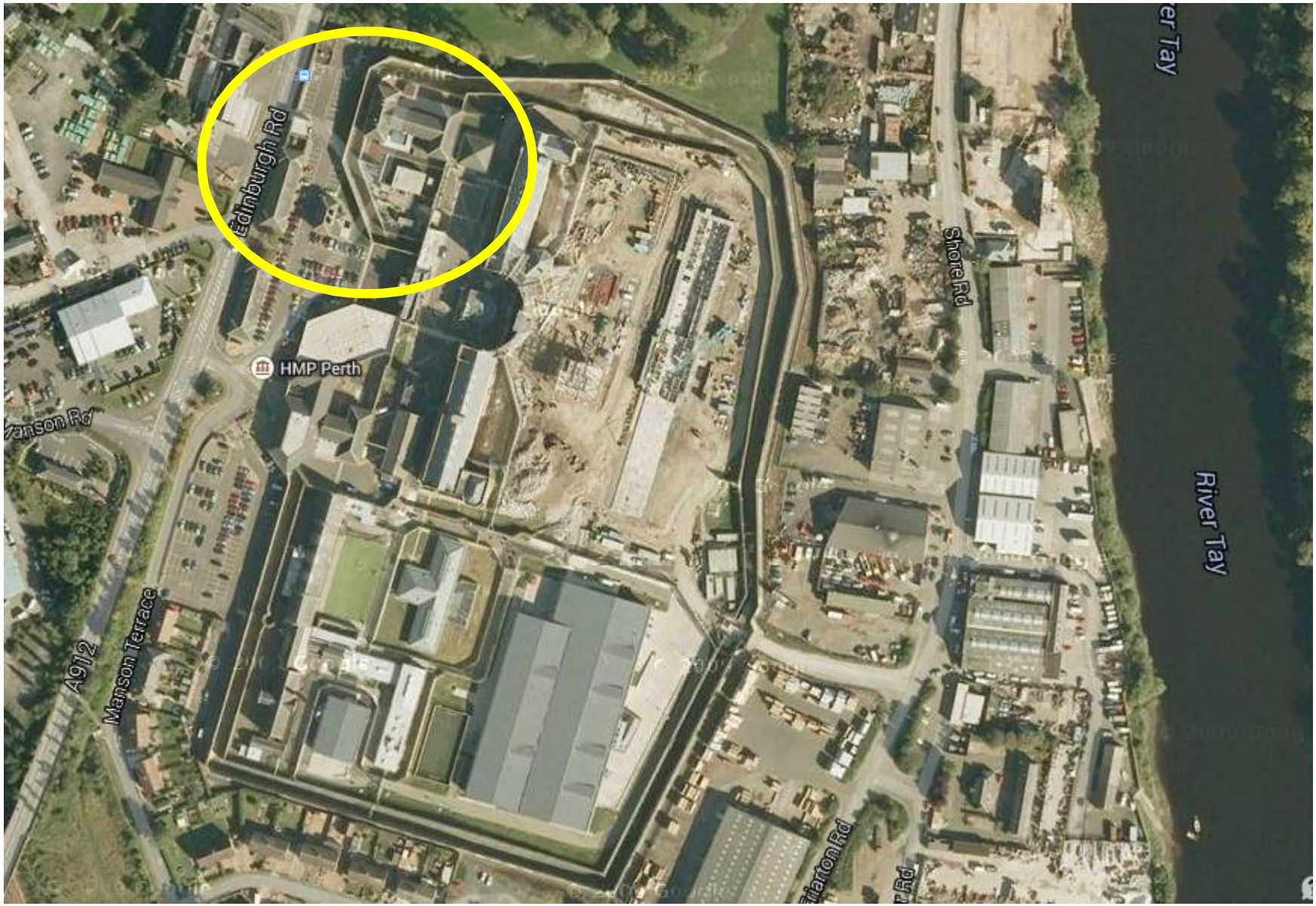
Multistage treatment – equivalent to a PPS

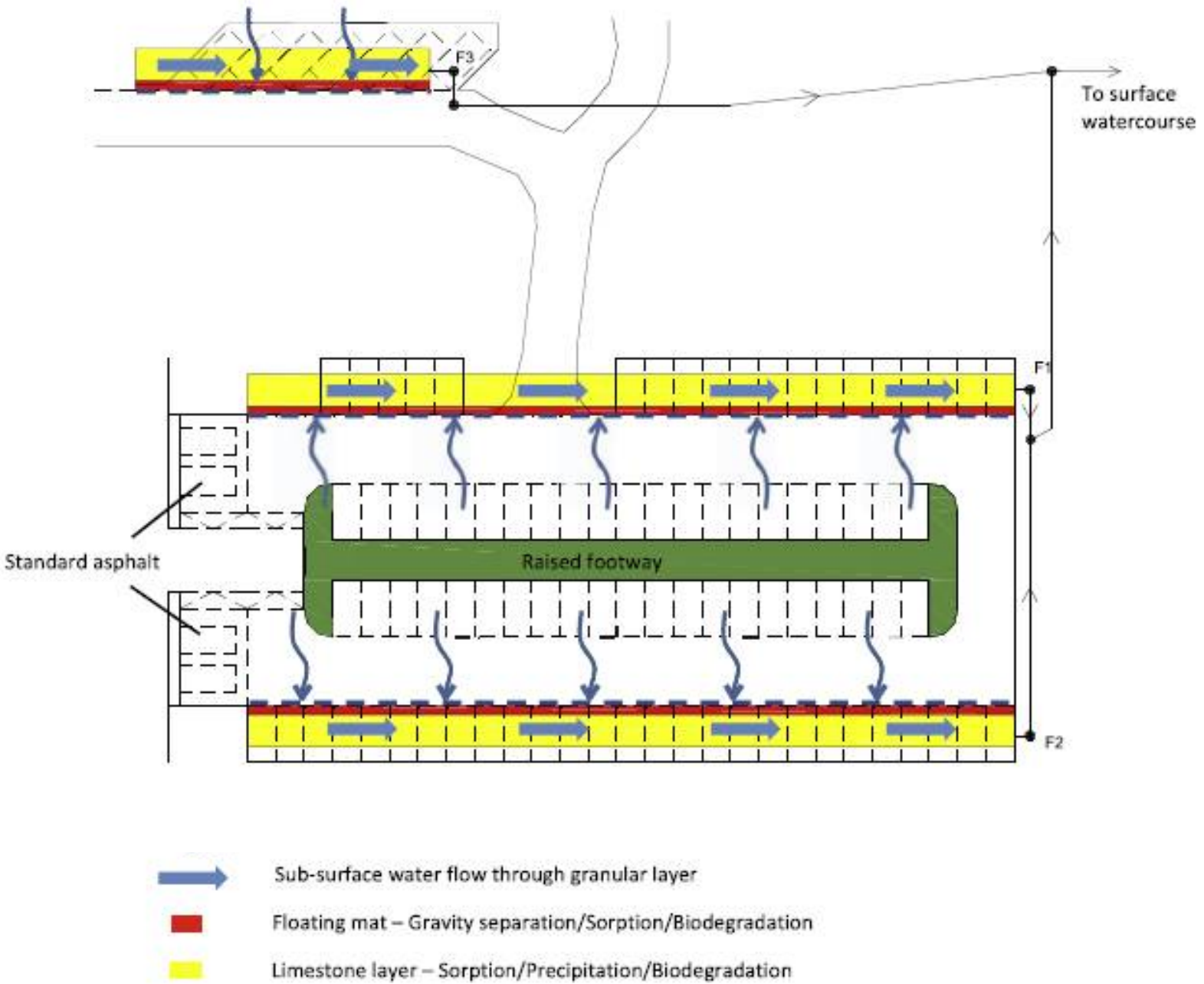
But not compromised by large hydrocarbon losses

Maintenance is much easier

Test Sites Studied

Macro-pervious pavement
Perth Prison
Visitors' Parking Lot


Edinburgh Rd
HMP Perth
Manson Rd
A912
Manson Terrace
Shore Rd
River Tay
River Tay

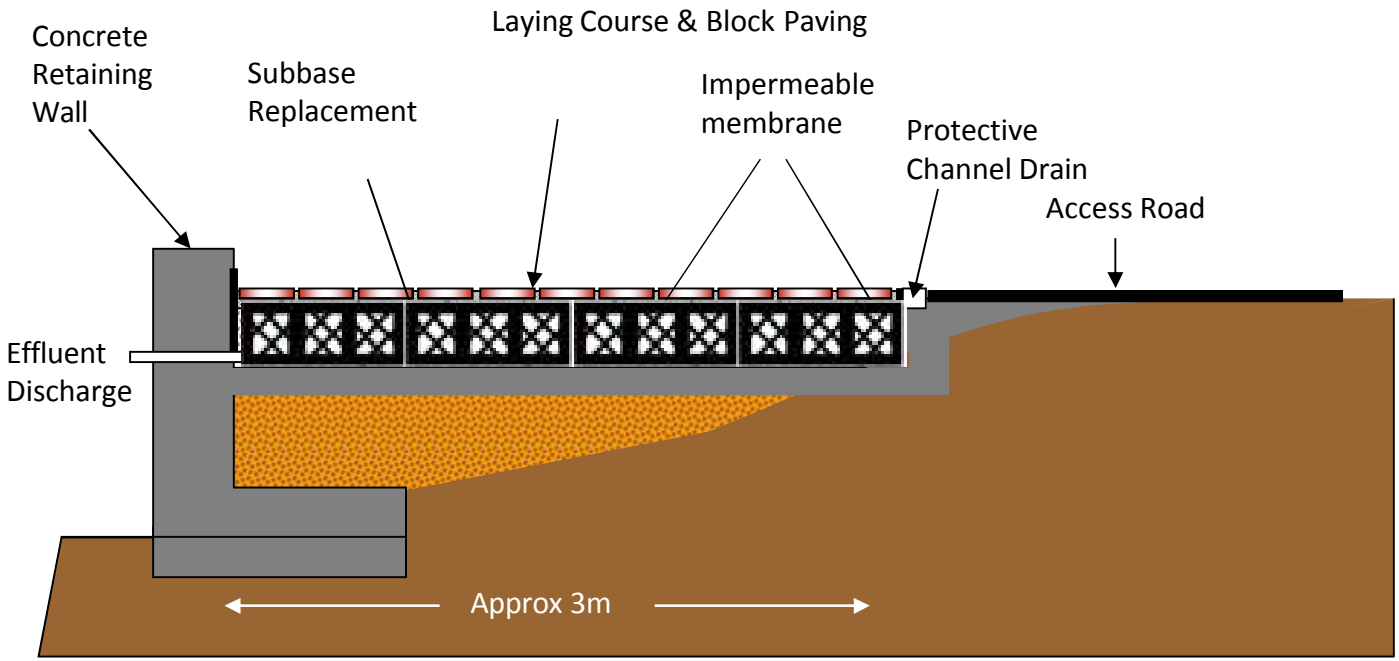

F3
To surface watercourse
F1
Standard asphalt
Raised footway
F2
Sub-surface water flow through granular layer
Floating mat – Gravity separation/Sorption/Biodegradation
Limestone layer – Sorption/Precipitation/Biodegradation

Monitoring at the Perth Site

- First phase started 2011 – looked at water quality only from the point of view as an effluent. Samples from inlet and outlet.
- Question asked by SPS- “could we use the water? ”- Roof water not available.
- Second phase of monitoring started 2014
- Additional parameters related to irrigation quality. PPS site added for comparison

Pervious Pavement
Bury, NW England

- Former 18th Century water-powered cotton mill, currently occupied by SEL Environmental Ltd.
- Former partners with Coventry University in a, Govt. Funded, Knowledge Transfer Partnership.



History

- Parking lot built as an experimental test bed.
- The 4 bay, block paved, area considered here had only previously been monitored for TPH and for only 1 year after construction
- Full monitoring regime commenced in 2014

Original Monitoring Parameters

- Suspended Solids, TPH.
- Metals- Copper, Zinc, Lead , Cadmium, Chromium, Nickel.
- pH
- Various nutrients
- BTEX

Additional Parameters

- Sodium, Potassium, Calcium, Magnesium
- Electrical Conductivity
- Boron

Results

Collected in Channels-Perth

	Liquid Contents			Retained Solids		
	Units	MEAN	MAX	Units	MEAN	MAX
TSS	mg/l	16312	66000	r	-	-
NH_4-N	mg N/l	0.23	0.85	r	-	-
Tot. Oxidised-N	mg N/l	0.25	0.58	r	-	-
Tot. P	mg P/l	11	38	r	-	-
Pb	µg/l	1180	2700	mg/kg	44	160
Zn	µg/l	7000	13000	mg/kg	194	340
Cr	µg/l	190	300	mg/kg	25	61
Ni	µg/l	1800	11000	mg/kg	26	77
Cd	µg/l	12	28	mg/kg	18	72
Cu	µg/l	1100	2500	mg/kg	43	160
Total Hydrocarbons	mg/l	30	150	mg/kg	3500	13000
Toluene	µg/l	-	<1	µg /kg	17	72
Ethyl Benzene	µg/l	-	53	µg /kg	1510	4200
Total Xylenes	µg/l	-	<2	µg /kg	66	201
Benzene	µg/l	-	<1	µg /kg	<10	<10

Perth Site – Both Surveys

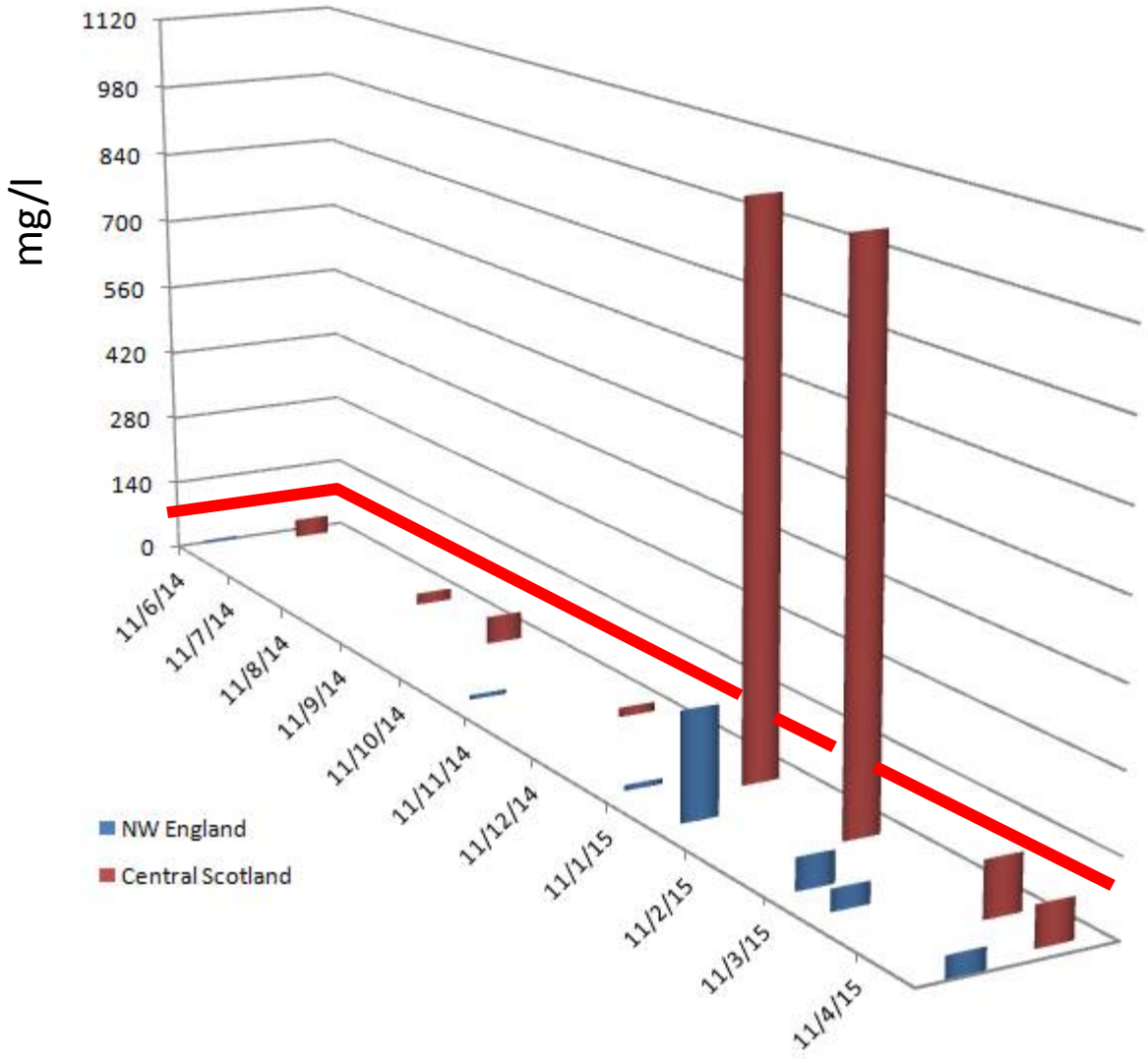
		Both Sub Catchments Maximum Recorded			
	Units	**2011/12**	**2014/15**	**Effluent**	**Irrigation Limit**
TSS	mg/l	18	8	30	50
NH_4-N	mg N/l	ND	0.4	0.42	7 (sensitive plants)
Tot. Oxidised-N	mg N/l	1.3	29(1.1)*	Not Available	
Tot. P	mg P/l	13(<0.4)*	<0.4	2.4	
Pb	µg/l	2.1	<2	144	5000
Zn	µg/l	280	72	1000	5000
Cr	µg/l	5.7	0.9	68	200
Ni	µg/l	8.4	5.9	400	500
Cd	µg/l	0.3	<0.2	1.8	10
Cu	µg/l	56	26	200	200
Total Hydrocarbons	mg/l	0.35	0.19	5	1.8 (C_{9-14})
Toluene	µg/l	<1	<1		
Ethyl Benzene	µg/l	<1	<1		
Total Xylenes	µg/l	<2	<2		
Benzene	µg/l	<1	<1	1-50 (Drinking Water Limits)	

	SEL- BURY		REQUIRED STANDARDS	
	Units	MAX	Effluent	Irrigation Limit
TSS	mg/l	26	30	50
NH_4-N	mg N/l	<0.2	0.42	7 (sensitive plants)
Tot. Oxidised-N	mg N/l	0.61		
Tot. P	mg P/l	<0.4	2.4	
Pb	µg/l	0.3	144	5000
Zn	µg/l	25	1000	5000
Cr	µg/l	7.1	68	200
Ni	µg/l	5.4	400	500
Cd	µg/l	<0.2	1.8	10
Cu	µg/l	52	200	200
Total Hydrocarbons	mg/l	0.12	5	1.8
Toluene	µg/l	<1		
Ethyl Benzene	µg/l	<1		
Total Xylenes	µg/l	<2		
Benzene	µg/l	<1	1-50 (Drinking Water Limits)	

- All results continue to show good quality from an effluent point of view and, for most parameters from the point of view of irrigation water.
- However pH and sodium were found to be a serious issue .

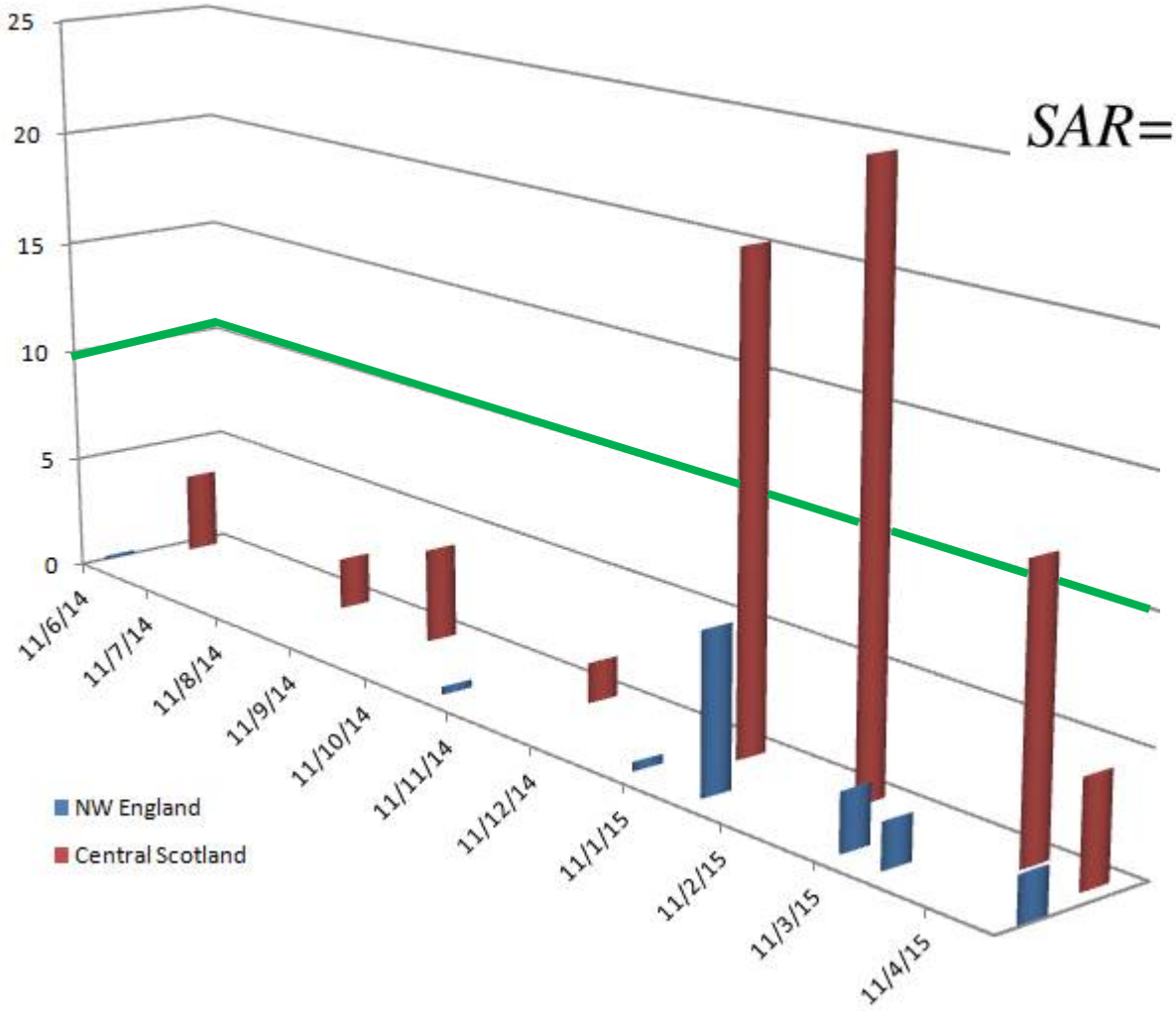
Sodium – Both Sites

Approximately 1 tonne of salt applied at Perth during winter months



70mg/l

Sodium Absorption Ratio- Both Sites



$$SAR = \frac{(Na^+)}{\sqrt{\frac{1}{2}[(Ca^{2+}) + (Mg^{2+})]}}$$

pH

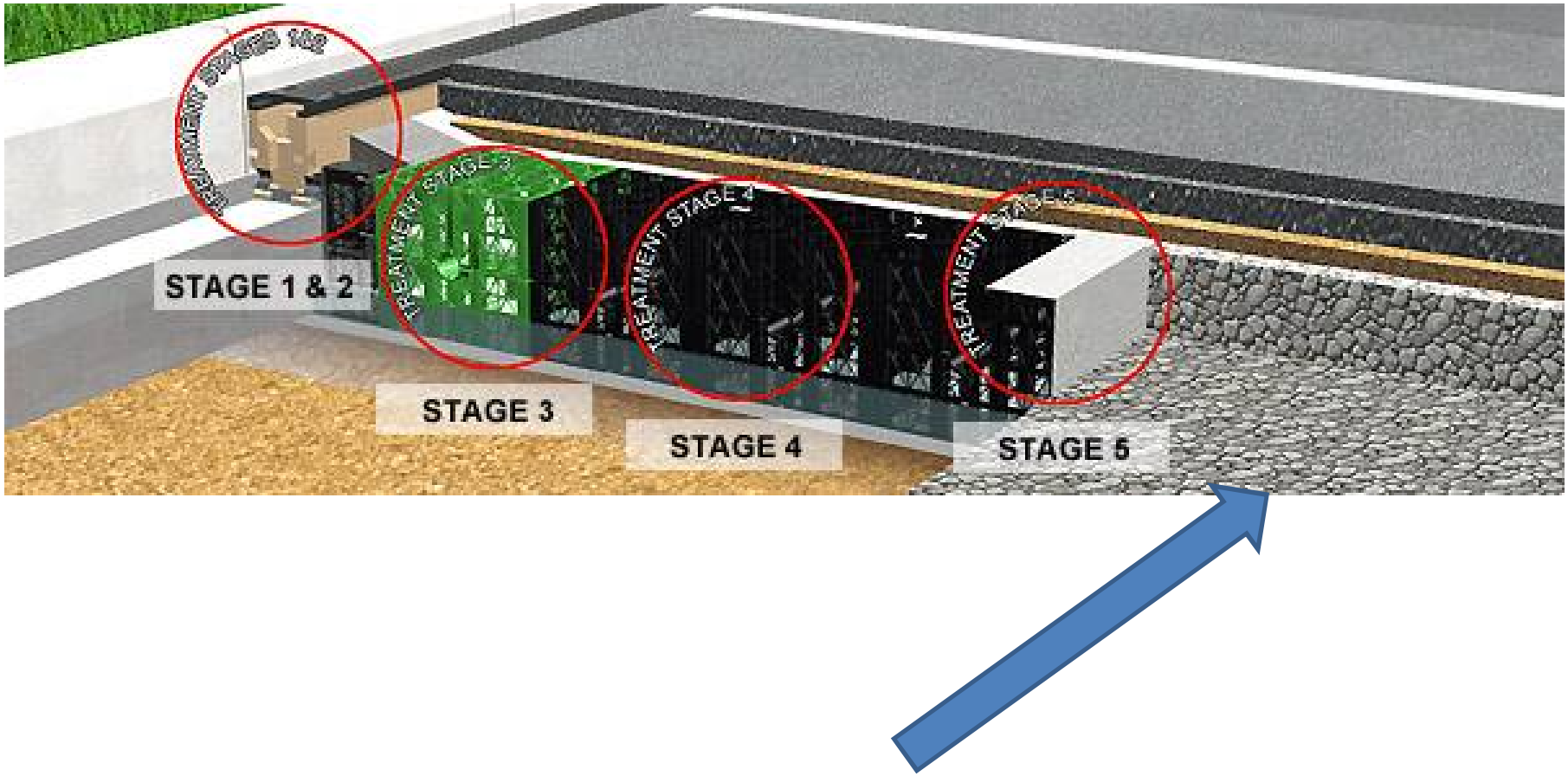
Central Scotland - All Results – Both Surveys

	Measured pH Values			Required Standards Irrigation Water	
CATCHMENT	MIN	MEDIAN	MAX	MIN	MAX
1	8.2	9.1	10.2	5-6.4	8.4-9
2	7.9	9.6	11.1		

NW England

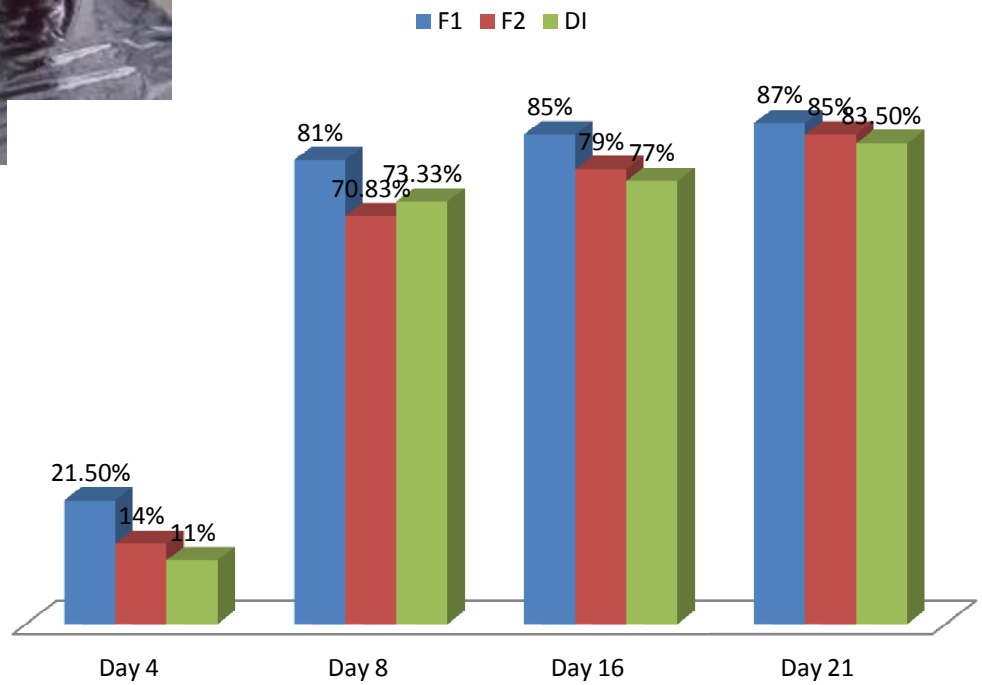
	Measured pH Values			Required Standards Irrigation Water	
CATCHMENT	MIN	MEDIAN	MAX	MIN	MAX
SEL CP 1	7.7	7.85	8.0	5-6.4	8.4-9

pH > 8 can give rise to clogging in drip irrigation systems.

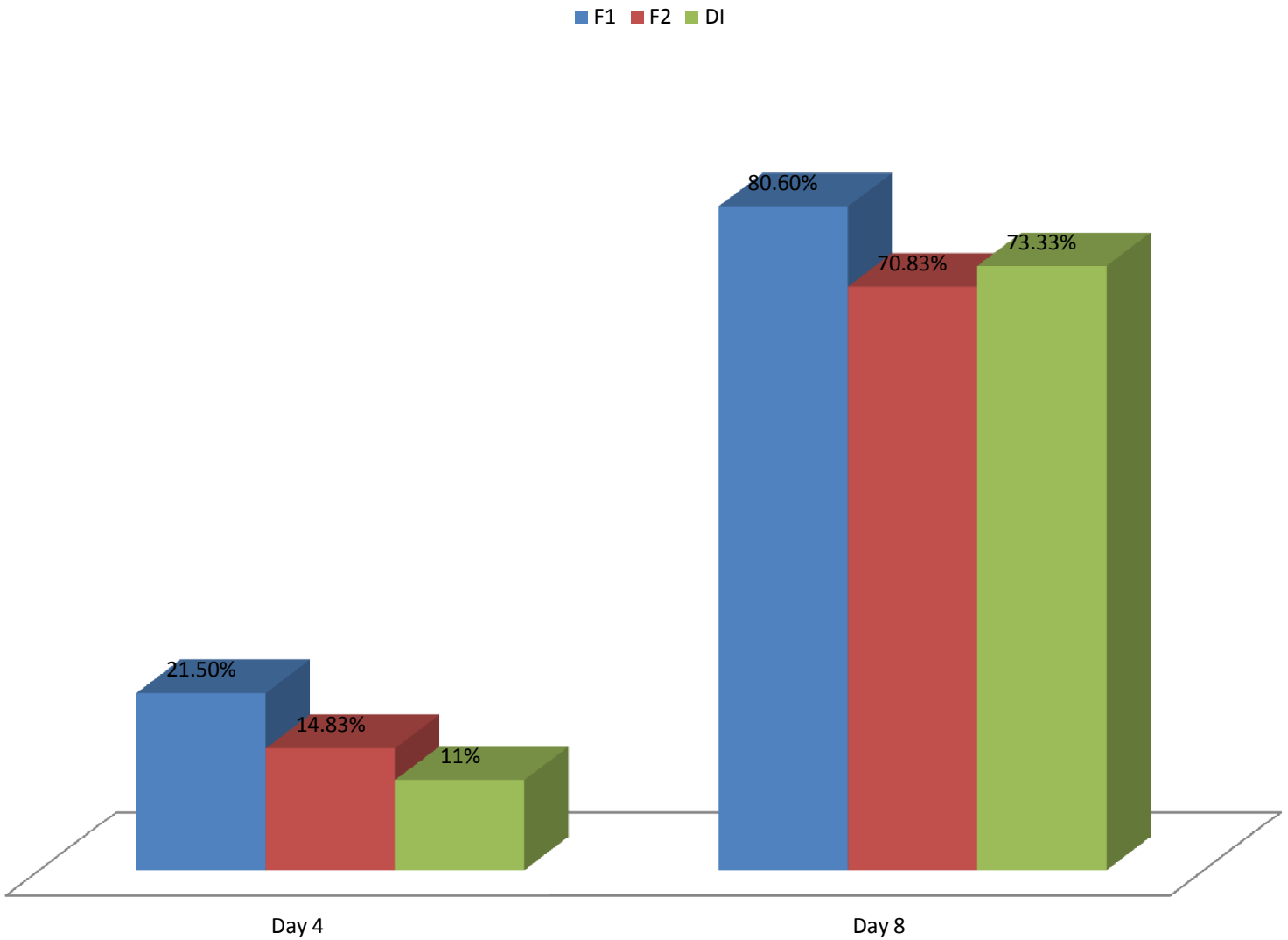


Choice of this material has major effect on effluent pH.
But also on precipitation of phosphate.

Irrigation of plants: Rye grass – *Lolium perenne*



Petridish Germination Test (Water only) - Ryegrass



Conclusions

- Need to manage water collection during winter to avoid issues with sodium.
- pH adjustment may be needed. If installing a new system we may control it with better choice of aggregate-optimisation required.
- Overall good potential to provide localised irrigation water.

Ongoing and Further Work

- Pot trials – Greenhouse experiment
- On site rainfall recording-additional parameters
- **Bury-site** - to be closed in 2016.
- Dismantle pavement and identify location and concentrations of trapped pollutants
- **Perth-site** - quantification of deposition rate within collection channels.

Acknowledgements

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