Performance results - EPIC Road filtration, SR28 Incline Village, NV.

Jonas Z. Sipaila, CEM

ABSTRACT

In October of 2016 **Nevada Department of Transportation (NDOT)** engineers in corroboration with **CH2M Hill** and **Evaporative Control Systems (ECS)** designers, contracted with Granite Construction to install the Environmental Passive Integrated Conveyance (EPIC) road filter system for storm-water management and treatment on a 1500‘ parking lot access road serving the new 3 mile multi use access pathway for Lake Tahoe.

The following spring snow-melt discharge water was sampled from current “state of the art” detention ponds (BMP’s) above and below the project area and compared to the discharge quality of the new EPIC sub-surface road filter.

The following picture shows the comparative water quality of the small basins above the EPIC system (left bottle), the large basin discharge water (right bottle), and The EPIC system discharge in the middle.

Fig 1. Comparative sample results from EPIC (center) to current BMPS.

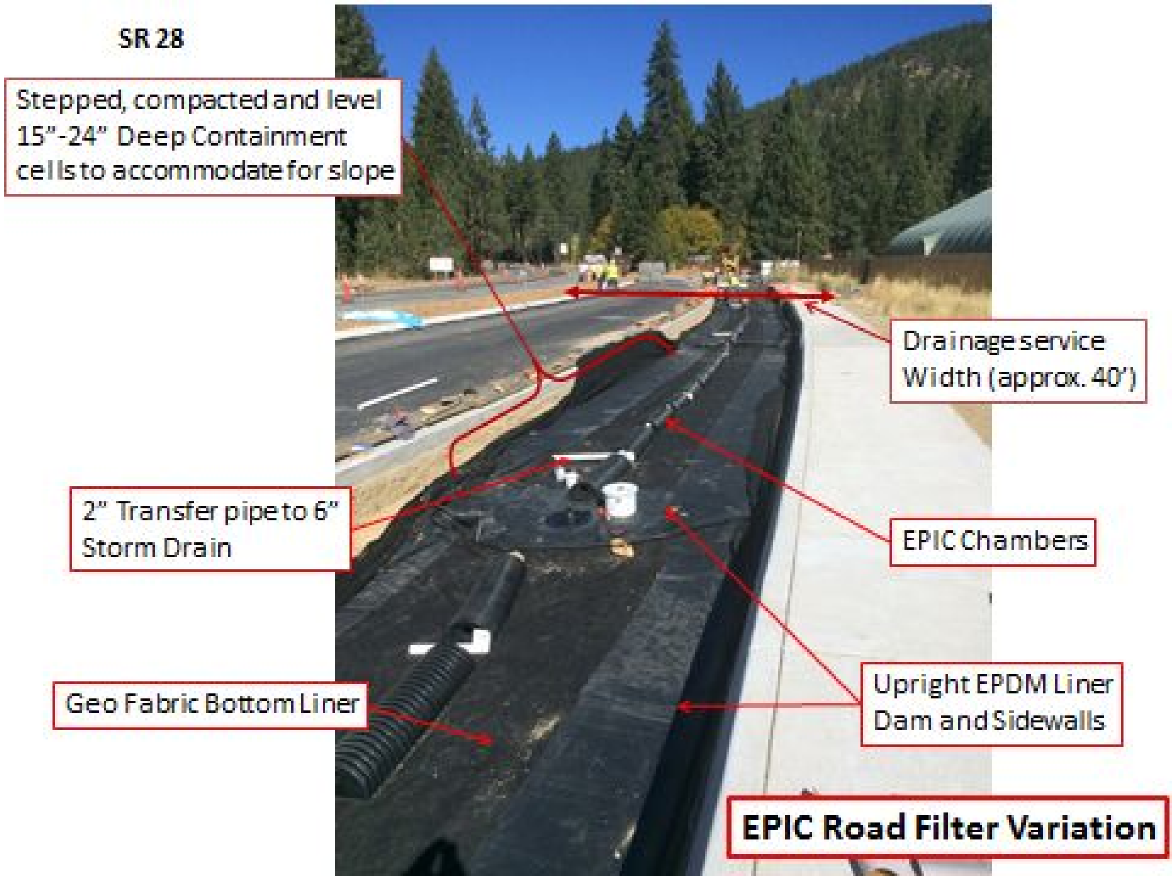

Fig 2. SR28 Construction details and functions

Components and Function explained

Absorption cells – The natural gradient of the access road is segmented into stepped and level underground benches in order to distribute infiltrated water across the entire bottom of the leveled bench to a 3" depth.

EPIC™ Chambers – The non-plugging chambers perform multiple functions of water distribution, oil/water separation, allowance of air movement into the fine gravel profile to retain aerobic conditions, a decanting process as water moves through the profile and an energy dissipater for water in motion. For more technical explanation of function and design read http://ecs-green.com/wp-content/uploads/2016/05/EPIC-ROAD-FILTER-DYNAMICS.pdf

2" Transfer Pipe – Once a 3" water depth is reached at the bottom of the profile, the transfer pipe connects to a parallel (not shown) and sloped 6" pipe to move the filtered water to the desired discharge point.

EPDM Liner walls – The L-shaped rubber liner walls create a dam between the stepped cells to retain the water to the 3" depth, and on the sides to prevent water infiltration into the road base /sidewalk elements adjoining the created cells. Without this impermeable check dam water would simply accelerate and move downslope through the porous gravel.

Geo-fabric liner – To provide a separation barrier between the sub-soil and the gravel fill of the constructed cell, a geo-fabric was installed on the bottom of the cell. It was also theorized that the porous membrane will allow water infiltration into the ground water formations.

Fill material – The 16” – 24” deep cavity was then filled and compacted with a fine gravel having the following ASTM sieve analysis. The homogenous fill served both as the base for the pavers and filtration /treatment zone for incoming storm water.

2164-#4 X #8 CHIPS

Procedure	Sieve/Test	Average	Unit
ASTM C 136	3/8" (9.5mm)	100.0	%
ASTM C 136	#4 (4.75mm)	79.7	%
ASTM C 136	#8 (2.36mm)	6.9	%
ASTM C 136	#10 (2mm)	5.3	%
ASTM C 136	#16 (1.18mm)	3.5	%
ASTM C 136	#30 (0.6mm)	3.1	%
ASTM C 136	#40 (0.425mm)	3.0	%
ASTM C 136	#50 (0.3mm)	2.9	%
ASTM C 136	#100 (0.15mm)	2.8	%
ASTM C 136	#200 (75um)	2.6	%
ASTM C 136	Pan	0.0	%
ASTM C-127	Absorption	2.31	%
ASTM C-127	SPGR (Dry,Gsb)	2.583	
ASTM C-127	SPGR (SSD)	2.643	
ASTM C-127	SPGR (Apparent,Gsa)	2.747	

Fig 3. Filter gravel ASTM particle sieve analysis

Once the structures and piping were assembled, they were simply buried and compacted with the fine gravel. Subsequently Belgard pavers are interlocked with course sand providing a functional and beautiful roadway surface.

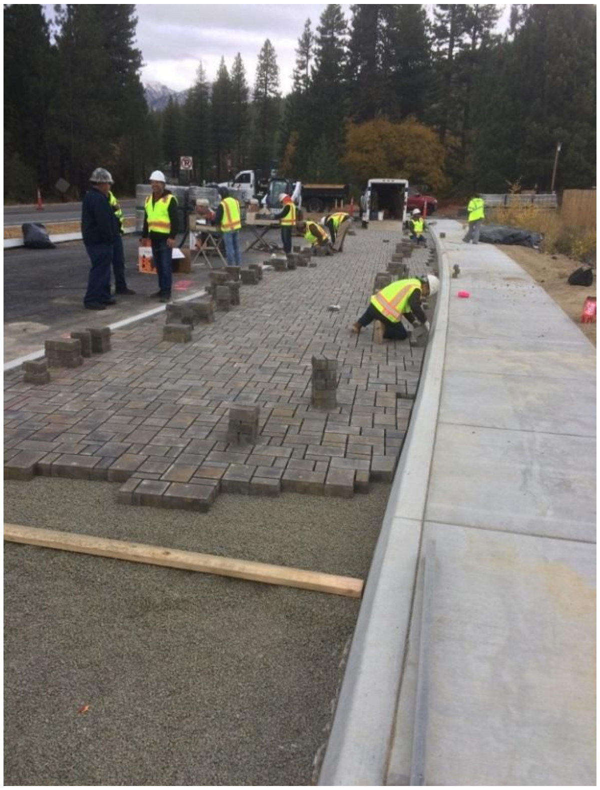

Fig 4. Porous Pavers over gravel base

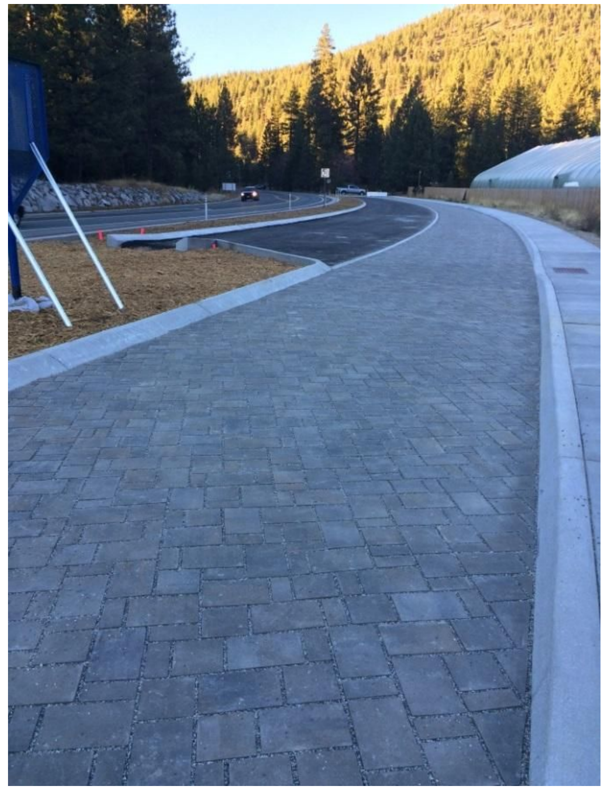

Fig 5. Finished paver surface

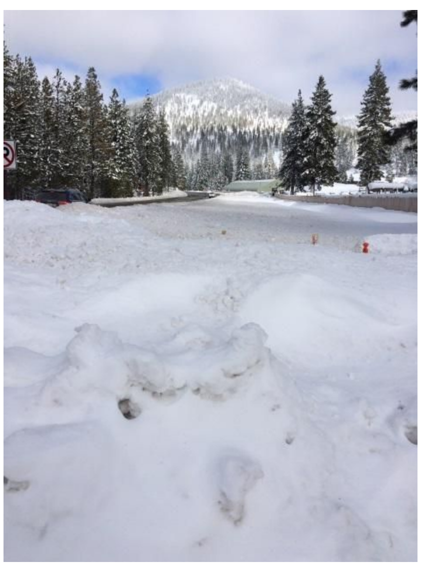

Fig 6. Snow dump buries project

The winter of 2016-2017 was a record snow year for the region. Five foot deep snow accumulated on the yet to be finished project where road snow was directly dumped on the profile from the adjoining all year highway. In April the start of snow-melt runoff exposed the darker and darker snow deposits along with residues left on top of the pavers. This provided the opportunity to study the effectiveness of the system.

Fig 7. Residues filtered on surface

As shown in the following picture, snow melt runoff receded directly into the paver profile with a very short travel distance on the paver surface. Compare this to the runoff situation on the left side where runoff through "engineered soils" (not over an EPIC drainage profile) simply flowed downhill and overflowed the curbing. The hoped for ground infiltration never occurred. Surface infiltration whether or not capped with porous mulch has a very poor infiltration rate especially on any soil with a clay content and slope.

Fig 8. No soil absorption and overflow left side – vs. quick absorption in Paver area right side

A currently common BMP (Best Management Practice) along sensitive eco-systems is the construction of detention ponds for erosion control. The theory is that water will slow down in a depressed created basin, the contaminants will settle out, and retained water will infiltrate into ground water formations.

Such a series of basins were adjacent to the EPIC project in a form of stepped and shallow (under 3' deep) ponds. The following pictures illustrate their effectiveness. In the first picture we note that the stepped ponds are not keeping up with the snowmelt rate as the ponds are full and ground infiltration is not occurring. It is also notable that low density material is simply stagnating on top of the water. Longer springtime water detention in open basins then simply provide breeding grounds for mosquitoes where depending on temperatures the cycle is completed in 4 days to four weeks. Ground infiltration is not occurring and evaporation loss may be longer than two weeks. Heavier particles (sand, silt, clay) may have settled at the bottom but in the process the non-compacted floc sealed the porosity of the base soil.

Fig 9. Adjacent Infiltration basin BMP **Fig 10. Basin overflows onto EPIC profile**

The second picture shows that surge flows due to heavier rain events or fast snow melt are not contained in the basins. In this case the adjoining surface basins overflowed over the sidewalk into the EPIC paver profile where they were absorbed. Of note is that higher flows in surface basins simply re-suspend settled contaminants which subsequently were retained as manageable deposits on top of the paver profile.

Fig 11

The unplanned adjoining surge flows into the EPIC profile did dislodge locking course fill sand in small areas of the surface paver structure, (see Fig 11) but the integrity of the coarser base foundation was not impacted by the abnormal focused flows. Large water flows were absorbed within a few feet of the focused dumping point demonstrating the effectiveness of handling fast moving water in surge situations. Sweeping the dislodged sand into the open paver crevices repairs the problem.

While technically the EPIC profile constructs a below ground detention basin 3" deep, ground infiltration into the base soil is probably not any better than surface ponds. During the sampling inspection the clear water flow rate from the 6" collection pipe was about 0.3 cubic feet per second (cfs) indicating that ground absorption was not occurring at a significant or measurable rate and/or the geo-fabric permeability was compromised.

Subsequent testing confirmed what is common with geo-fabrics. Simple rinsing of gravel (or any aggregate) dislodges adhered clay particles from the gravel and deposits them on top of the geo-fabric. In this experiment four pounds of the subject gravel was rinsed and collected on top of the geo-textile

Fig 12. EPIC discharge point

Fig 13. Clay filtrate on geo-fabric

producing a ¼" thick deposit of impermeable clay particles. While geo-fabrics can have a structural benefit to separate aggregates or insulate aggregates from native soils, the reliance of geo-fabrics to pass water into ground water formations is highly dubious and probably does not occur with any significance long term. As EPIC performance reliance is focused on surface filtration, the presence or absence of geo-fabrics in the EPIC system, or substituting the geo-fabric floor with a totally impermeable EPDM liner is an academic decision dependent on the intended destination of the filtered and treated water volume.

The new EPIC BMP was located between two existing "BMP's" at the project site. One was the series of small detention basins (previously discussed) above the EPIC Paver system and the other, a larger rock lined basin located below the system which was the last "BMP" before the discharge entered a creek that flows directly to Lake Tahoe.

Without disturbing the bottom sediment of the two surface basin systems, surface water was sampled and compared with the discharge point of the EPIC Filter at the terminal point of the 6” final discharge.

Fig 14. Surface BMP sampling

Fig 15. BMP vs. EPIC samples (center)

Dramatic water quality differences were obvious, dramatically reducing turbidity levels of storm water prior to entering Lake Tahoe or other bodies of water. The driving force for EPIC road filters however, is that it vastly improves safety conditions in the public driving corridors.

COSTS

In road construction activities, storm water collection infrastructure and additional adjacent current “BMP’s” are a significant part of construction. A sample breakdown of typical road construction costs are exemplified in the following chart. Additional “BMP” variations can greatly differ from project to project. In this example note that storm water infrastructure is $198 per linear foot and Curb and Gutter construction (which primarily deflects water movement) is $55 per linear foot. Combined we have a base line comparative cost of $253.

EPIC road filter designs offer a wide flexibility in design (from 1’ wide shoulder filtration strips at edge of pavement on the low cost end to wider paver networks under roadways or parking areas at the high end cost), and provide better storm water treatment quality at a cost fraction of current “BMP” approaches.

Fig 16. Road construction Costs

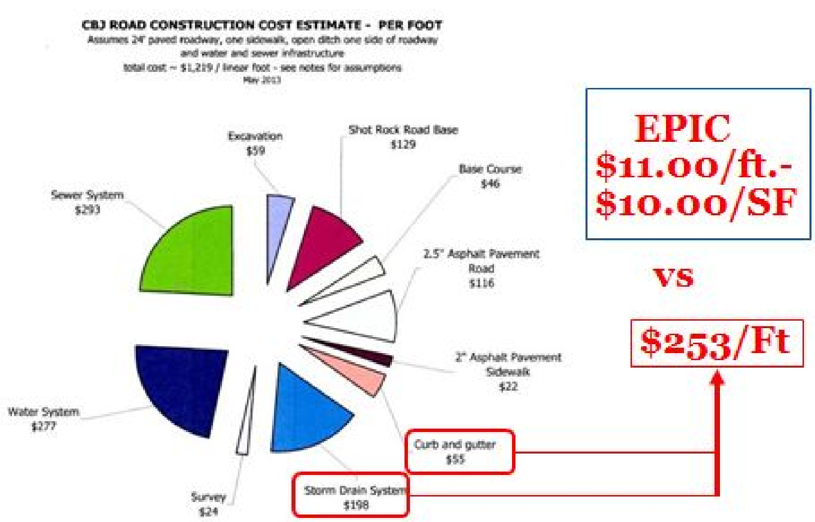

Fig 17. COMPARISON BENEFITS

Function	EPIC Filter	Detention Ponds	Comments
Ground water Infiltration	Minimal	Minimal	Soil porosity is compromised by clay particle deposition
Sediment removal	Complete filtration at the surface	Gravity settling as "floc" material at bottom of pond	Sediment retained and dewatered on easily serviceable hard surface.
Erosion Prevention	Yes	No	Abnormal surface flow events re-suspend sediment and rim edge overflow adds erosion
Mosquito breeding	No	Yes	Shallow, warm open surface waters encourage breeding of disease carrying mosquitoes.
Safety Issues	None	Yes	Open ditches along highways overturn vehicles; poor water management causes soft shoulders, ice formation on pavement during freezing.
Need for additional real estate	No	Yes	Open ponds require use of additional land. EPIC provides dual functions on same footprint.
Easy maintenance	Yes	No	Steep, soft embankments make ponds unserviceable
Oil/Water treatment	Yes	No	EPIC provides unique film separation and decomposition
Water flow control	Yes	No	Uncontrolled surface flows add erosion and structure damage to road surfaces
Water cooling	Yes	No	Water flow through cool underground gravel and structures stays cool before discharge. Important for oxygen content in Lakes and rivers.
Permanent Structure	Yes	No	Surface structures subject to damage, weed growth, natural erosion, unserviceable sediment.
Water loss	No	Yes	In dry climates EPIC provides potential resource of new water source for beneficial use. Open ponds simply evaporate and a water resource is lost.
Costs	Inexpensive	Expensive	Less than half the cost