UKSTT Annual Awards - Young Engineer 2014			
Title of Project or Report	**Holistic approach to infiltration and inflow exclusion**		
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Submission should:
be no longer than 1500 words, and
demonstrate your contribution to the field of Trenchless Technology

Judges will be looking for evidence of your **understanding of Trenchless Technology**, your **contribution** made, the **quality of the submission** and your **vision for the future** of Trenchless Technology. In line with other awards you should, where appropriate, identify in your submission factors such as **originality of approach**, **technical difficulty** and **innovation** as well as **customer care**, **client satisfaction**, **programme compliance**, **cost minimisation**, **safety record** and **environmental considerations**.

Are pictures included in the submission? **Yes**

Please attach your submission to this sheet or outline the project below.

Synopsis

The Environment Agency directive to water companies to reduce infiltration and inflow into sewers, was the catalyst for my appointment to head research which would identify and seal the most critical assets. Using different disciplines during the project identified business opportunities, which will further allow us to reduce our Totex.

Holistic approach to infiltration and inflow exclusion

Infiltration

Ground water infiltration into sewers is recognised as a considerable problem in the UK and around the developed world, and a recent Regulatory Position Statement from the EA, in Oct 2012 entitled 'Discharges made from groundwater surcharged sewers' LIT 7457 / 1409 12, stated :

'*We will not support any acceptance of continued, long term, groundwater infiltration into sewers where the infiltration risks the need for pumping out of sewers into watercourses'*

To put this in context, if you have a 'Gusher' infiltrating into a sewer at 1 l/s, that equates to a cumulative infiltration of over 31,000 m3 per annum. When you are pumping between villages to a sewerage works on the coast, the cost of that one leak could be as high as £10K per annum including treatment !! The Victorians created a wonderful dendritic sewerage system that has lasted the test of time, but it is now in need of focused repair.

Of course, in these economic times, all capital expenditure has to bring the best value and we have seen the comparative cost benefit (CB) analysis demonstrated within our area of Somerset during the recent winter flooding, where the EA expect £1 of flood defence expenditure to bring £8 of benefit. I deviate from my remit of sewerage, but only to demonstrate that we have the tools to better that CB, where a CIPR Silicate 'Patch' repair can give a conservative CB of at least £10-15, in geological areas where ground water induces a hydraulic lithology that could threaten the stability of adjacent buildings.

Don Ridgers revolutionised the consideration of infiltration when he launched his test to establish the viability of a lining system to prevent infiltration and exclude any post exothermic contraction problems of liners, at the UKSTT No Dig Show at Stoneleigh Park in 2006. From this point we have enjoyed the benefits of epoxy CIPP full-length liners to supplement the CIPR that already had stood the test of time.

The benefits in infiltration reduction are:

- Reduced treatment costs at the sewage works;
- Reduced power consumption when pumping forward to treatment;
- Reduced Opex and Capex for pump maintenance and replacement;
- Reduced premature initiation of CSO spills;
- Improved environmental standards;
- Improved customer experience in using facilities;
- Lower overall carbon footprint.
- More capacity in existing sewers for further development

In all, we have the tools to holistically solve infiltration, especially with 'Top Hats' and I have used all these techniques extensively over the last four years. The sealing of infiltration will be a major drive in AMP6 from 2015.

I recognised in 2012, that we needed a 21 Century appraisal and analytical location tool, giving a definitive method of leak detection for gravity sewers, which was not dependant on water table elevation due to seasonal rainfall, when using CCTV cameras, which is often failed to identify infiltration.

Liam MacFarlane Critical Sewers Engineer, Rehabilitation Team Wessex Water

The Evolution of Electro Scan

The Rehabilitation Team (RT) at Kingston Seymour use a mixture of British and American quality standards in their arsenal of trenchless procurement such as ASTM F1216 for the lining design along with BS EN ISO 11296: P4: 2011 and had been aware of major successes using Electro Scan (ES) to ASTM F2550 06 *'Standard practice for locating leaks in sewer pipes using the variation of electrical current flow through the pipe wall'*, in the City of Largo, USA, and had shadowed the process since 2008, then known as Fell 41.

The system has undergone a quantum leap in improvement and evolution, since being acquired by CEO Chuck Hansen of Electro Scan, Inc. Sacramento, California, and a detailed understanding of the system can be explored outside this paper. However, by way of a brief understanding the system works as follows.

Most sewer pipe materials such as clay, plastic, concrete, and brick are poor conductors of electrical current. As a result, if a defect exists in the wall of a pipe, then the leakage of electrical current will indicate the source of a potential water leak, whether or not water infiltration actually occurs at the time of the electro-scan.

Electro scanning is carried out by applying an electrical voltage between an electrode in an electrically nonconductive pipe and an electrode on the surface, which is usually a metal stake pushed into the ground. A simplified electrical circuit for this procedure is shown in Figure 1. The water in the pipe is at a level that ensures that the pipe is full at the probe location.

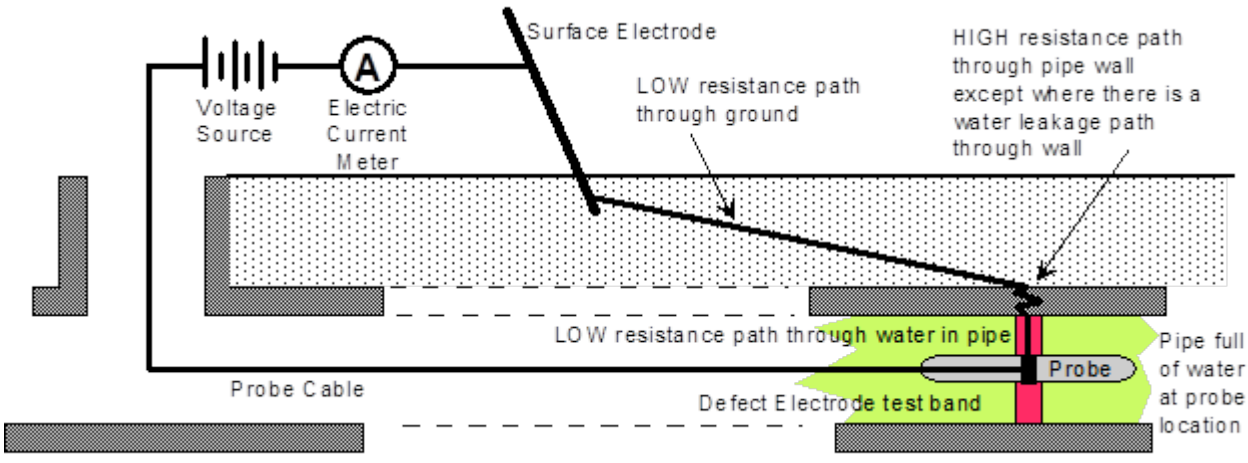

Figure 1 - Electrical Schematic of Electro-Scanning.

As the probe is pulled through the pipe the electric current flow and the position of the probe in the pipe are recorded and displayed in real time as a "current trace" via a Bluetooth connection to a Smartphone computer, with data sent to the Cloud (Figure 2).

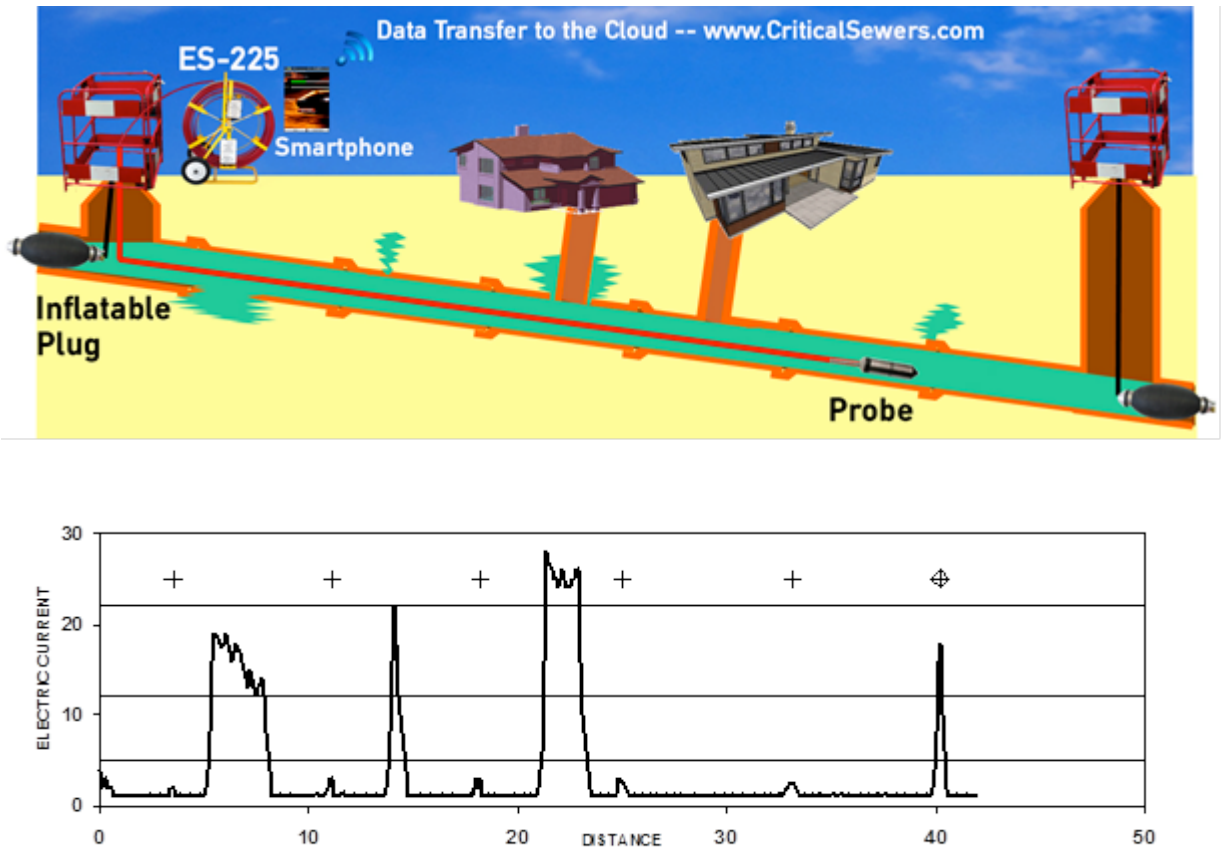

Figure 2. Electro-Scan Testing and Current Trace

My role in managing the ES was to bring our expertise to the partnership by establishing a process of drilling standpipes into the ground to data log water tables, correlated to flow monitors and rain gauges, to identify the quantities of groundwater infiltration per second.

Undertaking several Km of surveys across our region, we robustly trialed the ES unit, especially on Exmoor, identifying improvements to the hardware and working closely with Hansen's team on site.

The ES was very successful and extracts from the Mark, Somerset trials are shown in Fig 3 below. Some 43 sewer laterals were identified as the most critical assets with a cumulative infiltration of 12 l/s, giving over 1000m3 a day identified for exclusion by epoxy lining which would otherwise cost the company over £120K per annum in Opex.

Customers have been delighted with the targeted epoxy lining of major inundation, allowing them to use their facilities as normal. In addition, by lining we mitigate the open cut and occupation of highways with associated disruption. Amazingly the RT avoid over 60,000m3 of excavation a year and so avoid importing an equivalent quantity of backfill. That is 8000 muck away lorries not required on British roads. Our associated CO2 calculations show an 80% reduction of CO2 over equivalent open cut, and those calculations match those identified by Arizona State Universities Sam Ariaratnam, in his paper to the ISTT in Toronto in 2009.

But lining is not the only answer, in the process of utilising ES, we developed a method of sealing a difficult knuckle bend under Cerne Abbas High Street, temporarily sealing the sewer with a heavy duty calibration hose whilst rake drilling across the road to inject a

foaming hydrophobic structural Pu to seal the bend from outside. This prevented a £2K road closure for the day, and was economic, sustainable and customer friendly.

All of these works were completed with the most comprehensive safety considerations and RAMS in place. We must remember to reduce the time of occupation on site, automatically brings with it better safety and reduced exposure to danger for all. The acryonim for my division in Wessex Water is 'Safety, Quality, Time' and cost and in that order of importance.

All schemes administering the investigations of Es were completed to programme and within cost.

Client: Wessex Water

Site: Mark Causeway, Somerset Upstream Pipeline Ref: ERN10675

Summary List of Electroscan Data

Scan No	Scan ID	Date	From	To	Pipe Details			analysis_defect_grade				Litres per second
					length of scan (m)	dia (mm)	Material	None	Large	Medium	Small	
1	sww1_0151_nov72013104703am	11/07/2013	MH02	6001	19.37	100	VC		3			0.40
2	sww1_0152_nov72013112528am	11/07/2013	MH04	MH03	11.84	100	PF				10	0.10
3	sww1_0153_nov72013113129am	11/07/2013	MH04	6901	9.36	100	VC		5		1	0.25
4	sww1_0154_nov72013120947pm	11/07/2013	MH05	6901	5.72	100	VC			1	2	0.05
5	sww1_0155_nov7201313641pm	11/07/2013	MH08	4701	13.64	100	VC		4	1	7	0.50

Figure 3. ES results from Somerset

Conclusion

I chose to spend my first four years of my career in the RT. They are at the cutting edge of technology, and I wanted to have this trenchless technology foundation to allow me to rationalise potential savings and customer, environmental benefits on civils schemes as I move on through the major civil engineering business at the start of my career.

In that time I have been through all the in house bespoke CIPP/CIPR/GRP CPD units and built on their success by establishing the GPR in house business, whilst benefiting from the UKSTT secondment initiative when I spent time at Aiden last year. I now have a firm grounding in trenchless.

For the future, the RT and Electro Scan are developing other tools with the assistance of a nationally recognised university which will allow the mapping and risk analysis categorisation of concrete pipes which have suffered diminution of wall thickness due to erosion and chemical attack. This research project will be completed within 18 months, and should I win the Young Engineer bursary, I will use it to visit Hong Kong and China to further this research and to spend time advising the HK DSD, as they start their new 20-year sewer renovation project.