Phosphorus Removal at STW's in Cornwall

£2.8m phosphorous removal scheme at 3 STW's

by
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The towns of Camelford, Delabole and Bodmin, situated in Cornwall, benefit from a mild climate, due to the Gulf Stream, dramatic coastal scenery and a rich diversity of flora and fauna. Much of the surrounding area is moorland, open to the public and with well known cycling and walking routes such as the Camel Trail. The area is also historically important from a mining perspective, with a slate quarry and museum at Delabole. The quarry is over 400 ft deep with a circumference of a mile and a half. In 2007, South West Water identified a number of sewage treatment works in mid Cornwall that required a reduction in phosphorus levels in the final effluent being discharged to water courses. This was required to meet the European Urban Wastewater Treatment Directive as implemented by the Urban Wastewater Treatment Regulations 1994, and the National Environmental Programme.

Camel Trail and a tributary of the River Camel *courtesy South West Water*

The phosphorus removal requirements are set by the Environment Agency, having regard to the condition of the receiving water course. In this case the requirement is for the final effluent to contain no more than an annual average level of 1mg/l phosphorus as measured from 24 hour composite samples taken monthly throughout the year.

The reason for removal of the phosphorus is to avoid the occurrence of eutrophication within the received watercourse. Eutrophication is where the nutrient rich environment increases the production of algae and aquatic plants, subsequently producing changes in water quality that reduce light penetration and smothering of habitats. This can lead to large fluctuations in dissolved oxygen levels resulting in the death of fish and invertebrates. In freshwater systems phosphorus is generally the nutrient that limits plant productivity.

The sewage treatment works which required a reduction in phosphorous levels were Camelford, Delebole and Scarletts Well (Bodmin), which all discharge final effluent to the River Camel or its tributaries. The Rivers in turn discharge into the Camel Estuary which is an Area of Outstanding Natural Beauty.

The programme to undertake the work was scheduled over a 12 month period from April 2007 to March 2008.

Sites and Treatment Processes
The three STW sites were close together geographically but had a number of different treatment processes.

* Camelford STW is an activated sludge plant comprising screening plant, storm tanks, anoxic selector tank, compact activated sludge plant, final settlement tank, outfall and flow monitoring chamber and SAS thickening

* Delabole STW is a filter bed works comprising storm flow separation, screening, primary settlement, percolating filters final settlement tank, nitrifying filters, tertiary treatment (dynasand), outfall and flow sampling chamber.

* Scarletts Well STW is a filter bed works comprising storm flow separation, screening, primary settlement, six rock media filter beds, final settlement tank, outfall and flow monitoring sampling chamber.

The solutions for phosphorus removal had to be individually tailored to the needs of each treatment works in terms of chemical dosing algorithms, locations of flow monitors and dosing points.

Phosphorus Removal
There were several options but the two primary options are chemical precipitation or biological removal. In this instance, biological removal would have necessitated major alterations which were impractical as well as financially unviable. Therefore chemical precipitation was selected as the preferred process.

The most appropriate method for reducing the phosphorus

Metal salts & alkalinity dosing kiosks at Scarletts Well in Bodmin *courtesy South West Water*

concentration in the sewage is by dosing with a metal salt, either aluminium or iron, to precipitate the phosphorus as an insoluble phosphate.

To deliver the chemical, two dosing points were used; the first to remove most of the phosphorus, and the second as a polishing dose to the final effluent. It was also decided to dose downstream from biological treatment, to avoid the possibility of inhibiting treatment because of nutrient phosphorus deficiency.

The dosing system chosen was to pump chemical solution to a location with either a suitable hydraulic drop or a chamber with mixers which would guarantee chemical reaction times. A new dosing kiosk housed the equipment and provided a nominal storage volume of 30 days.

Alkalinity

The alkalinity of the sewage tends to be reduced by the dose of metal salt. At low alkalinities the waste water pH falls and the treatment performance of the works is inhibited. Also the pH may fall below the optimum for phosphate removal. For the soft waters within the area in question, the alkalinity must be supplemented by further dosing with sodium carbonate. This is supplied in powder form and delivered by a screw feeder system prior to the first dose of metal salts.

New kiosks containing hopper units fed with either a big bag or vacuum hopper filling system, and sufficient space for storage of chemical bags in the dry, were provided at each site. Each unit can run for four days without intervention (i.e. re-filling) Chemical storage space is sufficient for a minimum of 10 days supply.

Safety showers were also provided alongside the delivery area between the alkalinity and chemical dosing plants.

Tertiary Treatment & Phosphorus Monitoring

In addition to the metal salts and alkalinity dosing, tertiary treatment was provided in the form of a microstrainer to remove aluminium phosphate solids, and residual suspended solids which may contain some phosphorus.

Permanent sampling of incoming and final effluent levels of phosphorus was undertaken to allow the dosing profile of both metal salts and alkalinity to be determined over the course of a day.

Design

Each design was on the basis of providing a suitable solution for a 15 year design life, to reflect predicted increases in populations within the catchments served by the works. Predicted peak populations in the year 2022 are 3,200 at Camelford with full flow to treatment of 15l/s, 2,200 at Delabole with full flow to treatment of 7.8l/s and 6,800 at Scarletts Well with full flow to treatment of 46l/s.

The design of ancillary plant also took account of the extra mass and volume of sewage sludge that would be produced by chemical dosing - an increase of 12m^3 per day across the three sites by 2022.

Flow and Load Survey

A full flow and load survey was undertaken at each site in June/July 2007 as part of investigations to establish and specify the equipment necessary to achieve phosphorus removal. *Partech* phosphorus monitors, which use colorimetric analysis and determined ortho-phosphorus, total phosphorus. alum and pH, were successfully trialled over the same period.

Dosing Control and Profile

One of the most important elements of the dosing system was the dosing profile. This optimised the chemical dose and avoided under-dosing which would lead to high phosphorus in the effluent or overdosing. As a result chemical costs were kept to the minimum without the risk of residual metals in the final effluent.

The dosing rates were matched to the phosphorus load. The rate was controlled by a combination of a flow meter and an on-line phosphate monitor. It should be noted that there is not a direct relationship between flow and phosphorus levels, and as such a purely flow paced solution is unlikely to be sufficient for the 1mg/l consent.

A default look-up table was developed specifically for each site in the event of a failure in the phosphate monitor or flow meter. This identified appropriate hourly dose rates for a seven day profile.

Dosing trial

In order to prove the viability of the proposed solution a temporary dosing trial was conducted at Scarletts Well from October 8th to 23rd. This confirmed the viability of the chosen solution and the selection of WT18, as the choice of metal salt for the schemes.

The equipment used for the dosing trial consisted of two bunded IBCs, for sodium carbonate solution and aluminium sulphate/WT18, each equipped with a small dosing pump. A programmable timer/controller allowed stop and start times for each day of the week in increments of one hour.

During the trial, incoming levels of phosphorous ranged from 9-24mg/l. These reduced to 0.5mg/l in the primary effluent and 1.5mg/l in the final effluent. Higher final effluent levels were due to residual phosphorus in the filter beds. This played an important part in the final commissioning where allowance was made by starting dosing three weeks before the target date to ensure the residual levels in the filters reduced sufficiently.

Procurement

The project relies heavily on package plant with the key constituents being *Partech* monitors to establish the levels of phosphorus and determine dosing levels. Sodimate sodium carbonate dosing equipment to raise alkalinity levels, *Lintott* dosing system to deliver WT18 to assist settlement and remove the majority of phosphorus and WPL Microstrainers to provide a suitable level of tertiary treatment to remove any residual phosphorus within particles in the final effluent.

All these items are specialist and therefore have long delivery of up to 20 weeks that need to be incorporated into the project programme.

Construction

Edmund Nuttall Ltd undertook construction of all three projects, Construction activities can be split into three key elements.

* **Civils** - chambers, base slabs, sludge tanks;
* **MEICA** - cabling, MCC, power supply;
* **Package Plant** - kiosks, dosing systems.

Construction of the civils work started in November at all three sites, followed by MEICA in the form of preparatory work for the arrival of pre-packaged plant. The package plant arrived in February and March with the substantial benefits of being factory produced and tested, "bolt down and plug in" items of kit which significantly reduced construction time.

The Camel Trail and North Cornwall Trail, heavily used by local people and tourists in the summer, run alongside the river Camel and close to the construction works. To minimise disruption to the public, construction was undertaken in winter.

Conclusion

These projects represent a new chapter in the provision of nutrient removal for South West Water. The schemes at Camelford, Delabole and Scarletts Well have provided a suitable method of reducing eutrophication and maintaining the ecology within the river Camel both now and in the future. There will be an increasing number of projects of this nature throughout the South West in the future.

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