Inverness WTW & Reservoir:

new ultra filtration process provides *cryptosporidium* barrier

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A 'fast track' partnering project taking 20 months from design to operation has provided the City of Inverness and its environs with a water treatment facility of leading technology, capable of delivering 34 Ml/d of high quality water through a process of chemically assisted ultra-filtration, providing an effective barrier to *Cryptosporidium Oocysts.*

Inverness WTW View of micro-strainers *(courtesy Earth Tech Engineering Ltd)*

The project, one of the first major partnering exercises entered into by North of Scotland Water Authority (NoSWA) was awarded to *Earth Tech Engineering* on a Design and Construct basis in May 2000. The requirement to work in a partnering environment was driven by an Undertaking placed on NoSWA by the Scottish Executive to have a barrier in place, to prevent *Cryptosporidium* entering supply, by 31 December 2001. The fact that this was achieved in such a short time scale and to budget demonstrates the value of close teamwork, pooling of resources and the development of excellent working relationships from conceptual design and process selection through to construction and commissioning.

Existing facilities

Prior to completion of the works raw water from Lochs Duntelchaig and Ashie was abstracted and fed to the existing treatment facilities at Oldtown and Balmore. The basic filtration, pH adjustment and disinfection afforded by these facilities could no longer provide the degree of treatment necessary to meet the standards required by the Water Supply (Water Quality) (Scotland) Regulations 1990. In particular, the sources had been identified as high risk for *Cryptosporidium Oocysts* and, as a consequence, an undertaking date was placed by the Scottish Executive to have an effective barrier in place by 31 December 2001.

The two sources also varied in quality due to the shallow Loch Ashie being subject to periods of high colour and turbidity. The deeper and larger Loch Duntelchaig yields 27 Ml/d and provides a consistent high quality raw water. However, due to demand requirements there was a need to utilise the 7Ml/d yield from Loch Ashie hence, a flexible process was required capable of treating both sources with the ability to provide a barrier to *Cryptosporidium*.

On this basis the project team of NoSWA and Earth Tech undertook feasibility, pilot plant work and whole life costing analyses in order to determine the appropriate process for the treatment works. In addition, the project scope included construction of a 34 Ml/d treatment works, a service reservoir of 35 Ml and approximately 7.5km of 700mm diameter treated water pipe work to connect into the distribution system serving Inverness. New raw water pumps were also installed at Loch Duntelchaig together with a new pumping station at Loch Ashie to lift water to the works inlet.

Process selection & pilot work
The preliminary design phase consisted of a feasibility stage to investigate the process options available, culminating in a Value Management exercise undertaken by the project team to identify the preferred process. This indicated that chemically assisted membrane filtration was the optimum choice for the raw water envelope present in the sources. Following this decision an intensive period of pilot plant work was undertaken to evaluate the operating costs and performance of three potential membrane options. This enabled the project team to identify the most appropriate membrane supplier based on whole life costs and performance during the pilot trials.

The ultra-filtration system offered by *Norit Membrane Technology* proved to be the most appropriate for the particular raw water abstracted from the lochs. On this basis building envelopes were developed around the identified process to enable planning approval to be sought and the process design to be completed.

Detail design phase
The detail design phase was undertaken completely in house by *Earth Tech*, an ability that undoubtedly assisted in the timely completion of this 'fast track' project. The full process, civil, structural, geotechnical, MEICA and software design was produced by *Earth Tech* with the full involvement of NoSWA members of the project team in a true partnering environment.

An important early design related issue and key to obtaining planning approval was the requirement to produce an implemented scheme that was sympathetic to the existing environment. This required close liaison with the Highland Council, Scottish Natural Heritage and the Scottish Environmental Protection Agency (SEPA) to produce a complementary development that blended in with the indigenous flora and fauna. A major element in achieving this was the formation of a contoured mound from excavated material, landscaped through the transplanting of the natural heather turves, following surface stripping of the site for the works.

The process
The process route consists of micro straining to remove particulates greater than 80 microns in diameter followed by the addition of a chemical coagulant (poly-aluminium chloride). The coagulant enables colour colloids to be removed by the downstream ultra filtration membranes along with other particulates. Final chemical conditioning includes pH adjustment, using lime, phosphoric acid dosing to reduce plumbosolvency and chlorination to ensure more effective disinfection throughout the distribution system. This is the first WTW in the UK that combines chemical coagulation with ultra filtration.

The hollow fibre ultra filtration membranes, supplied by *Norit Membrane Technology* are a hydrophilic polyethersulphone blend with a pore size of 150,000 Daltons. This is roughly equivalent to 0.05 microns, around one hundred times smaller than the size of a typical *Cryptosporidium oocyst.*

To demonstrate that the guaranteed 4 log (99.99%) removal of *Cryptosporidium* sized particles is being achieved, an on-line membrane integrity test is performed periodically. Other treated water requirements include colour less than 5 Hazen and turbidity less than 0.2 NTU. The WTW is now producing water for public supply and has demonstrated a water quality typically well within these limits.
The membrane system comprises seven primary (6 duty/1 standby) and two secondary (duty/assist) racks. A bleed from the permeate is provided to supply clean backwash water. The membranes feature automatic backwashing and chemical cleaning by periodic Chemically Enhanced Backwashes (CEBs) along with automated integrity testing.. Dirty washwater from the primary membranes is recovered through the secondary membranes, with the dirty wash water from the secondary membranes in combination with the neutralised CEB pumped to sewer via a dedicated water pipeline.

Construction phase
A highly motivated site team, assisted and complemented by focused and driven subcontractors, undertook the construction phase. The speed of construction required daily team meetings on site to identify the key deliverables required in the following 24 hours in order to adhere to programme. At critical stages uninterrupted installation was introduced through shift working to ensure that milestones were achieved, Throughout, the project team worked closely to resolve construction issues and, as a consequence of the teamwork engendered, problems were overcome and installation completed to the tightest of programmes.

Commissioning
Commissioning was considered early in the design phase in order to incorporate several key commissioning facilities into the permanent design. The commissioning strategy was developed on an iterative basis by the project commissioning team, comprising key members of the project team from both *Earth Tech* and NoSWA. Throughout the development of this strategy SEPA were kept informed and were involved during the commissioning when there was a requirement to undertake controlled discharges to water courses. A particular example of the teamwork involved to resolve a disposal problem was the requirement to adjust the pH of raw water that had been used in 'drop tests' undertaken on the service reservoir. This water had been transferred from one compartment to the other and in doing so had been kept in situ for an extended period. This had led to the pH of the water rising to a level that would have prevented discharge to water course. The solution determined by the team was to inject carbon dioxide and introduce temporary mixing in in order to reduce the pH and consequently bring levels back to within acceptable limits. Safe discharge to watercourse was then permitted by SEPA.

The plant is currently supplying *Cryptosporidium* screened potable water to Inverness with take over planned for 28 March 2002, one month ahead of programme.

Inverness WTW and Reservoir represents the continued commitment by NoSWA to meet a demanding water quality improvement programme and was undertaken *by Earth Tech,* achieving the required undertaking date under a design and construct project valued at £15 million. ■

Note: *Jonathan Kay is a Project Manager with Earth Tech based at the company's Tankersley office near Sheffield; Peter Wilson is a Senior Project Manager for NoSWA based in Inverness; Peter Armstrong is Earth Tech's Construction Manager for Scotland and Northern Ireland based in Inverness.*

Inverness WTW Membrane skids *(courtesy Earth Tech Engineering Ltd)*