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Sarah Ryan(1), Hans Wouters(2), Jennifer MacNamara(3)

(1)(3) Conway Engineering
(2) Brightwork BV, the Netherlands, corresponding author: h.wouters@brightwork.nl

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| Introduction

As one of European Union's key strategic ports, Dublin Port has secured significant funding to transform its infrastructure over the next two decades. The €230m Alexandra Basin redevelopment (Fig. 1) is the first major project undertaken under the port's Masterplan 2012-2040. The aim of the five-year project is to deepen and lengthen 3km of the port's berths and provide an entrance channel with a depth of at least 10m. The dredging works are subject to strict regulation under planning and environmental consents for the project.

Figure 1 – Alexandra Basin Redevelopment Plan

Conway Engineering was appointed by Main Contractor, Roadbridge Keating JV, to design and build a turnkey solution for the treatment of contaminated leachate from dredging (Fig. 2), without which the works at the Alexandra Bain could not proceed. The contamination relates to historical ship building and maintenance at the port. The presence of toxic materials mean that stabilisation and treatment of sediment and leachate is required prior to re-use or disposal.

Figure 2 – Dredging in Progress

| The Challenge

They key challenge on this project was to develop a water treatment process that would enable dredging of this highly contaminated location to proceed while ensuring compliance with strict effluent discharge limits.

The presence of Tributyl tin (TBT) in the dredge was the key concern for the Environmental Protection Agency (EPA). TBT is a toxic biocide that was used in anti-fouling paints until it was banned in 2003. The toxicity of TBT prevented the growth of algae, barnacles and other marine organisms on ship hulls. However, it leached from the paint and accumulated in marine sediments at the port. To avoid reintroducing this toxic substance into the marine environment, the EPA set onerous discharge limits for discharges from the dredging works (ref. Table 1).

Table 1 – EPA Discharge Limits

Key Contaminants	
Mercury	0.00065 mg/l
TBT	0.000014 mg/l (14ng/l)
Arsenic	0.17 mg/l

Following an extensive literature review, Conway Engineering identified that there was little recent international experience in the delivery of treatment plants capable of meeting such stringent TBT standards. Conway Engineering therefore joined forces with Brightwork in the Netherlands to design a bespoke treatment process for the Alexandra Basin.

One of the key constraints in the design was the limited amount of data initially available to determine the characteristics of the leachate to be treated. This was due to both the variable nature of the dredge sediments and the ongoing analysis of stabilisation options. Due to the tight programme, a solution was developed for our client to allow the leachate treatment plant to proceed, but with flexibility to enable the process to be altered and extended on site.

The initial design of leachate treatment process was based on a geochemical characterisation study and supernatant samples taken from sediment in the basin. The limitation of this data was that it was not representative of the leachate from the dredge stabilisation process itself. The key unknowns included the pH and the amount of the contaminants that would be removed by the stabilisation.

Our analysis indicated that at higher pH levels (above 8) the TBT in the leachate is much more soluble and harder to remove. Therefore, facilities to adjust and optimise the pH of the leachate were incorporated in our design. A further constraint was the limited site area available.

Following examination of a range of options, lamella plate settling was selected as the optimum technology to remove contaminants within a small footprint. The design would allow for easy assembly and disassembly on site to enable relocation within the port if required.

Conway Engineering and Brightwork proposed a bespoke treatment process that included the following key elements to allow the plant to be modified or extended on site if required;

- Dual process treatment streams
- Online pH monitoring
- Inclusion of both acid and alkali dosing options
- Space for additional filtration equipment

| Design, Construction & Commissioning

The treatment process proposed combined coagulation, flocculation and tilted lamella plate settling. The process included two parallel treatment streams, each treating a flow rate of 3.45l/s during normal operation, but capable of treating the peak flow of 6.9l/s if maintenance was needed on one stream.

The process combines coagulation & flocculation in a flocculation tank, followed by settling in tilted plate separator (TPS). The coagulant (Alum) is dosed at an inline static mixer for rapid mixing. Flows continue into the flocculant tank where slow mixing promotes floc formation. Flows then gravitate into the settling tank where a Tilted Plate Separator (TPS) is provided (Fig 3). In this type of lamella plate system, a homogeneous laminar flow is achieved through each plate, promoting optimal settling efficiencies and fast removal of settled sludge. The flocs settle out on the lamella plates and fall by gravity to a sludge cone at the base of the tank. The TPS provides high settling rates within a very small footprint.

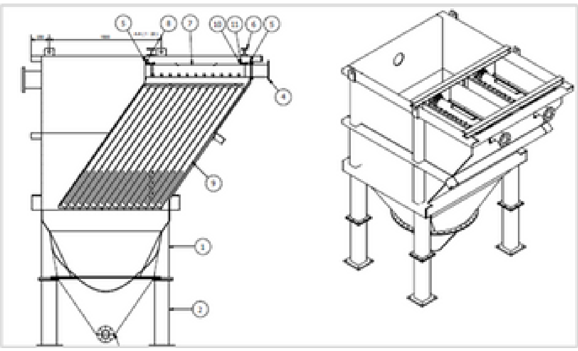

Figure 3 Tilted Plate Settler

Figure 4 Tilted Plate Settlers being installed on site

Key Features of the Design;

- Dual process streams, each capable of treating peak flow, ensuring no plant downtime of the plant
- Small footprint & fully bunded
- Fully automated controls with remote monitoring capability

The pipework, tanks and access platforms were fabricated off-site and delivered to site for installation and assembly.

Once dredging began on site, leachate from the dredge stabilisation process was pumped to the treatment plant. However, an analysis of the samples identified significantly higher concentrations of TBT in the leachate than had been present in the baseline samples used for design. In addition, pH levels were well above neutral, lead to "leaching" (increase solubility) of the TBT. As a result, the concentration of TBT in the leachate effluent was not reaching the discharge limit of 14ng/l, despite the solids removal in the treatment scheme being in line with the expectations.

The design team held a series of open discussions and workshops with our client Roadbridge Keating JV to analyse the problem and devise a solution to reduce TBT levels and allow dredging works to proceed. This open collaborative approach proved extremely successful in overcoming the challenges arising in the delivery of the project.
A number of key solutions were proposed to address the increased TBT levels in the leachate;

- Adjustment of the pH to neutral levels prior to coagulation, flocculation and lamella plate settling, thereby reducing soluble TBT levels.
- Re-use of part of the treated effluent as process water in the dredge batching plant, thereby reducing the effluent discharge volumes to the sea and reducing the use of potable water;
- Increased removal of solids downstream of the tilted plate separator by implementing a sand filtration stage and a granular activated carbon (GAC) filtration stage.

Before proceeding, a series of detailed lab trials were undertaken by Brightwork own laboratory to verify the design basis for the above proposals. The key issue was to ensure that a high level of TBT removal could be continually achieved without deterioration in performance of the filtration stages over time.

These lab trials (see Fig. 5) were executed with standardized granular activated carbon (GAC) columns to determine both the output concentrations and the adsorption capacity. Also, a "breakthrough curve" was composed to determine the stand-time expectancy of the GAC prior to regeneration. The results were used to design the full scale plant and ensure no deterioration in TBT removal efficiency over time.

Figure 5 – Lab trials - GAC Column Tests

The following two additional stages were then added to the process;

1. ***Moving Bed Continuous Sand Filter***

The Moving-bed Continuous Sand Filter is an upflow-type continuous sand filter (see fig. 6). As water filtration and sand washing can be performed simultaneously, continuous filtration is possible, with no interruption for sand washing. Feed water flows upward through the filter bed and filtrate is discharged at the top, with solids retained. Filter sand is continuously sucked into the lower end of the airlift and transported vertically towards the sand washer at the top of the filter. Stable solids removal is guaranteed in this process.

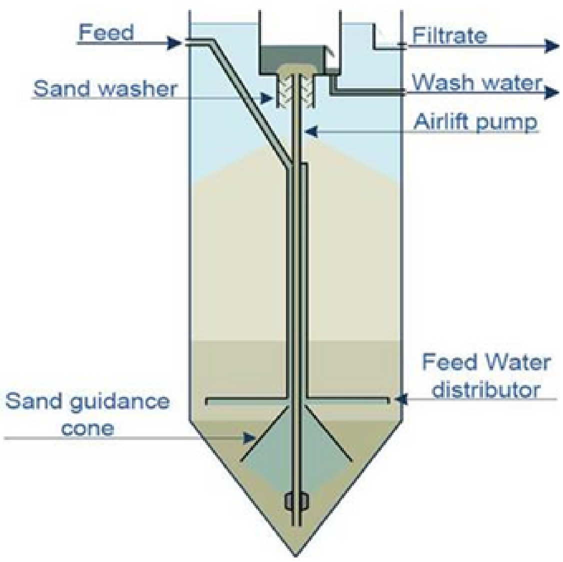

Figure 6 – Schematic of Continuous Sand Filter

In order to optimise the performance of the proposed filter system, a sophisticated remote monitoring tool was put in place to monitor the day-to-day operations. This tool, Sand-Cycle (www.sand-cycle.com) was developed by Brightwork to provide remote instantaneous access to a computer dashboard which provides all relevant process parameters in real time (see Fig 7).

Figure 7 –Sand Filter Monitoring System

This system is used to immediately identify and report any anomalies in plant operations. This technology is based upon RFID tags, which are moving together with the sand grains in the filter bed. These tags act as intelligent proxies for the sand grains and reveal the proper functioning of the filter.

2. ***Granular Activated Carbon (GAC) Filtration***

The second additional stage put in place consists of two serial GAC filters which are fed by gravity from the moving bed continuous filter. The serial set up allows the operator to swop filters, once the first stage GAC filter is saturated. With this robust process set-up, the maximum adsorption capacity of the carbon is utilized.

Figure 8 -Moving bed filter for solids removal

| Final Results

Following the extension of the treatment plant to include the additional filtration stages, the TBT levels in the effluent dropped significantly below the discharge limit, as shown in Figure 9, allowing dredging to progress on site.

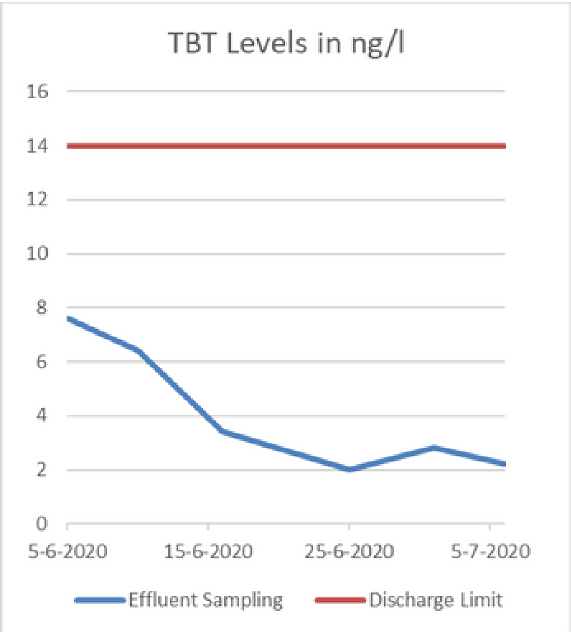

Figure 9 - Effluent Sampling Results

The leachate treatment plant installed was designed to be easily assembled and dis-assembled, allowing for re-installation at other locations. Due to its small footprint and ease of assembly, the plant has future potential as a temporary treatment plant for other dredging, waste or soil stabilisation projects.

Figure 10 – View from the Access Platform with Dredging operations behind

Conclusions and Future Potential

This project involved the design, build and commissioning of a turnkey solution for the treatment of contaminated leachate from dredging operations at Alexandra Basin. The key challenges included the level of contamination, the onerous discharge standards, the site area available and the limited sampling data initially available for design.

The open collaborative approach adopted by Roadbridge Keating JV, allowed Conway Engineering and our delivery partner, Brightwork, to work with our client deliver a bespoke treatment process that was optimised and extended on site to ensure compliance the strict environmental licensing in place.

Figure11 – View of the Completed Plant

Get in touch

Hegedyk 2, 8601 ZR Sneek,
The Netherlands

+31 515796550
info@brightwork.nl
www.brightwork.nl