Gartloch Hospital

Case Study
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CASE STUDY: GARTLOCH HOSPITAL

Location: Glasgow, Scotland
Development type: Residential (approx 450 new build houses and 150 new houses from existing building refurbishment)
Area: 40 Hectares

Key Topics:
Construction best practice: Erosion and sediment control plan, temporary works, monitoring
Sustainable Drainage: Three independent SUDS treatment trains
Legislation: Surface water discharge licensed under Controlled Activities Regulations (CAR)
Environment: Nutrient sensitive receiving water and surrounding fen classified of environmental importance

1. Aims and objectives

This case study investigates the planning, implementation and supervision of construction best management practices (BMPs) to minimise the impact on:

- The water environment during the construction phase, and
- The SUDS treatment train, intended to manage the (post-construction) pollution and flood risk from the development.

2. Learning points

- The impact of construction on the water environment
- Risk based regulation
- Temporary works to manage erosion and sediment

3 Site Overview

In 1889, the City of Glasgow bought Gartloch Estate, located on the outskirts of the City of Glasgow, for an estimated £8,600. In 1896 Glasgow City District Lunacy Board elected to build an asylum for the poor within the grounds. The hospital was closed in 1994 and the site sold for private development.
The main hospital building, classified as a protected grade ‘A’ listed building, is located within the centre of a hillock with surrounding ground to the east, south and west sloping towards open fen, marsh and ultimately the Bishop Loch. The surrounding areas (to the north, east and west of the site) are open farmland.

The Bishop Loch is one of seven small lochs within the area which are interconnected by a number of water courses, drainage ditches and lochans. The Bishop Loch and surrounding fen is classified as a Site of Special Scientific Interest (SSSI), Local Nature Reserve (LNR) and as a Site of Importance for Nature Conservation (SINC).

![Figure 1. Gartloch location & existing site and Bishop Loch Receiving water (Image produced from the Ordnance Survey Get-a-map service. Image reproduced with kind permission of Ordnance Survey and Ordnance Survey of Northern Ireland).](image)

4. Stakeholders & regulatory requirements

Approval of the development involved consultation with a range of stakeholders as indicated in Table 1 (below).

The environmental importance of the site necessitated both the Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH) to be key consultees in the planning process.

SNH raised particular concern about soil disturbance during construction and the potential impact on water quality and habitat of the Loch and surrounding areas. The Bishop Loch area provides habitat for many species of biological interest including; 14 species of water shrimp, 13 species of...
water snails, the nationally notable water beetle *Agabus unguicularis* and the moth *Limnaccia phragmitella* which is rare in Scotland.

Table 1. Gartloch Development Stakeholders & Interests

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Role</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decision maker</td>
<td>Regulators and interest groups</td>
</tr>
<tr>
<td>New City Vision</td>
<td>X</td>
<td>Planning bodies</td>
</tr>
<tr>
<td>Dougall Baillie Associates</td>
<td>X</td>
<td>Wild life</td>
</tr>
<tr>
<td>Local Authority</td>
<td></td>
<td>Heritage</td>
</tr>
<tr>
<td>Scottish Environment Protection Agency</td>
<td>X</td>
<td>Environment</td>
</tr>
<tr>
<td>Scottish National Heritage</td>
<td>X</td>
<td>Water quality</td>
</tr>
<tr>
<td>Scottish Water</td>
<td>X</td>
<td>Water quantity</td>
</tr>
<tr>
<td>Greenbelt Group Ltd</td>
<td>X</td>
<td>Local communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strategy planners</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Development control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Road/Transport</td>
</tr>
</tbody>
</table>

Dougall Baillie Associates (DBA) was commissioned as the water management consultant by the developer, New City Vision. DBAs involvement in the project spanned from the master planning feasibility, to detailed design and supervision of the construction phase.

The SUDS drainage strategy was developed during the period off 2004-2006 in consultation with the stakeholder group. This timescale is of particular importance as the development coincided with the introduction of the Water Environment (Controlled Activities) (Scotland) Regulations 2005, commonly referred to as the Controlled Activity Regulations (CAR). CAR introduced changes in how surface water discharges were managed within Scotland.

Two key concepts of CAR are of relevance to the development:

1. CAR introduced a risk based approach to regulation of water related activities, including discharge of surface water from developments. This involved three tiers of regulation; compliance with predetermined conditions (called General Binding Rules, GBRs), registration and licensing.

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2. CAR required that Sustainable urban drainage systems (SUDS) are used for all new developments in Scotland (with the exception of where run-off is from a single dwelling and its curtilage, or if the discharge is to coastal water).

Due to the environmental sensitivity of the Bishop Loch and surrounding area, the surface water discharge from the development was escalated to a simple license under CAR; believed to be the first to be issued in Scotland by SEPA.

The CAR License stipulated that the water environment must be protected:

- The water environment was protected during the construction phase by means of suitable temporary works and that a monitoring regime was implemented,

- Post-construction that the water environment was protected using a SUDS treatment train, commensurate with the level of pollution risk to the water receptor, was designed and implemented.

When the site was developed legislation governing adoption (and maintenance) of SUDS had yet to be introduced within Scotland.

Planning conditions stipulated that long term maintenance of the SUDS was catered for to ensure the treatment train operated as designed; this was initially overcome by agreeing transfer of ownership and responsibility of the open space areas (following completion of all phases) including the SUDS, to a private management company. This process has been used for the first of the ponds to be constructed (Pond A).
A change in conditions for SUDS adoption within Scotland\(^3\) has arisen since the initial planning consent. At time of writing the construction of the site is not completed; Pond B has been implemented but Pond C and the contributing phases have not yet begun.

Confirmation has been given by Scottish Water that the pond(s) design is satisfactory and that they will be vested\(^4\) within Scottish Water subject to the conditions for vesting in Sewers for Scotland 2\(^{nd}\) Edition.

### 5. SUDS Treatment train design

The selected SUDS strategy for Gartloch was agreed with SEPA during the consultation period. A higher level of treatment than would normally be necessary (for a residential development of this size) was required for the site due to the environmental importance of the Bishop Loch and surrounding fen areas. The design included a three treatment stage treatment train to ensure runoff discharging to the water receptor had been adequately treated.

\[\text{Pond A: 4Vt pond (2240m}^3\) plus attenuation to the 1:200 year storm + 20% allowance for climate change}\\
\text{Pond B: 2Vt pond (410m}^3\) plus attenuation to the 1:200 year storm + 20% allowance for climate change}\\
\text{Pond C: 2Vt pond (1400m}^3\) plus attenuation to the 1:200 year storm + 20% allowance for climate change}

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\(^3\) The legal definition of the term ‘sewer’ was amended under the Water Environment Water Services (Scotland) Act (2005) to include SUDS. Subsequently Scottish Water was obligated to adopt SUDS designed and implemented in line with the new technical standard (Sewers for Scotland 2\(^{nd}\) Edition) published in 2007, providing a formalised means for SUDS adoption in Scotland.

\(^4\) The process of vesting, or to vest, is the terminology used by Scottish Water for the process of adopting new infrastructure.
In addition to the three levels of treatment SEPA stipulated the final control in the treatment train was to be either a pond or a wetland as permanent water SUDS, providing a higher level of water quality improvement. The topography of the site played a large part in the final SUDS design. The existing buildings are situated at the top of a hillock in the middle of the site, with the surrounding areas falling away; this necessitated splitting the site into three sub-catchments, each of which was to be served by a SUDS treatment train before discharging to the Bishop Loch. Each management train consisted of three controls; permeable paving within each property curtilage, filter areas and retention ponds.

The ponds were located to suit both the topography of the site and to limit loss of existing woodland areas and habitats. They were designed with different water quality volumes (Vt); this was agreed during the consultation process with SEPA. Pond A was the first to be implemented and was designed to 4Vt; the water quality design standard at the time\(^5\).

When Ponds B & C were designed the consultant negotiated with SEPA to reduce the water quality volume from 4Vt to 2Vt, primarily to reduce the land take needed for the ponds. This negotiation coincided with a change in approach (within Scotland) to treatment volume, whereby it was considered that for low risk catchments\(^6\) one treatment volume multiple (1Vt) was acceptable. However given the sensitivity of the receptor SEPA required additional treatment to ensure it’s protection and stipulated that 2Vt ponds would be adequate for the remainder of the site.

To date, development of the site is ongoing with two of the three ponds implemented: Pond A located to the west of the site and Pond B located to the south west of the site.


\(^6\) Low risk areas as stipulated by the Controlled Activities Regulations, typically residential areas of less than 1000 houses and water bodies not under significant environmental impact.
6. Protection of the water environment during construction

The construction process can have a detrimental impact on the water environment if not adequately planned for. The process of building can involve stripping the land of vegetative cover, excavating ground, temporarily stockpiling materials, and re-grading the site levels.

Exposed soil and earth is easily washed off during rainfall events making its way to the nearest watercourse; by overland flow or via the drainage system used for the development site. This silt-laden water, if not treated, can significantly reduce water quality, destroy important habitats and kill local animal and plant species.

Best practice for construction is to use a series of measures and processes to ensure that polluted water does not reach the local water; referred to as erosion and sediment control techniques. These control measures form part of the construction planning process and should be implemented prior to the commencement of any site works.

As part of the stipulations of the simple CAR license issued by SEPA, and in order to gain planning approval, adequate means to protect the Bishop Loch and surrounding areas had to be prepared.

DBA prepared mitigative measures for the construction phase in the form of an erosion and sediment control plan (ESCP). This plan also served to protect the SUDS which were to be implemented alongside other infrastructure at the beginning of the build.

The ESCP communicated the key control measures within a series of simple drawings; the main document is shown overleaf (Courtesy Dougall Baillie Associates on behalf of New City Vision).

The plan was prepared in three stages:
1. Identification of pollutant sensitive receptors; an overview of the site topography and overland flow paths to receptors (Loch and low lying fen).

2. Erosion and sediment control drainage masterplan; sub-division of the site and calculation of contributing areas, location and sizing of temporary control measures necessary.

3. Erosion and sediment control plan; single page summary of measures used to communicate the process.

The key aim of the plan was to provide measures to ensure all construction runoff from the site would be treated prior to discharge to the receiving water / surrounding area.

The plan involved the use of an assortment of temporary best management processes (BMPs) for the construction phase; these scheduling of these were communicated using a simple matrix (Table 2).

Construction of the site was phased to minimise exposed areas and reduce risk of erosion and silt wash out. Areas under construction where exposed areas or stockpiled materials were at risk of being washed out were covered using matting/plastic sheeting or seeded.
Table 2. Excerpts of the Gartloch BMP matrix (Courtesy Dougall Baillie Associates on behalf of New City Vision)

<table>
<thead>
<tr>
<th>BMP MATRIX FOR CONSTRUCTION PHASES</th>
<th>Site Set-Up and Clearing</th>
<th>Mass Earthworks</th>
<th>Utility Installation</th>
<th>Roads Construction</th>
<th>Final Stabilisation</th>
<th>Wet Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EROSION PREVENTION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preserve Natural Vegetation</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ground Cover</td>
<td></td>
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<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hydraulic Applications</td>
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<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Plastic Sheeting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Matting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust Control</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Temporary/Permanent Seeding</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>Buffer Zone</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>SEDIMENT CONTROL</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Sediment Fence (internal)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sediment Fence (external)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Straw Bales</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Filter Berms</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inlet Protection</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dewatering</td>
<td></td>
<td></td>
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<td>X</td>
</tr>
<tr>
<td>Sediment Trap</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The predominant soil type for the site was fine clay; a soil type that can be difficult to remove from suspension when in water.

To overcome this floculants were used to maximise the settlement of suspended solids and ensure that runoff discharging to the Bishop Loch was of suitable quality. The temporary settlement basins were designed to achieve a 30 minute retention time for a 10 year storm event using anionic floculants (as shown in Box 1 below).

The floculant used was ‘Floc Block’; small (180mm x 180mm x 60 mm) solid blocks of slow release anionic floculant.

The blocks work by being placed at a point source outfall, and flow slowly dissolves the block releasing small amounts of floculant which binds stone, soil and clay fines, promoting rapid settlement. The floculant removes a large proportion of suspended solids from the site runoff, minimising the environmental impact on the receiving water.

**Box 1 Volume per hectare calculation for temporary basins**

<table>
<thead>
<tr>
<th>Predominant soil type</th>
<th>Sandy Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical settling time 1.0m</td>
<td>Greater than 7 days. Floculant acceleration required</td>
</tr>
<tr>
<td>Factor of safety</td>
<td>Design to achieve 30 minute retention for 10 year event</td>
</tr>
<tr>
<td>SPR HOST</td>
<td>40%</td>
</tr>
<tr>
<td>10 year 30 minute rainfall</td>
<td>13mm</td>
</tr>
</tbody>
</table>

**Volume to be retained per hectare of contributing area = 0.013 x 0.40 x 10000 = 52m3/ha***
Surface water runoff from the site was managed using a network of cut-off trenches to intercept overland flow and convey it to the flocculant enhanced settlement basins. Where site levels were steep checkdams were necessary to decrease the risk of channel erosion and to increase hydraulic residence time and promoting settlement of suspended sediments.

The in-channel checkdams were initially fabricated from straw bales wrapped in geotextile and anchored into the channel using timber stakes (Figures 10 & 11).

The geotextile wrapped straw bales had to be replaced regularly when the bales began to break down. To reduce the level of maintenance to maintain an alternative checkdam design was introduced; timber fabricated with a v-notch weir control.
Vehicular crossing points for site traffic over the temporary channels were provided by means of reinforced culvert sections over the trenches. These sections were identified using geotextile wrapped straw bales and traffic cones. Regular Inspections of the culvert crossings and channel conditions were carried out to ensure the temporary works were in good order.

As a further preventative measure silt fences were used both on the perimeter of the development and internally, at key points, to remove silt in overland flow. Vegetated buffer zones were used maintained to provide additional protection for the watercourses with a minimum diameter of 10 metres around the SSSI & 5

metres diameter around tributaries.
7. Monitoring and managing the temporary works

As part of the CAR license regular water quality monitoring was to be undertaken during the construction phase on the following basis:

- Once per week on active areas
- Once every two weeks on inactive areas
- Within 24 hours of storm event exceeding 12mm
- Daily when storm water runoff is occurring

The Water Management Team of Dougall Baillie Associates undertook a three tier monitoring process:

1. Visual assessment of the condition and operation of the temporary works,
2. Visual assessment of water quality, and
3. Water quality sampling at key areas of the temporary works.

The visual inspections were critical to ensure the correct operation of the temporary works, particularly at the beginning of the construction phase. The inspections identified shortfalls in operation of the temporary works and what action was required to remedy.
All inspections were documented and included a ‘snapshot’ of site conditions including the extent of construction activity, exposed surface/erosion risk and weather. All temporary works were inspected and condition and operation recorded and photographs taken to illustrate actual conditions. Water quality sampling was carried out to monitor turbidity and pH of runoff at discharge points of the temporary works discharging to the loch. Monitoring data was compared to baseline water quality data taken from the Gartloch Pool located upstream of the construction site (with locations identified using national grid references).

The temporary works were actively inspected and maintained by a dedicated maintenance team, with additional input from the DBA monitoring assessment, to ensure that they were effective.

Examples of operational issues identified and rectified as a result of regular inspection include:

**General areas:**
- Heavy sediment build up behind check dams & basins
- Silty runoff bypassing temporary works
- Failure of temporary culverts (to facilitate vehicular crossing over diversion ditch)
- Coagulant not replaced in settling basins
- Water quality sampling identifying high level of turbidity and requirement for additional silt fencing

**Temporary channels:**

The temporary channels provided adequate means to convey construction runoff to the settlement basins. Ongoing management of these basins and channels to ensure their effectiveness included:

- Re-diversion of temporary channels located near stockpiled materials; slippage of stockpiled materials into the channel reduced water quality and placed additional burden on the sediment basins.
- Infilling of ‘redundant’ channels and creation of new channels to suit construction needs, e.g. for new haul roads
- Dredging channels
- Stabilising channel banks to minimise additional sediment contribution
- Checkdams levels too high; damming water in the channel
- Implementing additional checkdams to minimise erosion

*Figure 14. Bale check dam higher than channel. (Image courtesy of Dougall Baillie Associates on behalf of New City Vision).*
Temporary sediment basins:

Maintenance / modification included:

- Replacing membrane wrapped straw bales (used for checkdams and central berms of the sediment basins) with more durable structures fabricated from metal, wood or formed clay.
- Reforming banks following slippage
- Adjusting levels of oil booms for performance
- Clearing blockages at inlet areas
- Introducing metal skips as forebay structures to reduce the need to dredge larger areas / reduce risk of damage to basin during remedial works

![Figure 15. Initial temporary settlement basin with oil boom. Note the straw bales wrapped in membranes to maximise flow path; bales degraded quickly and their replacement was labour intensive. (Image courtesy of Dougall Baillie Associates on behalf of New City Vision).](image15)

![Figure 16. Later style sediment basin adjacent to Pond A. Note the use of the metal skip in the foreground of the picture (acting as a forebay promoting sediment settlement which could be easily removed without dredging the entire structure) and the replacement of the straw bales with clay bunds (Image courtesy of Greenbelt Group Ltd).](image16)

Flocculant use:

The Floc-Blocks used within the channels and basins were successful in promoting settlement of the fine clays however there were several operational issues to overcome to maintain their effectiveness:

- Accumulation of washed through debris (construction material, leaf litter, etc) around the blocks resulted in polluted flows not achieving sufficient contact with the coagulant; this was overcome by increasing the monitoring of the blocks.
• In some locations, especially in the conveyance ditches, Floc Blocks had fallen from their position and were lying on the ditch inverts where contact with polluted water is limited.
• At the temporary basin inlets Floc Blocks are ‘stacked’ reducing the fall from the inlet invert to the Floc Block itself which reduces mixing and limits self cleansing.

Figures 17 and 18. Use of ‘Floc Blocks’; flocculant blocks used to enhance settlement of silt within the temporary works (Images courtesy of Dougall Baillie Associates on behalf of New City Vision).

8. Conclusions and recommendations

Silt laden construction runoff can have a detrimental effect on the water environment and this may result in substantial fines from the environmental regulator. Adequate means to manage runoff during the construction phase must be identified at the planning stage of any project and implemented prior to mobilisation.

Using erosion and sediment controls to manage runoff provides the added benefit of protecting SUDS infrastructure, reducing risk of additional work and cost to remediate prior to handover.

Once in place, it is essential that the temporary works are regularly inspected to review their effectiveness, highlight any shortfalls in operation and to revise the design and operation of structures accordingly. Local conditions may favour the use of certain techniques, or materials, and these are often best identified by operatives working on the site.

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