A LARGE MULTI-FUNCTIONAL BIORETENTION DEVICE

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ABSTRACT

In 2015, Ports of Auckland Ltd further developed their Wiri Inland Port site. This comprised an 8ha development of hard standing and buildings for cross-dock (i.e. de-vanning of containers) and cool store facilities. The site is within Auckland Council's Stormwater Management Area Flow 2 (SMAF2) which requires retention and detention of stormwater. Because downstream stormwater infrastructure was constrained, attenuation of extreme flood events was also required.

Land for stormwater treatment facilities was limited. Having a multitude of small devices would affect the operation of the inland port. Biosecurity requirements restricted the amount of vegetation near some operations. It was therefore decided to build one treatment device at the downstream end of the site. After considering the options, it was decided to construct a large bioretention device, covering an area of 100m x 20m =2,000 m^2. This represents about 2.5% of the catchment area which is considerably smaller than what would normally be required for treatment, retention and detention. This was primarily achieved by installing open storage units within the filter media to meet the volume requirements of retention and detention.

This paper describes the design process, the resource consent approval process, and the construction approach. It includes comments on the performance of the device following implementation.

KEYWORDS

Bioretention, rain gardens, design process, construction.

PRESENTER PROFILE[1]

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1 INTRODUCTION

Ports of Auckland Ltd has recently developed an 8.0ha Site (the "Site") at 131 Wiri Station Rd, Manukau, as a cold store, crossdock and warehouse. It forms part of a development referred to as the Wiri International Freight Hub. The cold store will house food products for distribution through the upper North Island via the road and rail network. The crossdock will provide for unpacking and repacking of cargo for distribution through the upper North Island via the road and rail network. The warehouse will provide a facility for cargo in transit between manufacturers and importers, and the Port of

Auckland on the Waitemata Harbour. The Site is well-located for this distribution activity as it is adjacent to both the road and rail networks.

The area is zoned "Heavy Industry" in the Auckland Unitary Plan (AUP). This zone provides for trade and warehousing use as a permitted activity. An undeveloped Heavy Industry site lies immediately downstream and contains an un-piped section of a tributary of the Puhinui Stream.

As part of the Site is shown within the 1% AEP floodplain and an overland flow path on the Auckland Council GIS Viewer, it is by definition a "Stormwater Management Area" under the provisions of AUP. The area is also subject to an AUP planning overlay Stormwater Management Area – Flow 2 (SMAF2). The SMAF2 overlay places additional requirements on development for the retention and detention of stormwater flows for non-greenfield sites. Retention of stormwater is aimed at infiltrating runoff into the underlying soils, while detention of stormwater is aimed at detaining stormwater during modest storms and releasing it slowly.

The development area drains into the Puhinui Stream which has network discharge consent obtained in 1992. The main condition of that consent was that "The BPO (Best Practicable Option) be adopted to control the discharge of pollutants in stormwater from the catchment". Auckland Council's interpretation of that condition was that the development should comply with the requirements of the AUP. In addition, Council advised that, as a downstream culvert was under capacity, the development should not increase flood flows from the Site.

2 PRE-DEVELOPMENT: STORMWATER

Prior to development, 70% of the Site was pervious and 30% impervious. The soils typically comprise fill overlying a basalt flow, which extend part way across the site. Anecdotally, evidenced by standing water around the site, there was significant runoff rather than infiltration on the existing site reflecting poorly drained surface soils (which are fill).

Stormwater was discharged from the Site via limited natural soakage into the ground and mainly via overland flows across Site into the existing watercourse downstream. Stormwater discharges from the Site were estimated using ARC (1999), resulting in flows of 0.6, 1.5 and 2.7 m3/s for the 2, 10 and 100 ARI events.

A triple set of 1800mm diameter pipes with an assessed capacity of $21m^3/s$ (approximately the 20 year ARI event) run along the southern boundary of the Site. The pipes convey flows from the upstream Ash Rd catchment into the existing open watercourse immediately downstream of the Site. Wiri Station Road forms a barrier for overland flows from Ash Road. Discharge from that catchment is therefore limited to the culvert capacity.

The existing downstream watercourse discharges into the State Highway 20 motorway culverts. The culverts were designed for a maximum discharge of $29m^3/s$, corresponding to the 100 year ARI event for ultimate development of the upstream catchment as industrial land.

Runoff from the site was primarily untreated.

3 DEVELOPMENT

3.1 GENERAL APPROACH

The Site was developed with about 91% imperviousness. The development comprises cold store, cross dock and warehouse buildings, access routes and carparking.

A range of options for stormwater treatment were considered, but a single bioretention device, incorporating flood detention was selected. As wetlands or wet ponds would not have been able to comply with the requirements for retention, only biofiltration devices were considered acceptable. The main driver for a single device was the reluctance to have vegetative strips throughout the development due to biosecurity issues within a customs bonded area and the food storage cold store. In addition, large cargo handling equipment being used on site are not compatible with vegetative strips or larger number of scattered devices.

A Best Practicable Option (BPO) approach to stormwater management, consistent with the network consent, was proposed. It comprised the following measures:

- Harvesting and re-use of rainwater from the cold store building roof.
- Use of painted coatings for steel roofs.
- Retention, detention and treatment of stormwater from the paved impervious areas (7.3 ha) using a single 2,000m^2 bioretention device.
- Treated stormwater will be discharged to the existing stormwater network via a stormwater outfall designed to manage scour or erosion at the outfall.
- An emergency spill response plan, as is normal practice, covering the actions to be taken in the event of an accidental spill. The plan was required under the Industrial and Trade Activities provisions in the AUP.
- An environmental management plan (EMP) covering management, maintenance and operations procedures as part of the business-as-usual activities on the site. The EMP also set out monitoring and reporting processes. The EMP was required under the Industrial and Trade Activities provisions in the AUP.
- Management of flood flows exiting the site so as to minimise potential adverse effects downstream.

3.2 SIZING OF THE BIORETENTION DEVICE

The bioretention device was sized based on the SMAF 2 requirements, as set out in the Proposed Auckland Unitary Plan (PAUP), with a 90th percentile 24hr rainfall of 25mm which corresponds to a runoff of 21mm for impermeable areas. The overall net volume of the device is approximately 1,500m^3 based on an impermeable area of 7.3 ha and a retention depth of 8mm and a detention depth of 13mm. The base of the device was set above the regional groundwater level and the existing triple culverts.

The bioretention device has an area of approximately 2,000m^2 and a depth of approximately 1.55m comprising:

- 300mm of live storage (600 m^3 storage)
- 300mm of sandy loam (porosity of 0.35), planted with the plant species described below (180 m^3 storage)

- 800mm of sandy loam/free draining aggregates with ChamberMaxx units. The ChamberMaxx units are a proprietary device which will provide void space and promote soil infiltration. (630 m^3 of storage)
- 150mm of free draining material to encourage soil infiltration (90 m^3 storage)

Detailed design of the device will be in accordance with the media specification for stormwater bioretention devices in Auckland Council (2013).

Plant species for the bioretention devices are marsh species able to tolerate both dry and wet soils and some level of inundation. They include:

- *Apodasmia similis* / Oioi / Jointed wire rush.
- *Ficinia nodosa* / Wiwi / Knobby club rush.
- *Carex secta* / Purei.
- *Phormium tenax* / Harakeke / Flax.

Because of the relatively large contributing catchment, runoff was collected in a conventional piped system and discharged into the bioretention device via upflow manholes with scruffy domes.

Subsoils and outlets to ChamberMaxx units were located at such a level to promote 8mm (580 m^3 of storage) of infiltration for the retention volume. The outlet system from the raingarden provided for the slow release of the detention storage.

3.3 PROVISION OF FLOOD CONTROL FLOWS

The Site is in the lower part of a large catchment discharging into the Puhinui Stream. From a catchment management perspective, it could be prudent to allow flood flows from the Site to discharge as quickly as practical, i.e. to minimise any flood attenuation storage. This approach reduces the likelihood for peak discharges from the Site coinciding with the peak discharge from the flood wave within the Puhinui Stream, which could increase flooding in the Puhinui Stream.

From a practical perspective some flood storage for runoff from the Site is available within the proposed raingarden as it is necessary to discharge the peak flows over a weir. The amount of storage resulting from this requirement was equivalent to 850 m^3. With this allowance for flood control the existing 2, 10 and 100 ARI events of 0.6, 1.5 and 2.7 m^3/s were increased by 30%, 7% and 2% respectively. This was seen as a compromise between an overall catchment management objective and resolving a local undersized culvert issue downstream (of SH20).

The bioretention device will provide a significant reduction of runoff for more frequent rainfall events. It will limit runoff resulting from rainfall up to the 90th percentile 24 hour rainfall through retention and detention.

The bioretention device outlet consists of a weir chamber, and concrete pipe all of which will be operational for the more infrequent events. The watercourse outlet structure includes a headwall, wingwalls and apron with adjacent riprap protection. Detailed design of the outlet structure was in general accordance with *Hydraulic Energy Management: Inlet and Outlet Design for Treatment Devices, Technical Report 2013 / 018.*

In the event of outlet blockage or exceedance of the 10 year ARI system capacity, flow will discharge via an emergency weir over the eastern end of the device into the downstream watercourse.

All building floor levels were well above the freeboard requirements for the 100 year ARI event.

The development is within the 100 ARI floodplain and occupies some 1,300 m^3 of flood storage. The bioretention device, in addition to the lower cartdock and road areas provide more than 2,800 m^3 of compensatory flood storage.

4 CONSTRUCTION

Construction mainly involved diversion of existing services, excavation to the invert levels, retaining walls around the perimeter of the device, installation of the inlet and outlet structures, placement of the granular backfill, installation of the ChamberMaxx units, placement of the soil layers, and planting. Except for having to co-ordinate the work around surrounding projects, construction was reasonably straightforward.

Figure 1: Bioretention Device during Construction

5 DISCUSSION

If the ChamberMaxx units were not used for this application, then the area requirement would have increased from 2000m^2 to 2,600 m^2 (i.e. 2.7% of the catchment imperious area compared with 3.6 %). This effectively created 600m^2 of industrial land.

Through the AUP process, the requirements for the sizing of bioretention devices changed. These changes included: applying the 90 percentile rainfall, but applying the difference for the resultant runoff between the existing landuse and post development; and having 5mm of retention. Using this approach would have required a total volume of

$1250m^3$, including a retention volume of $360m^3$. This would have resulted in the device having an area of 1650 m^2, a potential saving of $350m^2$.

The cost of the project was approximately $2,000,000 (2015) which corresponds to about $27per m^2 of impervious area (2015 dollars). This is relatively expensive when compared to other stormwater treatment devices such as wetlands.

The retaining walls around the device were expensive. They had to support a road embankment up to 3m in height above the device. In addition the design of the walls assumed that the soil media within the device could not be relied on for passive soil support because, during construction and if the device was regenerated, the support wouldn't be there, and the material was unconsolidated.

The loam soil is expensive, but is necessary for the infiltration of the runoff.

Having upflow manholes with scruffy domes was not ideal because they suffered from sedimentation. Subsoils were installed to discharge into the retention zone, but these were occasionally blocked. A new system was retrofitted which allow the subsoils to be cleaned via an external cleaning eye rather than from with the manhole.

The planting within the device has remained healthy. In terms of performance, the occupiers of the site have advised that they have rarely seen surface water within the device.

Apart from persons within the site, there is no ready access to the device. It does, however, provide a landscape feature within an industrial complex.

6 CONCLUSIONS

A single large multi-functional bioretention device was installed on an 8ha industrial site. It covered an area of 2000 m^2 with a retention and detention volume of $1500m^3$. In addition it provides 850 m^3 of flood control storage.

The use of ChamberMaxx units to provide subsurface storage enabled the device to be reduced in size by $600m^2$. The unit cost of the device was $27 per m^2 of impervious area which is relatively expensive.

Had the device been sized under the final unitary plan provisions (rather than the proposed unitary plan) the device could have reduced in size to 1650 m^2 (about an 18% reduction).

Overall, it is concluded that a single large bioretention device was appropriate for this large industrial site which contains food storage and customs bonded facilities.

Figure 2: Bioretention Device

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