A STORMWATER TREATMENT SYSTEM FOR DISCHARGES TO LYTTLETON HARBOUR

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ABSTRACT

Black Point is a small peninsula of approximately 50 hectares in Lyttleton Harbour between Diamond Harbour and Charteris Bay. It is proposed to subdivide this peninsula to form 50 residential lots together with generous open spaces. The developers wish to create a subdivision to be proud of, one that will have minimal impact on the environment, and one which will set the standard for future developments in the area.

Stormwater discharges from the site will be, indirectly, into the harbour and require consent from Canterbury Regional Council. The Regional Coastal Environment Plan identifies the water quality of the receiving environment as, *water to be managed for Contact Recreation and for the maintenance of aquatic ecosystems, and requires water quality to be maintained and, where necessary, improved for those purposes*.

Following completion of the subdivision, maintenance of the stormwater system will be managed by Christchurch City Council. Hence, the system has to be designed, constructed and able to be maintained by CCC such that it can comply with the Canterbury Regional Council conditions of the resource consent, without undue expense to ratepayers.

This paper describes the process undertaken to develop a stormwater system that meets the developer's aims and satisfies those of the Canterbury Regional Council and Christchurch City Council.

KEYWORDS

Stormwater Treatment, Treatment Train, StormFilter, Vortech Unit

PRESENTER PROFILE

Stuart Challenger is Team Leader of the Opus Christchurch stormwater team. Through this role he provides a technical and management overview on many projects.

Stuart has over 12 years engineering experience and ten years construction experience. He specialises in stormwater and infrastructure development. Stuart's work has included stormwater quantity and quality investigations, concept and detailed design, obtaining engineering consents for local authorities (including providing evidence at consent hearings), preparation of contract documentation and supervising physical works.

1 INTRODUCTION

Why bother treating the stormwater? Why not just let it run straight into the harbour, that's what it does at the moment?

Because where the discharges go to is a bathing beach that has been identified by Canterbury Regional Council as being an area for Contact Recreation.

Then why not just discharge off the cliff into the open harbour?

This paper goes through the development of a stormwater treatment system for a proposed subdivision in Lyttleton Harbour, Banks Peninsula.

Unlike the Christchurch area, which has flat grades for swales and good soakage, Banks Peninsula does not offer the same ease of stormwater treatment. A large proportion of the Peninsula is covered in loess, a fine wind blown material, that overlays highly fractured volcanic rock. The loess has a low permeability and much of it is highly erodiable. Development in Lyttleton Harbour also suffers as there is generally limited room or grades for the softer stormwater treatment solutions, so hard engineering solutions are often required.

As the discharge from the proposed subdivision will eventually enter an area of Lyttleton Harbour that has been identified as being for Contact Recreation, Canterbury Regional Council requires a high level of treatment.

When the subdivision design began the Territorial Authority controlling development in the area was Banks Peninsula District Council. During the design process Banks Peninsula District Council amalgamated into Christchurch City Council and changes in local authority requirements had also to be incorporated into the design.

2 BLACK ROCK SUBDIVISION

2.1 SITE DESCRIPTION

Black Rock subdivision is located on Black Point, a small rocky peninsula in Lyttleton Harbour covering an area of about 11 hectares. It is situated between Diamond Harbour and Charteris Bay. The headland of Black Point looks due north across the harbour to Lyttleton. The location is shown in Figure 1.

Geological conditions on site consist of loess and loess colluvium overlying volcanic bedrock. Loess deposits are up to 3.5m thick in some places while in others bedrock is at the surface. The loess is generally described as "*yellow-brown clayey silt with some fine sand*".

Existing stormwater drainage for the site comprises overland flow via natural depressions to the harbour; to the beach at Hays Bay to the south-west, over cliffs to Church Bay to the north-east and open harbour in the north-west. There is a small water course to the southwest of the site that drains the road above the site. There are also some springs on site and tunnel gullies where subsurface water has eroded the loess.

The catchment for the site is limited to the site itself as Marine Drive, the road above, forms the catchment boundary. The road directs the majority of flows from up-slope to either side of the site, part of the road runoff and hill discharge down the water course.

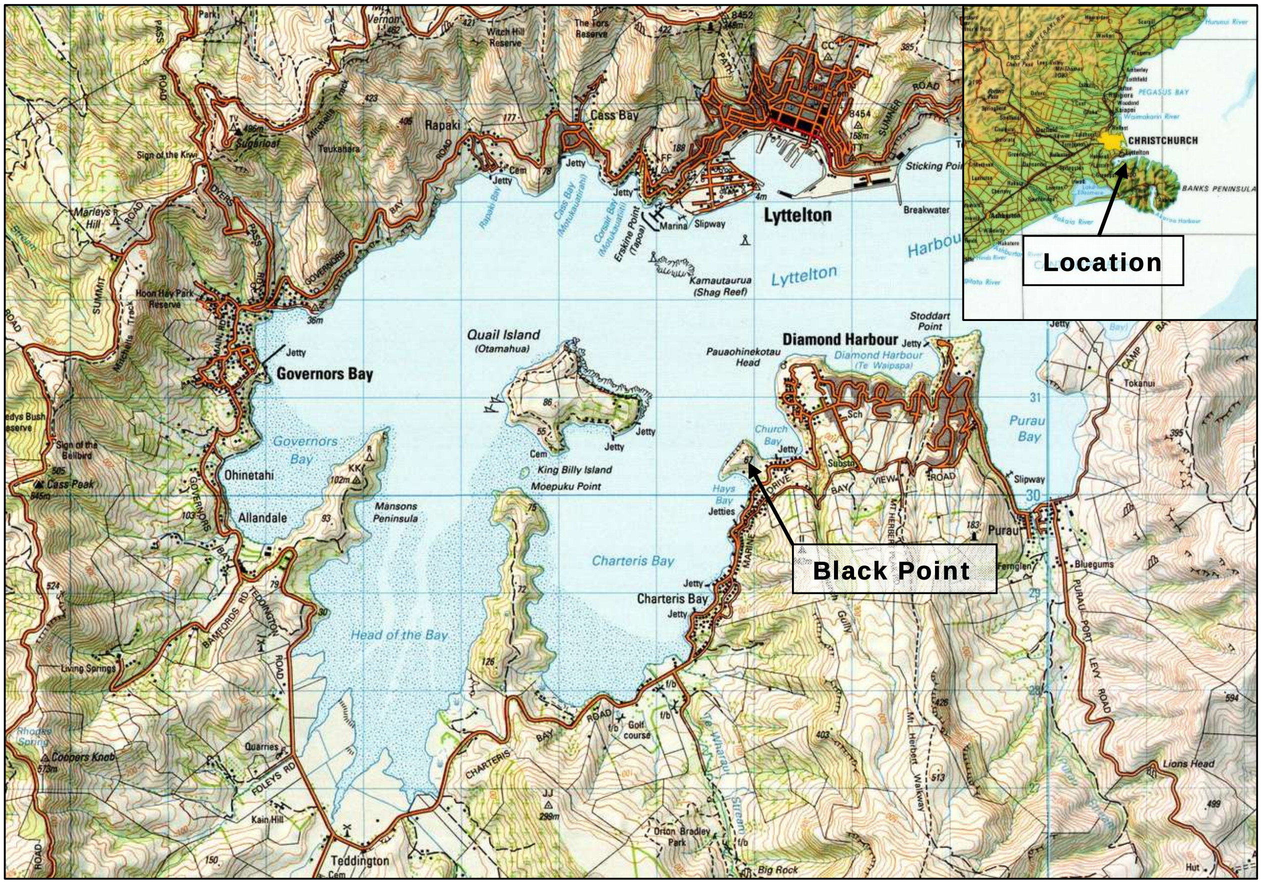

Figure 1: Site Location

2.2 SUBDIVISION PROPOSAL

The proposed subdivision will form 50 residential lots plus two reserves. Lot sizes will range in size from 860m² to 6,000m²; however the majority will be between 1,000m² and 1,500m².

The land is zoned for "small settlement" in the Proposed District Plan. While the land is zoned for this type of development the locals were concerned that any development on this prominent headland would ruin the aesthetic values of the area. In addition, they have observed recent developments around Lyttleton Harbour having significant impacts during the construction stage due to inadequate erosion and sediment control measures.

The small settlement zoning allows a dwelling density of "no more than one dwelling on any site 1000m^2 or less in area. Given the site contours, which limit the developable areas, there is potential for up to 78 lots. Such a development density however, is not in line with the Developer's aim.

The Developer's aim is "To create a subdivision to be proud off, one that will have minimal impact on the environment and one that will set the standard for future developments in the area". There will be a number of restrictive covenants that will attach to each lot including:

- No cats;
- Limited fencing;
- No unpainted roofing material.

The Developers are also proposing an extensive suite of measures to mitigate potential adverse effect to the local and coastal environment in the design of the subdivision. These include:

- Undertaking the minimum earthworks necessary to create the development;
- Implementation of a comprehensive Erosion and Sediment Control Plan;
- Implementation of a high specification stormwater treatment system.

The stormwater system has been designed to encompass the Developer's aim. A high level of stormwater treatment is to be achieved by using a treatment train approach. On-site detention tanks are to be installed to reduce the peak volume of stormwater discharged, collecting roof run-off, and where practical run-off from hard stand areas.

3 PROPOSED STORMWATER SYSTEM

3.1 STORMWATER TREATMENT IN THE CANTERBURY CONTEXT

Stormwater treatment in most of Canterbury is typically through swales and ponds, with discharge via infiltration. The Canterbury plains are fortunate in having flat topography, falling in a general west to east direction at about a 1 in 300 grade, providing a good substrate in which to form swales. Much of the Plains are also situated over alluvial gravels, which provide good soakage to any stormwater infiltrating the surface.

Banks Peninsula does not offer the same ease of stormwater treatment. This site is typical of much of the peninsula having loess overlying highly fractured volcanic rock. The loess has a low permeability and much of it is highly erodiable.

Development on this site, and much of the peninsula, also suffers as there is generally limited room, or grades, to permit the use of softer treatment solutions. Hard engineering methods are often required.

3.2 DESIGN PROCESS

3.2.1 CONCEPT DESIGN

As discussed in the previous section, there is limited room for 'soft' engineering solutions. There are flat areas that could be suitable for ponds; immediately adjacent to the foreshore of Hays Bay, and on the saddle in the middle of the site (see Photographs 1 & 2). A pond on the saddle would require nearly all of the stormwater to be pumped to it. This was contrary to the Developer's aim of minimising environmental impacts because of the power that would be required for pumping.

Photograph 1: View from the entrance to the Site looking north-west. Hays Bay is to the left of the photograph

It was considered that a pond near the foreshore was inappropriate as once the subdivision is complete Hays Bay will have public access[1] and a stormwater pond would be incongruous with the landscape values the developer wished to maintain. Therefore 'hard' engineering solutions were considered.

Photograph 2: View from the high point of the Site looking south east back to the entrance, Church Bay is to the left of the photograph

The concept design was based on reducing the amount of stormwater that had to be treated. This was to be achieved by having on-site detention for roof water and two stormwater systems.

[1] Currently access to Hays Bay is by walking around the foreshore from the Charteris Bay Yacht Club or by crossing private land.

1. A ‘dirty’ stormwater system to collect runoff from the roads and detention tanks for treatment, and
2. A ‘clean’ stormwater system to collect runoff from yards and reserve areas to be discharged untreated.

The dirty water was to be treated via a series of treatment methods:

- Road runoff to be collected, where practical, in swales,
- Where swales were not practical to collect road runoff sumps were to be fitted with catchpit filter bags,
- A pre-treatment device was to be installed;
- A high level treatment device was to be installed;
- The discharge from the final treatment device was to a swale to provide final polishing of the stormwater.

The preliminary design was for the pre-treatment to be provided by a sand filter treating low flows (about ¼ of the water quality design flow). The high level treatment was to be provided by a StormFilter, treating the flow from the sand filter and the by-passed flow, up to the water quality flow.

There will be two discharge points from the stormwater systems;

1. The main catchment is to discharge via a swale onto the developer’s land prior to an unformed legal road on the landward side of the foreshore. The discharge location can be seen in Photograph 3, to the right of the photograph, near the boat sheds.

Photograph 3: View looking into Hays Bay. This photograph was taken from the approximate location of the second discharge point shown in Photograph 4.

2. The minor catchment (down the ridge on the north-western side) is to discharge via a swale to a pipe drilled through the hill to an energy dissipation structure on to a rocky outcrop, around from the beach at Hays Bay. The approximate location of the proposed outfall from the minor catchment is shown in Photograph 4.

Photograph 4: Proposed location for outfall from minor catchment

It was decided not to discharge either catchment direct to the harbour because;

- The results of any monitoring would be affected by the existing water quality, and
- It was considered inappropriate to have a pipe going out across the foreshore.

For similar reasons, plus potential capacity issues, it was decided not to discharge from the main catchment to the existing watercourse.

Throughout the development of the concept design discussions were being held with Banks Peninsula District Council to ensure that they were happy with the proposal. Minor changes were made during this process to accommodate their wishes. The proposed concept design is shown on Figure 2.

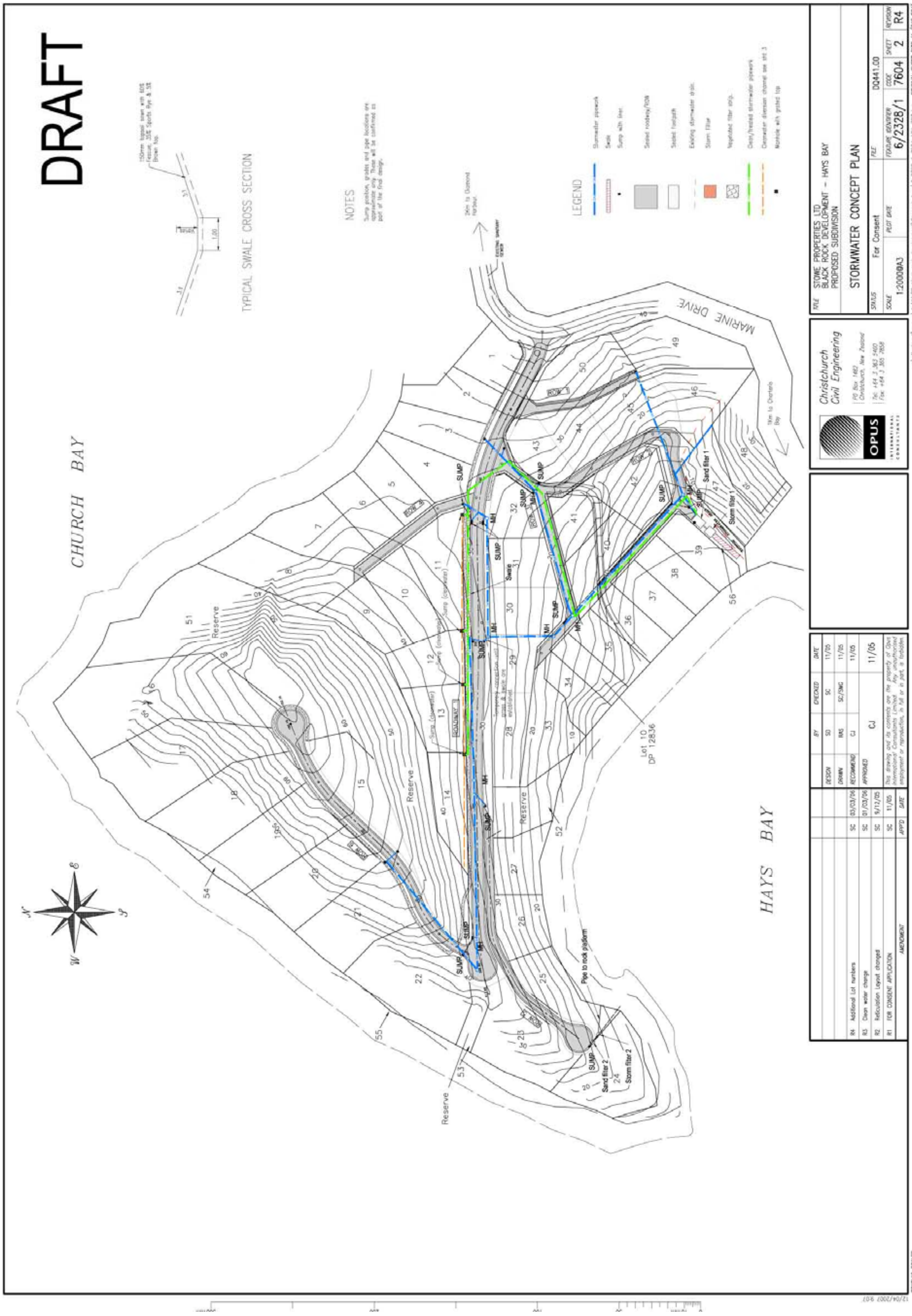

Figure 2: Preliminary Design

3.2.2 DETAILED DESIGN

Several factors during the detailed design process changed our concept design as summarized in Table 1 below.

Factor	Design Changes
Modified road alignment to achieve acceptable grades and lot access	Change in low points on roads and overland flow paths made swales impractical.
Preliminary Costings of concept design	More economic to replace "clean" and "dirty" pipework (with smaller treatment system) with a single larger pipe and larger treatment system.
Discussions with suppliers and Territorial Authorities indicated concerns with maintenance requirements of sand filter and catchpit filters	Alternative pre-treatment devices considered: vortex separation coupled with cartridge filtration selected.

Table 1: Changes to Concept Design

The final design will provide treatment to all road and roof runoff plus the yards and green spaces that drain to the roads. Treatment will be in a treatment train consisting of an Ingal Vortech unit followed by an Ingal StormFilter that discharges to a 30m long swale/vegetated filter strip. Flows greater than the design capacity of the proprietary treatment devices will by-pass the devices and flow into the swale. It is considered that such a system offers the high level of treatment desired by the Developer and required by Canterbury Regional Council. This design is shown in Figure 3.

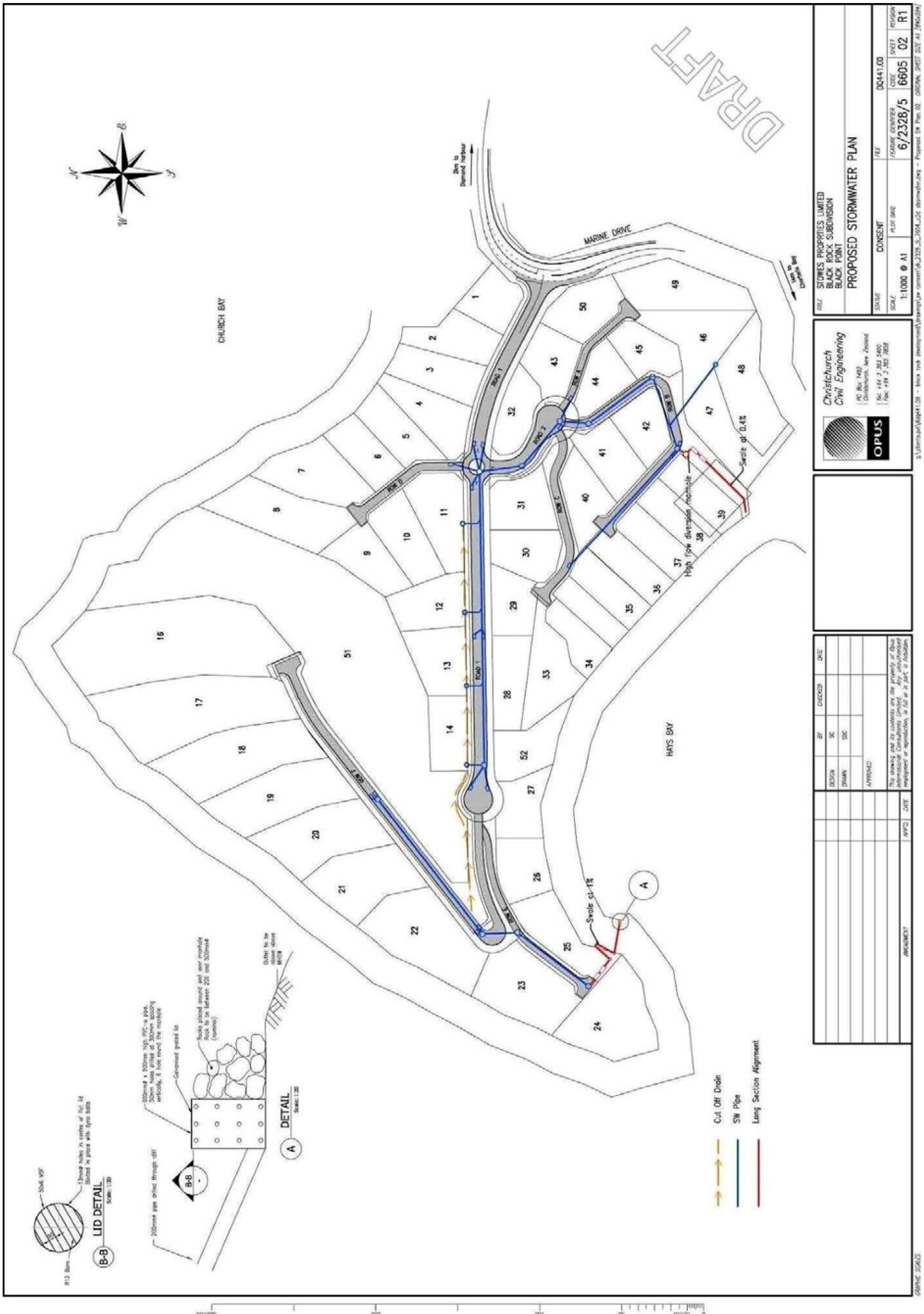

Figure 3: Final Design

3.3 DEVICE SIZING

The proprietary treatment devices proposed are flow based devices. The sizing of such devices is dependent on the rain intensity and the catchment draining to the device.

3.3.1 RAIN INTENSITY

Unlike the Auckland Region, Canterbury does not have any design guides for rain, so local rain data is used. As there are no long term rain gauges in Lyttleton Harbour our initial approach was to use HIRDS version 2.0. This was rejected by Banks Peninsula District Council as their experience was that it underestimated the intensity for Banks Peninsula. They recommended the use of HIRDS version 1.5.

The design intensity was calculated using the method in ARC's TP108. This intensity is calculated by multiplying the intensity of the water quality storm by a peaking factor from the normalised rain intensity (I/I_{24}).

The intensity of the water quality storm is (1/3 of the 2-year, 24-hour rain depth)/24.

As there is no rain data for the area we used the Auckland 24hr design storm peaking factor of 16.2.

$$i = 16.2 \times [(\text{2-year 24-hour rain depth})/3]/24 \qquad (1)$$

The 2-year 24-hour rain depth from HIRDS V1.5 is 86mm. This gave the design intensity for the water quality storm of 19.4mm/hr.

3.3.2 CATCHMENTS

The site was divided into four catchments as shown in Figure 4:

1. The catchment above the main subdivision road (Road 1), 2.8ha;

2. The catchment between the main subdivision road and Hays Bay, 2.8ha;

3. The catchment at the end of the main subdivision road going up the ridge, 0.8ha; and

4. The remainder of the site that cannot be collected in the reticulated network, 4.8ha.

Banks Peninsula District Council had concerns that the concentrated flows from the roof water tanks would cause erosion of the loess soils. To ensure that this did not become an issue the outlets are to discharge to the road kerb and channel. Where this is not possible by gravity a pump system will be installed by the lot owner.

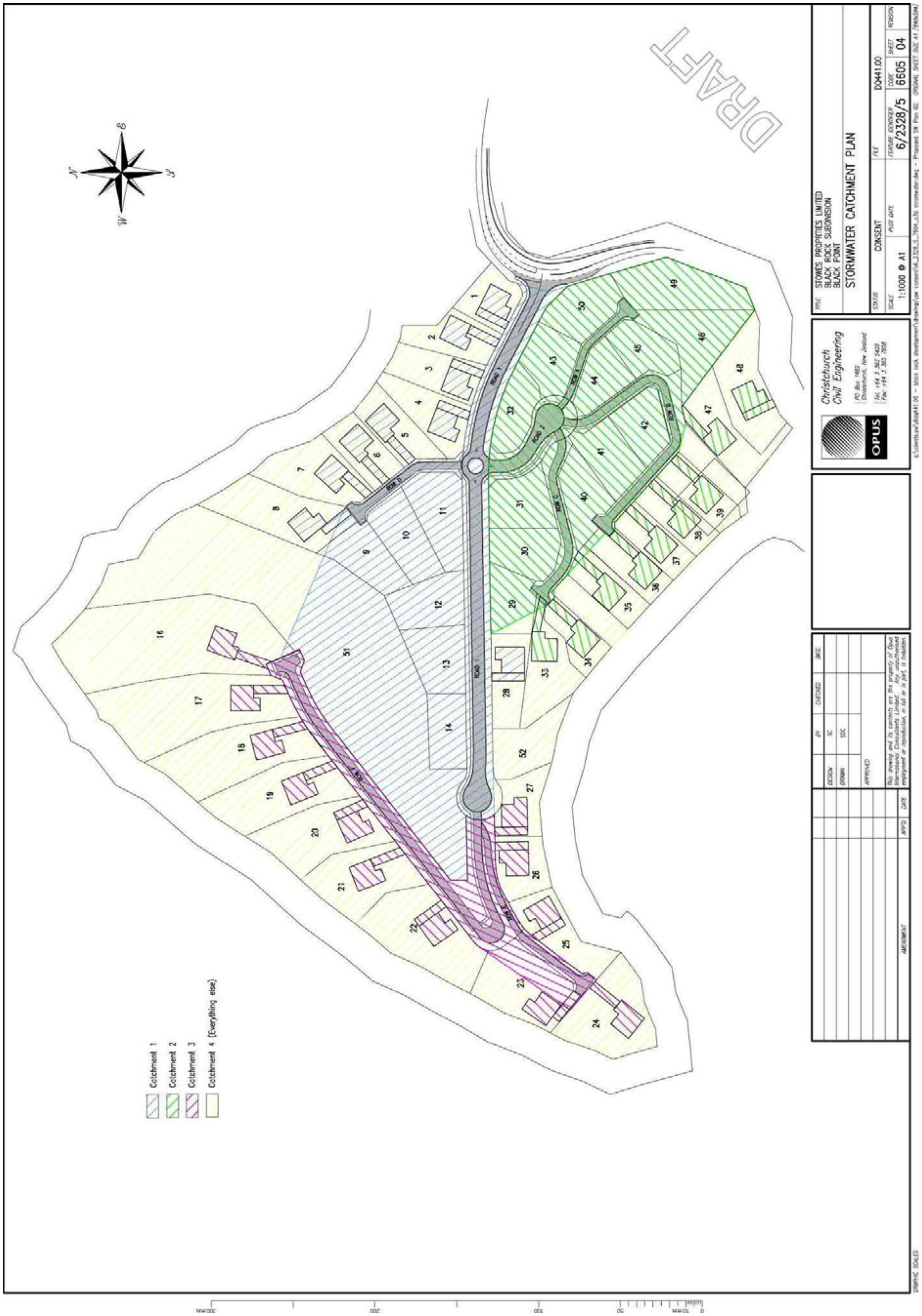

Figure 4: Plan Showing Catchment

4 STATUTORY PROCESS

The plans containing rules relevant to this Application are the CRC's Transitional Regional Plan (Transitional Plan) and the Proposed Natural Resources Regional Plan Chapter 4: Water Quality (NRRP). The effect of section 15 of the Act is that unless the discharge is expressly allowed by both Plans, consent will be required.

The Transitional Plan authorises stormwater discharges that meet certain conditions. The location of the development in the former Banks Peninsula District Council area places it outside the authorisation.

Similarly, the location and size of the development places it outside the bounds of a permitted activity under Rule WQL 5 of the NRRP and consent as a discretionary activity under Rule WQL 57 is required.

Canterbury Regional Council's Natural Resource Regional Plan (NRRP) requires, as one of the requirements for permitted activity status, (Rule WQL 5) for discharges of stormwater into water the removal of 75% suspended solids. This level has been used as a condition of consent for previous consents, yet there does not appear to be any robust scientific/economic basis for this to be set as a removal standard. Rather than set definitive removal standards it may be more appropriate for CRC to set guideline removal levels (as ARC has) and to look at the Best Practical Option of stormwater treatment as defined by the RMA.

While the discharge is not directly to the Coastal Marine Area (CMA), it will enter the CMA so consideration of the Regional Coastal Environment Plan needs to be made. The Regional Coastal Environment Plan identifies the water quality of the receiving environment as; *water to be managed for Contact Recreation and for the maintenance of aquatic ecosystems and the water quality maintained and where necessary improved for those purposes*.

The stormwater system has been designed to ensure that the stormwater receives the best treatment ensuring the maintenance of aquatic ecosystems and water quality.

5 RESOURCE CONSENT PROCESS

Resource consent was applied for on 8 September 2005, further information was sought by Canterbury Regional Council (CRC). A revised Assessment of Environmental Effects was provided in April 2006. The application was publicly notified on 22 July 2006. Seven submissions were received, one in support and six in opposition. During this process, Banks Peninsula was amalgamated into Christchurch City Council and the design progressed from preliminary to final.

Canterbury Regional Council had two main concerns relating to the stormwater system:

1. The performance of the proposed treatment train:- whether it would provide adequate protection of the receiving environment, and

2. The design flow rate:- whether this was appropriate to the site.

CRC were concerned that suspended sediment in the runoff generated from the loess soils would have a large proportion of small (<60μm) particles that would not be captured by the treatment system. The proposed treatment system has not been used before in Canterbury so they have no evidence that it will work in accordance with the manufacturer's claims.

CRC were also concerned that the proposed system did not treat the dissolved fraction of metals. Because of the proposed development density and the requirement that there are no un-painted roofing materials, it is anticipated that the dissolved fractions of metals will be low.

As discussed earlier, stormwater treatment in Canterbury is generally through 'soft' engineering solutions. CRC are reluctant to authorize devices that have not been 'proven' in Canterbury and sometimes require the developer propose monitoring of the device, also requiring a fall-back proposal should monitoring show the device is not performing to the required standard. In this instance we are offering what we consider to be the best technology available. Should this system fail to meet any imposed standards, so too would any other system. The NRRP permitted activity rule requires 75% removal of suspended solids. However, the Regional Council are also pushing compliance limits of 75% on discretionary activities.

CRC did not accept that designing the stormwater treatment devices to treat up to an intensity of 19.4 mm/hr would provide adequate treatment to ensure there were no adverse effects from the development. They proposed that a rain intensity of 25mm/hr was used[2].

The application was heard by an independent commissioner on 8 February 2007. The commissioner issued a preliminary determination, the key points or which are:

(a) Consent will be granted for 35 years.

(b) Parties are to consult over draft conditions including CCC.

(c) Hearing will then be reconvened.

Several meetings have been held (and at the time of writing, are still being held) between the Developer, Christchurch City Council, Canterbury Regional Council and the submitters. Canterbury Regional Council have proposed a draft set of conditions and the parties are negotiating proposed changes to them.

Christchurch City Council are concerned that as they will be taking over the system, the conditions of consent have to be capable of being complied with. Furthermore, any required maintenance must be capable of being worked into their existing maintenance schedules.

The submitters were mainly concerned about the erosion and sediment control plan. These concerns were addressed by changes to that plan that will be incorporated into the consent conditions.

During the negotiation process the submitters concerns were alleviated that the Developer was only in for the short term and would leave locals with another subdivision "gone bad". They could see that the Developer was trying their best to ensure that there would be minimal impacts from the subdivision.

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[2] The basis of this intensity is unclear, CCC use a water quality depth of 25mm to be treated in ponds, from CRC's evidence at the hearing there was no scientific basis for the use of 25mm/hr and it looked as though they has taken CCC's water quality depth of 25mm and transposed to an intensity of 25mm/hr.

One of the submitters, who lives above the site, has been recording 24 hour rainfall for over 50 years. We undertook an analysis of those records, which showed that the 2-year 24-hour rain depth was 41.5mm. When converted to a rain intensity for stormwater treatment design, this gave an intensity of 9.3mm/hr. This was discussed with Canterbury Regional Council and the Developer proposed that a design intensity of 10mm/hr be used. The Regional Council did not accept the rain data that produced this result but compromised their stance and proposed that a value of 15mm/hr be used for the design of the stormwater treatment devices.

It is proposed to monitor the treatment train over a minimum of 12 representative rain events to demonstrate that the system will remove 75% of suspended solids on an average annual basis. In order to obtain meaningful results it is necessary to carryout very robust and detailed monitoring and this will most likely involve automatic samplers and flow gauges. This is an expensive process and one that should rightfully be carried out by the product suppliers or Canterbury Regional Council if they are not going to accept the product supplier's results.

It is also proposed to install a tipping bucket rain gauge on site and record the rain fall to establish what the treatment design intensity is. One of Canterbury Regional Council's draft conditions is that should the analysis of the rain data determine that 80% of all rain events are less than 10mm/hr in intensity and the monitoring of the treatment train system indicates that at least 75% removal of suspended solids has been removed on a long term average, then the Consent holder can reduce the level of rainfall intensities the treatment devices can treat. While it will not be practical to actually reduce the level of treatment the devices provide, this may be able to be reflected in a reduction in the maintenance frequency of the system.

6 LESSONS LEARNED

This project was put together by a team consisting of the developer, resource management lawyers, planners and engineers, all from different firms. Territorial Authority officers, initially from Banks Peninsula District Council and then Christchurch City Council were involved as their acceptance of the proposal was necessary for the development to proceed. The key lessons learned were:

→ The best design team does not necessarily consist of only engineers.

→ If the system is to be taken over by a local authority treat them as your client, but remember who is paying your bills.

When the proposed design was modified, replacing the sand filter with the Vortech unit, it was not communicated to the Territorial Authority officers. This was picked up by the resource management lawyer, who was able to prevent the process slipping off track. Clear lines of communication had been established but were not being utilised to the full extent.

→ Ensure that lines of communication are established and used.

→ Any changes need to be brought to all parties' attention when they occur, with reasons why they have been made.

7 CONCLUSIONS

A stormwater treatment train is proposed to treat runoff from a proposed subdivision in Lyttleton Harbour. The treatment train of Vortech + StormFilter + swale/vegetate filter strip has been designed to achieve at least 75% removal of suspended solids from the stormwater.

Concern has been raised by Canterbury Regional Council that the proposed proprietary treatment devices have not been tested in Canterbury and may not perform with the fine grained loess material on site.

Draft conditions have been prepared by Canterbury Regional Council with amendments being proposed by the Developer and Christchurch City Council, to make them acceptable to all parties.

The proposed treatment train is considered a very robust treatment system by the designers and the suppliers, but such a system was required in order to satisfy Canterbury Regional Council concerns. The subdivision is a fairly low source of contaminants so this level of treatment could be overkill. Future monitoring will determine whether this is the case.

To determine the actual performance of the proposed treatment train, monitoring will be undertaken over a series of 12 rain events. The results of this monitoring will affect the ongoing maintenance of the system. It may also affect how stormwater discharges from other subdivisions are treated.

We are still working on the final conditions but it is anticipated that by the time this paper is presented consent will have been granted and works will have started on the site development.

While the receiving environment may be sensitive, the discharge will have very minor effects. The cost of treating a rain intensity greater than 10mm/hr increases significantly for a minor improvement in total reduction in contaminants. It is considered that the proposed system is one of the most advanced systems currently available and overseas trials indicate that it can be successfully be applied to this site. It is considered that the proposed system is therefore more than the best practical option.

ACKNOWLEDGEMENTS

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