Opus International Consultants Ltd
Auckland Environmental Office
The Westhaven, 100 Beaumont St
PO Box 5848, Auckland 1141
New Zealand

t: +64 9 355 9500
f: +64 9 355 9584
w: www.opus.co.nz

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Dr L McElhone
Dunedin City Council
P O Box 5045
Dunedin, 9058

3-awb95.00

Dear Laura

Second Peer Review –
Infrastructure Performance During June 2015 Flood Event – Follow-up

Thank you for your invitation to conduct a peer review of DCC's 26 April 2016 report on mud tank performance during the June 2015 flood event. The scope of the review is to review Council's 26 April 2016 report generally, and:

> Confirm whether the Council is able to assess the influence of the mud-tanks on flooding based on the information available, and comment on whether there is anything else that could be done to make that assessment"?

This letter presents the findings of this review.

1 Preliminary Comments

The report opens by re-capping on the June 2015 flood event, its effects and rainfall characteristics. Further context is provided by reference to the 2010 Integrated Catchment Management Plan (ICMP) studies of South Dunedin and neighbouring catchments, which provide maps of expected flooding for a variety of design events.

The ICMPs identified the likelihood of flow transfers from neighbouring catchments into the South Dunedin catchment, however the report notes that these flow transfers remain unquantified.

2 Comments on Mud Tank Performance

The report acknowledges that much of South Dunedin's stormwater infrastructure is 50-60 years old, however it is likely that many of the mud tanks are even older than this. Regardless, there is a wide variety of mud tank designs and configurations. Of interest to this reviewer are:

- The "sump" or debris storage space below the outlet pipe (ranging from 0-900mm above the bottom of the pit). A DDSB standard drawing for a Single No 1 Mudtank indicates a 300mm sediment sump is typical.

- The depth and diameter of the outlet pipe (typically 150 or 225mm diameter; depth not specified, but could be anywhere in the range 200-1100mm).

Two factors dictate the capture capacity of a standard mud tank: pit hydraulics and the degree of blockage. Each of these will be addressed briefly.

2.1.1 Blockage

Blockage is a practical reality for all surface runoff capture systems, and is normally managed through regular maintenance and a surplus of inlet devices.

Blockage can arise through debris blocking the grate at street level, or via accumulated sediment and litter accumulating in the tank to a depth sufficient for it to block the outlet pipe.

Grate blockage mostly arises from litter and vegetation delivered during the course of the storm. Council's contractors are typically aware of high risk locations and attend to these upon receipt of a storm warning and during the course of the event, however during large events it is simply not possible for them to attend to all mud tanks fast enough to avoid some surface flooding.

In mature catchments (i.e. fully built-up with few sediment-generating activities such as building or re-development taking place) such as South Dunedin, sediment generation is likely to be fairly low, although the autumn leaf-fall is a recognized problem. While actual data is sparse, one Auckland Regional Council study indicated a capture rate of 35kg solid matter per pit per year.[1][2] At this rate of capture, a typical sump-equipped mud tank should be good for several years' service before outlet pipe blockage occurs.

In the absence of regular maintenance sediment will build up to the point where blockage of the outlet pipe occurs, and sediment may even carry over into the outlet pipe, or half-siphon (if fitted), which will not be cleared by routine tank cleaning.

There are two situations where mud tank blockage may be apparent rather than real:

1. Where due to heavy rainfall the subsurface pipe system is running surcharged, resulting in water backing up in the mud tanks; and

2. Where two pits on opposite sides of an intersection are linked, with one acting as an inlet and the other as a "bubble-up" outlet. Because of the extremely low

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[1] Auckland Regional Council, *Quantification of Catchment Sediments and Contaminants – Literature Review*, TR2009/122. Note that the configuration of typical Auckland catchpits differs from Dunedin mud tanks, and sediment capture may differ accordingly.
[2] The 2016 City Care tank cleaning exercise removed approximately 6 times this amount, although this is likely to have accumulated over a longer period of time.

hydraulic head under which these systems typically operate their flow characteristics are poor and surface ponding is common.

Both of the above situations may easily be interpreted by casual observers as a mud tank "blockage".[3]

2.1.2 Mud Tank Hydraulics

Unblocked mud tank grates are relatively efficient in capturing flow in "sag" situations,[4] where they can be expected to capture 100 litres/second or more with a water depth at the top of kerb.

However, the limiting component is frequently the outlet pipe, where flow is governed by the pipe diameter and the available headwater depth.[5] Unfortunately no data is available for the depth of DCC's mud tank outlet leads, however assuming 600mm depth to invert, and unconstrained by tailwater conditions, the following flows are indicated:

Mud tank outlet pipe diameter (mm)	***Indicative flow*** (litres/sec)
150	15-25
225	40-70

It is readily apparent that mud tanks with 150mm outlet pipes have significantly reduced outlet capacity, even when unblocked.

By comparison, the estimated flow from a typical 100 x 80m South Dunedin city block,[6] subject to a rainfall intensity of 8mm/hr (which is approximately the sustained rainfall

[3] The bubble-up system may actually be blocked, due to debris under the outlet grate, or sediment build-up in the submerged pipe system, however it will be routinely full of water even when unblocked.
[4] Sag situations are where the mud tank is located in a dip in the topography, preventing bypass flow and forcing the approaching water to come to a complete stop where it can be effectively captured. Many of South Dunedin's mud tanks are located at the ends of blocks where the crown of the intersecting road creates a sag situation. Grate inlet capacities are much more limited in sloping or steep catchments due to flow bypassing around or overshooting the grate, but this case is less common in South Dunedin.
[5] Mud tank outlet pipe capacity is also influenced by the level of water in the downstream system. If the downstream pipe system is surcharged, outlet pipe capacity may be reduced, and the water backed up in the tank may even give the appearance that the tank is blocked.
[6] This is typical of the Prince Albert Rd to Moreau St area. Other city blocks are larger, but would also typically be served by a greater number of mud tanks.

intensity of the June 2015 storm) is 12 l/s,[7] which would normally be captured by two or more mud tanks.

Thus, we conclude that while the hydraulic efficiency of Dunedin's mud tanks is unexceptional, they should have been capable of meeting the requirements of the June 2015 storm, *if they remained unblocked*.

3 Comments on Mud Tank Maintenance

DCC's contract specification for mud tanks requires that:

> 95% of mud tanks shall have at least 150mm below outlet clear of debris

We note that this specification could permit up to 5% of mud tanks to remain blocked on a continuing basis, which we consider unsatisfactory. However, for the 95% of tanks where the 150mm rule is met, a sediment storage space of approximately 600 x 400 x 150mm, or 36 litres should be available. Conservatively assuming the captured sediment has a density of 1000 kg/m^3, this will equate to one year's sediment storage at the ARC accumulation rate.

Thus the 150mm rule could be a suitable basis for a roughly annual maintenance programme. However, another difficulty with the specification is that since mud tanks are almost always full of water to their outlet level, it is not feasible to determine by eye their sediment level, as this is below water level. Instead the level must be felt with a suitable probe, and this is problematic since the material is saturated and easily disturbed. The likelihood of sediment wash-out also increases as the sediment depth increases, which is another reason for keeping sediment levels below the tank outlet level by a good margin.

The contractor's proxy, that tanks should be no more than 30% full of sediment is no more helpful, since the same problems relating to determining sediment level occur. We also note that for tank depths of 600-1100mm, the proxy allows sediment depths of 180-330mm. With actual outlet pipes anywhere from 0 to 900mm above the tank base, there is once again a likelihood that some outlets will remain blocked.

In conclusion, we consider both the mud tank cleaning specification and the contractor's proxy to be inappropriate for ensuring the long-term efficacy and availability of the stormwater system. However, it is unreasonable to expect 100% of mud tanks to be clear 100% of the time, so further work will be required to arrive at a contractually fair and reasonable performance standard that will also deliver optimum system performance.

4 Potential Impact of Mud Tanks on Flooding

The ability of the South Dunedin stormwater system to capture and dispose of runoff in the June 2015 flood event is governed by at least three factors:

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[7] Calculated by the rational formula, with a composite c value of 0.65

- The ability of the primary collection system (mud tanks) to capture runoff;
- The capacity of the primary system (pipes) to convey the runoff; and
- The capacity of the Portobello Rd pump station to pump the runoff.

Actual system performance will be determined by the “weakest link” among the above factors.

Council’s previous report acknowledged that the Portobello Rd pump station operated below its potential during the storm, and also that rainfall was greater than the pump station’s design flow for a prolonged period.

DCC’s report does not assess pipe capacity in any depth, but does reference the ICMP report which identified numerous short-falls in pipe system capacity, even for the 10% AEP event.

We have shown above that despite the poor efficiency of mud tanks with small diameter or high level outlets, they should have been capable of capturing the sustained rainfall intensity of the June 2015 storm, providing they remained unblocked.

What would have made the mud tanks a limiting factor is blockage, and unfortunately the effect of this is both localised and very difficult to quantify in retrospect. Serious surface flooding was observed to occur, however it is unclear whether this flooding was attributable to blocked mud tanks or other pipe system deficiencies. For example, some mud tanks in low-lying areas may actually have acted as a relief point and *discharged* water during the height of the event.

Attachment B, C and D were reviewed to seek any possible correlation between observed mud tank condition and surface flooding. It must be first noted that the majority of blue shaded areas on the maps should be discounted, as they involve flooding that was already expected due to pipe system limitations. Comparing the observed (ORC) flood levels with the tank condition data, it is apparent that there is coincidence of flooding and recorded tank defects at quite a few locations, however the correlation is not definitive. There are locations that flooded where nearby tanks are not defective, and defective tanks where no flooding is recorded (acknowledging however that the ORC flood depth data is limited).

To further assess the influence of mud tanks on flood behaviour would require examination of individual precincts and possibly even individual mud tanks to identify likely flow paths and ponding areas. This could be done via site interpretation or with the assistance of computer modelling, both of which would require high resolution topographic data. The existing South Dunedin reticulation model does not incorporate individual mud tanks and leads, and would thus require considerable refinement before use. We do not consider that such a study is warranted in terms of the benefits to be gained.

5 Conclusion

In summary, the evidence reviewed suggests that blocked mud tanks probably did contribute to *localised* flooding during the June 2015 storm event. However, we cannot definitively link the performance of mud tanks to the depth, duration and extent of flooding experienced more generally. Due to pipe capacity and pumping limitations, the pipe system appears to have been full to capacity for a significant portion of the event so that significant surface flooding would have occurred in any case.

I trust these comments will be helpful as Council and the community navigate a path forward.

Regards

W D Bird

Warren Bird
Principal Environmental Engineer
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