

Lessons learned from one of New Zealand's most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

Best practice paper: Dewatering

Story: Dewatering

Theme: Construction

A paper which aims to establish consistency of dewatering practice.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz



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BEST PRACTICE PAPER: DEWATERING

KEY MESSAGES

- If you're pumping a high volume of water with high suspended solids, know where the solids are coming from (i.e. are you creating a void?)
- If you are adding pumps to keep up with dewatering, it is likely you'll need to add treatment devices. These two need to happen simultaneously.
- Check the dewatering risk zone and have the appropriate controls in place
- Know your soil type

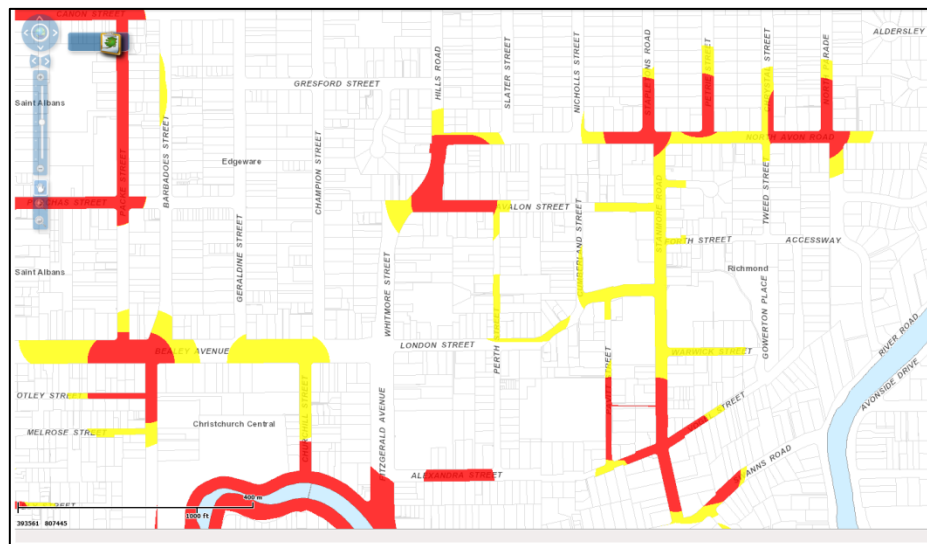


Figure 1: Dewatering Risk Zones

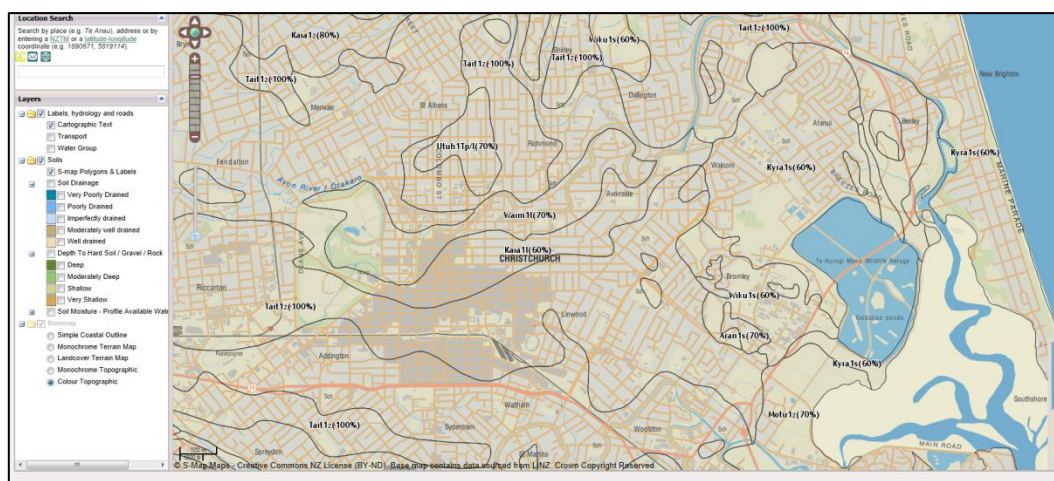


Figure 2: Soil Map (accessed from <http://smap.landcareresearch.co.nz>)

DEWATERING OF SITES

The purpose of this paper is to establish consistency of dewatering practice and allow visibility to dewatering assumptions and TOC allowance for the rebuild programme for the Christchurch rebuild.

Dewatering is a process that is required for most works which will be constructed below the water table. It is expected that most of the sewer renewal and pump station projects will require some form of site dewatering. There may also be a requirement for the dewatering of trenches for other infrastructure such as water supply and stormwater projects. A majority of surface rebuild works such as kerb and channel and road surface construction is not expected to require dewatering of sites for the rebuild.

There are several on site variables that need to be collated to allow a decision on the methodology that will be required for the site dewatering. Matching of known site conditions against the excavation depths required for completion of the design works will define likely methods of dewatering.

1. Typical Dewatering Methodologies

1.1. Dewatering of trenches with sump pumps

This involves the use of the lowest point in the trench for the collection of ground water. This low point has a pump installed which removes the ground water that has leached into the trench.

1.2. Dewatering of sites with Well pointing.

This involves the installation of a series of well points (small diameter steel shaft fitted with conical tips). These are attached to a pump to create a vacuum to remove groundwater through slots in the well points.

1.3. Dewatering of sites with Wells

This involves the installation of a bore/well of approximately 150mm in diameter. This can be either set up with a pump to create a vacuum or a submersible pump inserted into the bore.

1.4. Freezing of water table.

This involves freezing of the water table and therefore mitigation of the effects of a flowing water table.

2. Site Variables effecting dewatering Method Selection

2.1. Infrastructure rebuild requirements

The site specific rebuild specifications will allow visibility as to whether the ground conditions may affect the ability to construct the works or require further investigation into the ground conditions. Any works that do not require excavation depths below 600-700mm generally will not need dewatering.

If specific rebuild requirements require excavation below 600-700mm, further investigation into the ground water table will be required. This may be able to be gained from previous ground investigation, previous works in the area, or specific on site investigation. If previous information is being used for assessment, the time of year the data was gathered is of importance due to seasonal fluctuations in water table levels. All works that intercept the water table will require assessment for dewatering and possible allowance for these temporary works.

2.2. Depth of excavation required for works construction

The depth of the construction into the water table will aid the decision on the requirements of dewatering methodology. The greater the depth, the more likely it is that the works will require dewatering.

2.3. Water table depth

The closer the water table is to the surface, the more likely dewatering is required for the works. Also the deeper the excavation is into the water table, the greater the pore pressure and therefore the greater the possibility for ground water flows.

2.4. In situ soils

The final factor is the in situ soils. These will dictate the effects that the ground water levels will have on the dewatering requirements. The greater the pore pressure, the more effect this will have on the mobilisation of the in situ soils. There are six main soil categories: gravels, sand, silt, clay, peat and variation/mixtures of the above. Water pressure in each of these soils creates different velocities of water flow.

3. Soil Types

1. Shingles / Gravel

Large flows of ground water requiring wells if the excavation is to be deep and possible trench sumps if excavation is just into the water table.

2. Sand

Large/ medium flows of water. Trench stability low if sand allowed to run into excavation. Well pointing most effective method for dewatering.

3. Silts

Medium flows with stability mixed. Depends on the particle size in the silts.

4. Clay

Low flows with minimal trench stability issues. Water seeping into trench best dealt with sump pump in trench.

5. Peat

High to low flows. Specialist requirements as dewatering peat can result in compression of the layers causing settlement and damage to surrounding land and infrastructure.

6. Mixed soils

A majority of the conditions will be mixed and therefore the methodology is generally based on the predominant soil type.

Soil Information

To allow greater visibility of the method of dewatering required and allowed for in the TOC there are several sources of information to assess soil type.

The best practice is to investigate the soil and water conditions on site with test pits and bore logs but this is not the most cost effective. Other sources of information include CCC Webmap (which has bore log information on private properties for all new building developments on file), SMaps which contains information on what types of soils are present across Christchurch. T+T have produced a bore log map of the areas badly affected during the quakes. City Care has information of pre-road reconstruction investigations from 1970's on hard copy. ECAN also has well monitoring site data in several locations through Christchurch. There is also a large amount of knowledge with Contractors who have previously worked in the areas of Christchurch to be rebuilt which can be utilised during Early Contractor Involvement (ECI).

4. Site Investigation Overview

General site specific information should be obtained to allow correct dewatering methodology to be incorporated into the TOC and work package passed to the delivery teams. It is proposed that the best method of obtaining site specific soil profile and water level information is from excavating trial pits or bore log data.

There may also be information previously collected by several different agencies (CCC, Tonkin and Taylor), including previous experience from Contractors working on the infrastructure. The two preferred methods are:

3.1 Trial pits on site

It is expected that the information collected must meet the following parameters:

1. trial pits or bore logs should be excavated at approximately 100m centres along a site;
2. they should be excavated within 15m of the centreline of the trench;
3. they should be excavated to a minimum depth of 1m below the trench depth;
4. If trial pits are dug, photos of the soil profile should be taken immediately;
5. the trial pit should be left open for a minimum of two hours to allow the water table to settle and the depth recorded.
6. Date of test pits or bore logs should be recorded to allow calibration for seasonal fluctuations.

Advantages

- Performed at actual site of works.
- Real time information

Disadvantages

- Costly
- Assumptions made for seasonal variations

3.2 Historic Investigation Data

There are several other sources of in situ soil information that have previously been collected and may be of use in creation of site soil investigations.

- Contractor experience
- CCC (road reconstruction information)
- CCC (building consent soil investigation results)
- Tonkin and Taylor post earthquake reports

- ECAN soil profiles and well monitoring data

Once soil investigation results are analysed this will determine the expected dewatering requirements. This data and dewatering assumptions will create the basis for TOC allowance. These assumptions will be part of the project ECI process to allow input into methodology and therefore TOC.

4. Dewatering Methodologies

Methodologies will generally be based on the following table when infrastructure is below the water table. Methodologies will also be reliant on the depth of the excavation below the water table. Depth below the water table will finalise the methodology required.

| | Wells | Well Pointing | Sump in Trench |
|--------------|-------|---------------|------------------------|
| Shingle | √ | | √ (Shallow Excavation) |
| Shingle/Sand | √ | √ | √ (Shallow Excavation) |
| Sand | | √ | |
| Sand/Silt | | √ | |
| Silt | | | √ |
| Silt/Clay | | | √ |
| Clay | | | √ |
| Peat* | √ | √ | √ |

*Dewatering of peat can create subsidence issues requiring localised water table pressurisation to ensure surrounding structures are not affected by works.

4.1 Trench sump dewatering

- Used when only just breaching water table in high ground water flow soils (shingles).
- Used when breaching the water table at depth in low flow soils (clay, silty clay)
- Can be used when meeting interrupted water table with water entering half way up trench depth.

List of materials

- Size and number of pumps to be determined by the amount of water expected – pump sizing based on expected water flows and length of trench open.
- Suction houses
- Discharge houses
- Silt controls i.e. retrofitted containers/ silt busters or similar
- Environmental spill kits
- Pipe offcuts
- Poorly graded rounds

Trench Sump Pump Installation

Methodology and trench length and soil type will dictate the size of the pump required or if there is no grade whether there may be two pumps required.

Install sump at lowest point in the trench. Sump can consist of a hollow or encased poorly graded material. This decision will be based on insitu trench sub grade.

Install sump/hollow into trench with suction hose midway into sump depth. Ensure that suction hose is not placed at the base of the sump on insitu soil as pumping may mobilise insitu fines and have to be treated in the sediment tank / environment. To alleviate subbase soil mobilisation over excavate the low point and fill sump with poorly graded fill (ballast or large rounds) to raise suction inlet from the base of the sump excavation.

Connect hoses from pump to primary treatment area and ensure that this does not spill to the road surface and that it is directed to the sediment tank or receiving area.

Keep a constant flow path to the sump and ensure trench water doesn't escape into the infrastructure being repaired (sewer/stormwater).

Adjust the pump in an area that will not create noise issue or fumes in the work area. Mitigate noise issues with sound restriction device if required.

When refuelling plant/pump ensure that there is no spillage into dewatering area or overflow area.

Clean sedimentation tank as required to keep volume and settlement times consistent.

Ensure once work completed that sump area removed and poorly graded materials removed and backfilled and compacted properly.

Constantly monitor sediment tank suspended solids and adjust treatment of discharge as required (possible additional treatment methods below)

Advantages

- Cheap
- Mobile
- Easy to install
- Only operating during site construction works

Disadvantages

- Typically mobilises in situ sediment and resultant suspended solid treatment
- Can't be used for running sands
- Potential to take and discharge WW contaminants into environment
- Most common dewatering method to breach consent conditions

4.2 Wellpointing

- Used when breaking the water table to some depth
- Used for work in sandy, sandy/gravel and peat soils

List of materials

- 150mm pump (running for 24 hours).
- High Pressure water blasting Truck
- Suction hoses
- Discharge hoses
- Well points (up to 2 per 1.5 meters).
- Collection pipes
- Silt controls i.e. retrofitted containers/ silt busters or similar
- Auger/excavator
- Sharp sand

Well Point Installation

Pre Installation Checks

Before installing points check:

- that all joints are done up tight so they will not suck air
- that the rubber ball and keeper pin located inside the base of the of the sieve are in place and in good condition
- that the sieve itself is not damaged in any way that will allow sand to be sucked thru the point

When installing points make sure that the ground is clear of all gravel and tar seal. This is best done by digging a trench along the line of points or using an auger and digging/ drilling down to good sand before jetting your point down.

When points are installed it is important they are all the same length and to keep the sieves all at the same level as the water will only be drawn down to the top of the highest sieve and then it will suck air and will suck less water as a result .

When points are jetted in it is important to take note of ground conditions they are being jetted into is made up of. If the ground has sand layers mixed with layers of pug/clay then a large hole approx 250mm to 300mm in diameter needs to be created.



Once the point is at the required depth and diameter the water flow needs to be shut down until it is only just flowing out of the ground. At this time sand needs to be put in around the

point. This sand needs to be a sharp sand - concrete sand is very good for this. The low flow of water should be enough to float the small particles of fine sand and pug out of the hole but the concrete sand is heavy enough to sink to the bottom around the point. The idea is to get a good column of sand around the point and if there are layers of pug/clay it needs to extend above them to drain the water from above.



If the wellpoints are in the ground for an extended period of time and the flow seems to be slowing it could be because the sieves on the points are clogging up. This can be overcome by dropping the vacuum from the header line very quickly and back flushing the point.

It is important to check the whole system every day for air leaks as it does not take many leaks to reduce the vacuum and the amount of water being pumped.

Advantages

- Clean discharge – because the water is being drawn from a clean layer, once it is correctly established the discharge is also clean and doesn't require a great deal of treatment;
- Localised drawing down the water table level resulting in less discharge to the environment.

Disadvantages

- Dewatering has to be close to the trench/work area
- Best in uniform soil conditions
- Lead in times for work takes up more road environment
- Experience required for installation to gauge effective placement
- 24 hour operation

4.3 Wells

Used in gravel, gravel/sand, peat in situ soils.

Used when dewatering for deep excavations.

Used in high flow ground water zones

List of materials

- Submersable or vacuum pump.
- Possible electrical supply
- Drilling rig
- Suction houses
- Discharge houses
- Well casings
- Silt controls i.e. retrofitted containers/ silt busters or similar
- Environmental spill kits
- Auger/excavator
- Traffic management

Well Installation

A dewatering well is typically a 150mm dia. Shaft with a slotted tip that is installed so that the tip is embedded in a shingle/gravel layer. Typical range of depth of a dewatering well is 3.0 to 12.0m+, and may be governed by the capacity of the pump used. A well will lower the water table over an area in the order of 30m radius.

Installation – the well can be installed by:

- Augering a borehole and then inserting the shaft. This method is restricted to ground that will ‘stand up’ for long enough to allow the auger to be removed and the shaft installed;
- Driving a shaft with a pointed tip;
- Vibrating a shaft with a pointed tip;

Once the shaft is installed the well needs to be developed.

Pumping – a vacuum pump coupled directly to the shaft is normal, hence, the pumps maximum vertical lift can govern the wells depth/effectiveness. A submersible pump can also be lowered inside the shaft.

Discharge – once the well is established correctly there should be very little contaminants in the discharge, therefore, a relatively small sediment tank is usually sufficient. The rate of discharge can be high so a suitable outfall is required.

Advantages

- Clean discharge – because the water is being drawn from a clean layer, once it is correctly established the discharge is also clean and doesn’t require a great deal of treatment;
- In the right area it is very efficient at drawing down the water table level for a relatively large area;
- Can be installed away from the work area i.e. the well and pump can be in the shoulder/ berm to dewater a trench in the middle of the carriageway. May be useful where space is limited.

Disadvantages

- It effectively draws more water than is necessary, dewatering more than the specific work area. This can cause issues for surrounding ground/structures depending on soil conditions i.e. peat layers.

- Log lead in time for lowering the water table
- The wells can be difficult to establish. Experience is required to:
 1. identify when the tip has reached the shingle layer; and
 2. establish the well so that it is discharging clean water.
- 24 hour operation

5. Dewatering Equipment Location on Site

Once the dewatering methodology finalised there are several factors that need to be addressed when siting the dewatering works.

- Location to works to be performed (Wells only allow some variability)
- Size of the site available
- Speed of progression of the works
- Other users of the site (TMP and Resident access)
- Site size of dewatering works requirements
- Dewatering discharge points

All of these items may affect the ability to use the intended methodology.

6. Discharge to the Environment

It is standard practice to discharge dewatering water into the environment based on standard consent conditions. Typical factors that need to be addressed are the siting of the discharge, the effects on the discharge location and the ability of the discharge environment to accept the volume of discharge.

When de-watering we also have to be aware that we may not be taking just water from the water table. It is also likely that there will be sediment mobilised by the drawing down of the water table but there is also a chance that chemicals contaminating the water table will be drawn into the system. It is also prudent to be aware that the service being repaired may also provide contaminants that could be discharged into the environment if they are not appropriately managed. Therefore we have to ensure that we are aware of these variables and protect the environment through various methods of monitoring and treatment.

The SCIRT GIS system has the areas of possible contamination and there are additional requirements in the ITP regarding monitoring.

Proper containment of the WW system being worked on and removal of septic water when required.

There may also be opportunities to establish methods that don't mobilise water, such as ground freezing.

Other opportunities include choosing methods that don't mobilise sediments. In general wells and well pointing will only mobilise in situ sediments during establishment. There discharges once established generally result in clear water being discharged from the pumps.

Once the pumps are operating there are several possibilities to minimise the impact to the environment. These include using a method that won't mobilise the in situ soils, filtering through vegetation, collection with sediment control bag and flocculant socks, settling sediment through sedimentation tanks.

7. Methods of Discharge treatment

It is a requirement of the Global Consent to have a settlement tank as a primary treatment device before discharging to the environment. It is also required to have an oil separator when working in suspected contaminated ground water sites (locations available on SCIRT GIS system).

7.1 Sediment Control Tanks

These are by far the most common method of treatment of discharge water. If possible these should be placed out of the road environment on berms. The discharge hose should be hooked directly to the tank and not allowed to move in the first bay of the tank as this will disturb the settled sediment at the base of the tank. The tank must be suitable for the quantity of the discharge. If there are concerns about settlement times, tanks may be able to be used in series to increase discharge water withholding times and increase settlement of sediment. The first bay should also have the ability for an oil separator to be installed. This generally consists of a submerged outlet from the first bay to the second bay. There should also be a valve to allow draining of the collected oil/hydrocarbons from the first bay.

The overflow from the tank should also be controlled to the ground through the use of a pipe or hose. This will ensure that the water doesn't impact on the ground it is being

overflowed to. It will also allow the flow to be directed to the closest channel and then sump/swale.

Monitor the clarity of the water exiting the sediment tank, especially during excavation (2 hourly as part of ITP and consent conditions).

Ensure that sediment tank is appropriately fenced to ensure no access to public during site works and when site unattended.

Ensure that info at handover discusses whether the site is classed as contaminated.

All discharges to the environment require a consent.

Advantages

- Good gross settlement traps
- Sediment can be removed with suction trucks
- Allows additional treatment types on discharge water (oil separators)
- Ability of water to be accessed and used for other purposes (trench compaction, dust suppression)
- Can be used in conjunction with other methods of sediment capture

Disadvantages

- Not generally large enough to allow settlement times for clay particles
- Safety risk of water depth in public environment
- Large item to placed in the road environment

7.2 Filtering discharge through vegetation

This is generally classed as the use of areas of land to allow the water discharge to soak through the soil and back to the water table. In general this requires a large area or an area of heavy/rank grass growth to capture the fines. In these areas the use of swales and coffer dams can also be employed to collect the sediment and allow the water to drain away. At the conclusion of the type of filter it should be noted that there may need to be remediation of the soil through re-grassing or aeration to ensure that the deposited fines don't clog the soil structure.

It is important to remember that this type of treatment should be used as a secondary treatment after the discharge has been passed through a sedimentation tank to remove gross particles.

Advantages

- Discharge seeps into ground and not waterway
- Vegetation provides extended flow paths and captures sediment which is bound by grasses.
- Not in road environment

Disadvantages

- Needs grassed flow path
- Constant waterflow can compromise grass health
- Pores in ground can become clogged and require remediation
- Some maintenance required if coffer dams in place
- Rain events can mobilise discharged site sediment

7.3 Collection with sediment control bag / Flocculant impregnated sock.

This is a geotextile bag attachment which is attached to the pump outlet and filters the gross sediments from the discharge water. There are a large number of differing types of treatment in the market from straight pore size sieving to flocculent impregnated fabric. These systems vary in size, efficiency and cost, but should be investigated and considered where appropriate. These systems can also be used in series with other sediment treatment methods, such as filtering through vegetation.

Advantages

- Small in size
- Gross silt contained in small area
- Easy to disposed of silt

Disadvantages

- Unable to cope with large flows high pressure flows
- Silt must be disposed with bag
- Fines, silt weep out of bag
- Connection of pump discharge hose to bag is common point of failure

- Flocculant use is currently under investigation with ECAN. (some are eco-toxic if not bound by clay).

7.4 Flocculent Settlement Ponds

There are several proprietary solutions for this type of sediment collection. They require a constant monitoring process and also have not been fully agreed to by ECAN. They are also generally used on large scale sites dealing with sediment runoff from rain events rather than dewatering operations. Small volume and small site systems are being developed and may prove to be of use when tested in the Christchurch environment.

7.5 Opportunities for use of Dewatering discharge

Can the site water be used for dust suppression on streets? Assess when siting sediment tank.

Can the site water be used for establishment of planting/berm areas?

Can water be used for compaction requirements?

Do flocculants create issues with clay particles and not allow compliant compaction when used for dust suppression.

8. Complying with Water Take and Discharge Global Consent.

Firstly all site which have dewatering must also have a copy of the SCIRT Global Consent on site. The Project manager needs to fully understand the conditions and lead in times for activities covered by this consent.

The consent conditions are based on the total suspended solids (TSS) in the discharge. This is due to the research that shows the correlation between the TSS measure and stream health. Breaches of the TSS are generally noted through a visual check of the water being released into the environment. If required a sample is taken and tested in a laboratory (24-48 hr turnaround). It is recognised that this testing method does not allow immediate results for contractors to adjust their systems to meet consent conditions.

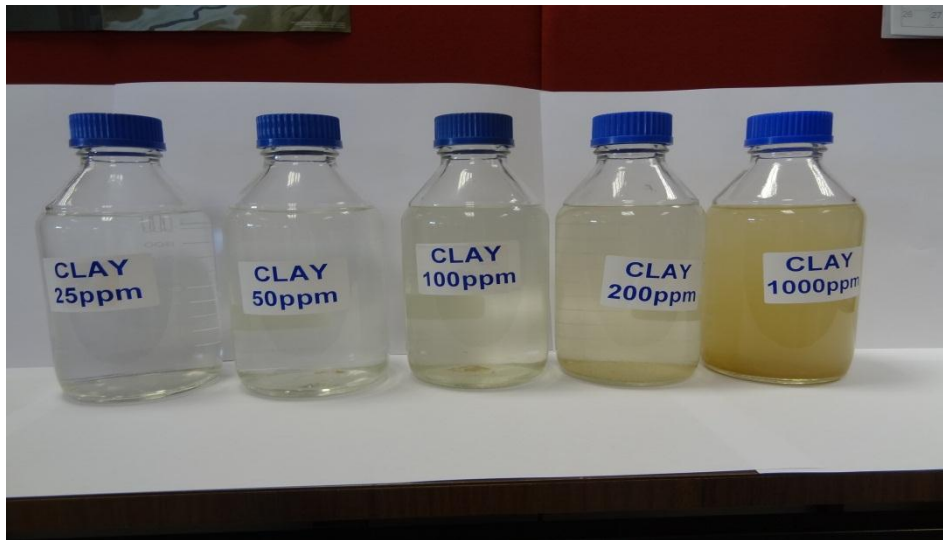
Other on site methods for assessing discharge have been suggested but a majority of these do not measure TSS directly. Other methods include conductivity testing, clarity tube and turbidity meters. To gain the TSS value for turbidity and conductivity, graphical correlation is required. This correlation generally requires base line testing of the environment which would cost a similar amount to TSS testing. The base line testing of the environment is also dynamic and needs to be assessed daily due to constant changes to the receiving environment. This will add additional costs to compliance greater than testing TSS remotely. Turbidity tube measurements are generally inaccurate due to operator assessment and sediment sizing being unknown.

Comparative samples have been suggested is to allow instant feedback on quality of discharge.

Due to primary tanks removing the solids which settle quickly the only particles with a long settling time will likely be discharged out of the primary treatment. It is therefore proposed that samples of discharge that meet the consent are created in a laboratory based on the typical particle size expected to be discharged from the primary tanks. These can then be used as a comparison between samples taken on site and allow approximation of the TSS value of the discharge.

Monitoring could then be done at the appropriate interval and possible compliance breaches could be addressed early. The visual testing is cheap and able to be done and recorded quickly.

This can then be noted in the ITP to show compliance with the Global Consent.



On going legacy

It is important that SCIRT delivery teams provide feed back on what has worked well and what has caused concern. It is also important to include ECAN with the successes and struggles to ensure visibility of the challenges of dewatering and contracting works in the greater chch area.

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