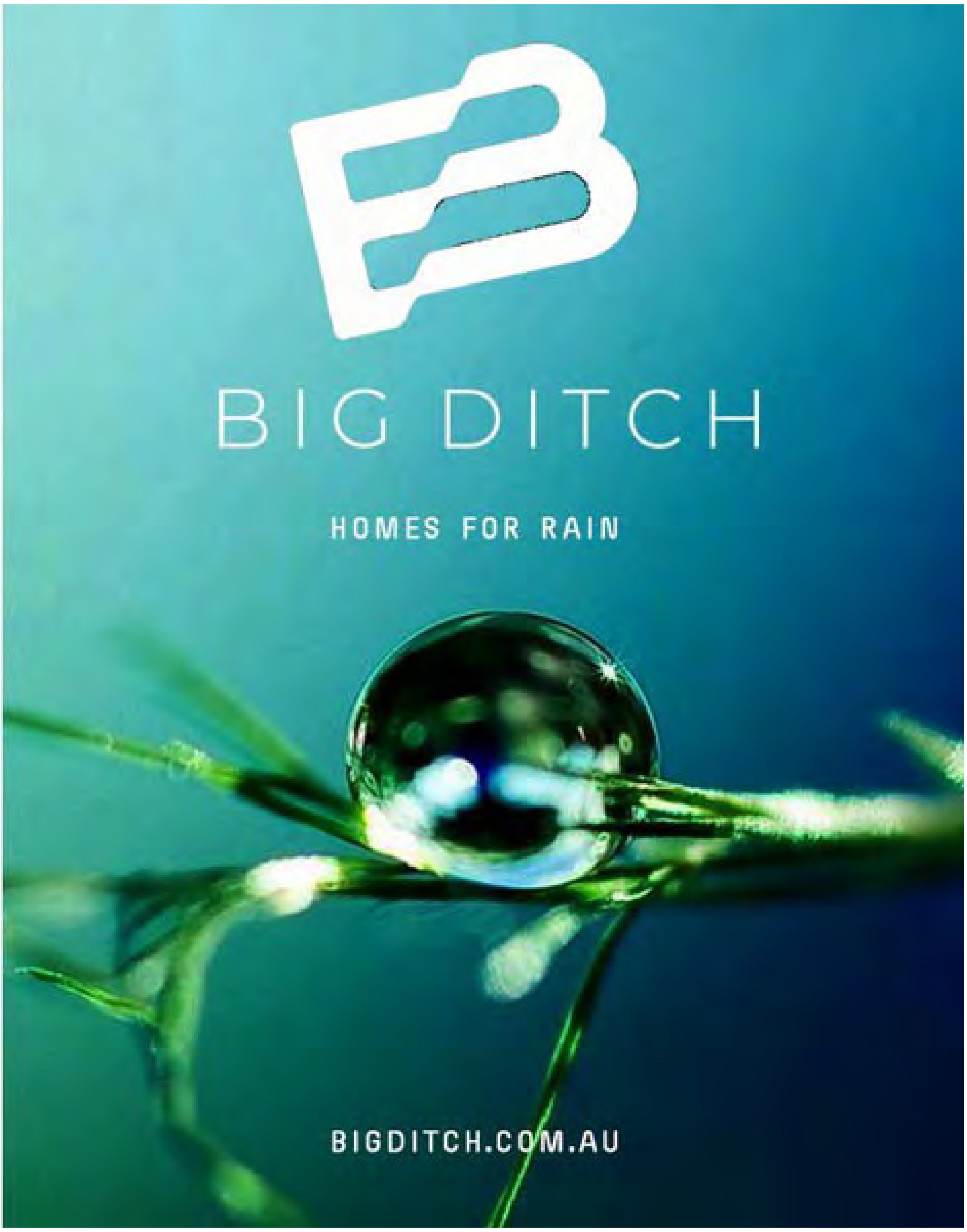


IN ASSOCIATION WITH

Water Quality Solutions

Dam Risk Assessment & Redesign Proposal

Project: Sienna Grange

Prepared for: Australian Unity

Client: Saskia Driscoll

| State Property Manager – NSW

| Asset Management - Independent & Assisted Living

Commissioning Client: Scott Tucker

| Managing Director

| Water Quality Solutions

Author: Lindsey Angus Hughson

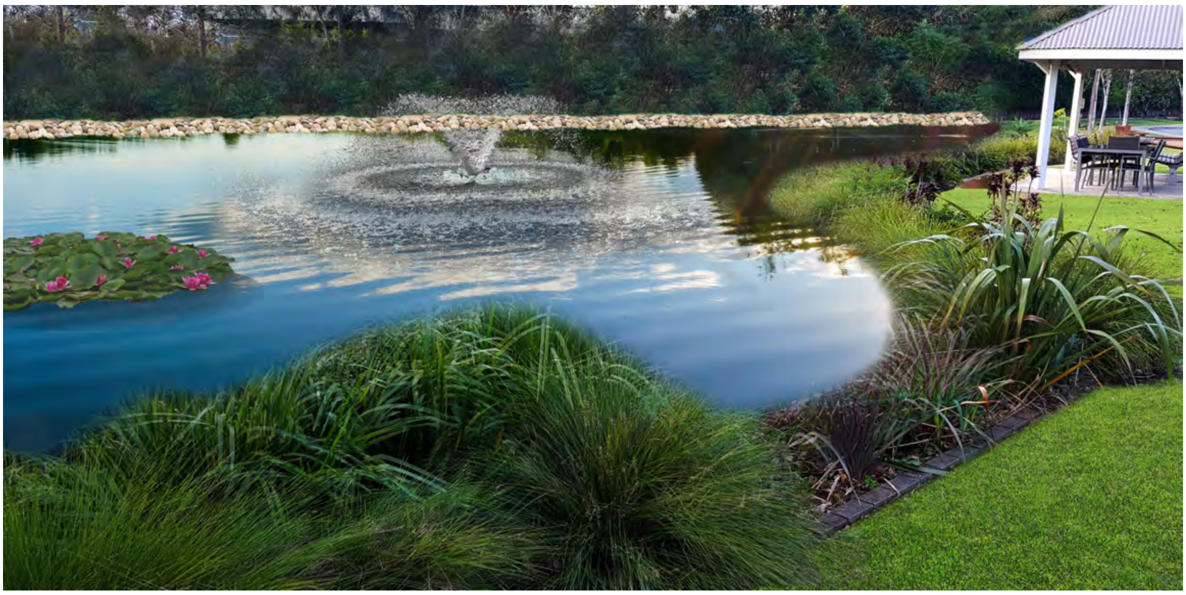
| Managing Director

| Big Ditch Dam Company

| Report Preface

Visual basis for report | 30th November 2019

What does success look like?



| Report Structure

- Client Needs
- SWOT Analysis
- Problem Statements
- Solution options
- Imagineering The Future
- Staging | Scheduling | Costing

| About the author

The findings in this report are a methodical examination of the condition of the water catchment feature at Sienna Grange.

The report is the result of my experience and approach to holistic & sustainable water harvesting, innovative dam design and rainwater harvesting optimisation.

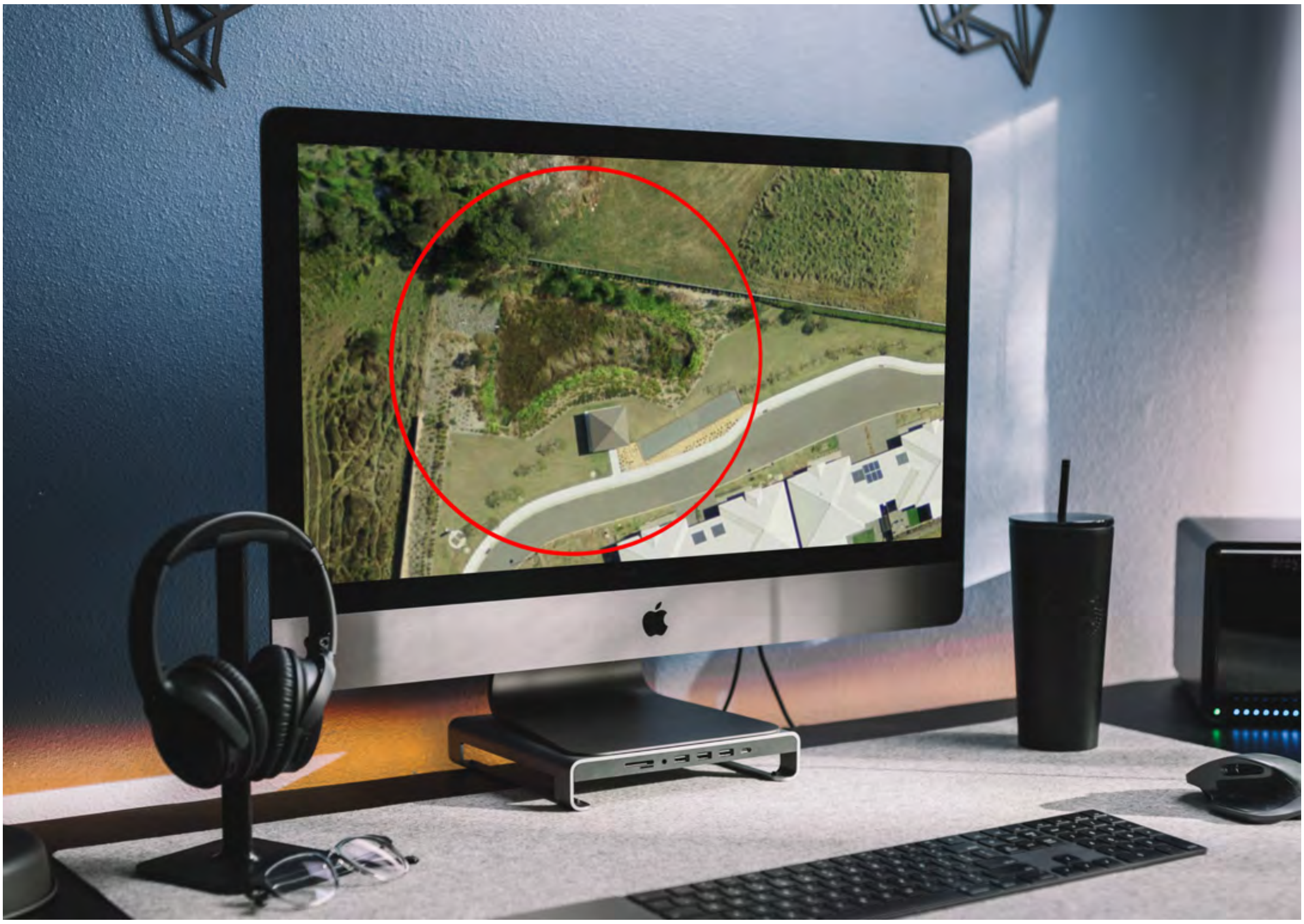
This knowledge is based on real world perspectives, intensive work experience and a deep investment in understanding structural dynamics and hydrological physics – including extensive research into the five stages of the water cycle, soil hydrology, water resource management and environmental watershed sustainability.

The advice I provide is based on:

- 15 years of dam building since retiring as President of BHP Diamonds
- the successful completion of 251 cutting-edge water harvesting facilities to date
- 28,800 hours of hands-on dam construction

Lindsey Angus Hughson | 2nd December 2019

http://bigditch.com.au/about



| Executive Summary

| Executive Summary

Making decisions about dam rehabilitation requires the vigilant & thorough evaluation of all current risks and problems associated with the dam in its current form.

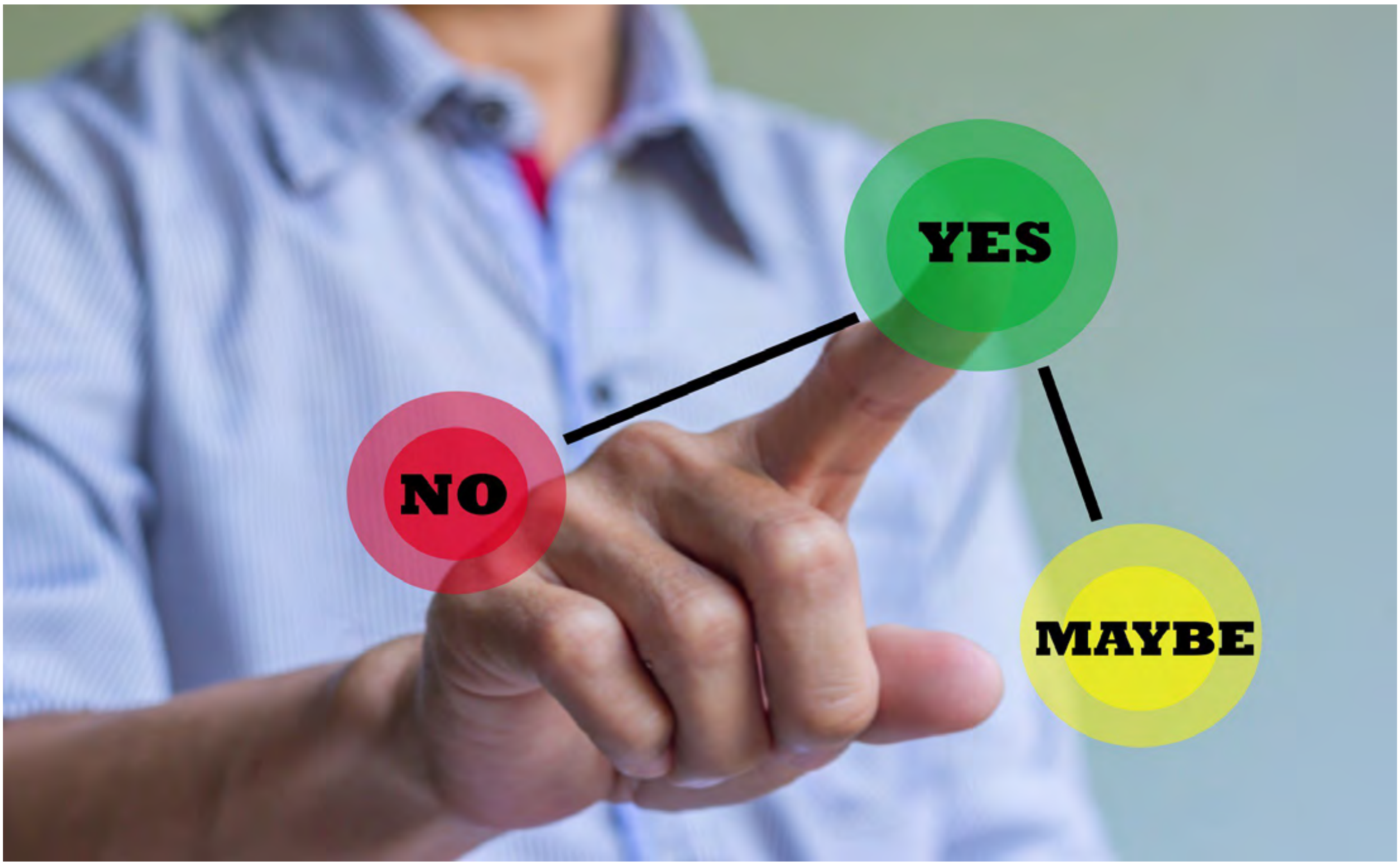
In this report, each problem is addressed with:

- a cohesive and comprehensive overview based on known technical information

- an analysis of how each problem is affecting the client's rainwater harvesting activities

The report starts with defining the client needs, then we undertake a SWOT analysis that looks at all positive & negative issues affecting the dam in a summary form.

The final section of this complete assessment is Design Options | ImagineeringThe Future – which looks at thought expanding advanced design options that are available for the dam and adjacent surroundings.

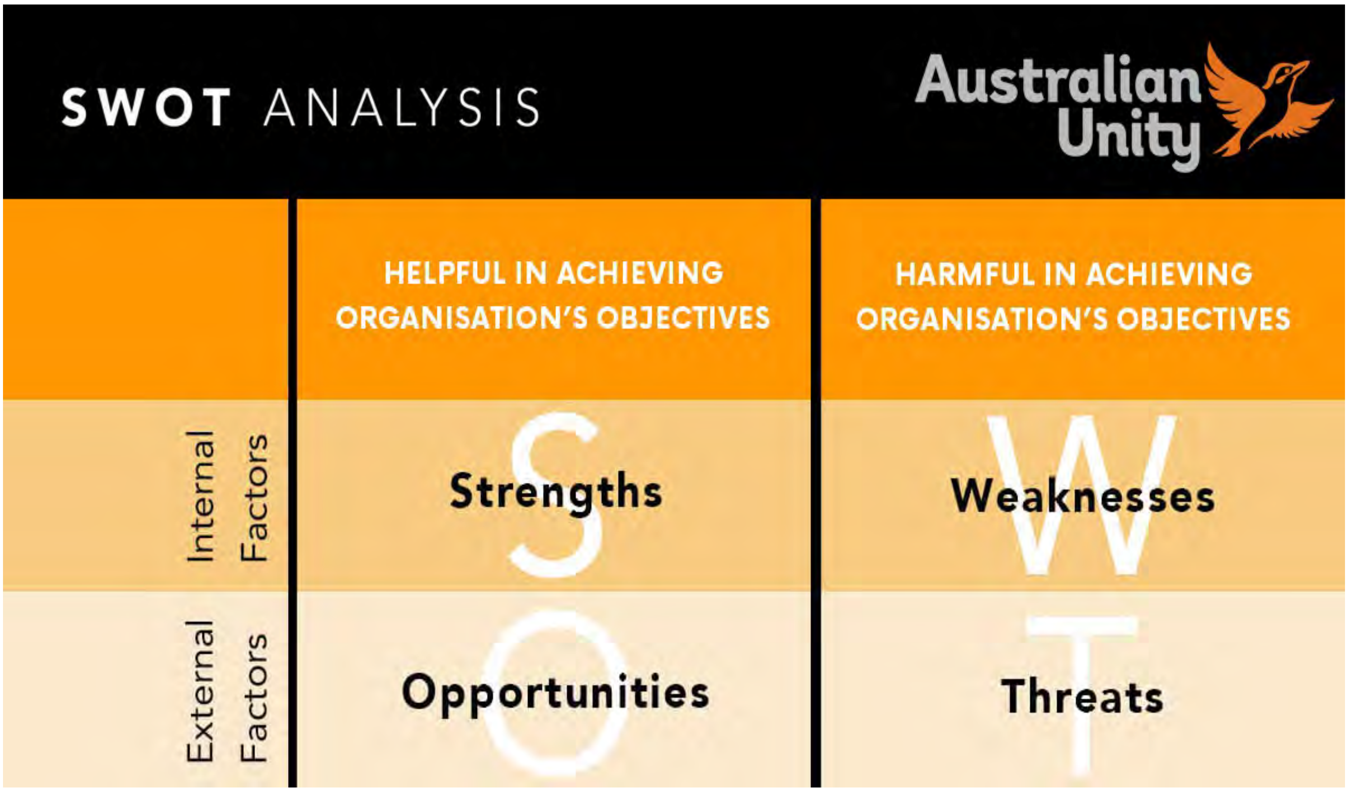


| Client Needs

| Needs. Not Wants

Based on a thorough on-site inspection & briefing by Mr Scott Tucker on 25th November 2019, the following client needs have been identified:

1. Quick win before Christmas
2. Remove unsightly reeds
3. Beautify water feature
4. Improve water quality
5. Possible green options for recycling & re-use



| SWOT Analysis

Bringing clarity and direction to the project

Strengths

- Great potential
- Dry conditions expected for December & early January

Weaknesses

- Numerous access issues
- Inside wall compaction not possible
- Weed growth access
- Wall ingress angle
- Maximum fill depth limited
- Poor water quality
- No workable spillway
- No recycling system
- No sediment traps

Threats

- Possible liability of current discharge
- Possible biological water hazard
- Adjacent surrounding infrastructure damage
- Extensive underground piping

Opportunities

- Could be resident activity focal point
- Improvement in resident quality of life
- Improvement in Australian Unity brand value
- Selling feature
- Design opportunities (see 'Imagineering The Future' section)

| Site Specifications

| What have we got to work with

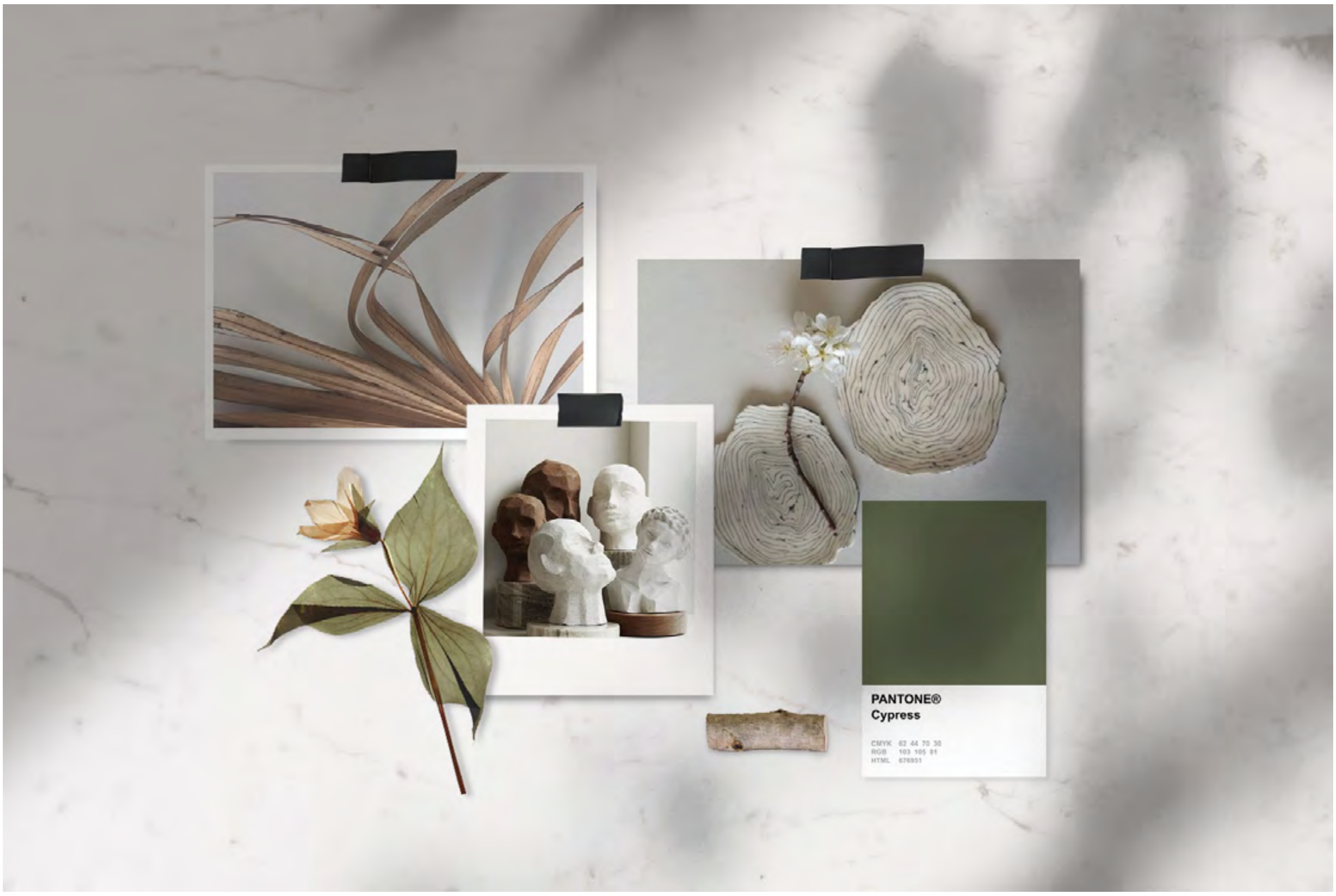
- Dam length 31m
- Dam width (widest point) 16m
- Dam width (narrowest point) 8m
- Dam depth 1.5m
- Total dam surface area at maximum volume 312m2
- Dam perimeter 167m at high water mark
- Total dam volume at maximum fill is 558,000 litres

The following information has been obtained from DFSI Spatial & Cadastral Services.

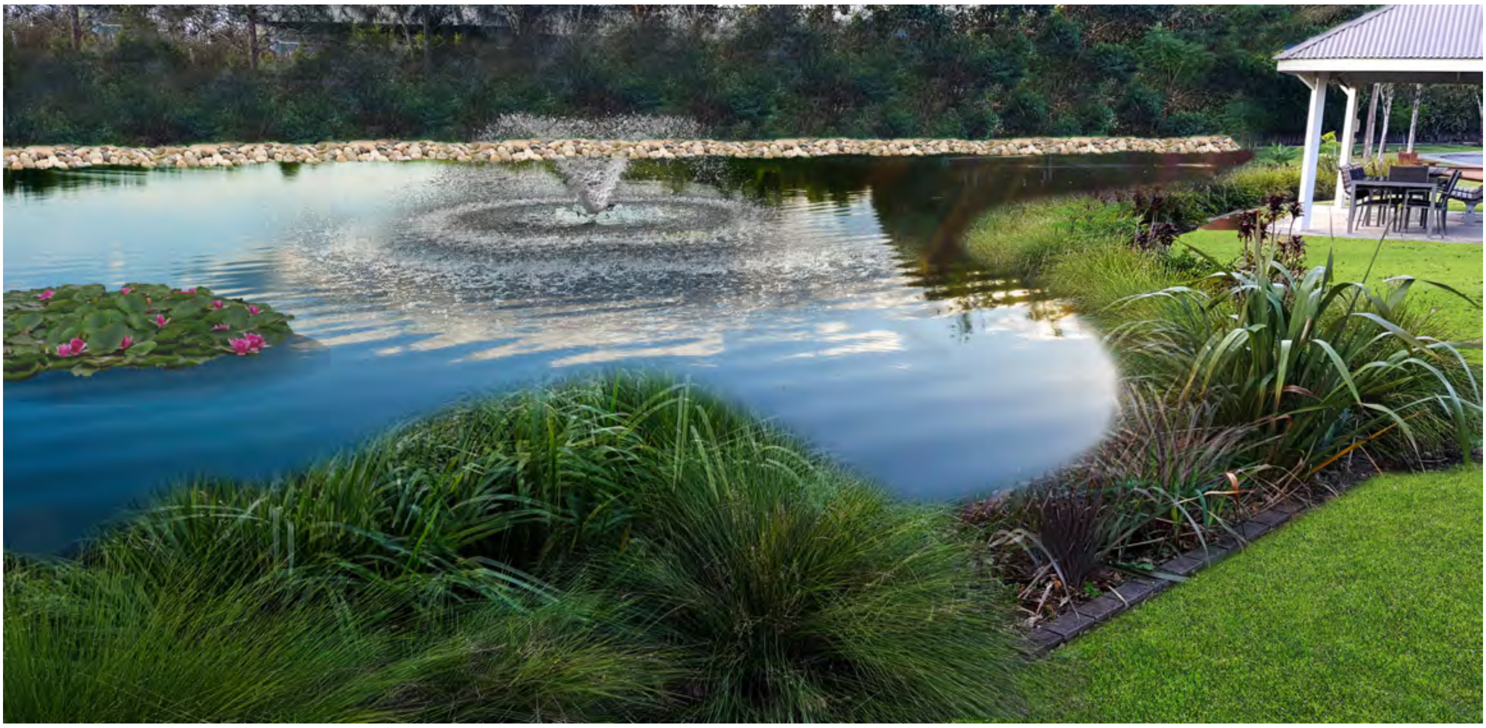
DFSI Spatial Services, on behalf of the Surveyor General and the NSW Government, creates and maintains a spatial representation of the State and acts as a single source of truth for foundational spatial information and survey infrastructure in NSW.

Design | Options

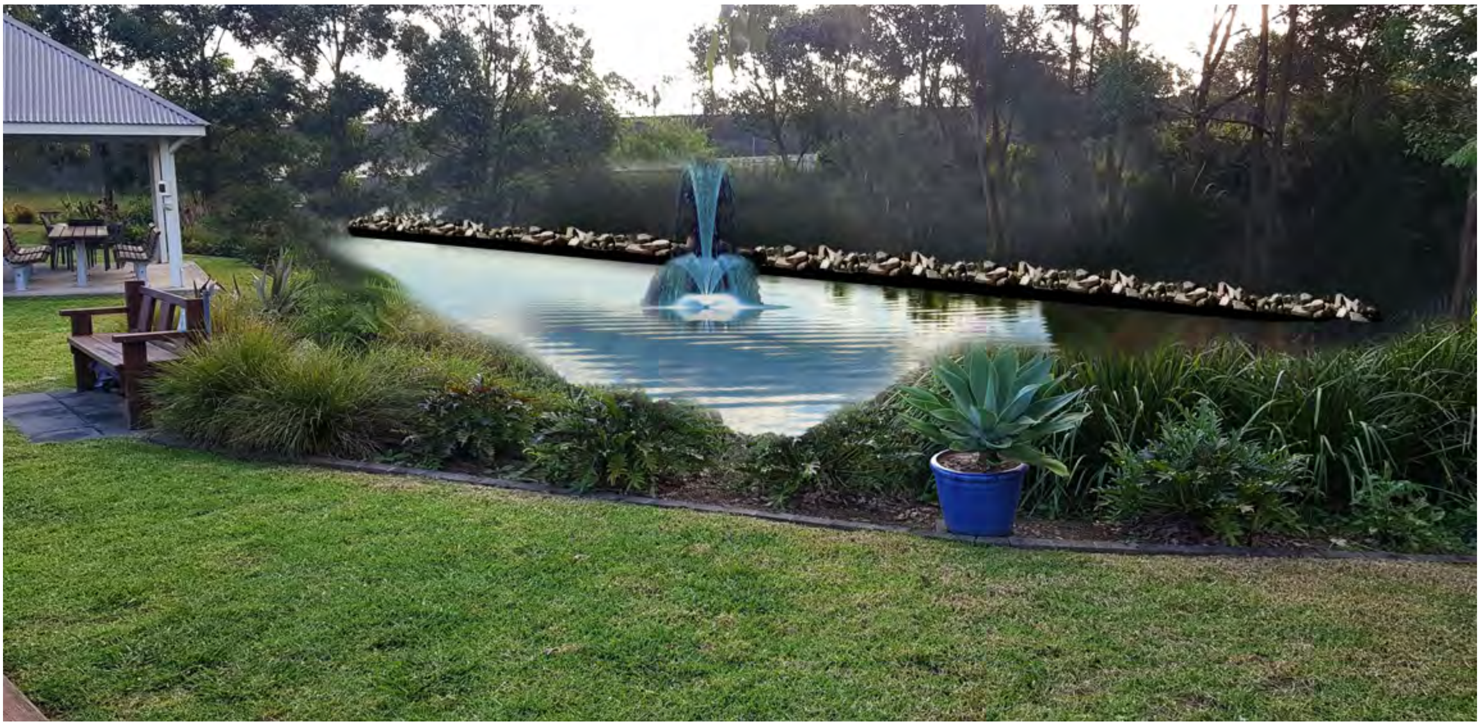
Coming soon | Beauty & Style



Palette Moodboard | Natural Urban



Perspective | South East



Perspective | North East

Perspective | North East Wall

Perspective | South East

Perspective | Gazebo View | Internal

Perspective | West View

Perspective | South Wall

Perspective | Pixie Dust Concept | North West Void

Perspective | Gazebo Exterior

Overflow | Options

Overflow | Options

The following overflow options were looked at and analysed.

These options have not been costed as they would form individual follow-on projects post dam construction.

The costing of the best option – sub-surface irrigation – would depend on the number of sprayers, and the area to be covered.

The cost to install an underground sprinkler system is approximately $3 per square metre – or $30,000 per hectare

Dam with overflow pipes in current spillway position

Pros:

Cost

Cons:

Contributes further to problem with neighbours property

Wastes water

Store overflow in subterranean tank

Pros:

Conserves water

Ability for second use of water

Cons:

Requires a large commitment of space close to dam

No obvious space available

Pumping required

Cost

Use overflow in sub-surface irrigation system

Pros:

Conserves water

Ability for second use of water

Beautification of drought affected lawns and plants

Can be put on timers

Low maintenance

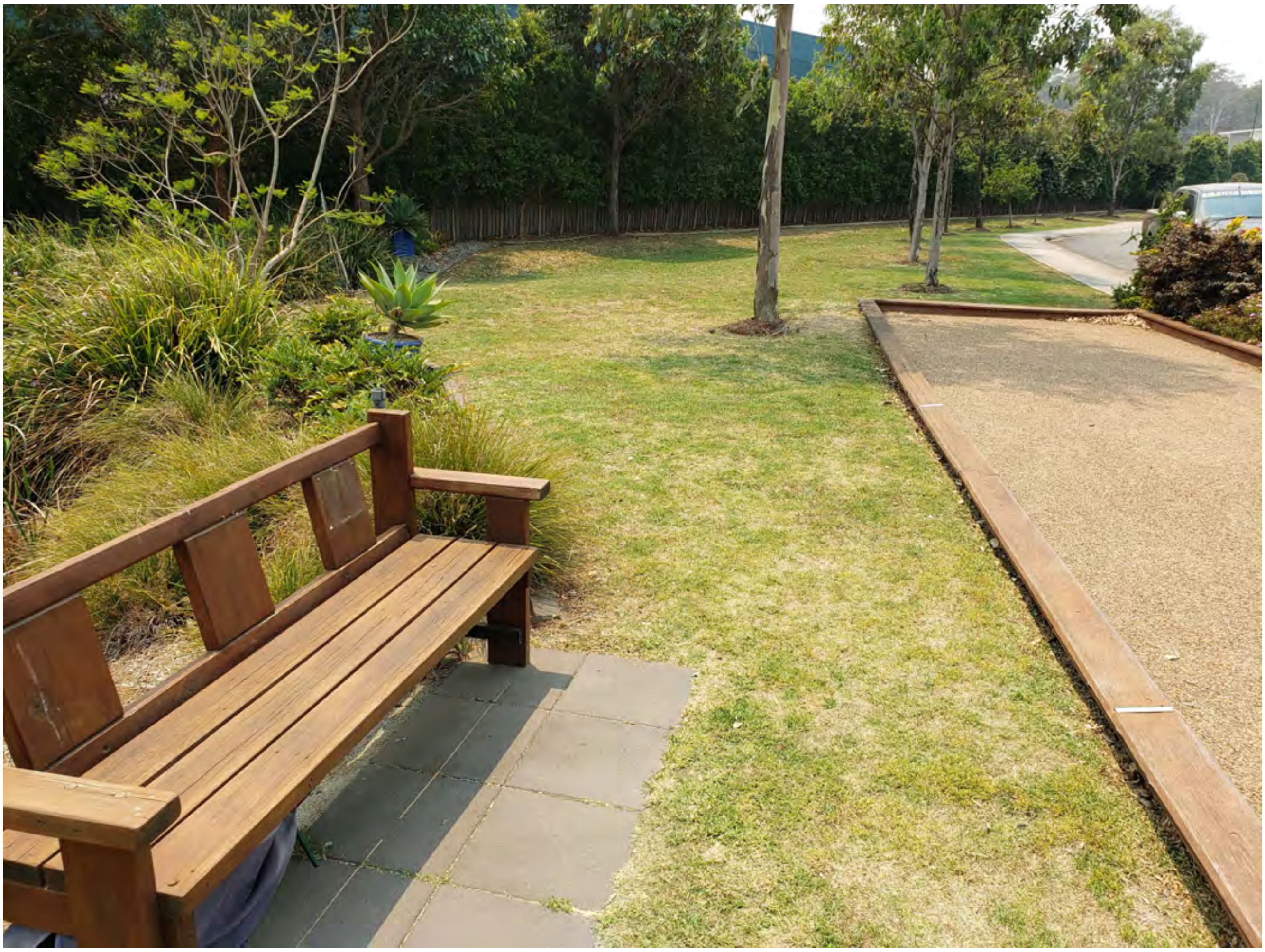
Can be applied to whole property

Cons:

Cost

Overflow | Options | Sub-surface Irrigation

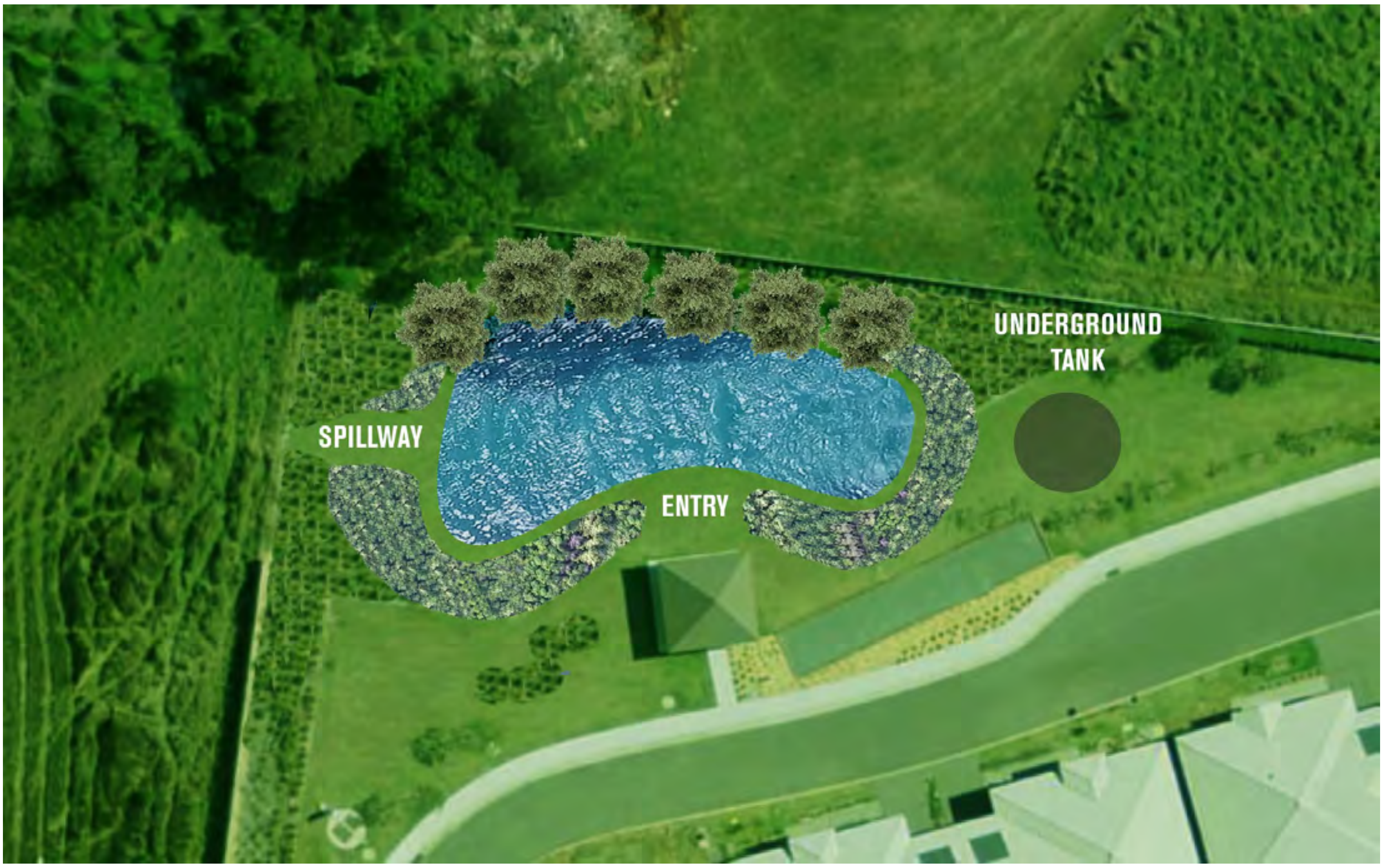
Overflow | Options | Sub-surface Irrigation | Transformation



Overflow | Options | Sub-surface Irrigation

Overflow | Options | Sub-surface Irrigation | Transformation

Overflow | Options



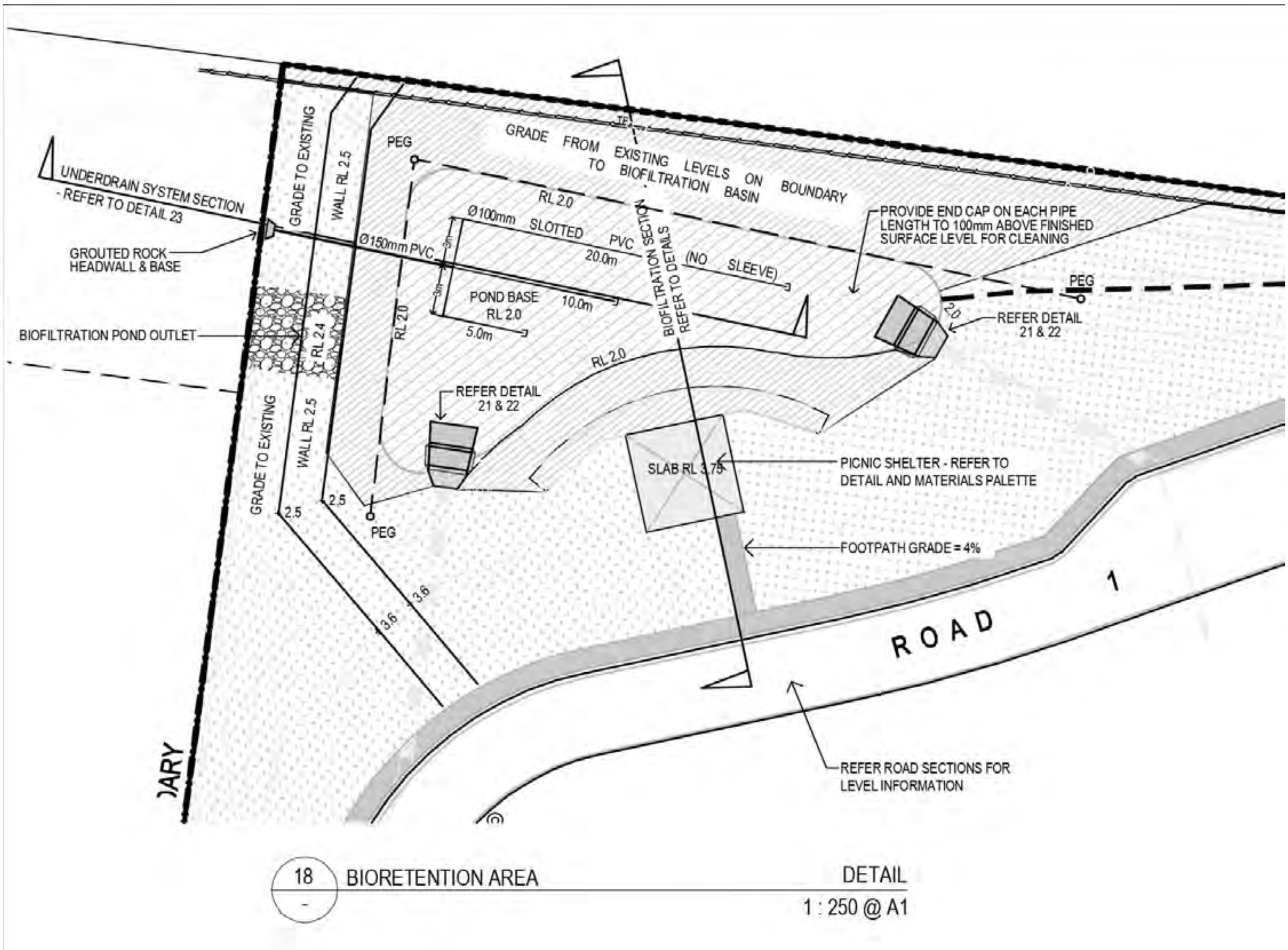
Overflow | Options | Sub-Surface Storage

| Current First Order Problems Identified

Problem | Dense weed growth

Due to overgrowth of dam flora, the reed growth is dense and well anchored to the dam base.

Implication: Enormous amount of organic material to be removed from site - or buried - or converted to compost



Problem | Subterranean pipes

There is an extensive system of sub-subterranean pipes

Implication: Will effect cost of sub-stratum operations

Problem | Water quality

Existing water volume in the catchment shows evidence of excessive turbidity and high levels of total suspended solids (TSS)

Implication: As high turbidity can result in gastrointestinal diseases, a measurement of Nephelometric Turbidity Units (NTU) would be required. Also, breaking the spillway to drain the water, or the use of a trash pump for a number of days to drain the dam before entry of labourers would be required to establish firm footing, and ensure workers are not entering a biological hazard

Important Note | Turbidity, Suspended Solids & Contamination

This water shows evidence of pathogens and other contaminants.

In stormwater, pollutants such as dissolved metals and pathogens can attach to suspended particles and enter the water course.

This is why an increase in turbidity can often indicate potential pollution, not just a decrease in water quality.

Contaminants include bacteria, protozoa, nutrients (e.g. nitrates and phosphorus), pesticides, mercury, lead and other metals.

Several of these pollutants, especially heavy metals, can be detrimental and often toxic

When the suspended solids concentration is due to organic materials, particularly stormwater run-off and decaying organic matter, the presence of bacteria, protozoa and viruses are more likely.

Such pathogens contribute to waterborne diseases like cryptosporidiosis, cholera and giardiasis.

Turbid water, whether due to organic or inorganic material, cannot be easily disinfected, as the suspended particles will "hide" these micro-organisms.

Turbidity is reported in nephelometric turbidity units (NTU).

Low turbidity levels are less than 10 NTU.

This water does not look like it would have a reading of less than 10NTU, because there is evidence of surface scum, muck and oils.

High turbidity levels up to 500NTU effect ecological productivity, recreational values, and habitat quality

If not removed, the causes of high turbidity can promote regrowth of pathogens in the water, leading to waterborne disease outbreaks, which have caused significant cases of intestinal sickness.

A disease outbreak in the nursing home, or more widely in Port Macquarie from this water would not be optimal

Notes | Bio Filter Design | Sienna Grange

The current bio-filter installation shows evidence of critical design flaws that are contributing to the possibly toxic turbid water.

Biofiltration is a pollution control technique using living organic material to capture and biologically degrade pollutants.

Common uses include processing waste water, capturing harmful chemicals or silt from surface runoff, and microbiotic oxidation of contaminants in air.

In laymen's terms, bio-filters take in dirty water, and discharge it as clean water.

Bio-filters are flow-through systems. The dirty water enters, flows through the organic material which cleans it through a process of natural filtration and toxin extraction, then the water exits the system at a level of 1-5 NTU.

Although biological filters have simple superficial structures, their internal hydrodynamics and the microorganisms' biology and ecology are incredibly complex – and perhaps not understood by all engineers as they approach the process from a theoretical basis, rather than a practical application of the processes.

Some things can't be learnt from books.

You have to build them to understand them

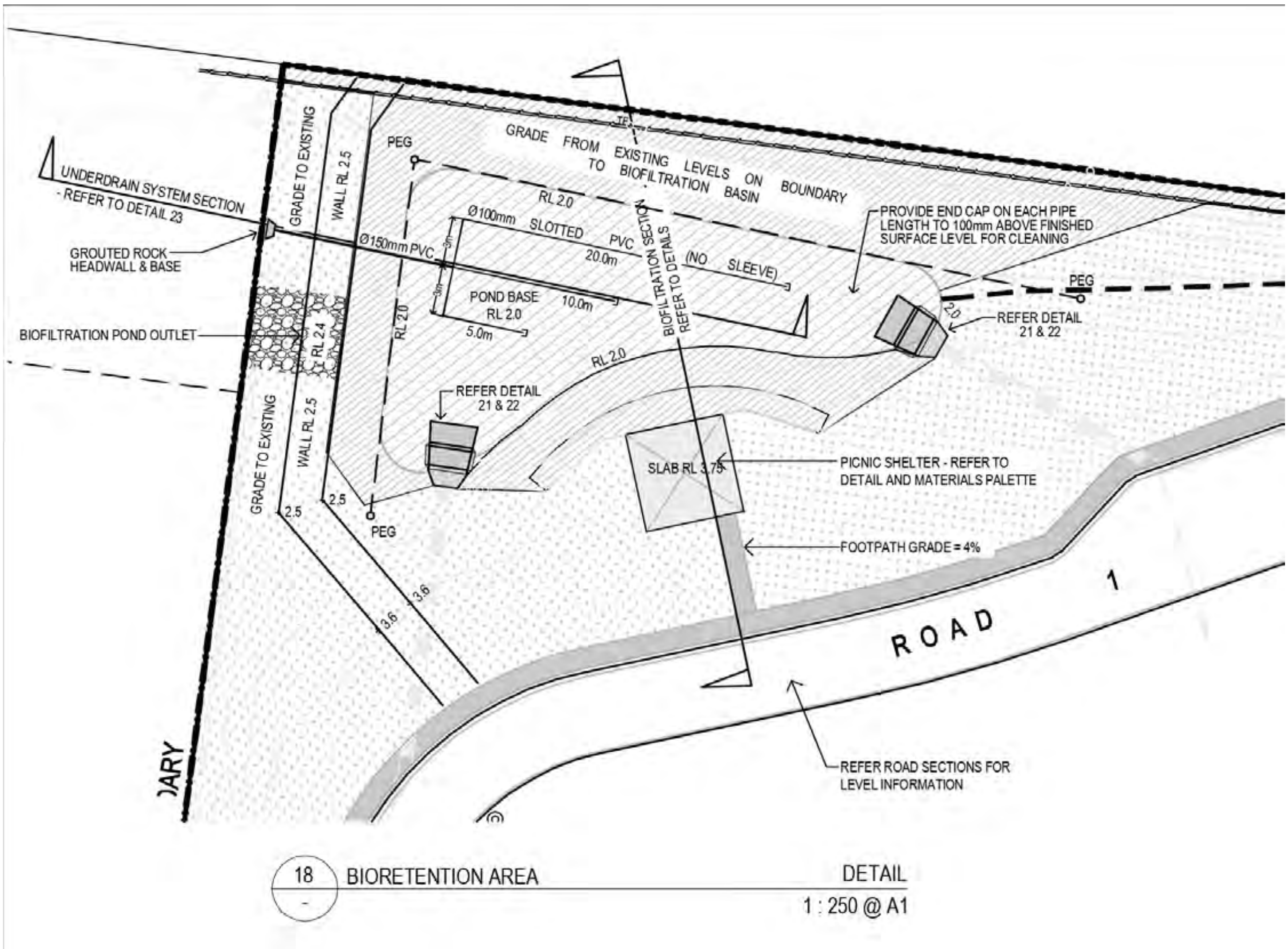
The important part of a bio-filtration system is the 'flow through'

If the dirty water doesn't flow through the system, it will not be cleaned, and exit as dirty as it entered – totally negating the whole purpose of the system.

The system at Sienna Grange is not working, otherwise the water would not look like it does.

And there is one very simple reason it is not working

This is the architect/engineer drawings of the bio-filter system in place at Sienna Grange.

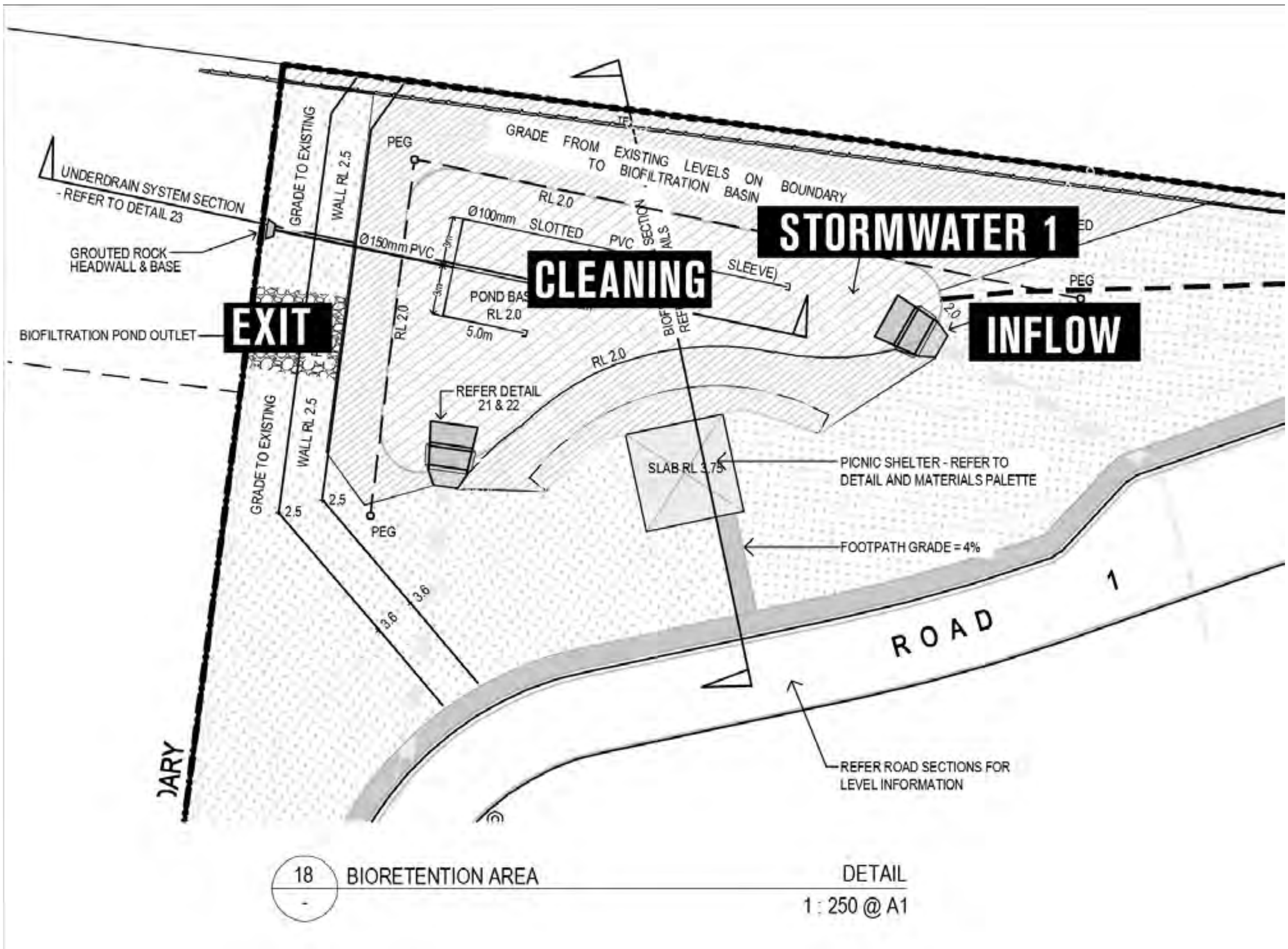


If you look carefully, there are two stormwater inputs to the bio-filter system

One to the right, one to the left.

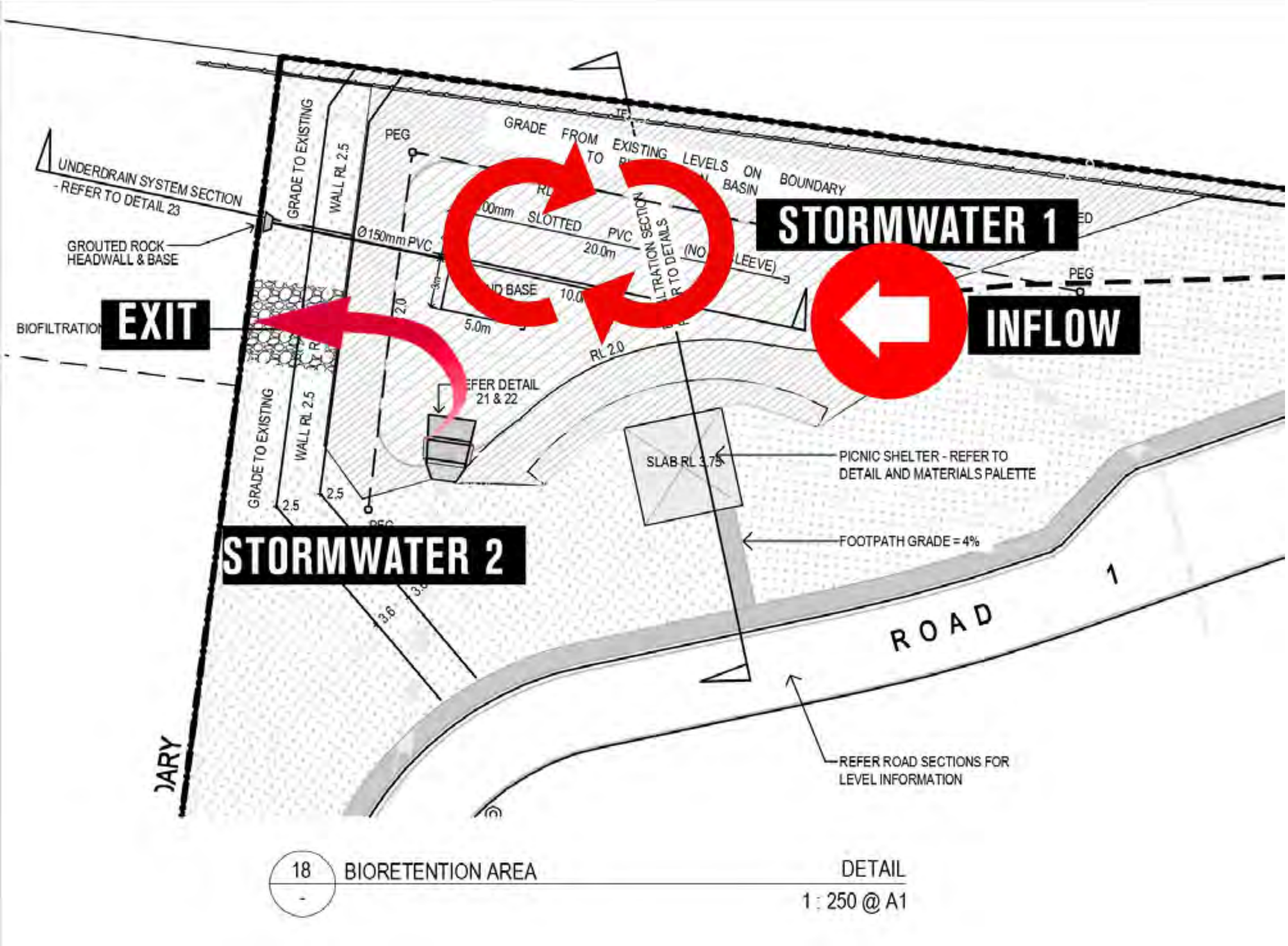
The problem is the one to the left

This drawing shows the expected fluid dynamics of the No 1 stormwater drain to the right e.g how it should be working correctly



Dirty water comes in at the right, flows through the system, then exits clean to the left.

However, the problems start with the location of the second stormwater drain



The actual dynamics of the system are:

Inflow from stormwater drain 2 is entering, and then immediately exiting to the left, without travelling through the filtration system

The inflow from stormwater drain 1 is entering the system, travelling through the filtration system, then hitting the dominant flow of stormwater drain 2, bouncing of it, then causing whirlpooling as it loops back towards the ingress point.

This means inflow from stormwater drain 1 is trapped in the system, going around and around in a slow motion whirlpool, unable to break the flow pattern of the second stormwater drain.

The implications of this are:

Flow from stormwater drain 1 is creating a growth of biomass – leading to an accumulation of matter in the filtering media.

This is what is called bio-clogging.

Bio-clogging can be controlled using physical and chemical methods such as

- using air and/or water to disrupt the biomat and recover flow
- chemicals such as peroxide
- biocide agents
- backwashes

But this bio-clogging is not being controlled

Under optimum conditions, including relatively low turbidity and high oxygen content, the organisms break down material in the water and thus improve water quality.

But the bio-clogging is starving the water of oxygen, killing the good micro-organisms – and leading to extreme turbidity

This system could best be described as a factory for growing water-borne diseases.

Problem | Overflow egress

Excess turbid water is discharging straight into neighbours property

Implication: This is a lawsuit waiting to happen. This is not a natural waterway, and it is effecting neighbours ground structure & footing – making future building on a large amount of the site impossible due to long term seepage.

The discharge is also undercutting the fenceline, which will result in a future liability.

My personal opinion is that this discharge should never have been approved or allowed

Urgent | Discharge of Turbid Water Into Adjacent Property

This is a real & present liability – and requires immediate action

What is happening?

A constant stormwater flow is being concentrated into a small area in the corner of the neighbour's property.

The Effects

Constant flow of water over a long period of time will soften the ground underneath – creating a bog

The discharge will spread in two directions – downward and outward.

Initial flow will soak downwards, until to hits hard sub-surface layers – either rock or non-porous clay. Normally this is at a depth of 4m in Port Macquarie

When that level is reached, the flow then spreads outward laterally (as it is presently)

The Implication

This type of flow will eventually turn firm ground into an unstable and un-natural bog.

The danger here is that I assume the neighbours property is zoned commercial – and therefore something like an office park could be built – which involves large construction footprints.

A Scenario

If the owner were to come along to build a large office park on this land tomorrow, he wouldn't be able to because of the bog like conditions that have been created.

There are two solutions to that scenario.

Firstly, massive deep footings to ensure the buildings are anchored and secure.

This is an extremely expensive exercise.

Secondly, all the bog material could be removed and replaced with firm ground (eg rockfill) to ensure a firm surface footing.

This is also a very expensive exercise.

Implications

If this were the situation, and the owner was faced with massive undertakings that would cost millions of dollars, it would not be surprising if he/she did some investigation as to why a large percentage of his/her property was a bog, when we are in drought conditions.

All he/she would have to do is follow the bright green grass – and it would lead straight to Sienna Grange.

He/she would have a couple of options -

- seek compensation
- seek remediation

Believe it or not, this is the best case scenario.

There are two very much worse scenarios.

Worst case scenarios

If there was contamination of the ground as well as bogging, the EPA would get involved – and that could result in a very large fine, as well as the cost of remediation.

The second very bad scenario involves acid sulphate.

Port Macquarie is badly effected by acid sulphate.

It sits in low flat ground without drainage, and is toxic to fish & oyster life if it reaches the waterways.

Due to this, it is rigorously policed to make sure no-one lets it enter the water course.

To me, the land next door looks like acid sulfate ground – because I've had a lot of experience with it.

Australian Unity may be responsible for pushing it into the water course – because it can travel through soft ground.

If this were the case, the brand damage to Australian Unity and Sienna Grange would be catastrophic.

I don't want to be alarmist, but I think it is important to give the principals a heads up.

Best case scenario

Forgetting about the very worst scenarios, the owner next door may have a case for asking Sienna Grange to remediate his land due to infrastructure work done on the nursing home property that concentrates the flow onto his property.

I have calculated the effected area is approximately 80,000 cubic metres (200m x 100m x 4m)

At a remediation rate of $200 per cubic metre (excavation, dumping, replacement with solid fill, repacking and compaction) this represents a possible future liability of $16,000,000

Remediation

Remediation is the process of restoring land that has been damaged, and effected with adverse physical properties - and has been reduced to an economically un-usable state.

Remediation involves the displacement of large volumes of soil and replacement with rock-like fill, to correct the various degrees of environmental degradation in the disturbed areas, while minimising environmental impacts.

Remediation protocols

For areas that have been rendered to an unnatural, disturbed, or damaged state – there is a protocol in place to restore this ground to it's original state.

- Cleaning up contaminated areas by removing/isolating contaminants.
- Physically stabilising the terrain, landscaping, restoring topsoil, and returning land to a useful commercial purpose
- The land and watercourses are returned to an acceptable standard of productive use (landforms and structures are stable, watercourses have acceptable water quality).
- Rebuilding the ecosystem that existed at the site before it was disturbed.

Solution | Discharge to neighbours property

- Immediately stop the discharge from entering the adjacent property
- Pray for hot weather to dry out the ground (which could take up to a year because of the soak depth)
- Hope that the owner has no immediate plans to build – or sell (which would initiate an inspection)

Notes | Water Courses

A watercourse is the channel that a flowing body of water follows.

Water courses can be wide and flat, or narrow and deep.

But they are easily observable in aerial photographs because years of flow always carve out flow patterns in the land that the water travels over.

Water courses can be dry or wet

A wet water course

A dry water course

There is no evidence that the discharge of the water from the Sienna Grange is being egressed into a natural water course

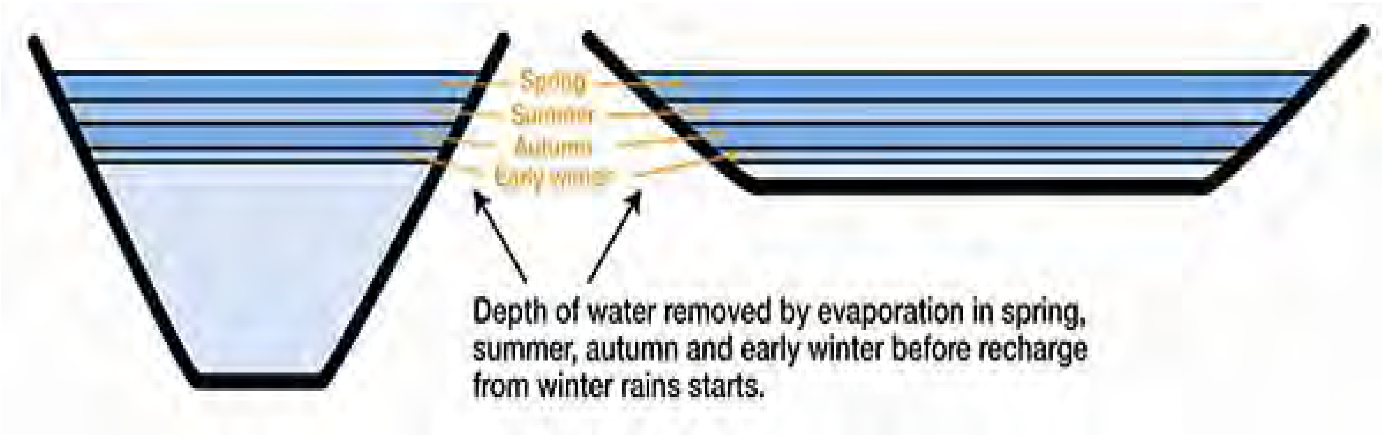
Further evidence of this is the photo below.

The seepage is travelling east to west towards its natural level of equilibrium.

The flow is actually being released on high ground, and flowing right to left seeking low ground.

This is not a natural water course

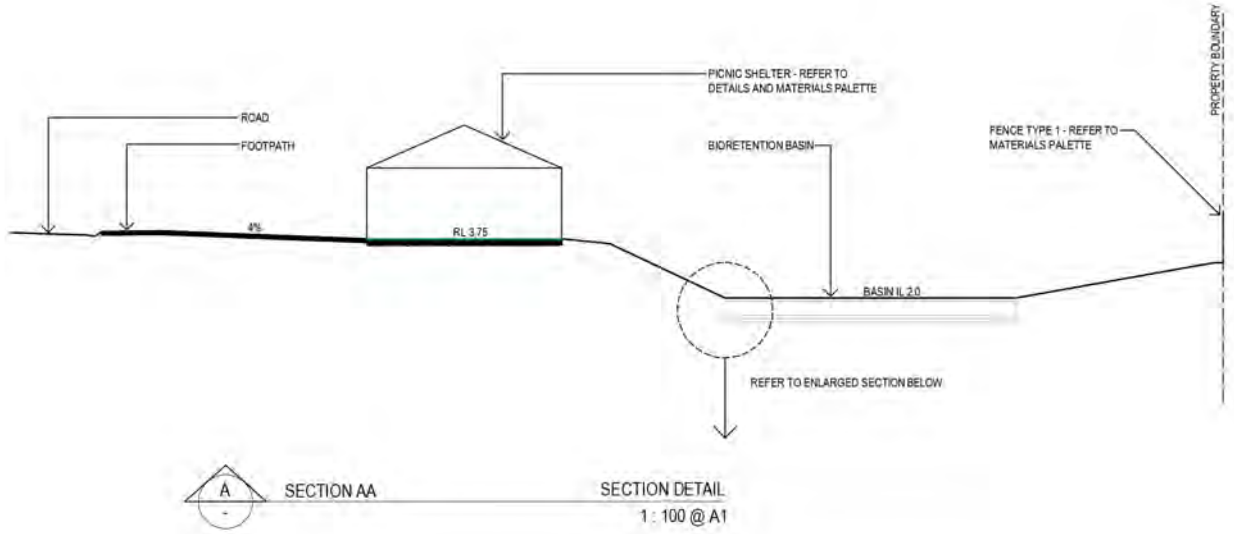
This is un-natural man-made saturation & destabilisation of previously economically viable firm ground.

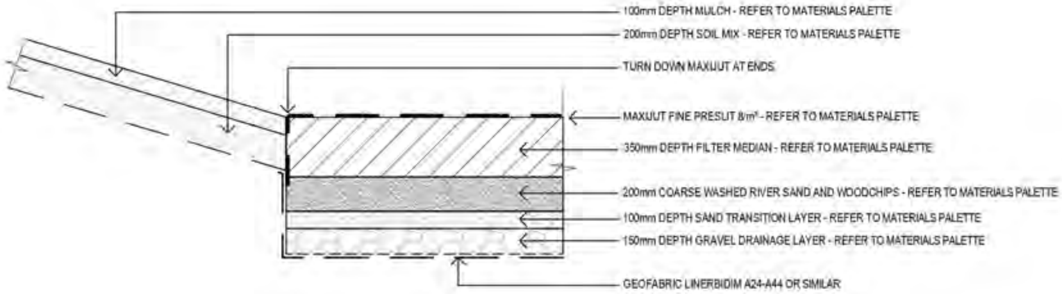


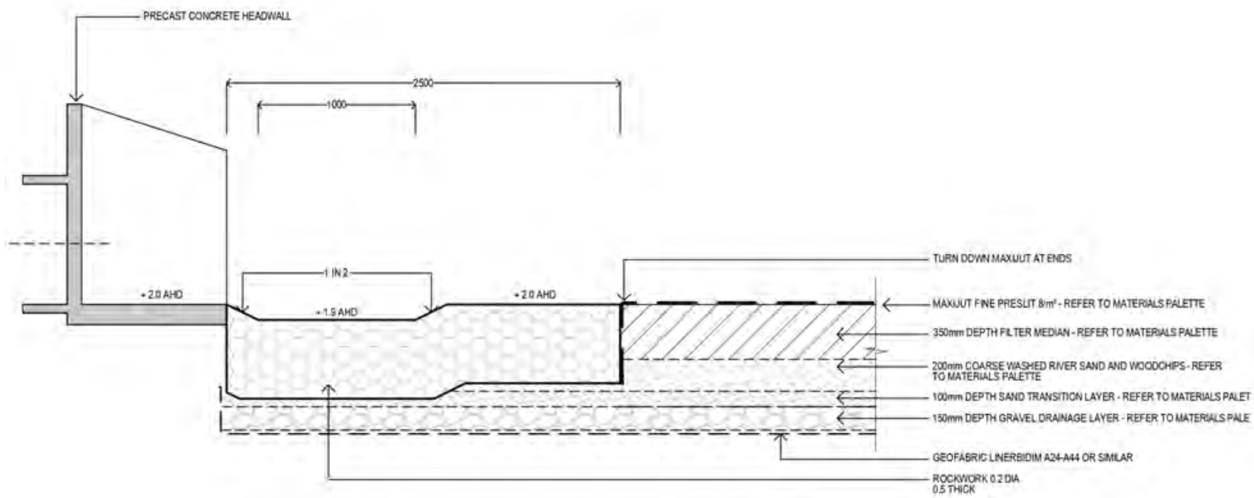
Problem | Lack of depth in the dam

Implication: This dam will always be subject to significant loss of volume due to evaporation unless significant excavations are undertaken to increase the DSV ratio.

However, significant excavation to the required depth of 4 metres faces significant hurdles (see next problem – unstable boggy base)







Problem | Unstable boggy base

Due to the construction techniques used in this dam, there exists a soft base of organic material that extends approx 1.9m below the surface.

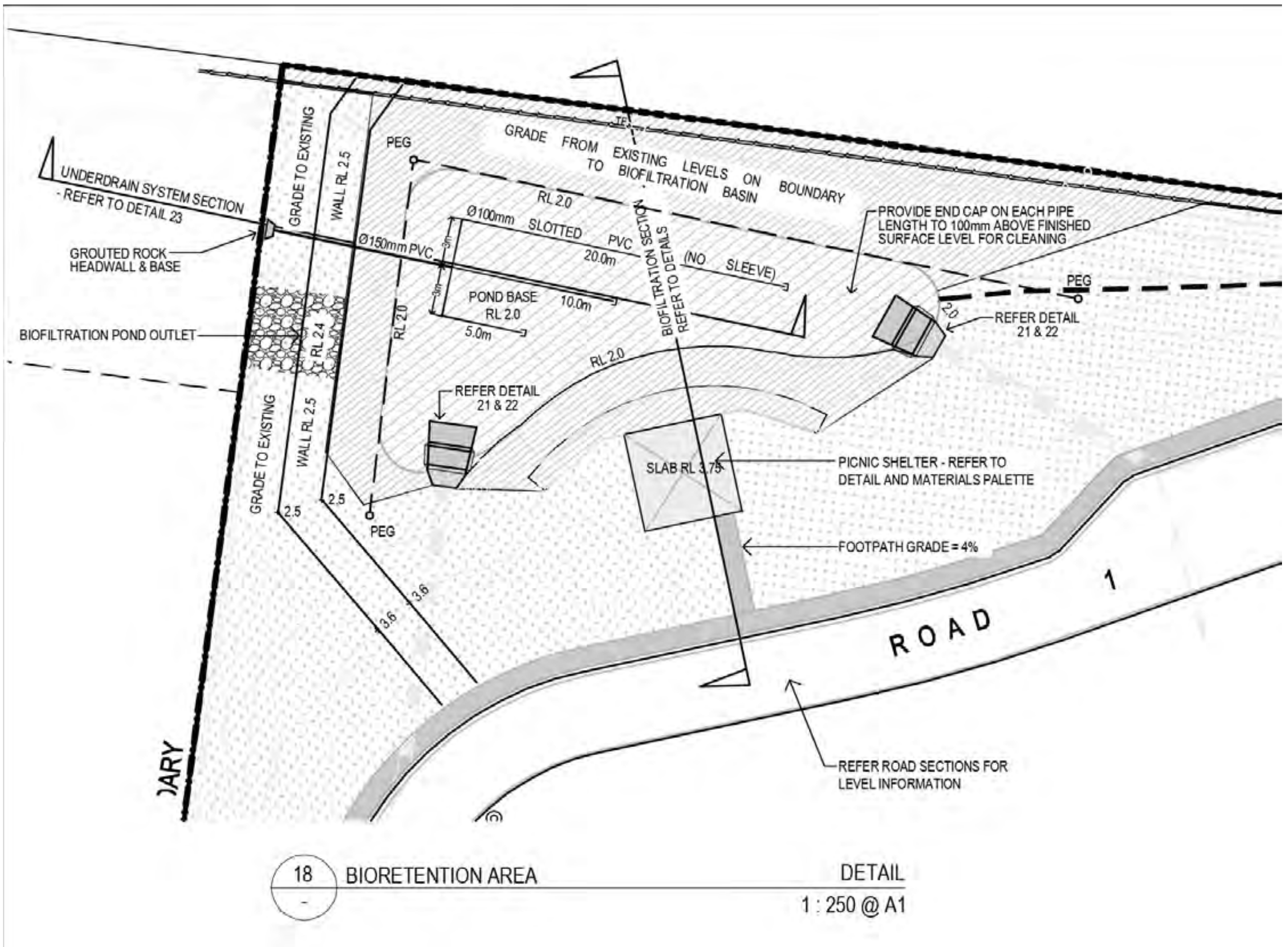
As this material remains constantly wet, the ground below it will also be soft – possibly for a further 3m in depth

Implications:

The ground will not hold a machine until hard ground is established

This would normally be achieved by exterior perimeter digging, but almost 80% of this dam has access issues that prevent that.

I have my doubts that this dam base will hold the weight of labourers, which also limits hand picking of reed growth.



Problem | Inflow backup

This dam has two stormwater inflows

Implications: When the water level is raised, these stormwater drains will backup an extra 2m in vertical height. It is important to understand the effect of this backup on surrounding infrastructure before the water is raised.

Problem | Confined space access issues

There is access issues on every side of the dam that is going to limit the solution options.

Those individual access issues are detailed on the following pages

Access issue | Dam perimeter edging

Implication: Machines will not be able to enter on three sides of dam

Access issue | Dam perimeter vegetative plantings

Implication: Machines will not be able to enter on three sides of dam

Access issue | Recreation gazebo

Implication: Machines will not be able to access or swing on 50% western dam edge

Access issue | Sewerage inspection sites

Implication: Machines will be limited in area they can traverse

Access issue | Sewerage inspection sites

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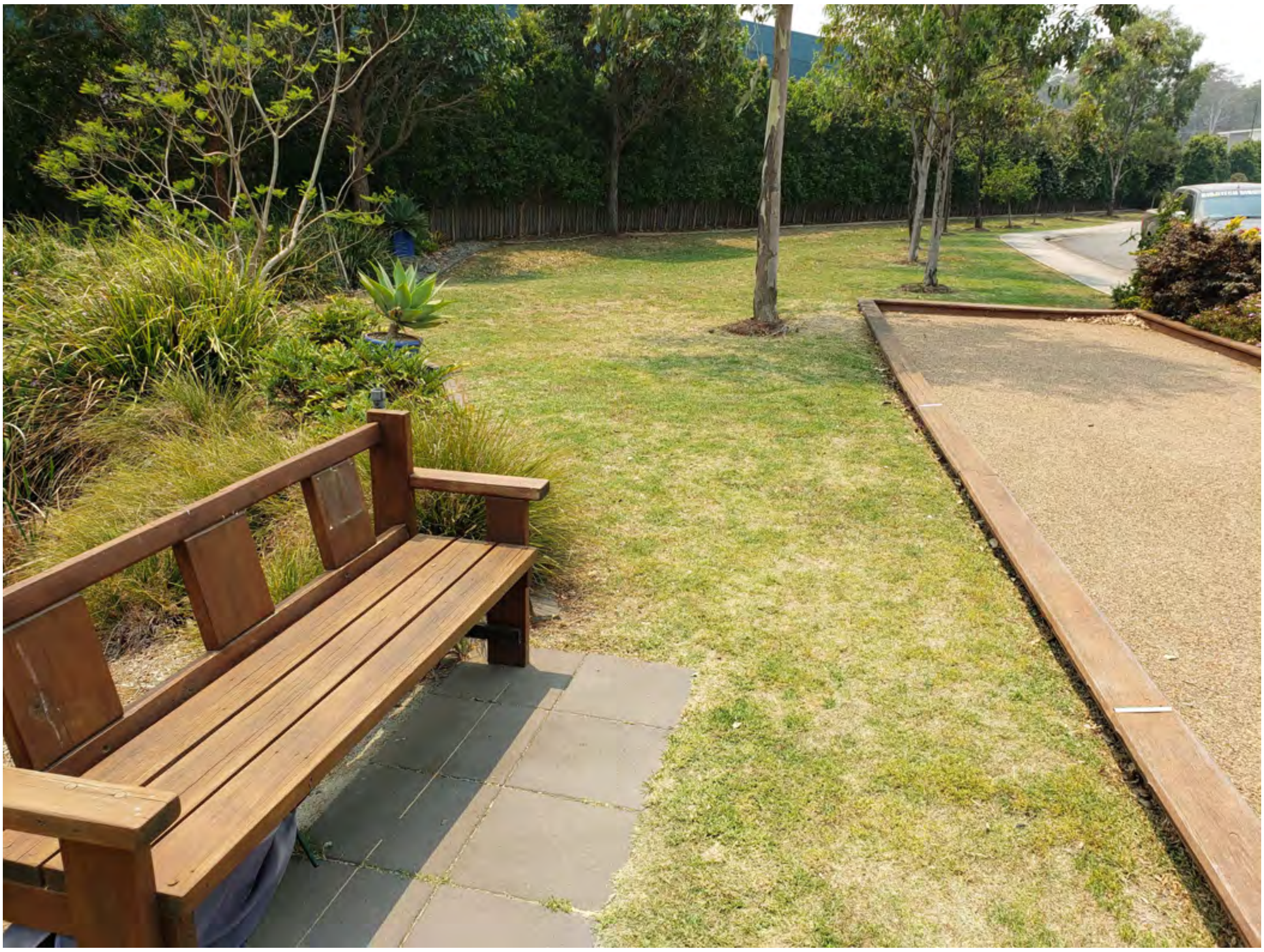
Access issue | Sewerage inspection sites

Implication: Machines will be limited in area they can traverse



Access issue | Recreation installation

Implication: Machines will be limited in areas of dams they can access

Access issue | Inflow pipe

Implication: Machines will be limited in compaction & seal they can achieve

Access issue | Trees on eastern perimeter

Implication: Machines will be unable to access eastern side of dam

Access issue | Vegetative growth in spillway

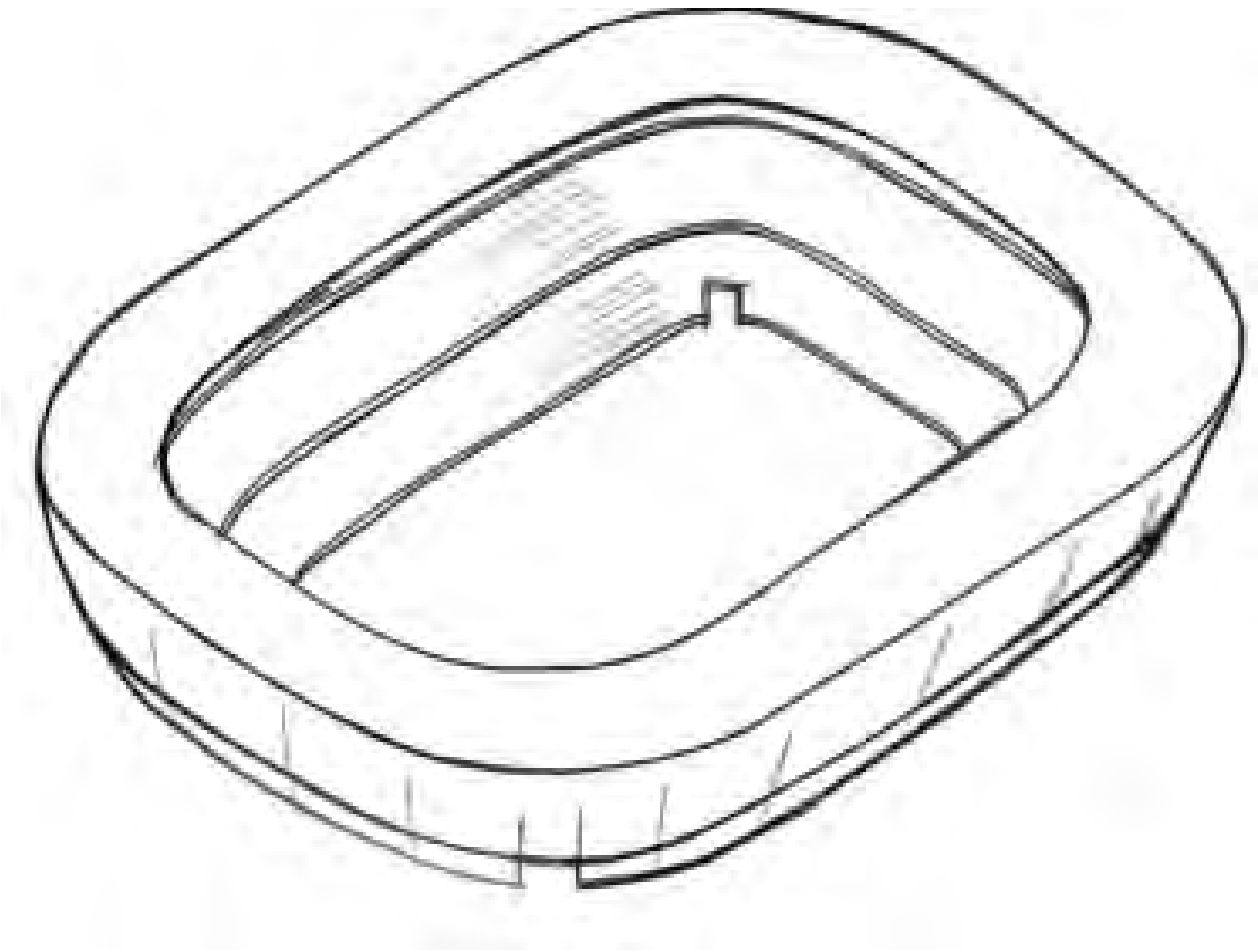
Implication: Vegetation will have to be removed by hand to allow build of spillway wall

Access issue | Rocks in spillway

Implication: Rocks in spillway will have to be removed to allow the building of spillway wall

Access issue | Fence at northern perimeter

Implication: Fence will limit the size of machine to be used to 3 ton



Access issue | Severe ingress angle of dam walls

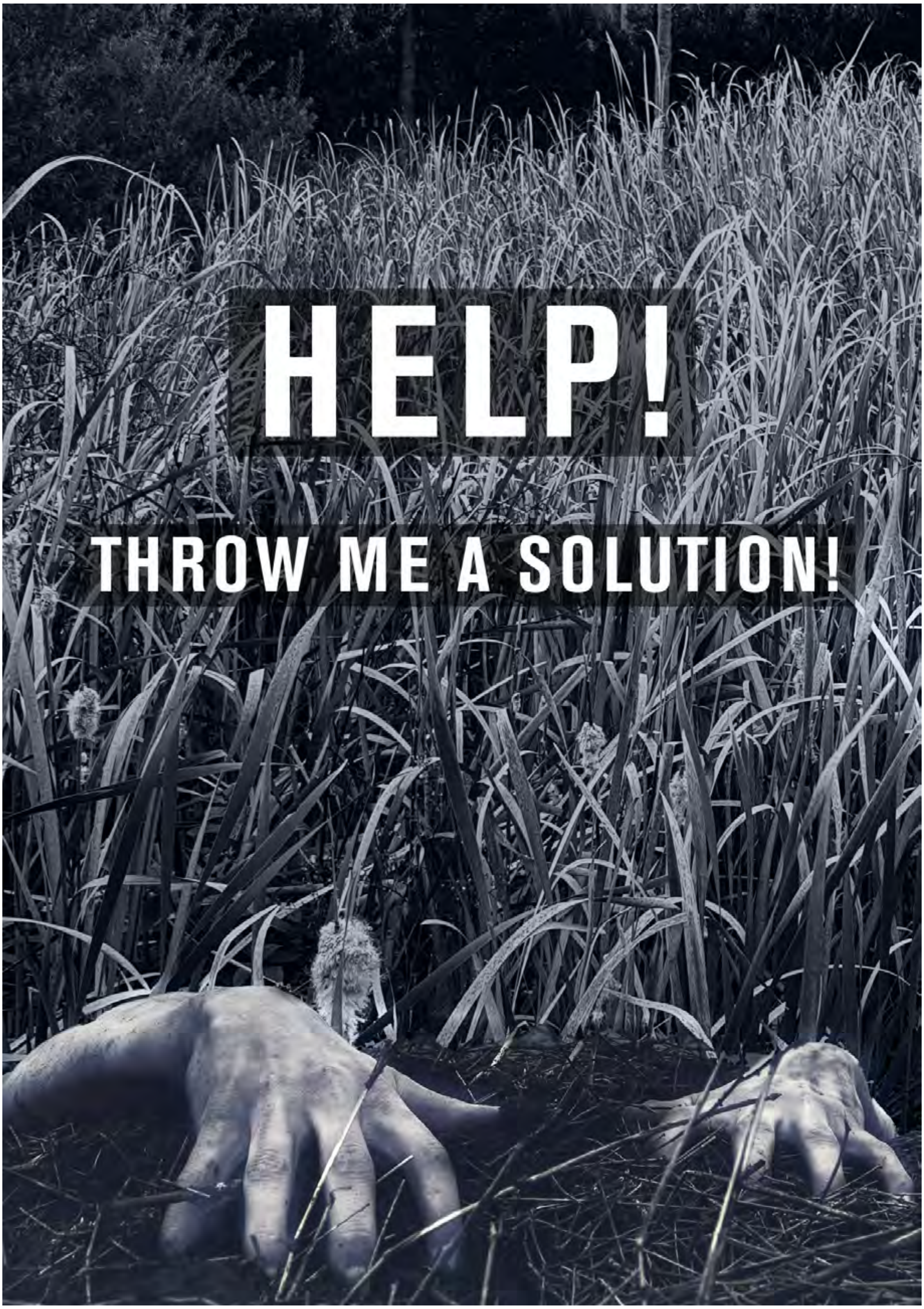
Implication: Machine compaction of walls will not be possible. Will require liner to seal dam

Access issue | Concrete paths & kerbing

Implication: Machines will not be able to access from southern, eastern or western sides of dam. Machine will have to have rubber tracks, but there is the possibility of concrete cracking due to traversing of 3 ton machine over concrete

Access issue | Fill for construction of spillway wall

Implication: Fill will have to be manually transited from the drop site to the spillway site – increasing costs significantly


HELP!
THROW ME A SOLUTION!

Solutions | Dam depth

Sump drain

Excavation could be achieved by a machine entering the northern end, and creating a deep sump into which the surface water will drain.

That sump will then need to be drained with a trash pump and removed from the site – subject to its toxicity.

This will have to be repeated on a weekly basis until a firm surface is achieved.

Solutions | Dam depth

Sump drain

Pros:

Removal of reeds and excavation of dam base simultaneously

Equipment available

Cons:

Many weeks of draining

Will be delayed by rain

Solutions | Reed Removal

There are a number of immediate options for weed removal given the unstable and quick-sand like footing in the dam base

Elevated platform

This will be achieved using a technique called air-picking – using an elevated platform apparatus with a worker suspended above the reeds

Solutions | Reed Removal

Elevated platform

Pros:

Easy access to machine

Rubber tyres so light footprint

Extended reach

Cons:

Slow

Doesn't achieve excavation depth

Solutions | Reed Removal

Aquatic weed harvester

This is a boat-like machine used for the harvesting and removal of dam weeds.

Solutions | Reed Removal

Aquatic weed harvester

Pros:

No danger of bogging

Cons:

Slow, but not as slow as elevated platform

Best in water, not bog

Limited manoeuvrability in bog-like conditions

Better for floating weeds

Doesn't achieve excavation depth

Limited access to machine

Solutions | Reed Removal & Depth Excavation

Long Reach excavator

This is an excavator with an extended boom that can reach in excess of 15m – compared to standard machine reach of 7m

Solutions | Reed Removal & Depth Excavation

Longreach excavator

Pros:

Depth and reed removal achieved simultaneously

Cons:

Entry would have to be from neighbours property

Very large swing radius

Limited availability of longreach machines

Float costs due to boom length

Twice as expensive as standard excavator

Very large machine

Solutions | Reed Removal & Depth Excavation

Amphibious excavator | v1.0

This is an excavator with float like tracks that allows it to float on the surface.

Solutions | Reed Removal & Depth Excavation

Amphibious excavator | v1.0

Pros:

Depth and reed removal achieved simultaneously

Cons:

Amphibious machines are very large

Float costs due to machine size

Confined space of dam

Limited availability of amphibious machines

Cost of amphibious machines

Machine float from distant location

Solutions | Reed Removal & Depth Excavation

Amphibious excavation | v2.0

This can also be achieved by operating an excavator on a floating removable base.

Solutions | Reed Removal & Depth Excavation

Amphibious excavation | v2.0

Pros:

Depth can be achieved while removing reeds

Little remediation required

Cons:

Limited availability of floating platform

Delays due to sourcing platform

Limited to smaller machine

Solutions | Reed Removal & Depth Excavation

Build a bridge. And get over it | v1.0

Reed removal and deep excavation can be achieved by digging up the surrounding grass area and moving it into the dam to create a narrow dirt bridge – which would extend from the southern end to the northern end.

The excavator would move to the northern end, and begin to work backwards and remove the reeds and the dam base, while also pulling up the bridge.

There would be a large hole created in the grass area, and this would be refilled with the bridge and the reed material as it is pulled back out of the dam

Solutions | Reed Removal & Depth Excavation

Build a bridge. And get over it | v1.0

Pros:

Cheaper option

Immediate result

No need to move fill offsite

Cons:

Fill limited

Significant remediation of landscaping

Remediation of grass

Significant eyesore during construction

Stormwater drain running straight through excavation site

Damage to southern end of dam and landscaping

No access from heavy excavator

Road damage

Concrete damage

Solutions | Reed Removal & Depth Excavation

Build a bridge. And get over it | v2.0

The most optimal solution for reed removal and achieving significant dam depth – before Christmas - is the following:

Strike a deal with the neighbour, pull the dirt bridge from the corner of his land, enter the Sienna Grange dam from the northern end, fill the dam with neighbours fill, work towards the southern end. When the southern end is reached, work backwards, remove reeds and dam base, and refill neighbour's property by packing all fill into the original excavation.

Solutions | Reed Removal & Depth Excavation

Build a bridge. And get over it | v2.0

Pros:

Easy access

Cheapest option

Immediate result

No remediation of landscaping

Abundant fill to make land bridge

No need to move fill offsite

Loading off trucks from neighbours property if fill removal required

Remediation of neighbours bog achieved at no extra cost

No subterranean pipes

No eyesore during construction

Cons:

Neighbour permission

Reconstruct fence

Costings | Dam Works

Costings | Dam Works

Approximate & estimate costings and duration for the two most appropriate options for dams works (including reed removal & dam deepening, but not including dam liner or removal of any material from site) are as follows

Build A Bridge. And Get Over It | V1.0

Float ingress – 1 day

Excavation of material for land bridge – 3 days

Construction of land bridge – 5 days

Removal of land bridge, reeds and dam base – 10 days

Repacking of excavation – 3 days

Landscape remediation – 5 days

Liner trench – 1 day

Float egress – 1 day

Total days – 29 days

Total cost – $75,168 exc GST

*Does not include removal of material from site because if the material is toxic, it will have to be removed and dumped with EPA approval

**Does not include remediation of bitumen and replacement of broken concrete edging and pathways

Build A Bridge. And Get Over It | V2.0

Float ingress – 1 day

Clearing – 1 day

Excavation of material for land bridge – 2 days

Construction of land bridge – 4 days

Removal of land bridge, reeds and dam base – 8 days

Repacking of excavation – 3 days

Landscape remediation – 1 day

Liner trench – 1 day

Float egress – 1 day

Total days – 22 days

Total cost – $57,024 exc GST

*Does not include removal of material from site because if the material is toxic, it will have to be removed and dumped with EPA approval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The End