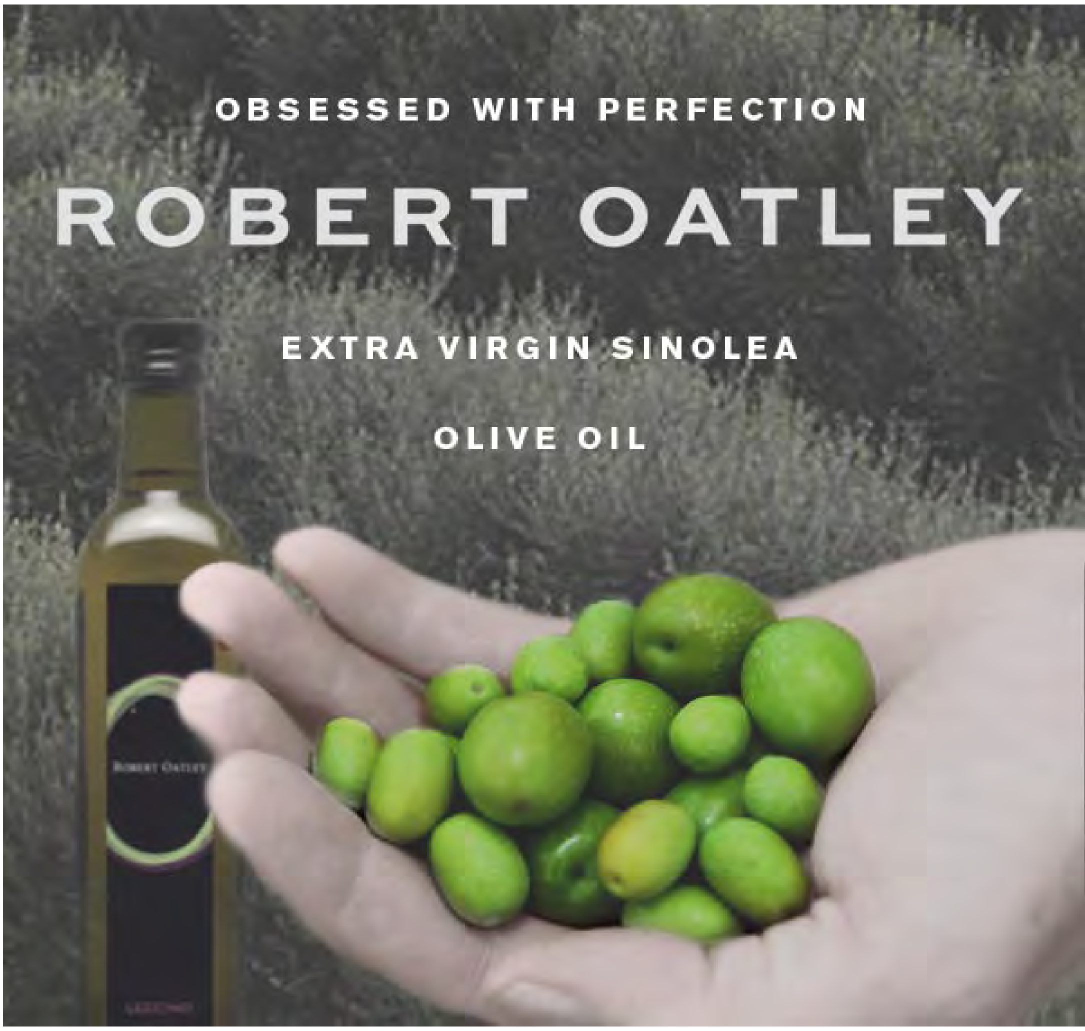

OBSESSED WITH WATER
BIG DITCH
DAM COMPANY



Dam Risk Assessment & Performance Audit

Location: Canadian Lead Rd Gulgong

Prepared for: Robert Oatley Olives

| Report Principals

Principal Client
Mr Ian Oatley
Robert Oatley Olives

Commissioning Client
Mr Scott Tucker
Water Quality Solutions

Managing Client
Mr Craig Stubbs
Robert Oatley Olives

Author
Big Ditch Dam Building Co.

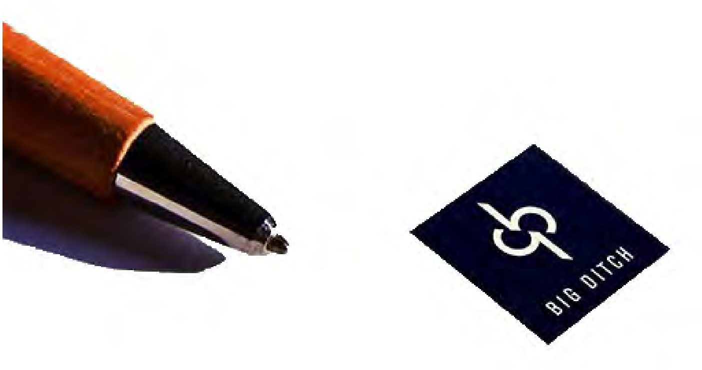
Report Date
18th November 2019

| Report Preface

Visual basis for report | 15th November 2019

What does success look like based on clients 1st brief?

| Report Structure



PART 1

- SWOT Analysis
- Client Needs
- Problem Statements
- Imagineering The Future

PART 2

- Design Options

| A Non-Traditional Introduction

| Hello

That box does not belong to me – and I am not going to unpack it and give its contents to you.

The findings in this report are a methodical examination of the condition of the dam at Canadian Lead Road Gulgong - and it also identifies future opportunities outside the initial brief

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

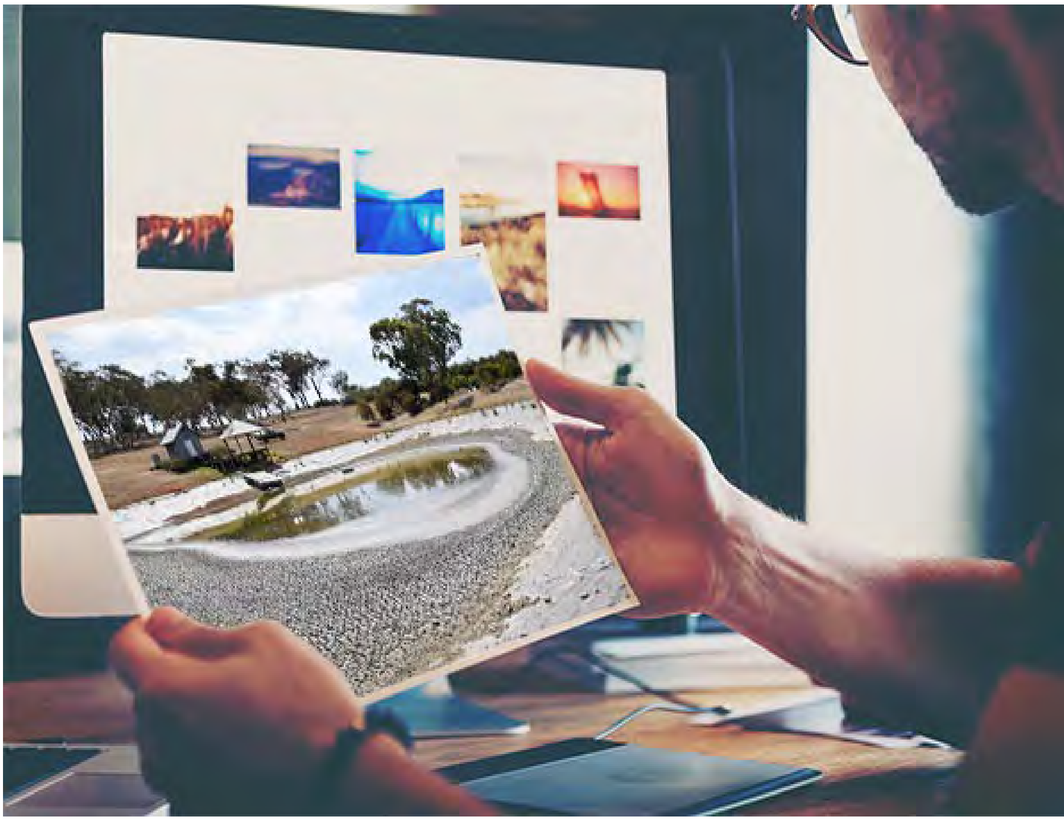
The advice I provide is based on:

- 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

References are available on request



| 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.

Each problem is addressed with:

- a cohesive and comprehensive overview based on known technical information

- an analysis of how each problem, or is, effecting the client's rainwater harvesting

- specific details about how each problem came to exist

The report starts with a SWOT analysis that looks at all positive & negative issues affecting the dam in a summary form.

For those not wanting to wade through all the technical analysis that is the basis of this Risk Assessment & Performance Audit – but would prefer a 15 second elevator pitch of the report instead – you can turn to this page and see each issue documented in point form.

The final section of this complete assessment is 'Imagineering The Future'.

This part of the report looks at the future big picture opportunities that have been identified for the dam and adjacent surroundings.

| SWOT Analysis

| Strengths

- Good position
- Great potential
- Dry conditions expected for December

| Weaknesses

- Suitability of construction materials
- Inside wall compaction
- DSV ratio
- Wall ingress angle
- Weed growth
- Poor material distribution
- No spillway
- No flow inhibition system
- No sediment traps
- The island is badly designed

| Threats

- Potential dam collapse due to design flaws
- Long range forecast of rain in late January that will cause project complexity and cost increases if the project is started after rainfall

| Opportunities

- See 'Imagineering The Future' section

| Site Specifications

| What have we got to work with

- Dam length 98m
- Dam width (widest point) 68m
- Dam width (narrowest point) 42m
- Dam depth 3m
- Total dam surface area at maximum volume 4576m2
- Dam perimeter 304m at high water mark
- Total dam volume at maximum fill is 16.1 megalitres

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.

| Locational Brand Values

| Design Synergy Through Compatibility

I have a long held process of identifying the brand values of the surrounding environment contiguous to the proposed water feature to achieve aesthetic feature compatibility and ensure visual alignment with the topography in which the project sits.

These brand values are always expressed as single words, and they inform and direct the design options I present to the client

Based on the initial site visit to the project & business location, the following environmental & corporate brand values were identified.

- Unique
- Premium
- Innovative
- Artisan
- Memorable
- Timeless
- Passionate

| Client Needs

| Needs. Not nice to haves

Based on a thorough & extensive on-site briefing by Mr Craig Stubbs on 15th November 2019, the following client needs have been identified:

- Stop water losses from dam
- Make the dam hold water at full volume
- Make the dam beautiful
- Stop weed growth
- Slow high velocity inflow into dam
- Remove the island because it is ugly

| Current First Order Problems Identified

Problem | Suitability Of Construction Materials

The dam walls have been constructed with an inappropriate and porous material causing it to lose significant water volume via transpiration through the dam wall

There is evidence of that ultisol (commonly known as red clay) has been used in the construction of the walls.

Red clay has less than 35% base saturation and no shrink–swell property.

It known as a dispersive clay. Red clay particles are able to move about freely in water because they are not bound to other clay particles, nor to organic matter.

Red clay is inappropriate for dam wall construction as it will not retain water, but rather let water drain straight through.

What should have been used is a flocculate clay (white clay).

Flocculate clays are the opposite of dispersive clays.

In white clay, the particles will bind readily to one another and flocculate. Such materials are not prone to tunnelling.

The utlimate in flocculate clays is Bentonite – which has a shrink–swell ratio of 1 to 400.

That means that each molecule of Bentonite swells to 400 times its original mass when saturated with water.

During this process, Bentonite becomes a super coagulate – meaning that when saturated, it holds the water and refuses to let go of it.

(coagulate - to gather together and cause to thicken into a coherent permanent mass)

In effect, the water captured in the Bentonite stops other water travelling through the wall – and more importantly, Bentonite becomes more effective each and every day it is submerged.

There is no degradation in performance over time

Solution | Suitability Of Construction Materials

Options

- Add Bentonite
- Utilise dam base material
- Add liner

Problem | Inside wall compaction

There is an evident lack of appropriate compaction on the dam walls, causing slow seep water losses into the pervious dam abutment.

The dam wall seems to lack a zone of low permeability in its central core and inclined core to stop flow-through.

The resultant lowering of water surface level due to release of water into these high permeability zones is causing excessive resource drawdown.

Solution | Inside wall compaction

- Re-engineer wall with appropriate compaction

Problem | Evaporation

The depth to surface to volume ratio (DSV) is probably the most serious problem, but the effects are not immediately obvious, so it therefore requires more explanation than other issues.

The dam is badly designed with regard to its DSV ratio

A bathymetric analysis of the current shape and depth shows that this dam is capable of losing $59,000 worth of water every year

(bathymetry is the study of water depth)

The current the depth vs surface area vs volume ratio of .33 is causing the aquatic inversion layer (also known as the thermocline) to be in an abnormally low position relative to the water surface and the dam base - and is therefore causing excessive & significant water warming and loss through evapotranspiration

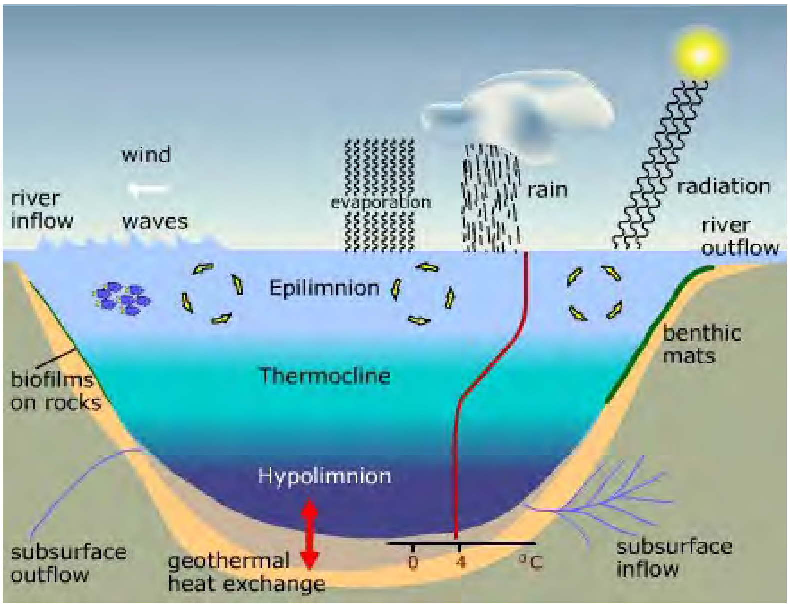
The lack of depth in the dam is also causing the inversion layer to have an abnormally low thermal lapse rate – eg the lower depth is not as cold as it should be.

(the thermal lapse rate is the rate at which the temperature of water changes with depth – normally 3 degrees Celsius per metre on an exponential scale)

In basic terms - water becomes colder with depth, but warmer as it approaches the surface.

Evaporation happens when water molecules are heated to a higher temperature than their surrounding environment.

At this point, they start to detach from the water body and rise into the atmosphere and are lost – returning to earth eventually as rain



As the sun shines - it heats the water to a certain depth – usually 1.5 metres.

This is where the aquatic inversion layer exists in most water bodies.

All water between this level and the surface is subject to warming and therefore loss through evaporation.

Most water below 1.5m depth is not.

Warm water (known as epilimnion), which is less dense, will sit on top of colder, denser, deeper water (known as hypolimnion) with a blanket-like impervious thermocline layer separating them.

Very little mixing of the warm water and the cold water occurs because of this aquatic stratification

When you swim in a lake, you can feel the cold hypolimnion below the aquatic inversion layer – normally this occurs around your toes.

When you swim in the shallow end of a swimming pool, you don't feel the aquatic inversion layer.

In shallow pools, this means that 100% of the water is heated up and would be lost to evaporation over a short period of time.

In lakes, the first 1.5 metres of water is warmed up, but many many metres beneath are not.

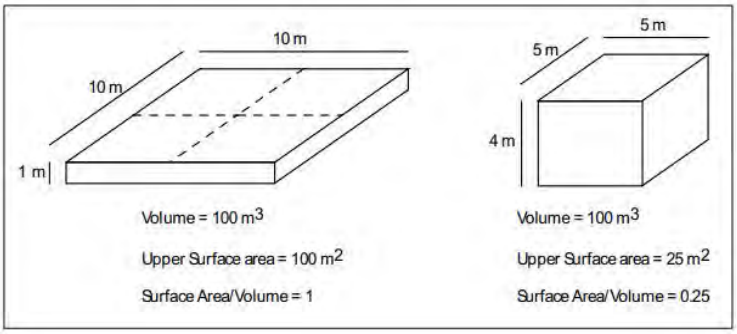
If the lake was 150 metres deep, only 1% of it's total volume would ever be lost to evaporation.

This is why lakes do not dry up.

Inversion layers are a permanent and important feature of water with depth.

The dam being discussed is currently like a big teacup saucer, with 50% of the water contained in it when full being subject to evaporation.

This is best visually represented by the graphic on the left



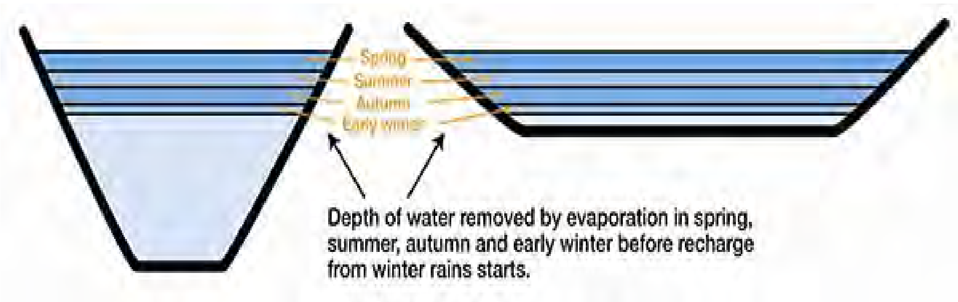
With a total depth of 3m and the inversion layer at 1.5m, this means the inversion layer is sitting in the middle of the depth axis, thereby exposing 50% of total volume to evaporation.

The dams current DSV value is .33

If the dam was 6m deep, its DSV value would be .16, and this would mean that evaporation losses would be reduced by 50%.

This would mean a saving of 59 megalitres of water per year

Compare the dams below. Both contain the same volume of water.



The depth of water removed by evaporation will be much the same in both dams, but the total volume of water lost from the shallow dam will be significantly more.

The dam that is deeper and has steeper sides will retain water for longer – because the water will be cooler in this dam, thereby helping to reduce evaporation.

Evaporation is hard to measure precisely due to the number of factors that effect it – such as:

- air temperature
- water temperature
- latitude
- longitude
- tidal action
- surface area
- depth
- wind velocity
- turbidity
- currents
- temperature range
- humidity

However, a basic calculation will show that a water body with 100% of its total volume effected by high direct heat exposure will lose up to 2% of its total volume every day to evaporation.

(I have conducted extensive experiments on this subject, and that data and photographic evidence is available if required)

This all means that this dam in its current configuration could lose its total volume every 50 days – or 7.3 times per year if it were to fill every time it emptied

Given the dams total capacity of 16.1mgl - a total of 118.04 megalitres is capable of being lost purely to evaporation from this one dam.

In monetary terms, if one were to price water at $500 per megalitre – this would represent a financial loss of $59,000 each and every year.

Solution | Evaporation

Wind and heat are the biggest natural factors influencing evaporation.

There are four proven options to minimise the effects of evaporation in this dam

- increase DSV ratio through base extraction
- increase DSV ratio by altering wall ingress angles
- floating edible plants will reduce evaporation by 80%
- vegetation windbreaks will lessen wave action evaporation

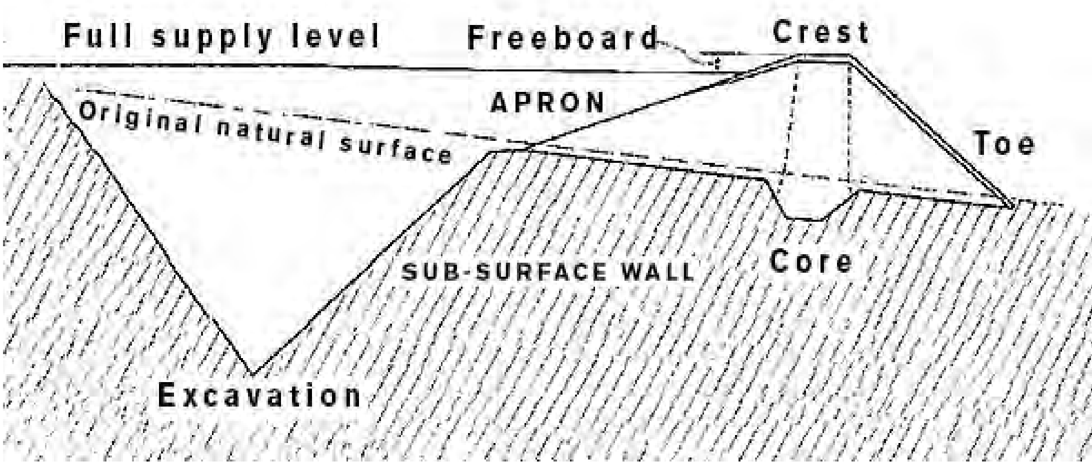
Problem | Wall Ingress Angle

The current inside wall batter angle is problematic for a number of reasons:

- it facilitates excessive evaporation losses because more of the total water volume is kept closer to the surface
- it reduces the total volume of the dam significantly, thereby increasing the need for costly water replenishment
- it encourages weed growth because aquatic weeds will only grow in shallow water

The current ingress batter angle of approach at 17 degrees would be classified as ineffective and inefficient design.

A dam wall should consist of two parts when looked at in cross section – the apron area and the sub-surface wall



The apron is the area from the dam wall crest to the anticipated low water mark (normally just shy of the inversion layer).

This is the area of the dam wall that is affected most by rises and falls in dam levels – and is also the area that needs to groomed and maintained to ensure the dam aesthetics are optimal no matter what the water level.

Modern dam best practice is to construct the apron at 22.5 degrees (50%of 45 degrees) for two reasons:

- it allows the dam perimeter to be groomed to the waterline with a tractor and slasher and thereby avoids the ugly growth of flora that occurs on the edges of old dams because those dams have been constructed with walls in excess of 45 degrees

- more importantly, it stops the dam becoming a drowning danger for stock and children. A 22.5 degree angle of ingress allows anyone, or anything, to egress (walk back) out of the dam, rather than having to climb a wall.

The second part of the dam wall is the sub-surface wall – and that part of the wall should spend its whole life below water

The sub-surface wall extends from the inversion layer to the dam base.

The sub-surface wall normally angles down from the apron - but not in excess of 33.75 degrees, which is 75% of 45 degrees.

If the angle exceeds 33.75 degrees, compaction becomes less effective and more costly as machines compacting the surface will 'reverse tippy toe'.

Imagine a dozer moving up a very steep wall – its centre of gravity and therefore compaction weight moves to the rear to a small area of around 600mm2 at the end of the tracks.

This is financially inefficient because it increases the machine hours required to achieve effective sealing compaction.

This dam shows no evidence of intelligent or effective wall design – and indicates that it was constructed by a general earthmover.

This is not to criticise the contractor responsible for the dam construction.

As a professional, I don't indulge in such activity because it is not productive in creating a solution - but it is important to understand when formulating the solution.

My belief is that you cannot criticise someone for not knowing what they don't know.

The photo below shows a dam with a batter angle of approach of 16 degrees in the process of being altered to a 22.5 degree ingress

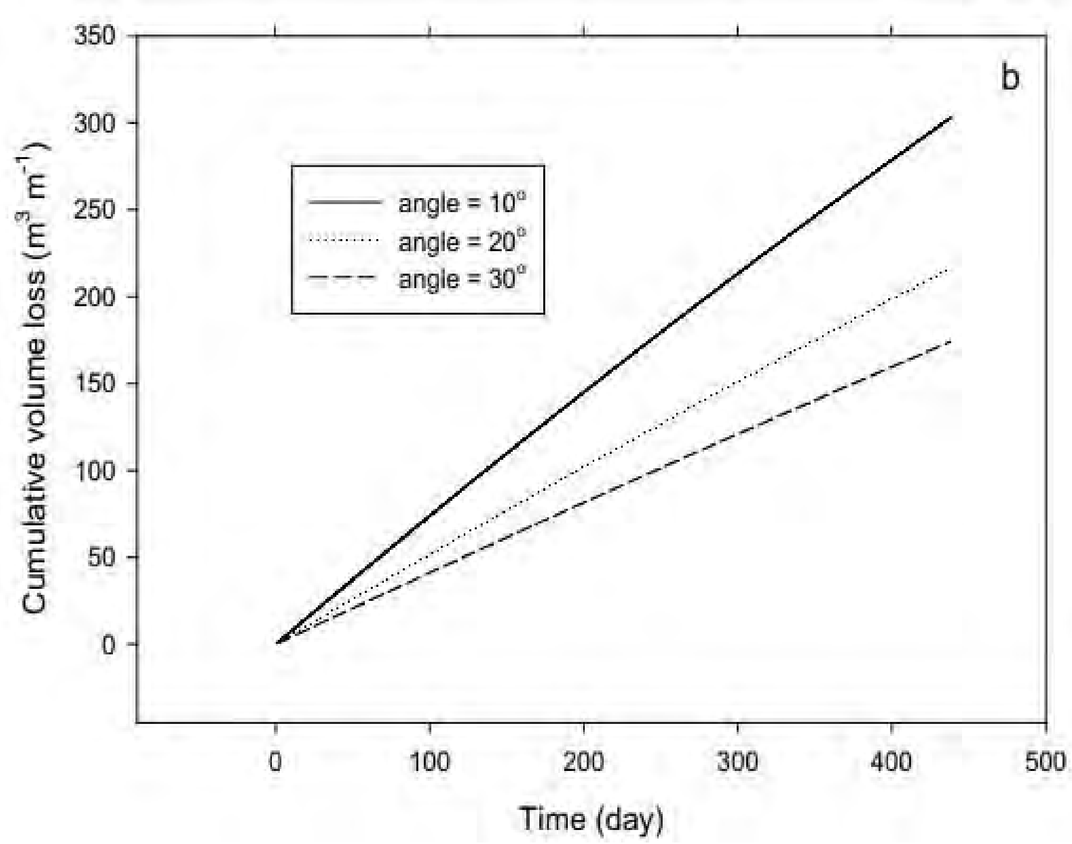
(notice the weed growth around the shallow edge to the left and right of the prep cut)

The photo below shows a dam being altered from an aggressive and dangerous linear angle of ingress (right side of the dam)

The reshaped left side is now a faceted wall consisting of apron and sub-surface wall with alternate interior angles intersecting at the line of expected inversion

This is how the dam walls at Gulgong would look after rehabilitation

The chart below shows the effect of angle change on evaporation losses



Solution | Wall Ingress Angle

- Re-construct walls with appropriate angles and dropoffs

Problem | Weed Growth

Weed growth is caused by a number of factors, and is one of the most serious problems that effect Australian dams

Weed causation factors include:

- excessive shallow areas created by low profile dam walls.
- a lack of deep water encourages growth of weeds that root to the wall because it increases their access to sunlight
- a lack of shade trees around the dam increases the amount of sunlight the weeds can access
- excessive water salinity caused by evaporation increases weed growth
- a lack of oxygenated water causes increases in non-beneficial bacteria – which in turn promotes excessive and aggressive weed growth
- a lack of 'good' competitor flora on dam edge and dam surface to suffocate any weed infestations
- the lack of beneficial flora in the dam means that the water is not being naturally cleaned – and this dank water is inviting to weeds
- nutrient inflow from up-dam dry ground areas during rainfall will also encourage weeds
- sediment inflow also encourages weeds, and there is evidence of a significant amount of sediment in the dam base at Gulgong
- excessive evaporation losses and significant variations in water levels leaves dead and decaying plants in the dam, and this leads to deoxygenation of the water . This kills beneficial aquatic organisms and encourages weeds
- general poor quality stagnant water quality is one of the major factors in the establishment of aquatic weeds.

Weed growth is not evident in the dam at present due to low water levels.

However, the spores will still be present in the cracking sub-stratum – where they can access air and sunlight, and they can exist in a dormant state for up to 10 years.

When they have access to rain or water supply, they will immediately re-generate.

These spores have to be removed from the wall, and this would be achieved when the wall is re-engineered

Solution | Weed growth

- Remove & kill spores
- Deepen dam
- Increase wall angles
- Improve water quality
- Introduce competitor flora
- Introduce sediment traps
- Introduce shade trees
- Introduce aeration
- Decrease evaporation
- Stabilise dam levels

Problem | Poor material distribution

There is a volume of good quality flocculant non-porous clay covering the dam base – but this has not been distributed and layered into the dam wall.

The evidence that this clay exists in the base is that even though rain has been almost non-existant, the base is holding water – and only losing it to evaporation.

While being briefed by Craig, I did a field friability test on material that was 3 metres from the waters edge. This material showed significant water holding ability.

However there is no evidence of this material on the walls.

Craig told me that scrapers were employed to bring clay in to stop the water losses that were being experienced.

It is at this point that I have to make assumptions about why there is good quality material in the base, and not on the walls – but I am reasonably comfortable in the veracity of these assumptions.

My hypothesis is based on specific knowledge of two seemingly un-connected elements of the mystery – firstly, soil hydrology with regard to dam dynamics - and secondly, the use of scrapers

Soil hydrology and dam dynamics

I would say that one reason the flocculent clay was dumped in the bottom of the dam might be because there was no evidence of seepage on the outside walls (indicated by bright green areas of well watered grass), and therefore the thought process by the powers that be at the time would have been....

'well, there's no evidence that it's leaking out of the walls, so it must be leaking out of the bottom'

This is not an unreasonable assumption.

But it is not necessarily correct.

The reason being, if the walls are experiencing gradual seep, the water travels very slowly through the wall material.

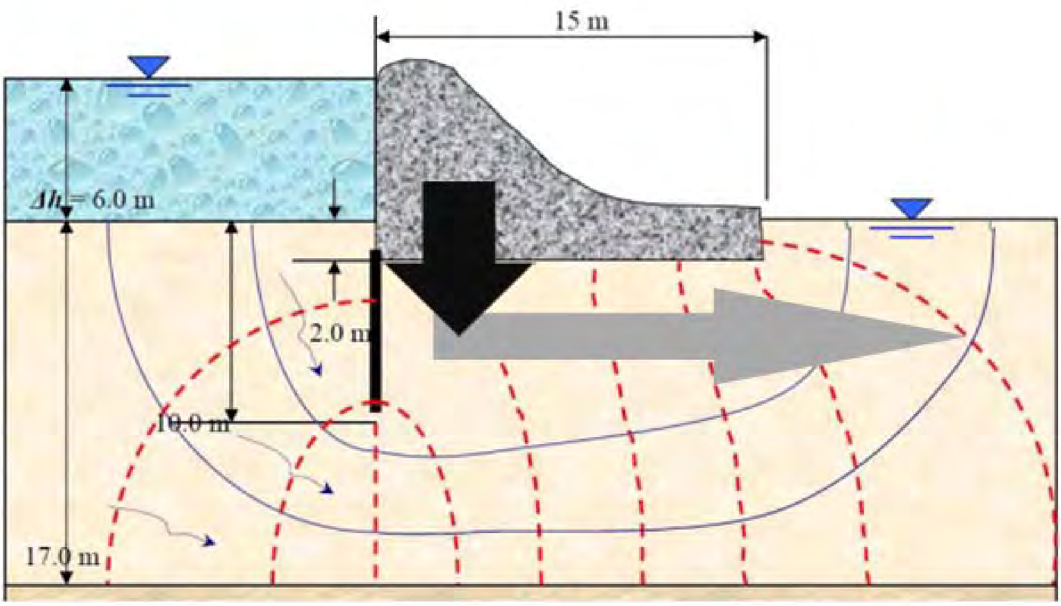
These walls have a significant surface area exposed to direct sunlight and the entire mass of the wall heats up, therefore evaporating the water as it travels laterally inside the wall – resulting in no seepage reaching the outside toe of the dam.

The other consideration is that if water is slow seeping out through the wall, but there is not significant water pressure behind it due to low dam levels, the water will enter the wall, but then slow due to the lack of lateral force, and then follow its course of least resistance – which is downward.

This will result in the water slowly seeping out through the base of the wall, and then travelling freely through the sub-stratum under the core key and the toe of the dam – leaving no surface evidence of leakage.

It travels freely because the area under the lower limits of the key and the outside dam wall toe are usually un-compacted porous ground.

This results in seepage losses with no surface evidence



Scrapers

The second reason for the un-distributed flocculent clay could be the use of scrapers.

The scraper is a very large piece of equipment which is used in mining and construction industries for heavy earthmoving applications.

The photo below shows a scraper making a massive D8 dozer look like a toy.

Scrapers are excellent machines for extracting large volumes of material from a distant site, transporting it, and then laying it out at the destination site.

Scrapers can significantly reduce the cost of each cubic metre of material moved and relocated.

However, scrapers are also known in the industry as 'widowmakers'.

This is because they can carry up to 63 tons of material (a typical tip truck carries 12 ton), they have a maximum speed of up to 38 mph, they travel quickly over rough terrain, they are articulated – so the cab and the bowl carrying the load move independently – often violently – and this is exacerbated by the tires being air-filled.

These factors make scrapers very unstable compared to other earthmoving machines.

This instability means that when unloading, they have to lay out their load on flat ground – which could be the reason the flocculent clay is only in the flat dam base.

However, if this is the case, it is not necessarily all bad news.

If scrapers were utilised – there could be a large volume of good material present due to the amount of load scrapers can carry.

Once a sump is created to isolate the water remaining in the dam, this material could be pushed up onto the wall as show in the photo below – reducing the need for coagulate materials to be bought in.

Solution | Poor material distribution

- Integrate dam floor material into dam walls

Problem | No spillway

No design consideration has been given to a 1 in 100 year weather event when constructing this dam.

By law, all dams in Australia have to be built to withstand such an event.

This dam is at serious risk of breach due to over-topping

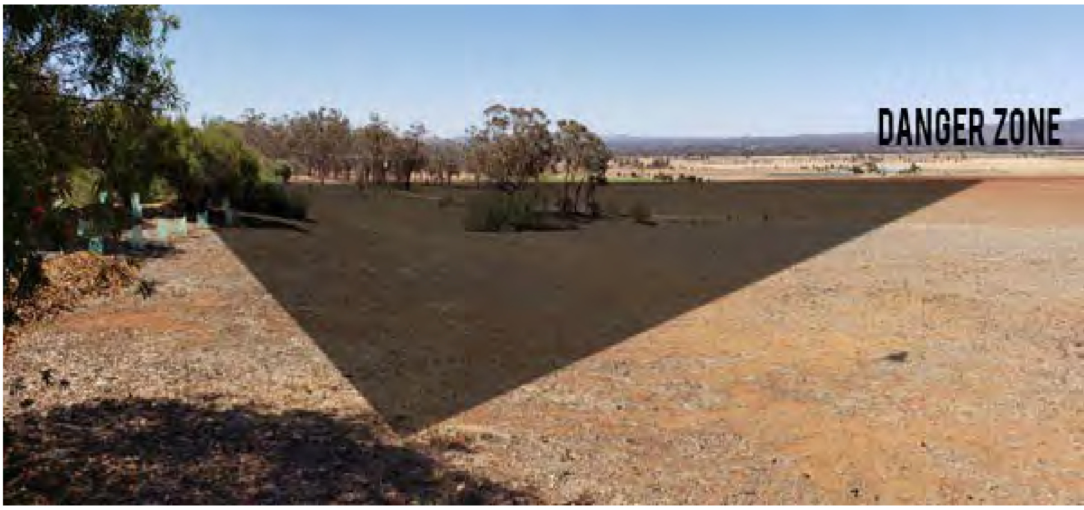
If we were to have a black swan event (which are actually not that rare), this dam is in danger of significant failure because it has no spillway.

In a fill event, the overflow water would top the dam wall, and then lead to its complete collapse.

The total volume of the dam would explosively exit within seconds as seen below when the Fujinuma Dam in Japan overtopped in 2011

Such an event is known as a land tidal wave – and it could kill anyone down dam if they were in the impact zone – which would extend for approximately 2 kilometres.

At a minimum, the dam wall collapsing would wipe out the olives and grapes in its path, leading to significant financial losses.



This is a significant liability waiting to happen, and should be addressed urgently.

Solution | No spillway

- Construct spillway

Problem | No flow inhibiter system

There is no mechanism in place to slow down significant inflow caused by a 1 in 100 year event.

Significant volume entering the dam at maximum velocity from the hill above the dam site would be akin to aiming a hose with a nozzle at a sand castle.

The result would be that the turbulent water tunnels through the dirt, and once reaching the other side, the tunnel widens quickly, leading to complete loss of wall integrity and total collapse.

This is the typical reason for collapse of mining company tailing dams during abnormal wet season downpours.

Dam collapse due to tunnelling has killed thousands of people. The last such event happened just last year in Brazil when the Brumadinho tailings dam killed at least 179 people

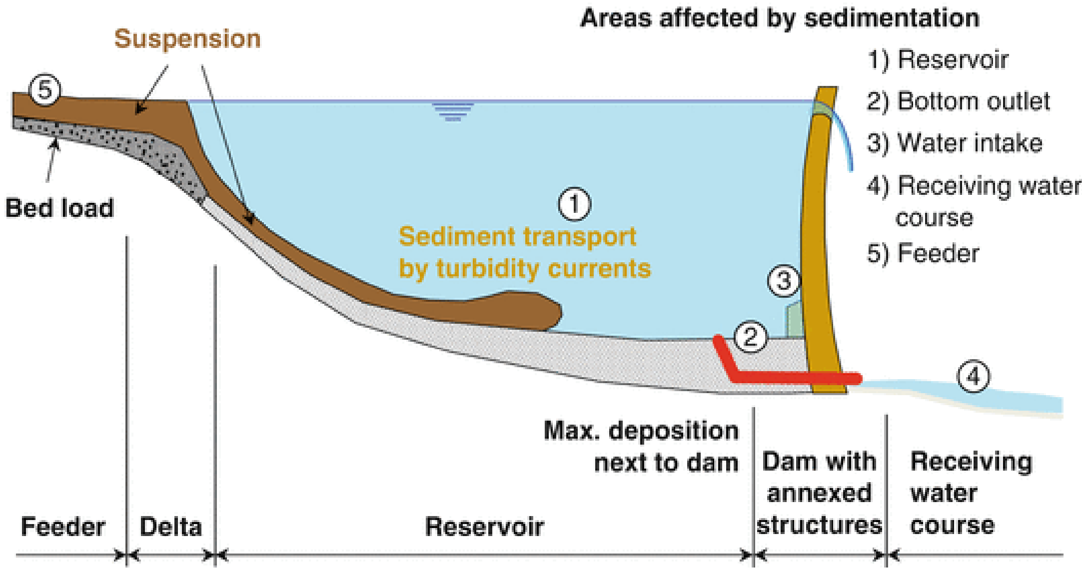
Solution | No flow inhibiter system

- Construct flow calming system

Problem | No sediment traps

There are no trash racks are in place to ensure that sediment doesn't enter the dam.

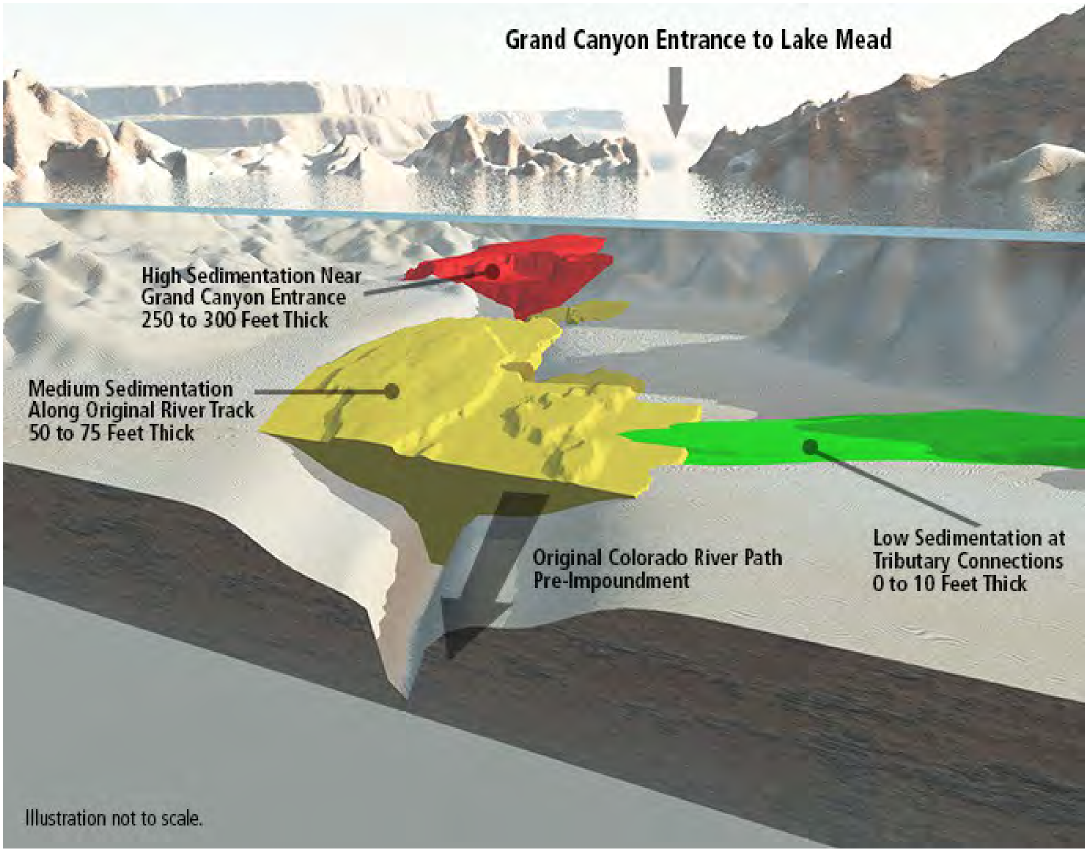
Sedimentation is a major problem for Australian dams



Every time it rains, this dam will lose a certain amount of depth due to sediment in-flows.

Over 10 years, the dam could lose as much as half of it's volume.

Sedimentation doesn't just effect small dams



The problem becomes worse in drought conditions, because there is no grass to filter the sediment before entering the dam.

Also, in low rainfall periods, trees drop their leaves, and these leaves break down on the ground due to dry conditions and animal activity, then when it rains, the residue adds significantly to sedimentation.

Trash racks can take various forms

Organic material trash rack

Rock trash rack

Boom systems

Net systems

Settling dam systems also known as pre-dams

These are the innovative anti-sedimentation systems that allow the sediment to settle before entering the main dam

FOOD FOREST No.1 OVERFLOW & DiSPERSAL POND

FOOD FOREST No.1 FILTRATION & OVERFLOW POND

Landform settling berms

These are another innovative type of sedimentation capture system.

These designs are multi-purpose. They catch sediment, but also slow inflows to the dam and beautify the dam surrounds by holding water in the ground, leading to abundant growth patterns

Solution | No sediment traps

- Construct sediment management system

Problem | The island is ugly

Islands in dams are beautiful

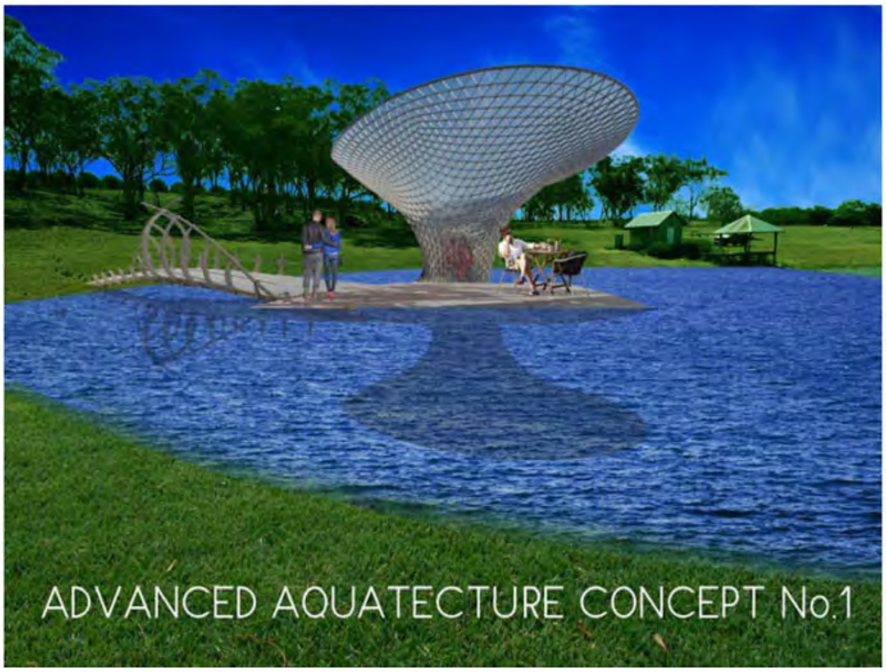
And they are one of the most requested features in innovative decorative dams

The problem with this island is that it is badly designed

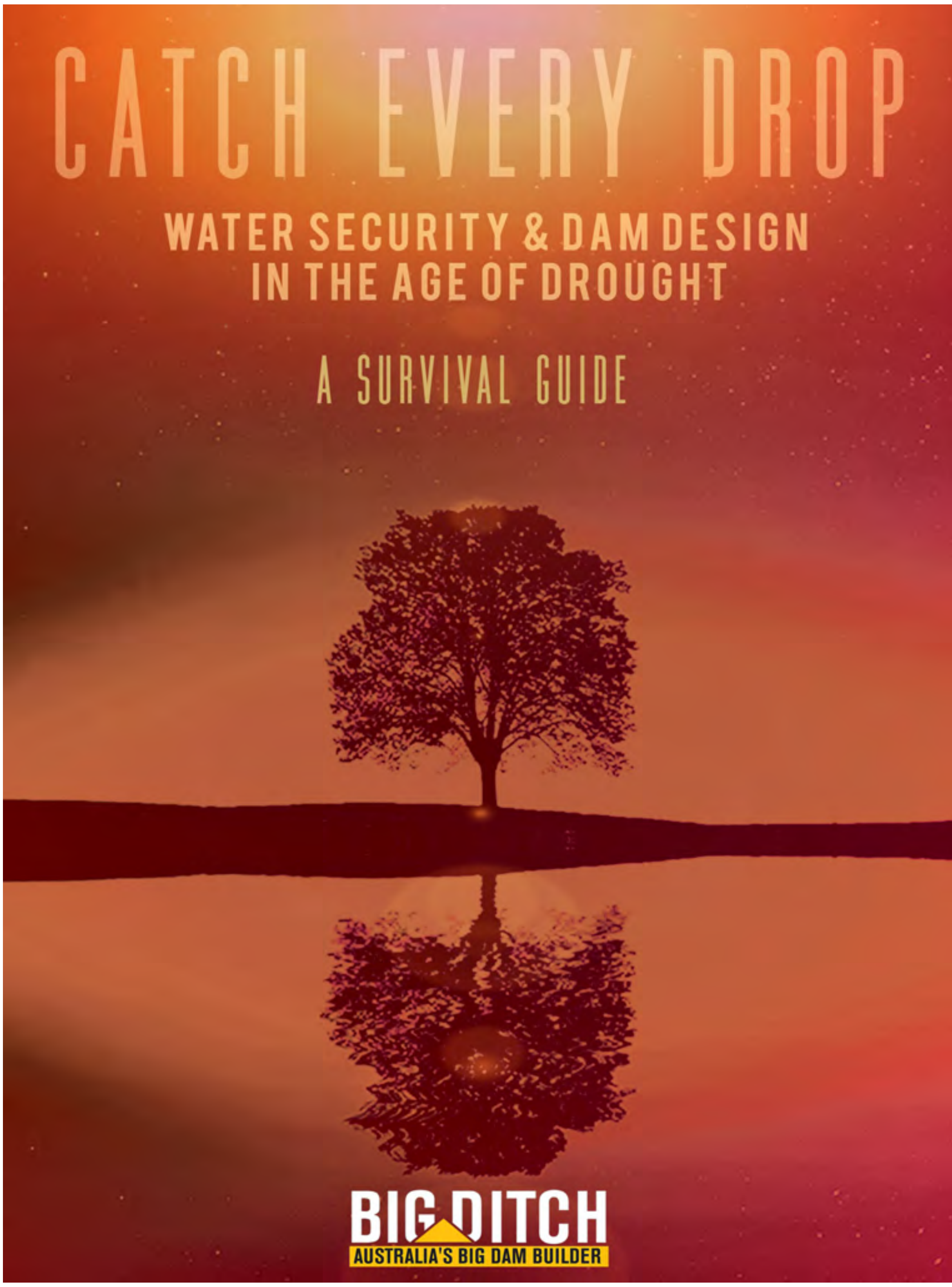
We can remove it

Or we can make it beautiful

See DESIGN OPTIONS for full listing of design concepts


ADVANCED AQUATECTURE CONCEPT No.1


ADVANCED iSLAND DESIGN CONCEPT


CATCH EVERY DROP
WATER SECURITY & DAM DESIGN
IN THE AGE OF DROUGHT
A SURVIVAL GUIDE
BIG DITCH
AUSTRALIA'S BIG DAM BUILDER

Intelligent bio-swale system design for Robert Oatley Olives

Less rainfall will be available in Gulgong, but an intelligent sustainable swale design harnesses more of it – and stores it in the ground

Having a Swale of a time with passive irrigation

There are two ways to capture and store water in rural environments:

1. In dams
2. In the ground

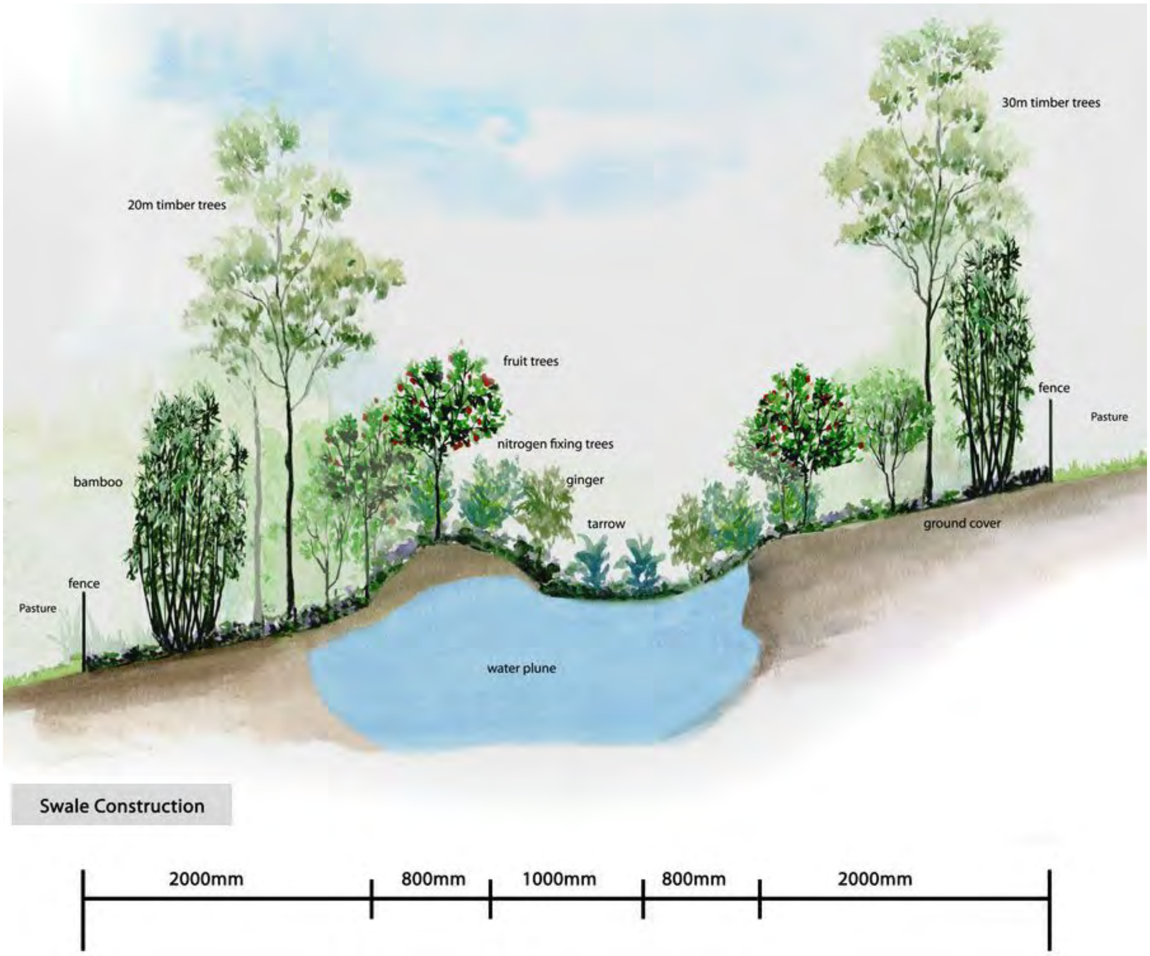
Swales capture and hold water in the ground – and turn hard barren ground into nutrient rich soils.

As water flows across a typical surface or landscape, most of it will run off quickly without having a chance to soak into the soil, even on land that appears flat or very gently sloping. With a swale, the water flows into the trench, where it slowly seeps deep into the soil. This produces little to no runoff.

Constructed swales are passive irrigation basins designed to manage water runoff, filter pollutants, increase rainwater catchment and facilitate the development of abundant food forests in barren areas.

The swale concept has also been popularised as a rainwater harvesting and soil conservation strategy in permaculture. It is a water-harvesting ditch on contour, and it is also called a contour bund.

Swales can be utilised in rural environments as seen below

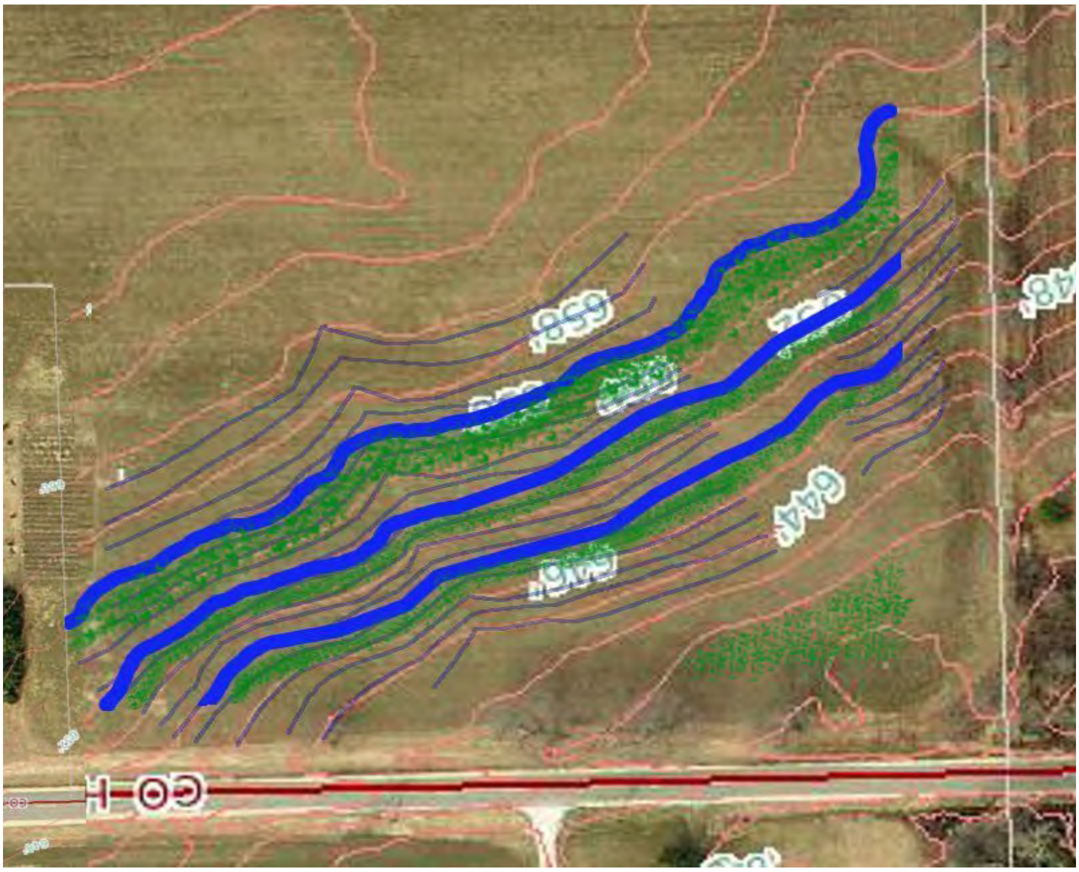


Swale Construction

Swales can also be utilised in urban environments

You've probably seen swales in your built environment, but maybe didn't recognise them as intelligent rainwater management systems

In rural environments, swales are used to slow, capture and store runoff by spreading it horizontally across the landscape along elevation contour lines

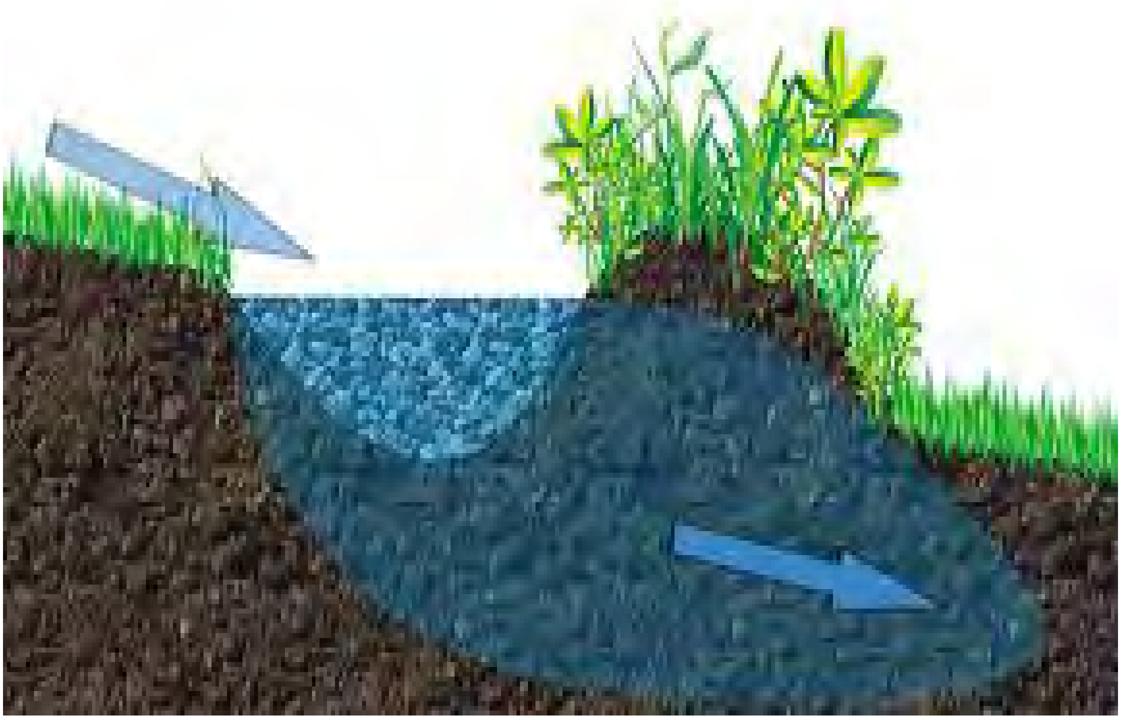


The true magic of swales in rural environments is that they facilitate capturing and storing rainwater runoff in the soil – which over time can create nutrient rich soil and build self-sustaining low maintenance ecosystems with abundant flora in once barren areas.

Swales catch water and direct it to where it's needed, which is in the soil.

Barren hard ground is thirsty, and the organic matter held in swales acts like a sponge, easily holding several times its weight in water.

One cubic metre of dry soil can hold three cubic litres of rainwater that would otherwise have been lost to runoff. Instead of water running off or pooling above ground, swales direct it downward into an underground reservoir.



This becomes a built-in, self-watering system. When water is needed, it is naturally released. No further work is required on the clients part after the swale is built.

This underground reservoir attracts microorganisms. Suddenly the soil is alive, and you're generating organic matter and fertiliser right in the place where it is needed.

This means fewer inputs, which saves money and time. The more the organic matter builds, the more moisture it holds. With more organic matter, the better the system can withstand both floods and droughts.

More importantly, swales are being used in hot barren climates to convert hostile environments into abundant food forests

The construction of swales

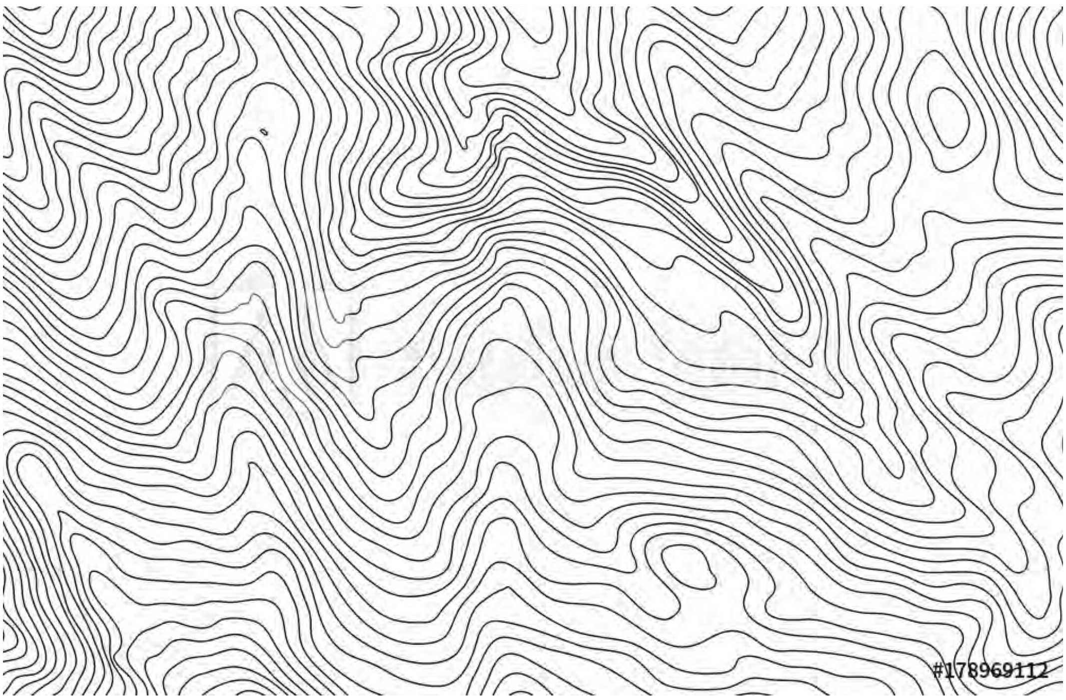
A swale is created by digging a ditch on the contour and piling the dirt on the downhill side of the ditch to create a berm – as a concept, it's as simple as that

However, in execution it's a little more complex

Step 1: Observe contour lines and drainage patterns on the site.

Where does the water travel across the ground when it rains, and where does it go?

Step 2: Identify the ideal contour lines for the swales.



The rules for siting swales are:

- 3 metres away from buildings (water must drain away from building)
- 6 metres away from the edge of a steep slope
- Uphill from low spot that doesn't drain well

Infiltration tests are then done on the selected contour lines to ensure an infiltration rate of at least 1 inch per hour.

Step 3: Mark the contour line.

Contour lines are marked every 3 metres. Swales built off-contour are not actually swales by definition, and go by other names, such as keyline trenches or diversion trenches.

Step 4: Dig a trench along the marked contour line.

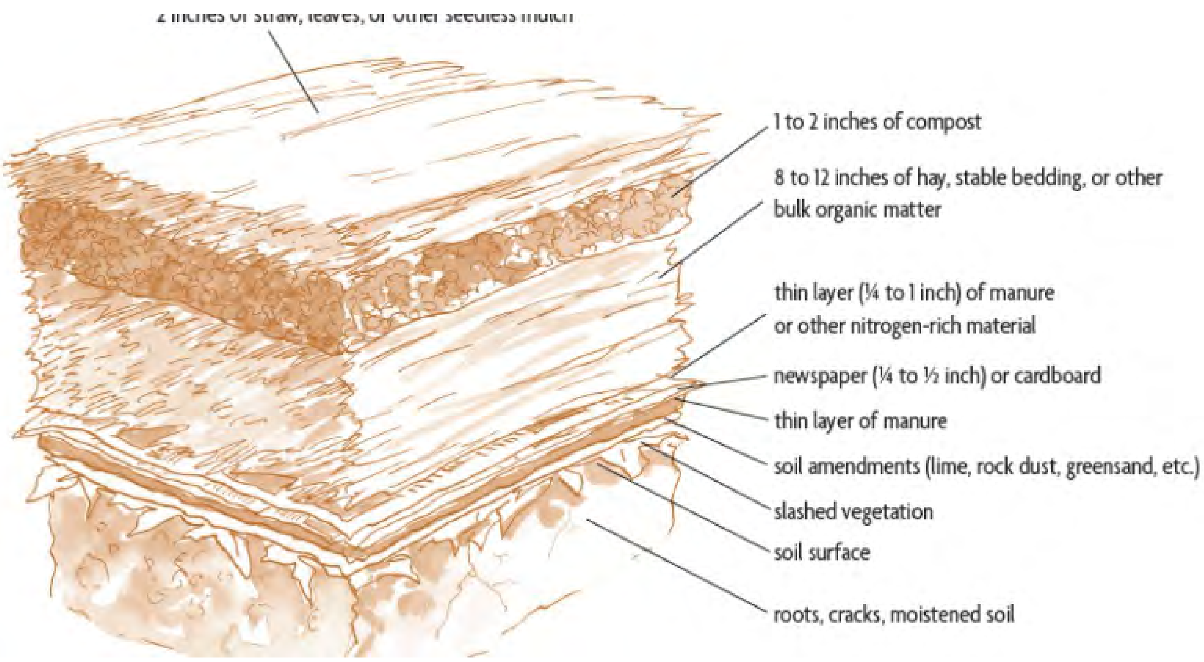
Typical trench depth: 1 metre deep
Typical trench width: 2 metres wide
Length: Varies by needs, size of the space, and how much water can be caught

Step 5: Mound the soil from the trench on the downhill side to create a berm.

Step 6. Sheet Mulching & Plantings

Sheet mulching is a layered mulch system that nurtures the soil, and can be as simple as three layers: cardboard, compost, and straw.

This is an excellent repository for brown waste such cardboard, sticks, fallen tree branches from the property – and all cuttings, trimmings and green waste from the olive and grape plantations



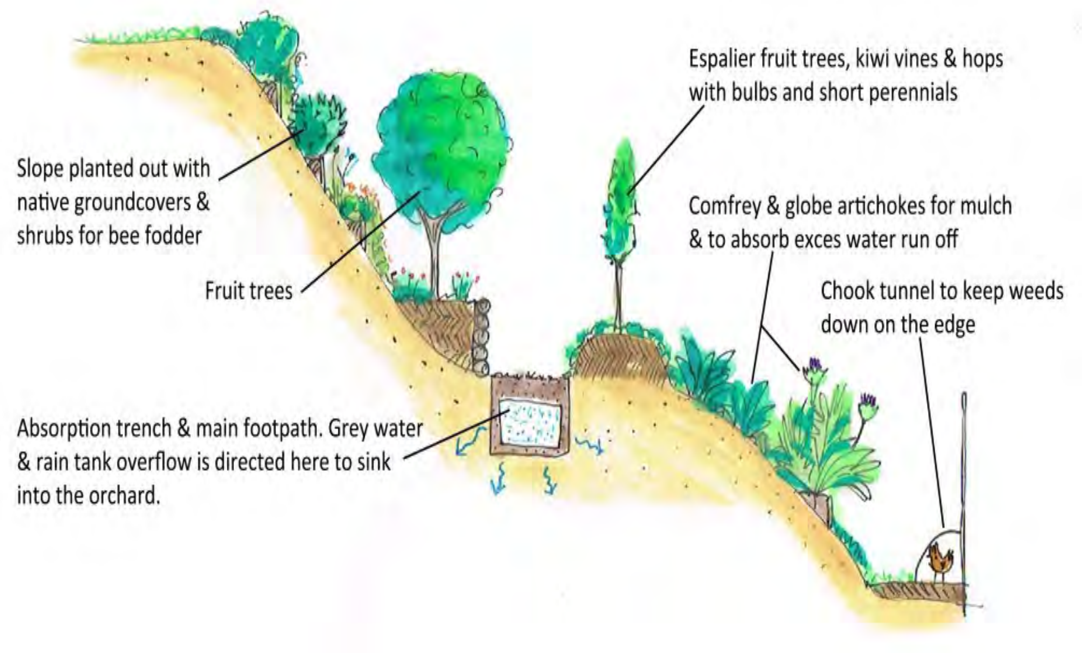
First, you start with a biodegradable weed barrier like cardboard along the swale downside.

From there, you build a thick, layered substrate of compost and mulch.

As the materials break down, worms move in, softening the soil below, and creating a healthy, aerated planting bed where there was once dead and compacted clay. Water also helps the decomposition process get going.

The sheet mulch bed is then complete and ready for planting out

Step 7: Plant out the swales



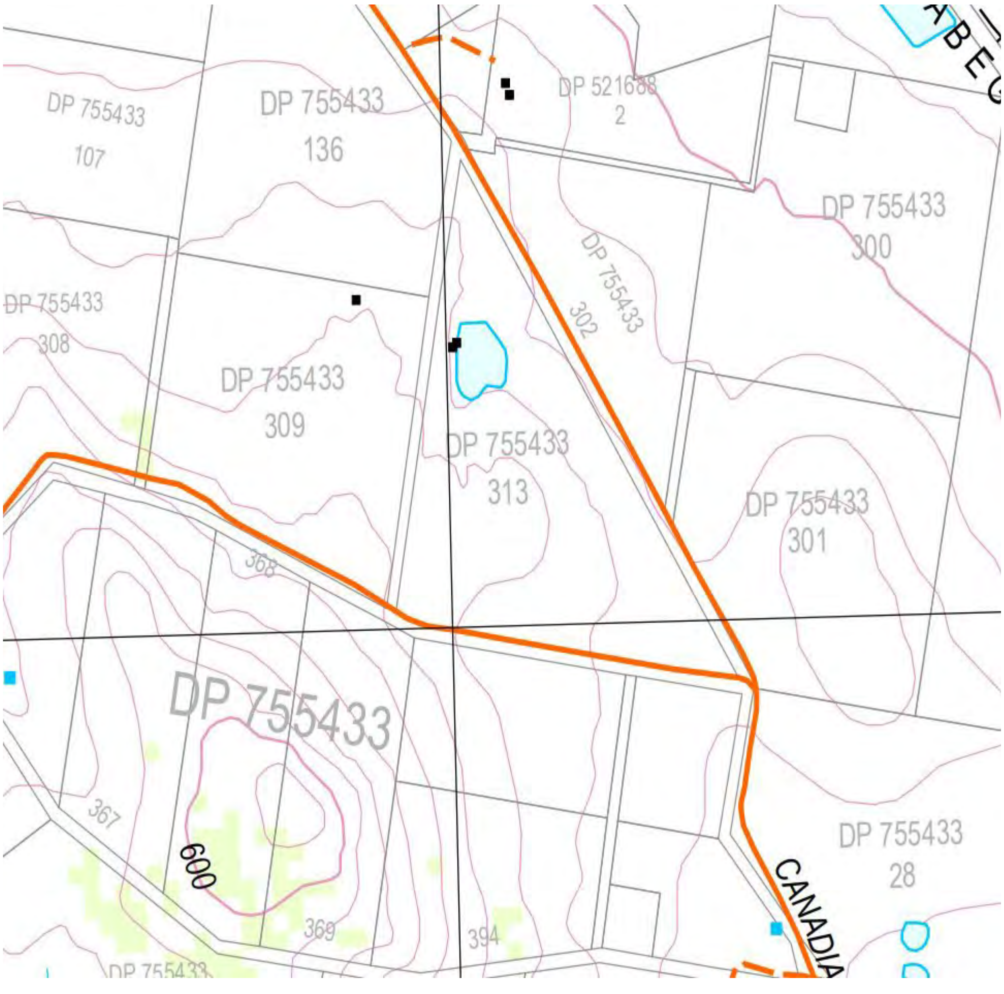
We recommend planting perennials that will grow permanent, thirsty roots to stabilize the system. In desert areas, plantings are typically placed in the swale trench, while in non-desert areas, it is typical to plant the berm.

Step 8: Build Redundancy into the Swale System.

We always think about where the water will go when the swales overflow.

We create keyline dispersal trenches that have redundancy built in that can handle a 100-year rain event.

Topographical reference map for swale design at Robert Oatley Olives

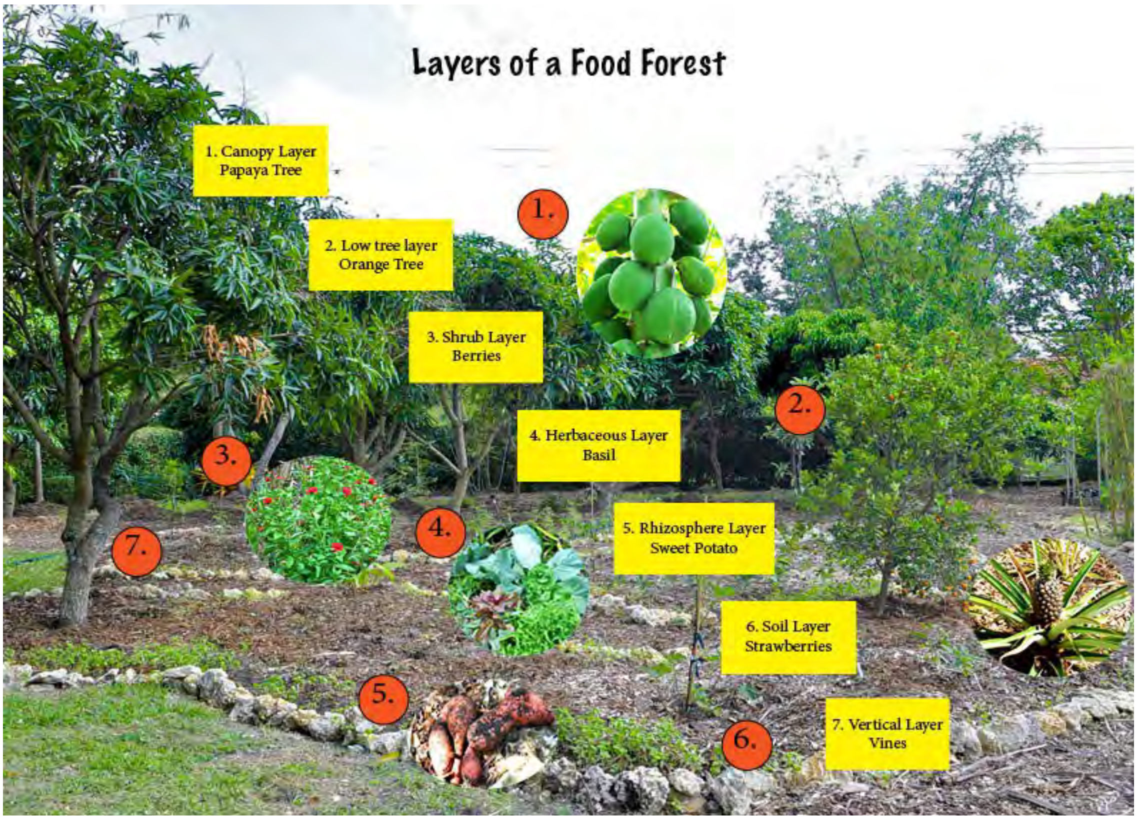


How to create an abundant food forest in drought prone Gulgong

What is a Food Forest?

A food forest, or edible forest garden, is a future food production strategy based on an ancient 2000 year old farming philosophy first discovered in Morocco.

A food forest mimics a forest edge that is planted with edible plants, with all of the vertical layers of a forest growing together: tall trees, small trees, shrubs, herbs, and ground covers.



All of these layers of the forest stack together, each situated for sufficient sun exposure. Intertwined, they produce a vibrant, productive, low-maintenance, and self-maintaining ecosystem.

A healthy forest doesn't need humans to weed or fertilise.

Green farming on steroids

Food forests in barren environments create a bio-diverse ecosystem instead of a monoculture.

This lessens the threat of pests, reduces the need for fertilizer, lowers the amount of maintenance required, and increases and diversifies the yield.

This diversity encourages more stability in the system

The Benefits of a Edible Food Forest

Food forests don't disturb or destroy the soil integrity like traditional farming.

Rather, they continually enrich soil with organic matter as leaves fall and plants die back for the winter.

Consequently, the food forest model can help to restore land, biodiversity, and habitat - while creating an edible yield.

Edible Forest Design for Robert Oatley Olives

Before

Edible Forest Design for Robert Oatley Olives

After

Intelligent Swale & Catchment Design for Robert Oatley Olives

Before

Intelligent Swale & Catchment Design for Robert Oatley Olives

After

The End