TIM VAUGHAN RACING

Pant Wilkin Stables, Aberthin

Water Balance Assessment

July 2022

Project Information	
Project:	Pant Wilkin Stables, Aberthin
Report Title:	Water Balance Assessment
Client:	Tim Vaughan Racing Ltd
Instruction:	The instruction to undertake this Water Balance Assessment was received from Jonathan Lambe of Lambe Planning & Design Ltd acting on behalf of the Client.
File Ref:	14547-Water Balance Assessment-02

Approval Record	
Author:	Jessica Roberts BSc (Hons) MCIWEM
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Document History		
Revision	**Date**	**Comment**
01	10/06/22	First issue
02	01/07/2022	Second issue- Updated following Client comments

This report will remain valid for a period of twelve months (from the date of last issue) after which the source data should be reviewed in order to reassess the findings and conclusions on the basis of latest available information.

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Figures

Introduction

Waterco has been commissioned to undertake a Water Balance Assessment to ascertain the viability of three proposed fishing lakes located at Pant Wilkin Stables, Aberthin, Cowbridge, CF71 7GX.

A desk-based Water Balance assessment has been prepared using readily available online data, anecdotal information from the client and information obtained from a site visit in April 2022. The purpose of this assessment is to establish the hydrological feasibility of introducing three new lakes to the site and ascertaining their long-term viability to support fish (for fishing) and for amenity value.

Existing Site Conditions

The site covers an area of approximately 5.42hectares (ha) and is centred at National Grid Reference (NGR): 302021, 174117. A location plan and an aerial image are included in Appendix A.

Online mapping (including Google Maps / Google Streetview imagery, accessed May 2022) shows that the existing site comprises an existing agricultural field. The site is situated on land owned by the wider Pant Wilkin stables with Llanquian Wood to the north, agricultural land to the east and west, with the A48 to the south. Access is currently provided by the existing Pant Wilkin Stables entrance to the east of the site.

Local Topography

A topographical survey has been provided by 360AD Limited in April 2021. The topographical survey indicates that the site slopes from approximately 107.26 metres Above Ordnance Datum (m AOD) in the south to approximately 91.26m AOD in the north.

Topographic levels to m AOD have also been derived from a 1m resolution NRW composite 'Light Detecting and Ranging' (LiDAR) Digital Terrain Model (DTM). LiDAR levels generally corroborate with those on the topographical survey.

Topographical information is provided as Appendix B.

Published Ground Conditions

Geology

The British Geological Survey (BGS) online mapping (1:50,000 scale) indicates that there are no superficial deposits recorded on site. The underlying bedrock in the northern extent of the site comprises the Friars Point Limestone Formation and the underlying bedrock in the southern extent of the site comprises the Gully Oolite Formation consisting of Limestone. The geological mapping is available at a scale of 1:50,000 and as such may not be accurate on a site-specific basis.

A limited intrusive investigation, comprising the excavation of 2No trial pits has been undertaken by others to establish the underlying ground conditions (geology and groundwater levels).

Two trial pits were excavated to a maximum depth of 2m below ground level and generally confirmed the published geology. Soil was recorded up to a depth of 2m overlying the bedrock. Groundwater or evidence of groundwater was not recorded in either of the trial pits. A summary of the investigation, including a plan showing the trial pit locations, is provided as Appendix C.

Hydrogeology

According to the Aquifer Designation data, published by BGS and obtained from GeoIndex Onshore online mapping [accessed June 2022], the underlying bedrock is classified as a Principal Aquifer. Principal Aquifers are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.

The EA's 'Source Protection Zones' data, obtained from MAGIC's online mapping [accessed June 2022], indicates that the site is not located within a Groundwater Source Protection Zone.

The Cranfield University 'Soilscapes' map [accessed June 2022] indicates that the site is underlain by *'Freely draining slightly acid but base-rich soils'.*

Development Proposals

The proposal is for the provision of three fishing lakes* with islands and two associated reed beds for infiltration purposes to accommodate any overflows from the fishing lakes. Five pontoon structures are also proposed to provide fishing points together with a timber amenities hut and a vehicular access point and parking. It is understood that the proposal is intended for tourism, leisure, amenity and biodiversity benefits.

**it should be note that whilst the development plans refer to lakes, the current proposals are such that they would be better defined as ponds, however for the purpose of this assessment, they will continue to be referred to as lakes.*

Development plans are provided within Appendix D.

Water Balance Assessment

The proposed lakes (included within Appendix D) will be situated within the Pant Wilkin sub-catchment, which forms part of the wider Nant Aberthin catchment.

Given its location, the Nant Aberthin catchment has been used as a proxy for the purpose of the Water Balance Assessment. The Pant Wilkin sub-catchment (herein referred to as the sub-catchment) drains to the area where the lakes are proposed and as such has been investigated in more detail. A sub-catchment description is included within Appendix E. A description of the wider Nant Aberthin catchment is included as Appendix F.

Conceptual Sub-Catchment Flows

The catchment assessment for Pant Wilkin sub-catchment has been used to inform the conceptual sub-catchment flows. The information available suggests that flows in the majority of the sub-catchment are very likely to be subsurface, even during heavy rainfalls. Flows are generally expected to infiltrate under the highway (A48). The exception to this is the small zones of saturation excess overland flow near the proposed outlet at Lake 1 (Appendix D). This zone of saturation is associated with a paleo-hollow, as described in Appendix E. It is also likely that flows in the soil outside of the paleo-hollow infiltrate into the limestone bedrock and flow as deeper groundwater in the limestone bedrock.

Therefore, to summarise, the overland surface water runoff from the existing catchment is currently limited.

Potential Options

On the basis of the current understanding of the sub-catchment and the anticipated conceptual flows discussed within this report, three potential options have been considered with regards to the feasibility and viability of the proposed fishing and amenity lakes.

Option 1- The excavation of lakes into Existing Soils and Bedrock

This is the most simplistic option and considers the excavation of the lake into the existing material, with little or no engineered additions.

Desk based and site observations indicate that the underlying soils are relatively permeable, providing minimal water bearing capacity. The Friar's Point limestone and Gully Oolite limestone bedrock are also very permeable. This strongly suggests that the lakes would only potentially be viable during rainy periods in the winter and would very likely be dry most of the year.

On this basis Option 1 is **not considered to be a viable option** and is therefore not considered further.

Option 2- The lakes are excavated and shaped using imported clay.

Option 2 proposes the importation of clay to create relatively impermeable lined lakes. The clay will act as a barrier to vertical and horizontal migration of water, retaining it in the lake structure. In the absence of a watercourse to act as "in-flow" to the lakes, the viability of the lakes is reliant on rainfall, surface and sub-surface flows reaching the lake and the evapotranspiration rate, collectively termed as the "water balance".

The water balance on a lined lake depends on the ratio of the lake area to the catchment area, i.e., the minimum ratio is 1 when the lake has vertical walls and no external catchment. For a lake with sloped or battered perimeter the ratio is a little higher than 1 unless the lake side slopes are very shallow.

In either case, of vertical walled lakes or battered slopes, the viability in winter is generally good but in drier summers the water levels will fall progressively throughout the summer months until only small stagnant pools remain or in some years dry up completely.

Vegetated areas in lakes and shallow lakes makes the viability of the lakes even lower, as shallow water warms and evaporates more easily and wetland marginal vegetation, can evapotranspirate more water than unvegetated clear water areas.

In an average rainfall year, the rainfall and evapotranspiration balance will allow the lake to remain albeit at a lower level. In an extreme year of very low rainfall, the water levels of the lakes would drop significantly which would affect the water quality, subsequently impacting the lakes viability for fishing.

Option 3 – The lakes are excavated, shaped, and lined using imported clay and a proportion of the surrounding catchment is lined with clay underneath the soil.

Option 3 considers providing an engineered solution to reduce the permeability of part of the sub-catchment by replacing the soils with imported low permeability clay. The aim is to increase the run-off that will enter the lakes, thus shifting the water balance in favour of enhanced retention of water in the lakes.

The proportion of the catchment that has the potential to be underlined with clay, has been calculated based on topographical features and ownership boundaries and is shown in Figure 1. Given the potential for water losses, associated with an isolated paleo hollow, an area of 70,000m^2, has been considered based on professional judgement.

Figure 1 – Approximate area where clay underlining may be feasible

Generally, in locations with an intermediate rainfall such as this, the ratio of catchment area to lake area for a year-round viable lake needs to significantly exceed 1. Based on professional judgement and given the current understanding of the catchment to date, it would be prudent to have a catchment area to total lake(s) area ratio of at least 3.

The merits of Option 3 have been assessed with respect to the water balance and water quality information which is included as Appendix G.

Throughflow and Storage of the above options

Option 3 is impacted by throughflow. Throughflow is the movement of water through the lake system; including but limited to surface and sub-surface run off, precipitation, evaporation and evapotranspiration. Throughflow is required to maintain a wide range of ecological habitats and to provide the highest water quality. However, even with a restricted throughflow the lakes would be sufficient to accommodate a more limited range of species (i.e cyprinids/carp family) during most years. In drought years, where long periods of no throughflow is predicted, cyprinids/carp may require additional water or oxygenation to improve water quality.

For options 2 and 3, there may be capacity within the proposed islands associated with the lakes for storage of water, for use during periods of water stress. By estimating the size of the islands and using a depth of 2m, there is potential to accommodate 1,500 m^3 of storage and is likely to be insufficient to fully mitigate the impact of a more extreme drought. Inflow and other storm flows could be enhanced by creating storage tanks and underground plastic crate systems below the reed bed areas which can more effectively intercept flows. This system could potentially provide storages of 3,000$m^3$and 2,000m^3 under each reed bed.*

*Please note, these figures are for indicative purposes only and will need to be verified at detailed design stage.

In drought years, potable mains water could also be utilised for an emergency use (for short periods of time). The limitations associated with potable mains water is discussed below (i.e. requirement for dichlorination).

Therefore, option 3 with storage as highlighted above, would be considered to be the most feasible option, ensuring to limit the fish species to cyprinids/carp.

Furthermore, if a wider range of fish species is considered, alternative sources of throughflow will need to be investigated.

Alternative Sources of Throughflow

The below alternative sources of throughflow have been considered which are only applicable if a wider range of fish species is considered.

Detailed water catchment modelling would need to be considered if any water extraction from boreholes is considered (which is currently not proposed based on utilising option 3 with storage, limiting fish the species to cyprinids/carp).

Borehole

The site lies on limestone classified as a Principal Aquifer, however the availability of groundwater from boreholes within this strata may not provide a sufficient continuous supply to maintain the water levels in the lakes. Consideration would need to be given to the impact of any groundwater supply on other existing supplies in the locality. A more detailed investigation, such as pump tests, to prove that such extractions will not affect flows will be necessary.

The quality of the groundwater would need to be suitable for the intended purpose. Limestone aquifers typically result in hard water, high in both calcium and magnesium. Hard water is reported in some instance to affect certain types of fish, altering breeding and inducing diseases.

Potable mains water

To sustain a throughflow of 1 l/s daily using potable mains water is likely not financially viable and unsustainable for more than few days at 80 m^3/day at current Welsh Water rates but may be useful in an emergency for fish in drought conditions, however mains water is unlikely to be suitable to sustain the intended habitats without further treatment e.g. de-chlorination.

Recirculation

It is possible to pass the outgoing water through biofilters and chemical filters to remove excess fish-derived pollutants. The resultant water can be pumped back to the top of the system of lakes and oxygenated in a spray to flow back through, however such systems require the throughflow volume to be large to reduce the residence time of polluted water; this requirement increases the power and pipe diameter needed for pumping.

Highway drainage

The A48 drains to the paleo-hollow, which is approximately 5,000m^2, potentially providing an additional source of water which could be utilised if interception is feasible, however highway drainage is often contaminated with pollutants detrimental to aquatic life, e.g. zinc and hydrocarbons. If it is to be utilised, then provision must be made for decontamination and accidental spills before joining the general flows.

Photovoltaic panel water collection

The field to the east of the new access track, shown in Figure 1 above, could be utilised as a ‘solar panel farm’ without clay underlining. This would be a non-standard use of collecting rainwater shed from panels and using impermeable channels leading it to the general flows of the upper lake. However, it would require a decontamination step, perhaps as simple as passing the flow through soil, as PV panels can shed metal ions detrimental to aquatic life.

Note that all values of volumes and flows are indicative and do not constitute a storage design or throughflow design for fish /amenity viability.

Drainage Considerations During Extreme Rainfall Events

Development proposals are for three new lakes with the capacity to attenuate large flows derived from rainfall. The outfall of the proposed lakes is directed to the reed beds where the flows from the outfalls will be infiltrated. During the winter months, to avoid excess flows overwhelming infiltration in the reed beds during high rainfall events, a freeboard within all of the lakes, of at least 300mm will be required.

Conclusions

The proposal is for the provision of three fishing lakes with islands and two associated reed beds for infiltration purposes to accommodate any overflows from the fishing lakes. Five pontoon structures are also proposed to provide fishing points together with a timber amenities hut and a vehicular access point and parking. It is understood that the proposal is intended for tourism, leisure, amenity and biodiversity benefits.

Waterco attended the site in April 2022 and a total of two trial pits were excavated by others to examine the underlying geology and groundwater levels on site. The trial pits were excavated to a maximum depth of 2m below ground level and generally confirmed the published geology. Soil was recorded up to a depth of 2m overlying the bedrock. Groundwater or evidence of groundwater was not recorded in either of the trial pits.

The information available suggests that flows in the majority of the sub-catchment are very likely to be subsurface, even during heavy rainfalls. Flows are generally expected to infiltrate under the highway (A48). The exception to this is the small zones of saturation excess overland flow near to the proposed outlet at Lake 1. This zone of saturation is associated with a paleo-hollow. It is also probable that flows in the soil outside of the paleo-hollow infiltrate into the limestone bedrock and flow as deeper groundwater.

Desk based and site observations indicate that the underlying soils are relatively permeable, providing minimal water bearing capacity. The Friar's Point limestone and Gully Oolite limestone bedrock are also very permeable. This strongly suggests that the lakes would only potentially be viable as lakes during rainy periods in the winter and would be dry most of the year, unless a clay liner/or similar is used.

On the basis of the findings of the assessment, it is concluded that:

Option 1-The excavation of lakes into Existing Soils and Bedrock

Given the permeable nature of the existing underlying geology, option 1 is not considered viable for the amenity fishing lakes as the lakes would only potentially be viable during rainy periods in the winter and would very likely be dry most of the year.

Option 2 -The lakes are excavated and shaped using imported clay.

In an average rainfall year, the rainfall and evapotranspiration balance will allow the lake to remain, albeit at a low level. In an extreme year of very low rainfall, the water levels of the lakes would drop significantly which would affect the water quality, subsequently impacting the lakes viability for fishing.

Option 3 – The lakes are excavated, shaped, and lined using imported clay and a proportion of the surrounding catchment is lined with clay underneath the soil.

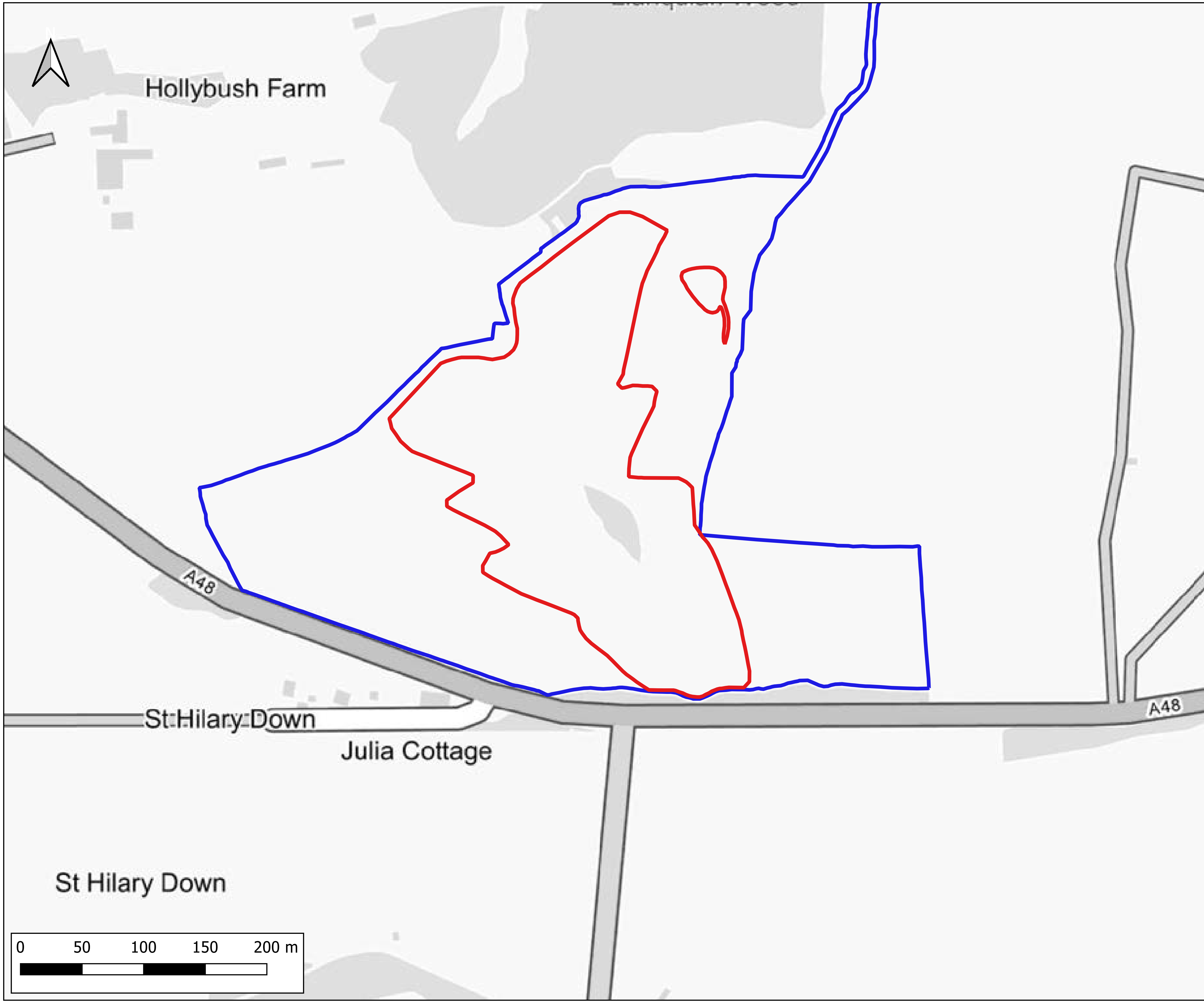
Option 3 is impacted by throughflow. Throughflow is required to maintain a wide range of ecological habitats and to provide the highest water quality. However, even with a restricted throughflow the lakes would be sufficient to accommodate a more limited range of species (i.e cyprinids/the carp family) during most years. In drought years, where long periods of no throughflow is predicted, cyprinids/carp may require additional water or oxygenation to improve water quality.

Therefore, option 3 with storage as highlighted above, would be considered to be the most feasible option ensuring to limit the fish species to cyprinids/carp.

Recommendations

- Install a gauge board within each lake to monitor lake levels.
- Ensure that the bank level is set so that there is at least a 300mm freeboard above the overflow pipe level within all of the lakes.
- Detailed design for the clay catchment area.
- Detailed design for the potential storage options during water stress years.
- Establish if a Flood Risk Assessment, Drainage Strategy and Infiltration Assessment for the proposed lakes is required.

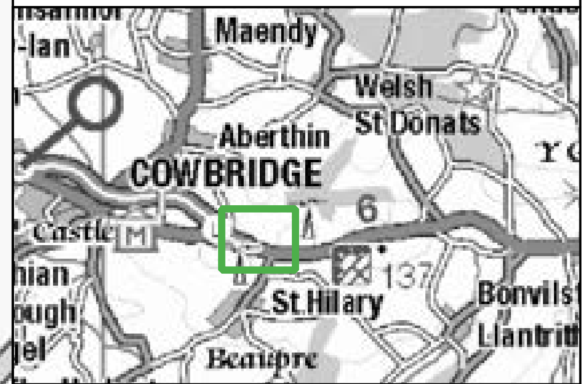
Appendix A Location Plan and Aerial Image



Notes:
1) All dimensions are in metres and all levels in metres above Ordnance Datum unless stated otherwise

LEGEND

- Site Boundary
- Land under client's ownership
- Watercourses
- Waterbodies



CLIENT:
Tim Vaughan Racing Ltd

waterco
www.waterco.co.uk

SCHEME:
Pant Wilkin Stables, Aberthin

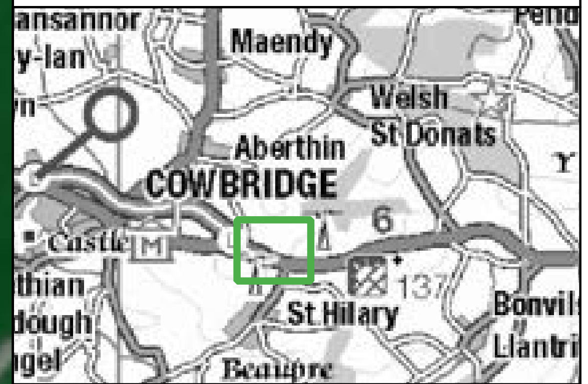
PLOT TITLE:
Location Plan

PLOT STATUS:			DATE:
FINAL			19-05-2022
DRAWN:	CHECKED:	APPROVED:	PLOT SCALE AT A3:
RM	AW	NJ	1:3000
PLOT NAME:			REVISION:
14547_Location_Plan			-

Notes:
1) All dimensions are in metres and all levels in metres above Ordnance Datum unless stated otherwise

LEGEND

- Site Boundary
- Land under client's ownership



CLIENT:

Tim Vaughan Racing Ltd

www.waterco.co.uk

SCHEME:

Pant Wilkin Stables, Aberthin

PLOT TITLE:

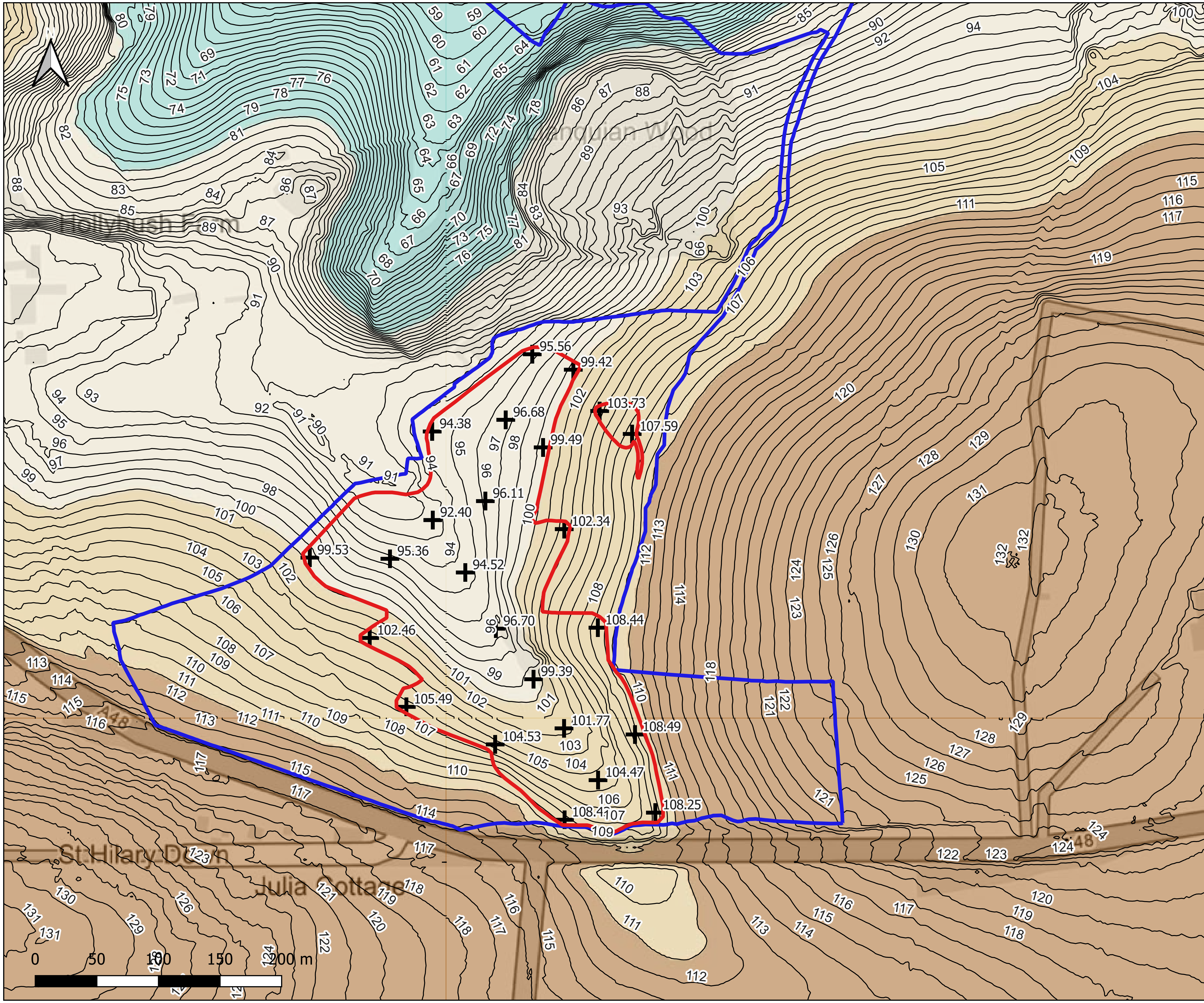
Aerial Plan

PLOT STATUS:	DATE:
FINAL	19-05-2022

DRAWN:	CHECKED:	APPROVED:	PLOT SCALE AT A3:
RM	AW	NJ	1:3000

PLOT NAME:	REVISION:
14547_Aerial_Plan	-

Appendix B Topographical Data



Notes:
1) All dimensions are in metres and all levels in metres above Ordnance Datum unless stated otherwise

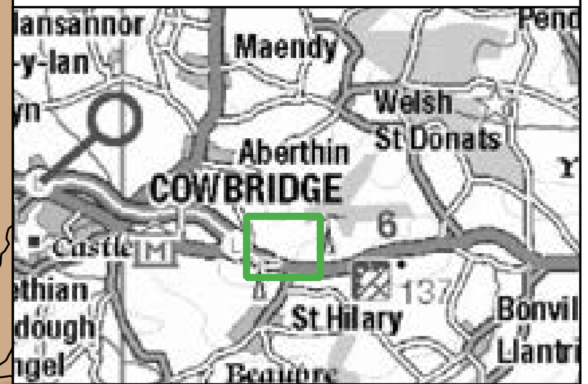
LEGEND

- 1m Contour
- Site Levels
- Site Boundary 2
- Land under client's ownership

Ground Elevation (m AOD)

Band 1

- <= 50.0000
- 50.0000 - 80.0000
- 80.0000 - 100.0000
- 100.0000 - 111.0000
- > 111.0000



CLIENT:

Tim Vaughan Racing Ltd

waterco

www.waterco.co.uk

SCHEME:

Pant Wilkin Stables, Aberthin

PLOT TITLE:

LiDAR Plan
2m Resolution
Data from Natural Resources Wales

PLOT STATUS:			DATE:
FINAL			19-05-2022
DRAWN: RM	CHECKED: AW	APPROVED: NJ	PLOT SCALE AT A3: 1:3000
PLOT NAME: 14547_LiDAR_Plan			REVISION: -

Appendix C Site Investigations

Trial pit investigation

Waterco attended the site in April 2022, on the day of the site visit the weather was warm and dry following a generally dry period. The purpose of the site visit was to examine the underlying geology and groundwater levels on site.

In total, two trial pits (TP1-TP2) were excavated, these locations were chosen based on hydrological considerations, topography and site layout. A map showing the approximate trial pit locations is provided within Figure 1 below:

Figure 1 – Approximate Trial Pit Location Plan

TP1

The first trial pit was excavated to approximately 2 metres below ground level (m.bgl). The topsoil was generally a strong red-brown colour which became increasingly silty and clayey with depth. The clay close to the lowest point was discontinuous, as evidenced by the intermittent smears from the excavator bucket. There was no sign of gleying or mottles which would indicate periodic waterlogging. Very few stones were seen in the soil and no bedrock was found. No indication of groundwater was seen.

Figure 2 – Photograph showing the inside of TP1

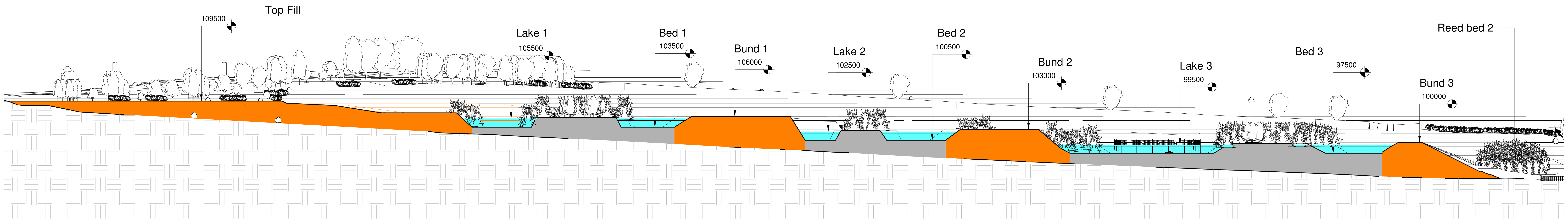
TP2

The second trial pit was located within the area known to pond during heavy rainfall events. The trial pit was excavated to a depth of approximately 1.3m deep, which was limited by striking bedrock at approximately 0.7m.bgl. The bedrock was seen to be roughly stratified and broke up into fragments of 100-200mm thick. Fresh surfaces showed a hard, dark grey limestone and closer examination revealed lighter specular reflections from calcite- later shown to be crinoid fossils. The excavation released a foetid odour when the rock was fractured. One rock sample was a paler reddish-brown limestone but its horizon was not identified on site and was possibly from a small area. Overall, the rock appeared to be the mapped Friar's Point limestone. Weathering surfaces on the rock interface were red clay with no indications of tufa. This suggests that flows within the limestone from higher up do not exit from below at this low point, although the surfaces of the rock partings were moist.

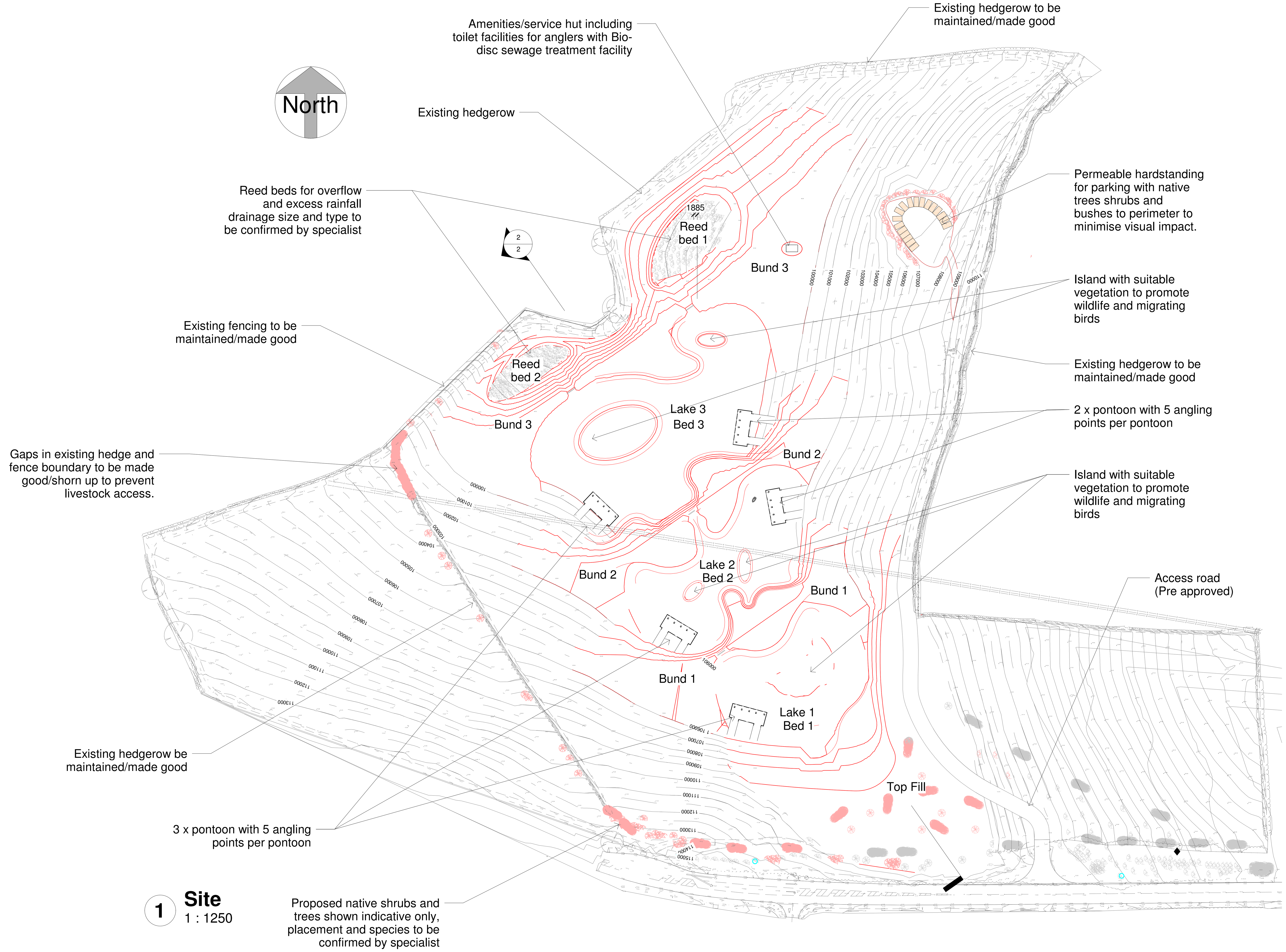
The soils identified were red-brown, silty loam with no stones and a sharp discontinuity at approximately 0.4m in depth, a possible plough-pan effect or an old excavation. No gleying or mottles were noted indicated a lack of periodic waterlogging despite being known to pond.

Figure 3 – Photograph showing the inside of TP2

Appendix D Development Plans



2 Section 1
1 : 500



1 Site
1 : 1250

<u>Approx. Area of Lakes</u>

Lake 1 = 3850 m²

Lake 2 = 4866 m²

Lake 3 = 8262 m²

Total = 16,978 m²

Minimum depth = 0.5 m

Maximum depth = 3.5 m

average depth = 2 m

Total area subject to altered levels including lakes = 47,230 m²

Total area of subject field = 134,750 m²

25 Fishing points open to anglers 24 hours a day all year round

<u>Fish Species</u>

Lake 1-2 - Silver fish, Roach, Rudd, Dace and smaller Carp. (Smaller Carp will be transferred to larger lake when developed.)

Lake 3 - Specimen Carp

NOTES

1. All dimensions are in millimetres unless noted otherwise.
2. All levels are shown in millimetres unless noted otherwise.
3. Do not scale from the drawing. Use figured dimensions only.
4. Any discrepancies to be reported immediately to the Designer/Engineer.
5. This drawing to be read in conjunction with all relevant Architects, engineers, subcontractors and specialists drawings and specifications.

ALL DIMENSIONS TO BE CHECKED ON SITE: Contractor to check and verify all building and site dimensions. The Contractor is to comply in all respects with the current Building Regulations whether specifically stated on this drawing or not. This drawing must be read and checked against any other specialist drawings provided & manufacturer's recommendations. Tabled quantities are for guidance only all specialist Consultants & Contractors to check and verify. Any discrepancies in all of the above must be reported to the Design team prior to installation

CDM - If we are appointed as a Designer or Principal Designer, for the Pre-Construction Phase only, we can only carry out our duties for that phase. This means that we will give all relevant design information for consideration in the Construction Phase Plan / Health & Safety File to the Client at the end of the Pre-Construction Phase. It will be the Client's responsibility to pass that information on to the Principal Contractor and any other Contractors or Designers, which the client subsequently appoints.

PLANNING ONLY

Notes:

Tabled quantities are for guidance only all, specialist Consultants & Contractors to check and verify. Software to produce these layouts is only suitable for creating visuals and this exercise has been done on this occasion for this purpose only.

Reed bed Note:

Overflow reed beds are shown indicatively and are subject to a full Ground survey and specialist drainage design in accordance with the surround environment and the specialist's design for the proposed lakes and bunds.

Bund & lake design notes:

CONCEPTUAL DRAWINGS ONLY – all elements shown artistically are subject to a full design by a qualified civil engineer for Local Authority and environment agency's approval.

rev.	drawn	chkd.	apprvd.	date	description
C	GT	ND		02/07/21	Additional information added
B	GT	ND		24/06/21	Additional information added
A	GT	ND		17/05/21	Amended layout

Client
Mr Tim Vaughan
Pant Wilkins Stables
Aberthin, Cowbridge
CF71 7GX

Project
Fishing Lake Development

Title
Proposed Site

360AD Limited
Architectural Design
& Visualisation Consultancy
First floor 29 Bocam Park
Pencoed Bridgend CF35 5LJ
t: 01656330997
email enquiries@360ad.co.uk
web www.360ad.co.uk

date	drawn	checked	approved
April 2021	GT	ND	

scale @ A1	Project number
As indicated	21-012

status	System Number	drg. no.	rev.
Concept	21-012-b	2	B

NOTES

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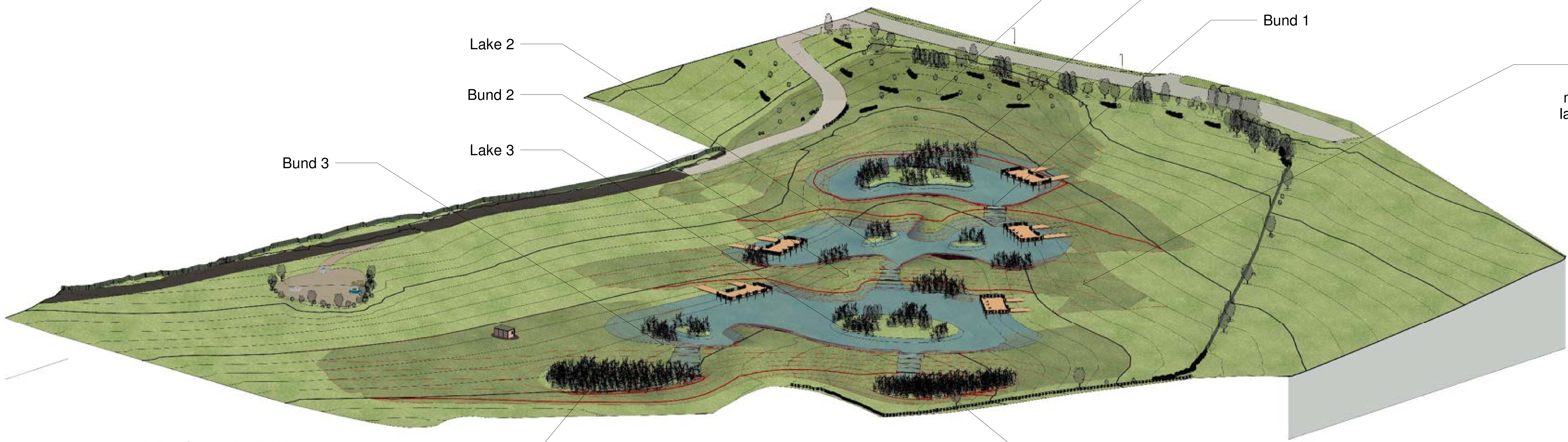
1 **3D Existing**



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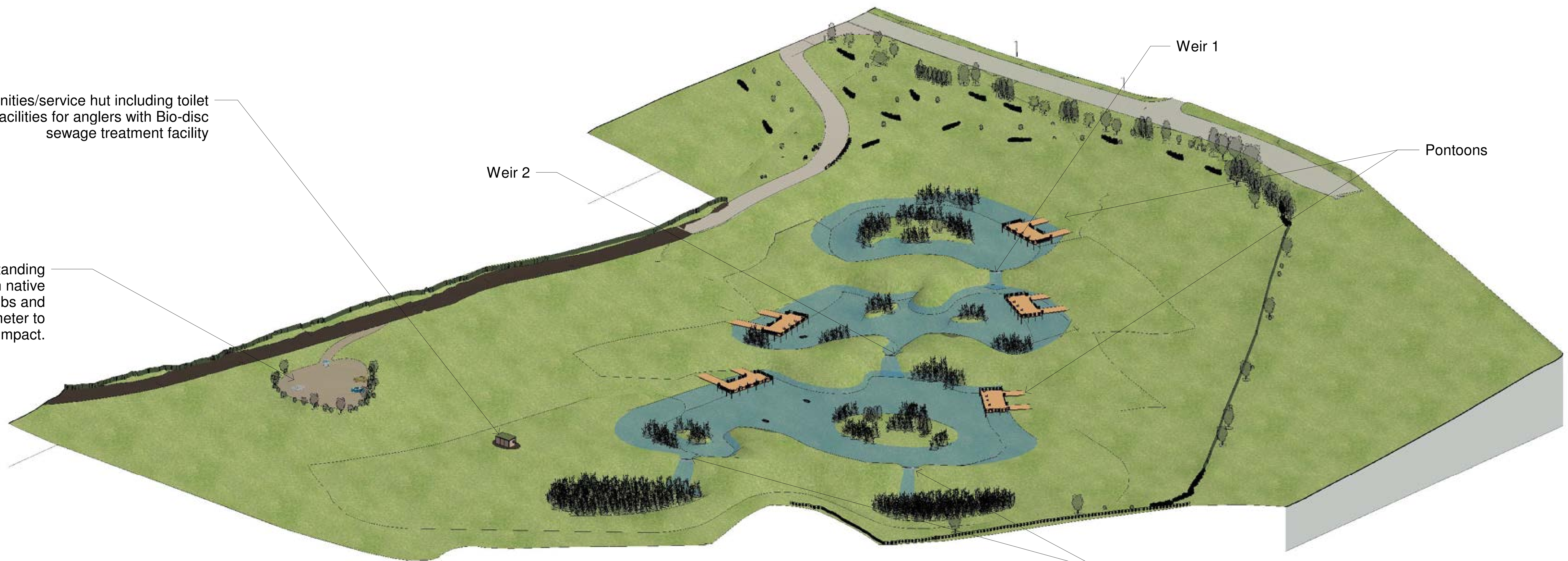

3 **3D Proposed**

PLANNING ONLY

rev.	drawn	chkd.	apprvd.	date	description
C	GT	ND		02/07/21	Additional information added
B	GT	ND		24/06/21	Additional information added
A	GT	ND		17/05/21	Amended layout

Client
Mr Tim Vaughan
Pant Wilkins Stables
Aberthin, Cowbridge
CF71 7GX

Project
Fishing Lake Development

Title
3D Views

360AD Limited
Architectural Design
& Visualisation Consultancy
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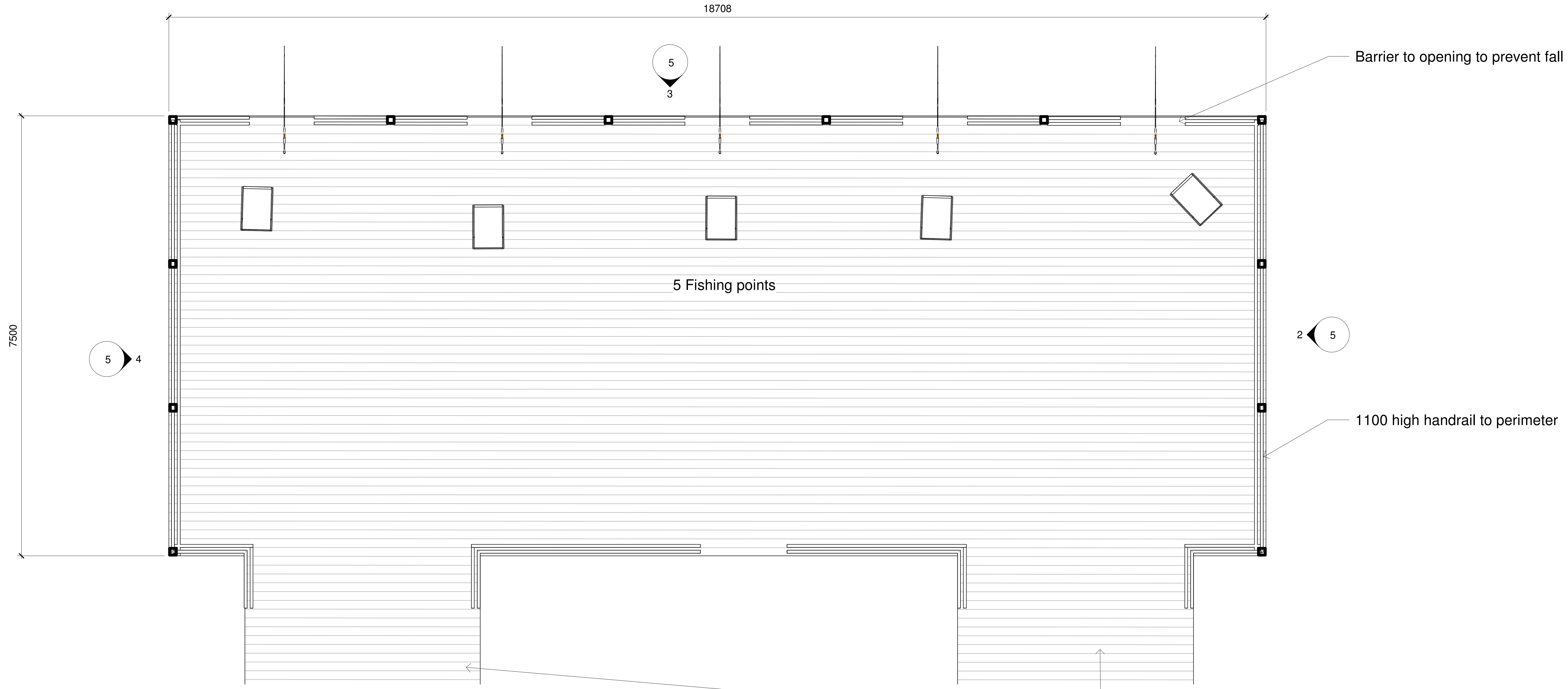
web www.360ad.co.uk

date	drawn	checked	approved
April 2021	GT	ND	

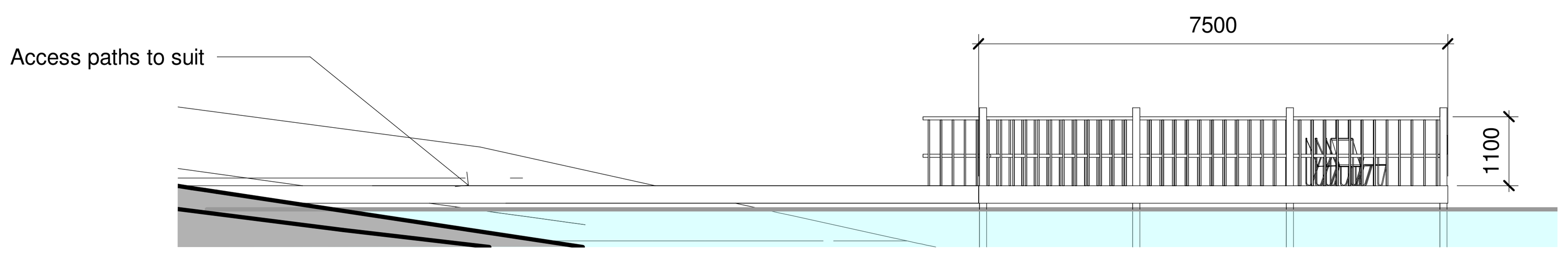
scale @ A1

Project number 21-012

status	System Number	drg. no.	rev.
Concept	21-012-b	3	B



1 Plan
1 : 50



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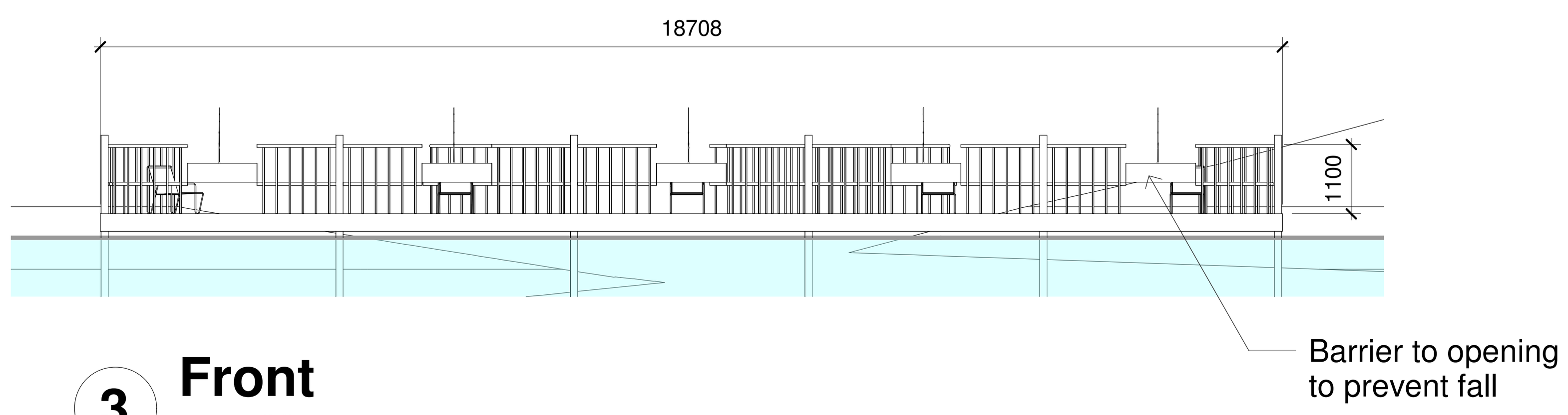

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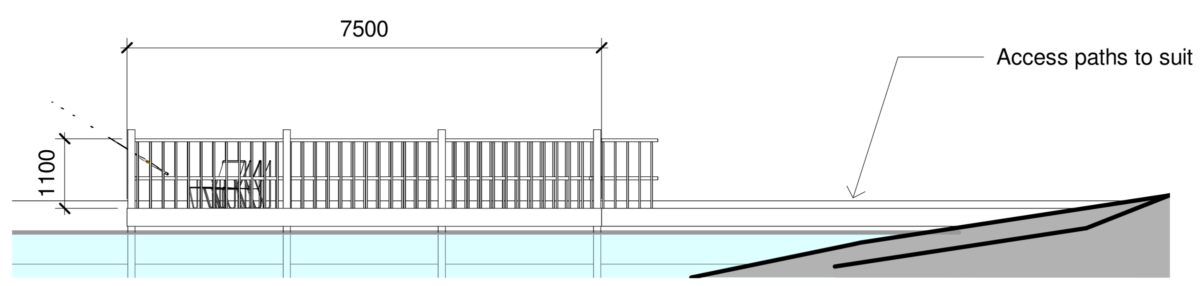

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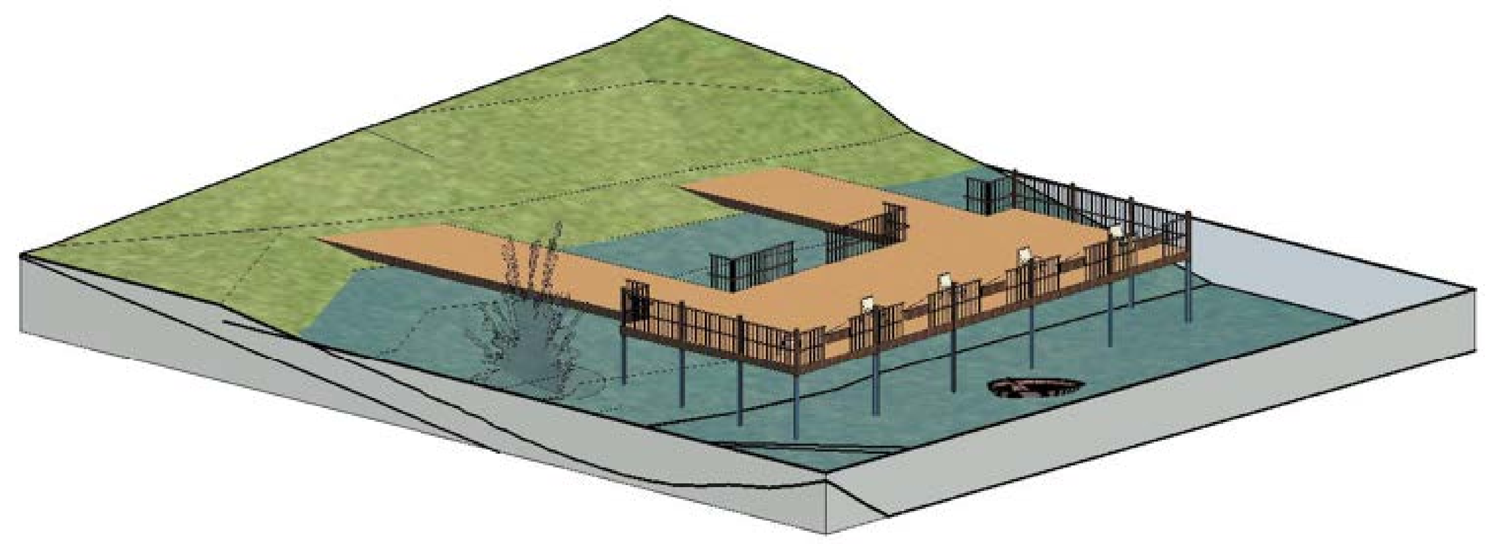
1 : 100



3D View

NOTES

1. All dimensions are in millimetres unless noted otherwise.
2. All levels are shown in millimetres unless noted otherwise.
3. Do not scale from the drawing. Use figured dimensions only.
4. Any discrepancies to be reported immediately to the Designer/Engineer.
5. This drawing to be read in conjunction with all relevant Architects, engineers, subcontractors and specialists drawings and specifications.

ALL DIMENSIONS TO BE CHECKED ON SITE: Contractor to check and verify all building and site dimensions. The Contractor is to comply in all respects with the current Building Regulations whether specifically stated on this drawing or not. This drawing must be read and checked against any other specialist drawings provided & manufacturer's recommendations. Tabled quantities are for guidance only all specialist Consultants & Contractors to check and verify. Any discrepancies in all of the above must be reported to the Design team prior to installation

CDM - If we are appointed as a Designer or Principal Designer, for the Pre-Construction Phase only, we can only carry out our duties for that phase. This means that we will give all relevant design information for consideration in the Construction Phase Plan / Health & Safety File to the Client at the end of the Pre-Construction Phase. It will be the Client's responsibility to pass that information on to the Principal Contractor and any other Contractors or Designers, which the client subsequently appoints.

rev.	drawn	chkd.	apprvd.	date	description

Client
Mr Tim Vaughan
Pant Wilkins Stables
Aberthin, Cowbridge
CF71 7GX

Project
Fishing Lake Development

Title
Pontoon Layout

360AD Limited
Architectural Design
& Visualisation Consultancy
First floor 29 Bocam Park
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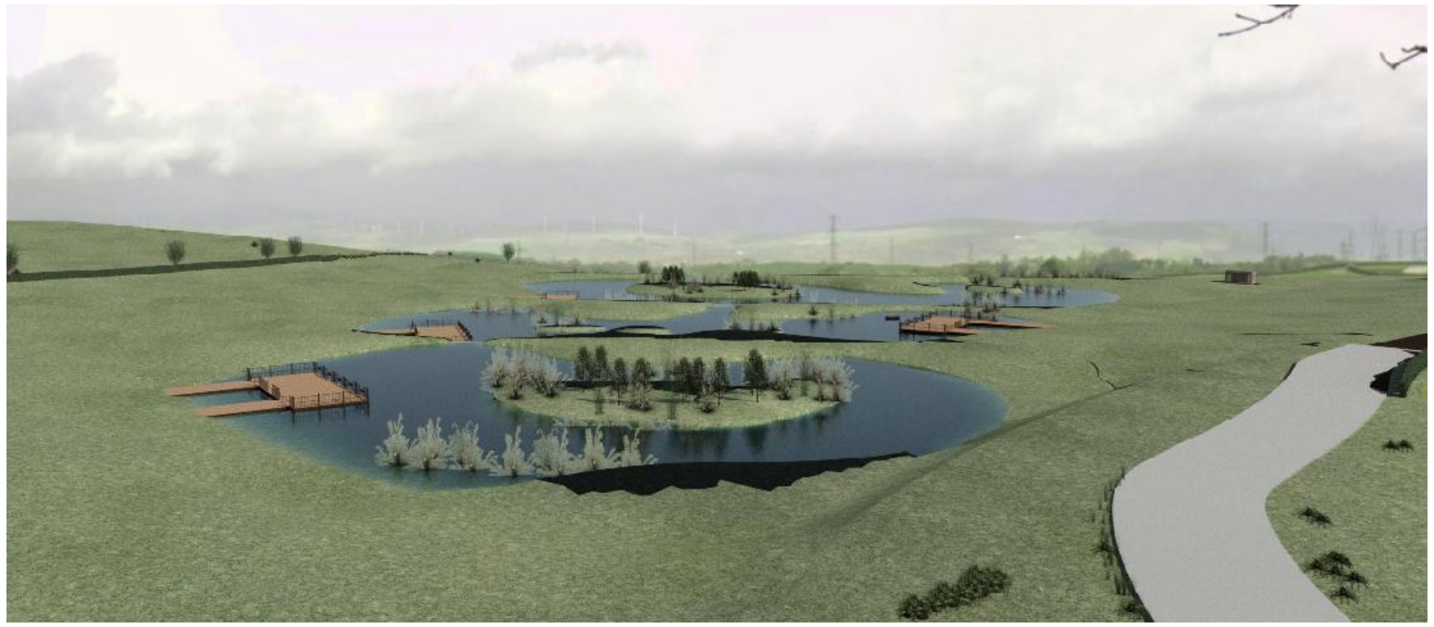
web www.360ad.co.uk

date	drawn	checked	approved
April 2021	GT	ND	

scale @ A1	Project number
As indicated	21-012

status	System Number	drg. no.	rev.
Concept	21-012-b	5	



Artists Impression

Client
Mr Tim Vaughan
Pant Wilkins Stables
Aberthin, Cowbridge
CF71 7GX

Project
Fishing Lake Development

Title
Images

360AD Limited
Architectural Design
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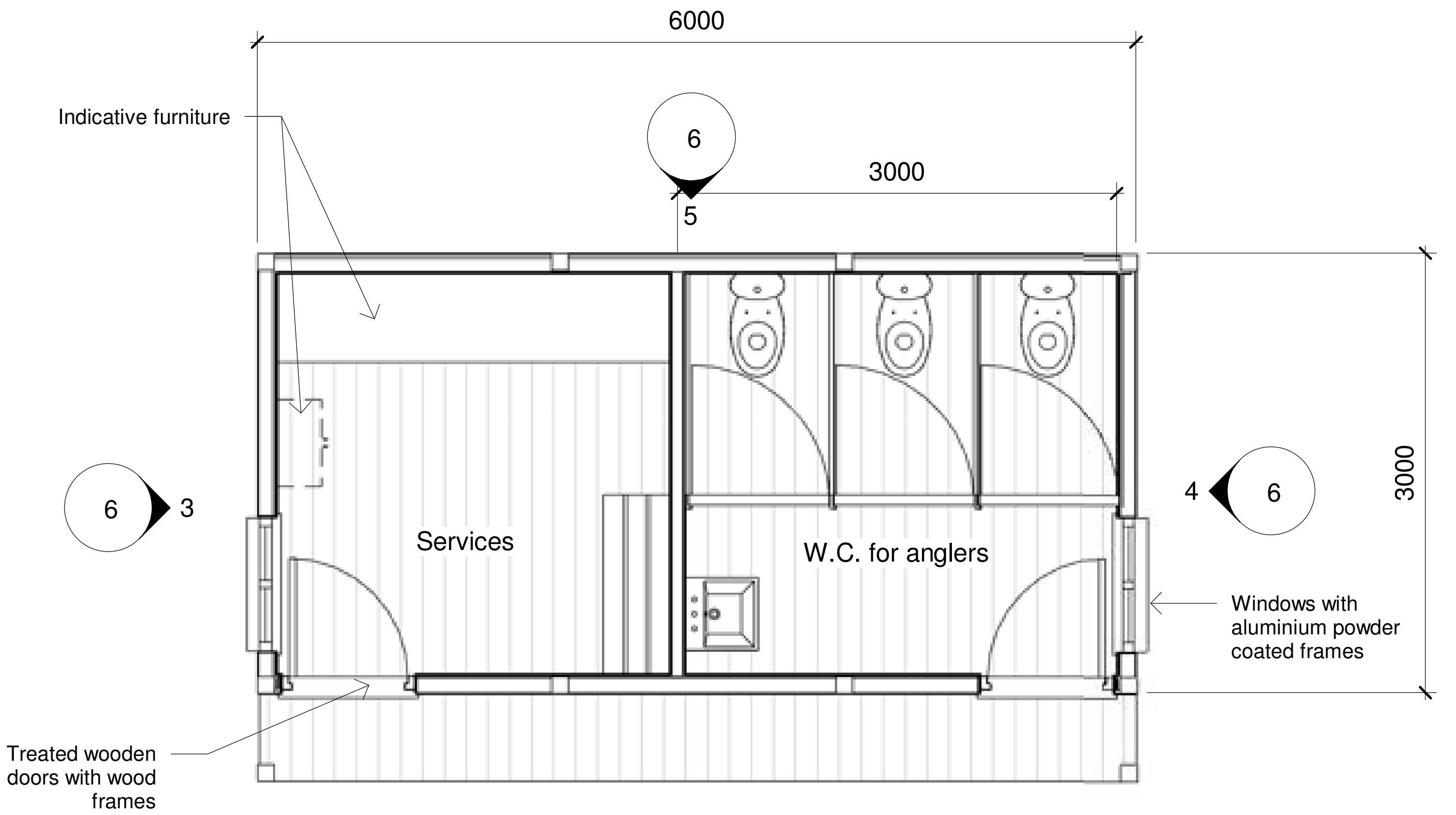
date	drawn	checked	approved
April 2021	GT	ND	ND

scale @ A3	Project number
1 : 1	21-012

Status	System Number	drg. no.	rev.
Concept	21-012-b	4	

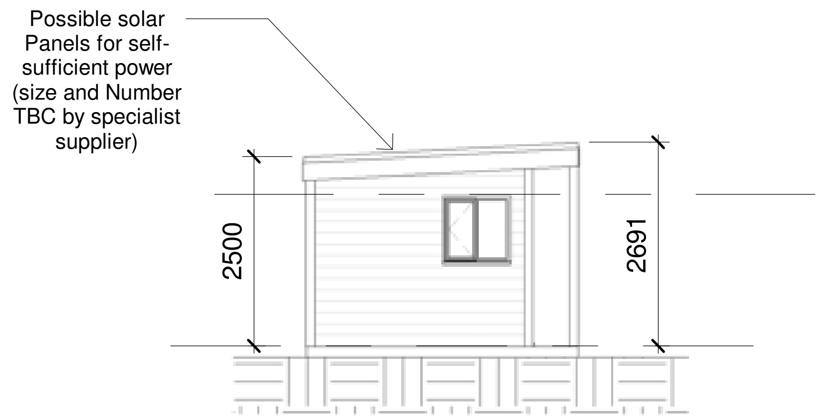


1 Floor plan
1 : 50

TEMPORARY STRUCTURE
(Pre-fabricated for minimal disruption to the area during installation)
Timber construction fishing amenities and services hut.

3D View

2 Front
1 : 100



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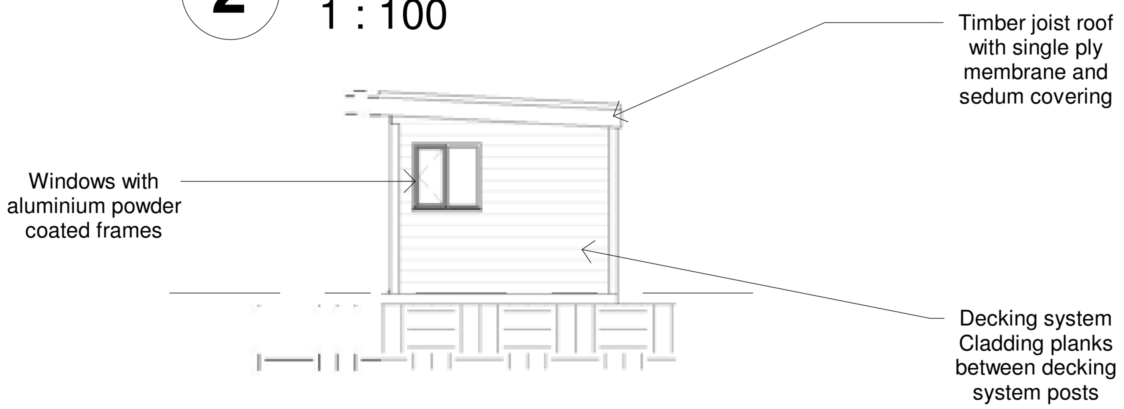

4 Left
1 : 100

5 Rear
1 : 100

NOTES
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rev.	drawn	chkd.	apprvd.	date	description

Client
Mr Tim Vaughan
Pant Wilkins Stables
Aberthin, Cowbridge
CF71 7GX

Project
-

Title
Fishing Services/amenities hut

360AD Limited
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date	drawn	checked	approved
07/21	GT	ND	Approver

scale @ A3	Project number
As indicated	21-012

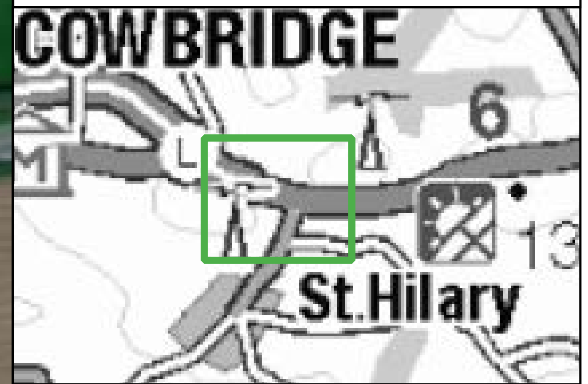
Status	System Number	drg. no.	rev.
Project Status		6	

Appendix E Pant Wilkin Sub- Catchment

Pant Wilkin Sub-Catchment Location

LEGEND

Pant Wilkin sub-catchment



CLIENT:

Tim Vaughan Racing Ltd

waterco

www.waterco.co.uk

SCHEME:

Pant Wilkin Stables, Aberthin

PLOT TITLE:

Pant Wilkin Sub-Catchment

PLOT STATUS: FINAL			DATE: 25-05-2022
DRAWN: RM	CHECKED: AW	APPROVED: NJ	PLOT SCALE AT A3: 1:3000
PLOT NAME: 14547_Catchment_Extent			REVISION: -

ABBREVIATIONS

AEP	Annual Exceedance Probability
AM	Annual Maximum
AOD	Above Ordnance Datum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CC	Climate Change
CDs	Catchment Descriptors
CEH	Centre for Ecology and Hydrology
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
DDF	Depth-Duration-Frequency
DPLBAR	Mean drainage path length (km)
DPSBAR	Mean drainage path slope (m/km)
DTM	Digital Terrain Model
EA	Environment Agency
FARL	FEH index of flood attenuation due to reservoirs and lakes
EA	Environment Agency
FEH	Flood Estimation Handbook
FPEXT	Floodplain Extent
FSE	Factorial Standard Error
FSR	Flood Studies Report
GEV	Generalised Extreme Value
GL	Generalised Logistic
HOST	Hydrology of Soil Types
LiDAR	Light Detection And Ranging
NRFA	National River Flow Archive
NRW	Natural Resources Wales
OS	Ordnance Survey
POT	Peaks Over a Threshold
PROPWET	Index of Proportion of time that soils are Wet
QMED	Median Annual Flood (with return period 2 years)
$QMED_{CDS}$	Estimate of Median Annual Flood from Catchment Descriptors
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SEPA	Scottish Environment Protection Agency
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
UAF	Urban Adjustment Factor
URBAN	Flood Studies Report index of fractional urban extent
$URBEXT_{1990}$	FEH index of fractional urban extent
$URBEXT_{2000}$	Revised index of urban extent, measured differently from $URBEXT_{1990}$
WINFAP	Windows Frequency Analysis Package – used for FEH statistical method

Pant Wilkin Sub-Catchment Description

The size and extent of the Pant Wilkin sub-catchment, herein referred to as the sub-catchment has been determined using SCALGO Live software (SCALGO) and is estimated to be approximately 0.37km^2. The catchment aspect is northerly and there is one dry-hollow, trending south-east to north-west, which is possibly a paleo-hollow from the last glacial period. Historical mapping has been viewed on the National Library of Scotland. The OS 25" 1890 map shows that there were a number of small quarries on the north side of the A48 highway. No further distinguished features were identified.

The Soil mapping: 1:250 000 Soil map of England and Wales; sheet 2 Wales has been reviewed and shows that the main soil mapped within the catchment is 541p, a Brown Earth of the soil association Malham 2. Described as: *'well drained often stoneless, silty soils over limestone, shallow in places especially on crests and steep slopes.'*

The descriptors for the sub-catchment have been downloaded from the FEH Website in May 2022. A summary of some of the descriptors are provided within Table 1 below.

The sub-catchment has a high responsiveness to rainfall (BFIHOST), which is typical for soils over limestone. The elevation of the catchment varies from 90m to 130m AOD with an average steepness of 93m/km. The DPLBAR is 0.72km and the DPSBAR is 93.9m/km.

The FARL value is 1, indicating that there are no defined ponds located within the catchment extent. The catchment generally comprises grassland for equine use or arable, on rolling hills with low tree cover and discontinuous hedge-lines.

The annual average rainfall, in the standard period 1961-1990 ($SAAR_{6190}$) is 1126mm, which is neither exceptionally dry or wet catchment.

Table 1 – Summary of Descriptors extracted from the FEH Website (May 2022)

Catchment Descriptors (CD's)	FEH Value
BFIHOST19	0.763
DPLBAR	0.72
DPSBAR	93.9
FARL	1
FPEXT	0.0082
SAAR	1126
URBEXT2000	0

SCALGO Live has been used to generate a theoretical flow path map, as outlined in Figure 1. The key features identified have been confirmed or otherwise by on-site observations and anecdotal information provided by the Client, as follows:

- The small pond labelled as 'A' was confirmed by the client as being present ephemerally during heavy rainfalls.
- There is no anecdotal information to confirm that the larger pond labelled as 'B' has historically filled with standing water in the past during heavy rainfall events. Whilst an absence of proof is not conclusive, on-site observations did not provide any indication of historical waterlogging, e.g., change in crop density or colour.
- To the southern extent of the site, a long concrete retaining wall supports the A48 Highway. There are no visible drainage flows at the centre of the hollow, other than weep holes. This suggests that the soils and rock infiltrate any rainfalls arriving at the south side. A concrete-derived white calcite deposit emanating from a short horizontal crack in the retaining wall is evidence of an active seep but of an insignificant magnitude.
- No channelling, either permeant or ephemeral, was seen along the theoretical flow routes examined suggesting that flows are subsurface at all times. No botanical indications (i.e., plants that indicate seeps or flows) were seen in the fields or below the retaining wall weepholes.
- Highway drainage was noted at the low point coincident with the theoretical drainage flow route along the paleo-hollow. The outlet of the highway flows is not known but may have been obscured by the current works. New drainage is being installed where the new access road meets the A48 highway.

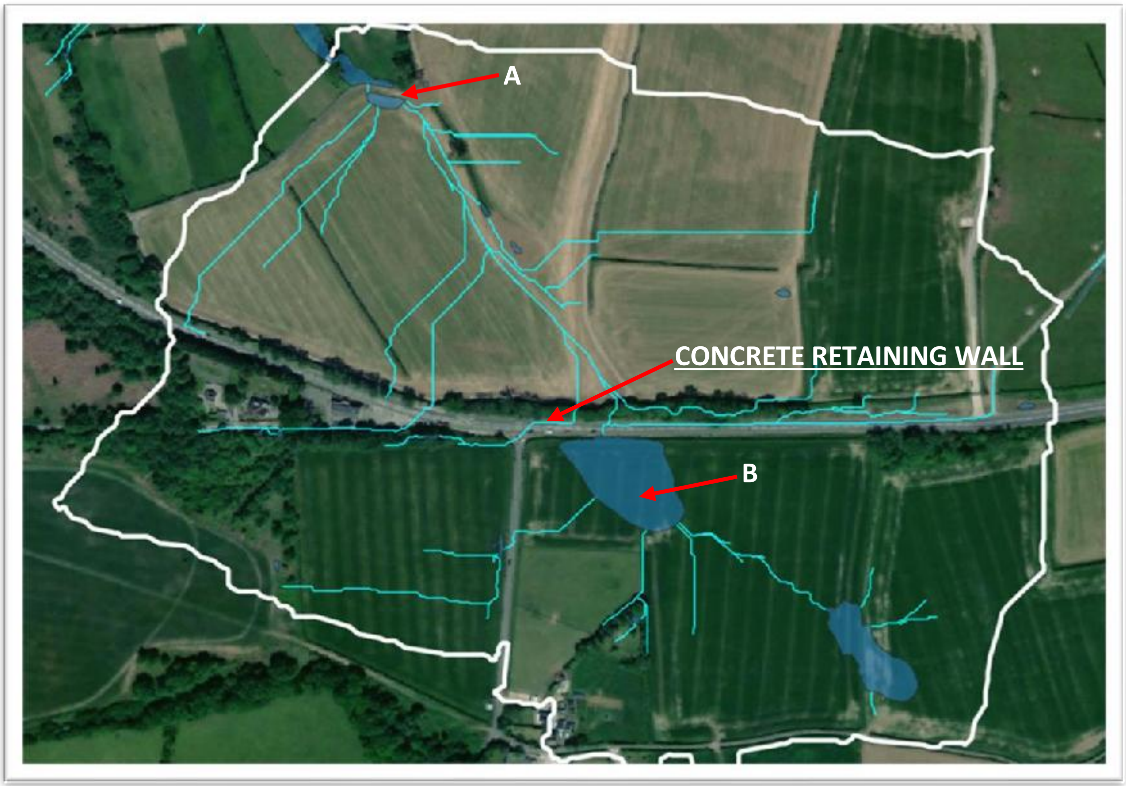
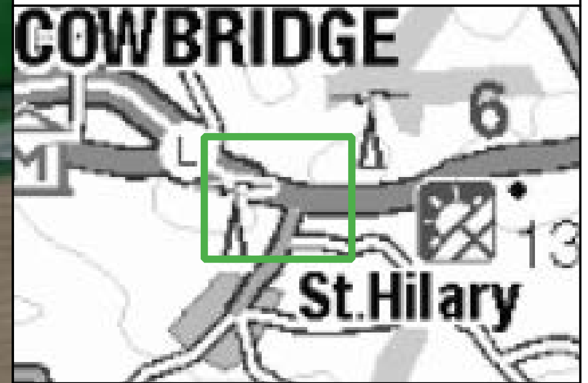


Figure 1 – Annotated SCALGO LIVE mapping showing a theoretical flow path

LEGEND

Pant Wilkin sub-catchment



CLIENT:
Tim Vaughan Racing Ltd

Waterco
www.waterco.co.uk

SCHEME:
Pant Wilkin Stables, Aberthin

PLOT TITLE:
Pant Wilkin Sub-Catchment

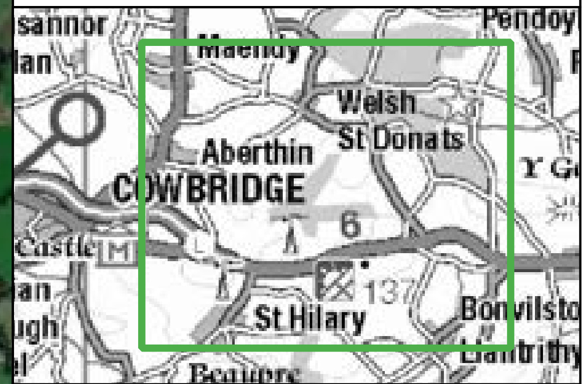
PLOT STATUS: FINAL			DATE: 25-05-2022
DRAWN: RM	CHECKED: AW	APPROVED: NJ	PLOT SCALE AT A3: 1:3000
PLOT NAME: 14547_Catchment_Extent			REVISION: -

Appendix F Nant Aberthin Catchment

Nant Aberthin Catchment Location

LEGEND

Nant Aberthin Catchment



CLIENT:

Tim Vaughan Racing Ltd

waterco

www.waterco.co.uk

SCHEME:

Pant Wilkin Stables, Aberthin

PLOT TITLE:

Nant Aberthin Catchment

PLOT STATUS: FINAL			DATE: 25-05-2022
DRAWN: RM	CHECKED: AW	APPROVED: NJ	PLOT SCALE AT A3: 1:15000
PLOT NAME: 14547_Catchment_Extent			REVISION: -

ABBREVIATIONS

AEP	Annual Exceedance Probability
AM	Annual Maximum
AOD	Above Ordnance Datum
AREA	Catchment area (km^2)
BFI	Base Flow Index
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$URBEXT_{1990}$	FEH index of fractional urban extent
$URBEXT_{2000}$	Revised index of urban extent, measured differently from $URBEXT_{1990}$
WINFAP	Windows Frequency Analysis Package – used for FEH statistical method

Nant Aberthin Description

The Nant Aberthin catchment (4.5 km^2) was examined for flows only within the vicinity of Pant Wilkin stables to the housing along Llanquian Road and from Aberthin where the stream is close to the highway.

The channelled flow route of the Nant Aberthin through the Pant Wilkin stables is complex. On the day of the site visit, the channel was dry with some indication of some dried mats of algae, signifying a recent flow. The link between the Nant Aberthin and the Pant Wilkin proposed lakes catchment is described below within Figure 1. Although there was no evidence of above surface flows on the catchment, it is thought that these flows are sub-surface (beneath the catchment).

A small (0.13 km^2) catchment generates a small tributary joining the Nant Aberthin, which was seen flowing under the Llanquian Road, whereas the Pant Wilkin catchment (0.37 km^2) is dry which suggest that flows are strongly controlled by the underlying limestone flows through rock fractures, as the smaller catchment outlet is approximately 40m below the level of the dry trial pit 2.

Flows increased in the channel further downstream alongside Llanquian Road but then disappeared as flow was taken to feed the large artificial pond. The pond was only partially full and a very deep channel (>2.5m), presumably the original stream route.

Indicative calculations have been undertaken which suggest that the pond has an approximate surface area of 9000m^2 and volume of 3000 m^3 when full, suggesting an average depth of 0.3m. As this depth will be much lower in summer it indicates a significant potential loss by evaporation.

Downstream of the pond flows continued in shallower channels past housing and became more permanent with typical botanical indicator plants of perennial flow.

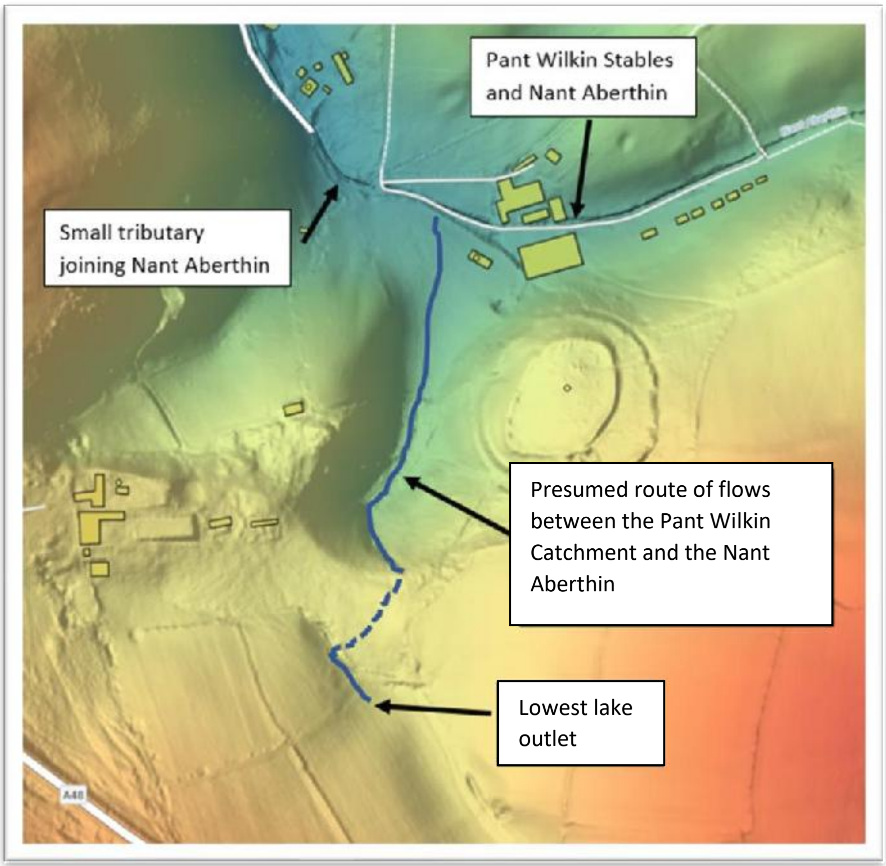

Figure 1 –Potential flow route from the Pant Wilkin catchment

Appendix G Water Balance and Water Quality information

Water Quality and Water Balance for Option 3

Water Quality

The type of usage of the lakes is very dependent on water quality.

For amenity aesthetic use only, i.e., visual appeal, the water quality can be allowed to fall due to lack of fresh inflowing water or throughflow. However, dissolved oxygen levels may fall as algal growth increases to the point of loss of visual appeal in some months in peak summer. If the surrounding artificial clay lined catchment is returned to grassland, the amount of fertiliser, if any, may have to be limited to avoid complete and permanent eutrophication of the lakes. Eutrophication not only loses visual appeal from the agal scum growth but may in the worst case allow the growth of toxic cyanobacteria (old name: Blue-green algae).

For amenity fishing use, the criteria becomes more onerous. Some warm water adapted fish can withstand lower oxygen levels and somewhat lower water quality levels (with regards to ammonium, nitrates and phosphates). Cold water fish, e.g., typical UK river fish require higher water quality and are likely to fail to thrive in lakes without a continual or regular intermittent water throughflow. The specific species of fish and requirements would need to be assessed and determined with an ecologist.

The lakes as designed (with the added clay catchment) will be partly cascade and partly one-time flow, i.e., the upper lake may receive only water from the surrounding clay catchment and rainfall (both one-time flows) whereas the lowest lake will receive water that has passed through the upper two lake (cascade flow) and some flow from the surrounding clay catchment plus rainfall. Cascade flows decrease water quality after each pass through the cascaded lakes.

Water throughflow and augmentation of flows

Even with a clay catchment surrounding the lake the small ratio (catchment area to lake area) available, approximately 3.1:1 will mean throughflow will dry up to near zero frequently in the summer months, particularly in July/August, although the lakes will remain at a lower level.

A detailed throughflow analysis for lake ecology and fish species/stocking levels is beyond the scope of this study but an approximate estimate will be helpful in understanding the choices available for alternative supplementary water sources. By assuming that there is an evaporation loss of 3.5mm per day in summer from the lakes with minimal vegetation and a designed depth of over 1m; a suitable throughflow would be approximately 0.7 l/s to hold the lakes in balance but perhaps twice that at 1.5 l/s to sustain a true throughflow through the cascade of lakes. This approximate calculation is for amenity use only to sustain the lakes but may also be suitable for some warm water adapted fish.

A throughflow of 0.7 l/s sustained for two months during a severe drought to hold the lakes in balance only, requires approximately 3600m^3 of water.

Time to Fill and residence times

The time to fill using average rainfalls and evapotranspiration is estimated to be 3 years, using the lake areas alone. By adding clay to the catchment, the time to fill is estimated to be approximately 1 year. The residence time for water in the lakes is important for lake health and pollution levels.

With a throughflow of only 0.8l/s the residence time is greater than 1 year, which is a poor residence time. Such long residence times can lead to excessive polluted waters with fish.

The hydrological implications of the type of constructed catchment and flows

Under option 3 the requirement to remove the soil and replace with clay covered by soil can be interpreted in several ways. Hydrologically, the clay layer must have a combination of thickness and quality that significantly reduces permeability, i.e., it may be a thick layer of poorer quality clay or a thin layer of high-quality clay. Any breaks or shrinkage cracks, particularly in the lakes or the catchment approaches to the lakes will significantly reduce flows well below any estimated flows. Trees around lakes or landscaping using trees needs to be considered as roots may penetrate the clay layer or they may be uprooted in a gale disrupting the clay layer.

Clay thicknesses can vary over the site, from thinner at the boundaries to thicker below the lowest lake but stability in wet weather also needs to be considered, as initially flows are likely to concentrate at the clay-soil boundary; possibly initiating small landslips.

Note that 70 000 m^2 of clay underlining maybe between 15 000 tonnes and 30 000 tonnes depending on the clay type and thickness, such amounts may not be available at one time, in which case a staged construction linked to hydrology may be appropriate.

The thickness of soil added back to the clay surface can be kept to a minimum allowable for grass growth but this has the disadvantage of making the extended catchment very flashy or responsive to rainfall. Thicker layers of soil allow for more soil water storage reducing flashiness and extending the baseflow which contributes to throughflow refreshing lake water quality.

Where the clay layer ends at an uphill boundary hydrologically the layer should be tapered in thickness to allow for any possible external soil flows that may be passing into the constructed catchment area, otherwise flows may be deflected or well upwards creating wet soils and losing water that is valued for the lakes.

During very dry periods, even with stored water additions, the clay along the lake margins may be exposed, allowing deep cracks to penetrate into permeable areas below. Depending on the volume of throughflow available provision may have to made in the design to mitigate such drought inflicted damage.

The two planned wetlands, with or without potential storage below may have to be designed with very low throughflows in mind and in consequence their own deeper soil water storage.

Estimation using a Low-Flow report

A low-Flow report was commissioned from Hydro Solutions in May 2022 by Waterco for the larger Nant Aberthin catchment (4.5 km^2) that includes the small Pant Wilkin sub-catchment (0.37 km^2). The suggested flows scaled from the larger catchment to the smaller from the report were not seen in the trial pit dug at the lowest point. At the time of the trail pit observation, the previous month had been dry but not unusually dry, suggesting that flows were not only subsurface but sub-rockhead in the deeper fractured limestone.

This observation suggests that the scaled values of the Low-flow report are over-optimistic due to the difficulty in scaling in catchments with limestone and scaling in very small catchments. Low flows in particular can sink into fractures and stream beds then run dry for some distance before reappearing, as seen on the Nant Aberthin. Observations on the Low flow commissioned catchment as a whole, the Nant Aberthin, were not inconsistent with the given values, as flows of tens of litres per second were seen downstream of the Nant Aberthin pond, although the presence of alluvium in the pond area strongly influences the probability of flows being surface in-channel or hyporheic within the channel bed.

Using an estimate of the artificial catchment area (0.07 km^2) where the subsurface could be reprofiled, the soil would be removed and a layer of clay added followed by the soil being relayed on the clay surface gave values ranging from as low as 2.7 l/s in July to as high as 10.75 l/s in January, scaled from the larger flows. The estimated change in the original soil to the altered soil profile's ability to pass flows to subsurface has been estimated by reducing the soil's BFIHOST from 0.796 to 0.300. This change increases the captured flow by approximately a factor of 4, estimated from ReFH2 software and catchment descriptors from the FEH webservice. Although the values appear to be in the range required for the potential lakes, they have significant uncertainty from the method of derivation.

The same method scaled from the larger catchment, using the report's exceedance flow values suggests that flows in the altered Pant Wilkin catchment will not fall below 1.41 l/s for 90% of the time (i.e., 1 chance in 10/10% that they will) and not fall below 0.78 l/s for 99% of the time (i.e., 1 chance in 100/1% that they will). These two flows are similar to the estimated throughflow to sustain the lakes levels from evaporative loss and the throughflow needed as a minimum to refresh the lakes water and remove fish derived pollutants.

Lowflows scaling suggests that the lakes will lose a throughflow to refresh the water for fish 10% of the time and will be unable to sustain the lakes even in level 1% of the time. From evidence in trial pits and from the Nant Aberthin it is likely that these flows are significantly overestimated, i.e., failures (water stresses) will happen more frequently than suggested.

Table 1 –Pant Wilkin catchment monthly mean flows scaled from Nant Aberthin catchment and adjusted with ReFH2 to the constructed clay area

Annual	BFIHOST adjusted-ratio of total flows Q1-REFH2 Pant wilkin-clay area flows, 0.076km^2, (l/s)
January	6.44
February	10.75
March	9.9
April	8.63
May	6.86
June	4.6
July	3.47
August	2.69
September	2.76
October	3.11
November	5.8
December	8.77

The information in Table 2 has been estimated and scaled from the LowFlow Report May 2022.

Table 2 –Percentile exceedance flows scaled from Nant Aberthin catchment and adjusted with ReFH2

Percentile	BFIHOST adjusted ratio of total flows Pant Wilkin clay area (l/s)
5	18.95
10	14
20	9.41
30	7
40	5.52
50	4.31
60	3.39
70	2.55
80	1.98
90	1.41
95	1.13
98	0.92
99	0.78

The information in Table 3 has been estimated and scaled from the LowFlow Report May 2022.

Comparison of a dry year and wet year using local data and the effect on the planned constructed catchment and lakes.

Lowflows uses data from many similar catchments of flows sustained in drier periods but as discussed may be in error. An indirect method is to use rainfall data and evaporation estimates to estimate mean flows. For comparison two years were chosen from recent decades that were particularly rainy or particularly dry. Monthly rainfalls were examined from Bute, Cardiff and evapotranspiration data from CHESS (Climate Hydrology and Ecology research Support System) of CEH (Centre for Hydrology and Ecology) were centred on a 1km square over the Pant Wilkin catchment. A very simple rainfall minus evapotranspiration method was used to estimate mean throughflows to the outlet of the lowest lake.

As the time-step was monthly it was assumed that the constructed catchment of 70000 m^2, including the lakes, was in equilibrium with no major recharge from, or loss to, groundwater, as if the system were isolated. This may be close to reality over longer time periods as the flows outside the clay catchment will be expected to infiltrate into the rock below and pass under the clay, although in heavy rain over short time periods some flow may enter the upper boundary.

Evaporation from the lakes was assumed to be the same as well-water grassland. This is a fair assumption for a very simple model, as the lakes evaporation depends strongly on depth, temperature and wind speeds. The effect of increased evapotranspiration from wetland, constructed and natural growth, was assumed to be negligible.

The two years chosen for their climatic effect on Pant Wilkin constructed catchment were 2000, a particularly wet year country wide with widespread flooding and an annual rainfall of 1504mm(33% above the long term average of 1126mm) and 2003, a year with prolonged dry periods, annual rainfall, 851mm(25% below average).

In Figure 1, the rainfall in 2000 can be seen to be much heavier in Spring and Autumn/Winter. By comparison the drier year, 2003, began with low Winter rainfalls and stayed low for months only picking up by next Winter. The rainfall variability was also much larger in the wetter year than the drier year.

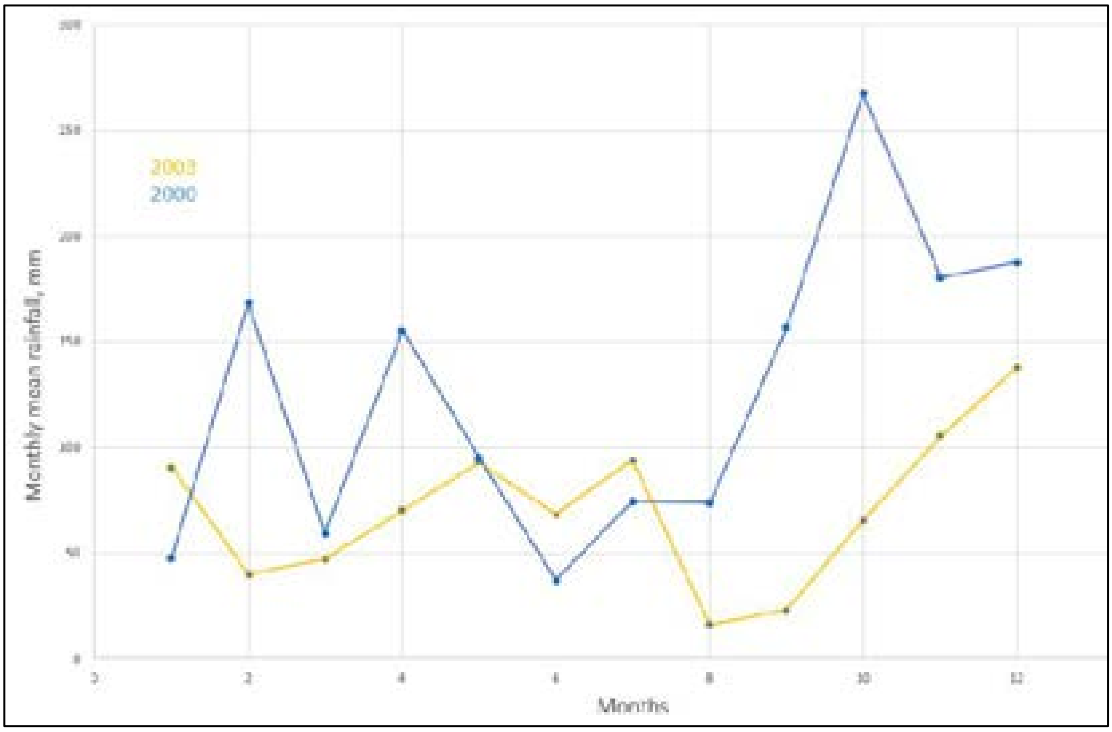

Figure 1 – Rainfalls in wet year 2000, compared to dry year 2003

Although the rainfalls are very variable, the loss from evapotranspiration is controlled by vegetation and tends to be less variable. This is reflected in the flows plotted in Figure 7 resulting from the balance of rainfall minus evapotranspiration on the constructed catchment. It can be seen that even in a wet year (2000) there are periods when throughflow drops to zero (zero or negative values). However, the dry year (2003) loses adequate or any throughflow in early spring and only regains it by next winter, a period of nearly 9 months, Figure 2.

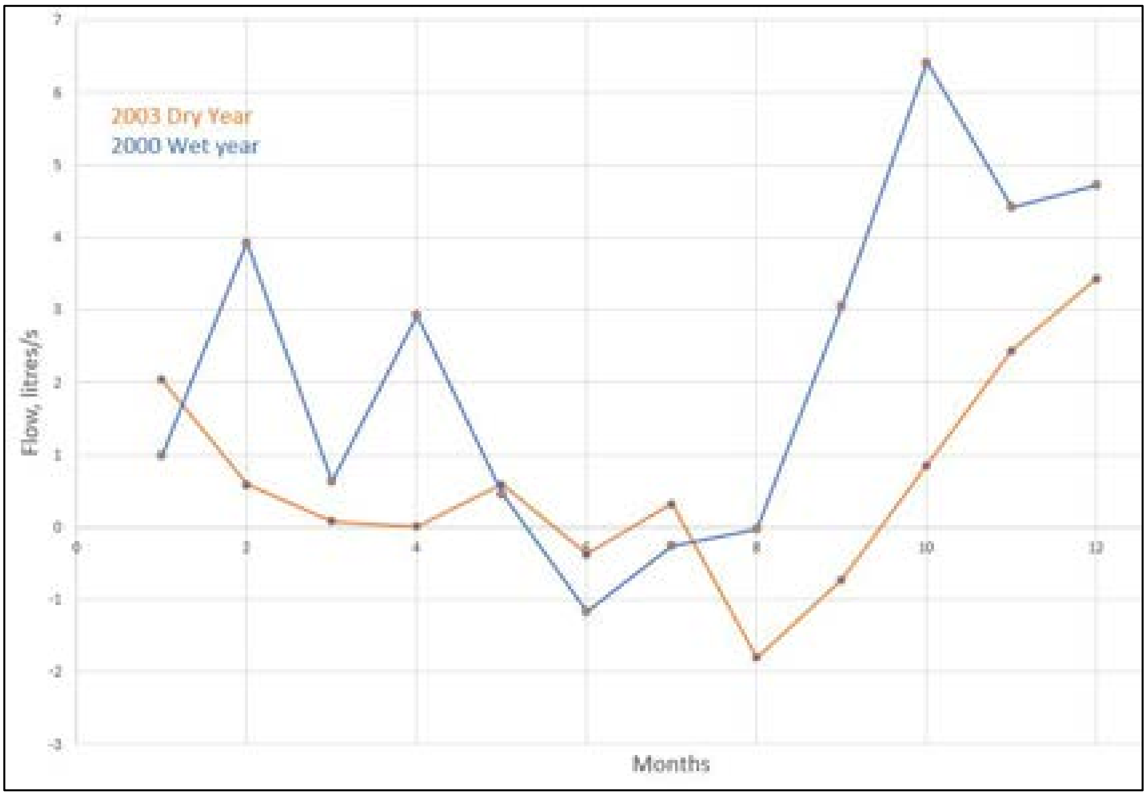

Figure 2 – Mean monthly throughflows for the years 2000 (wet) and 2003 (dry)

The Lowflow report, scaled to the Pant Wilkin catchment suggests that throughflows would be adequate in most years and in most months throughout the year. This is contradicted by the simple analysis using rainfall, evapotranspiration and ReFH2 rainfall runoff software, used for the two comparison years, which suggest inadequate throughflow in most years in summer and a severe loss in a high-water stress year (2003).

Table 3 – Throughflow comparison dry year (2003) with wet year (2000)

Month	Flow 2003 (l/s)	Flow 2000 (l/s)
January	2.04	0.99
February	0.59	3.93
March	0.08	0.63
April	0.01	2.93
May	0.59	0.46
June	-0.37	-1.16
July	0.32	-0.26
August	-1.8	-0.03
September	-0.73	3.05
October	0.85	6.42
November	2.44	4.42
December	3.43	4.72

KEY

(red)	Low or no throughflow
(amber)	Barely adequate throughflow
(green)	Good throughflow