4. Design

4. Design

Detailed Design:

“the complete and precise physical description of all parts of the structure to be constructed”

Note: where one phase ends and the next phase begins can vary from project to project

4. Design

Detailed Design - Introduction

- **Detailed Design Purpose** – Enabled EA to use contractors on 'Construction Only' Framework and agree key scheme details with landowners before they were built (no further input from designers)
- **Modular Design** – Development of suite of 'Standard Details' to enable re-use of template details / design drawings on future sites (e.g. DMRB, SfA etc)
- **Pre-Construction Information** – Designers Hazard Elimination and Management Record (DHEMR) and Hazard Map issued along with Client PCI information
- **Maintenance and Monitoring Plan** – Landscape Management Plan (Operation and Maintenance Manual) and Monitoring Strategy

4. Design

Failure Modes – Leaking Dams

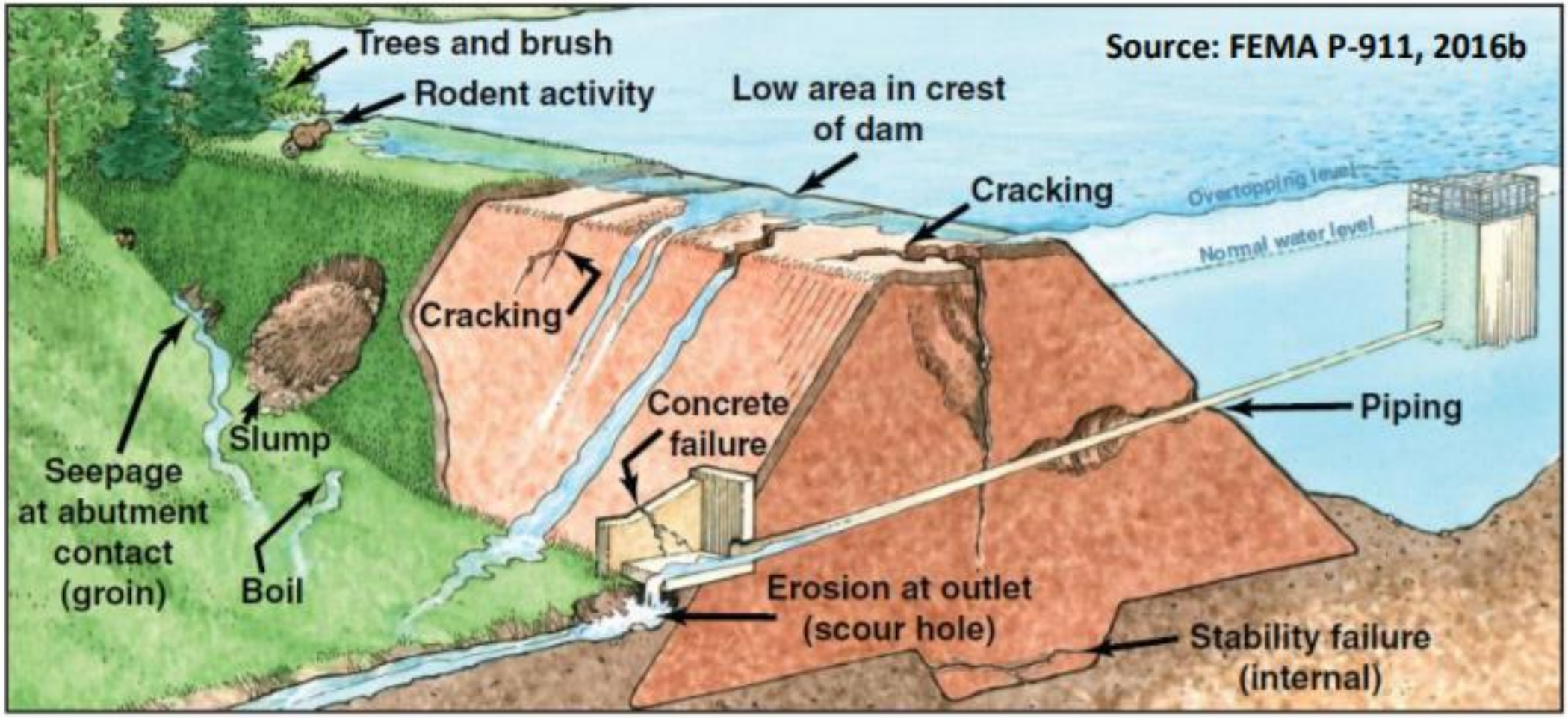
Jeremy Repairs Dam #ClarksonsFarm - YouTube

Leaking Dam #ClarksonsFarm - YouTube

Failure Modes – Earth Bunds

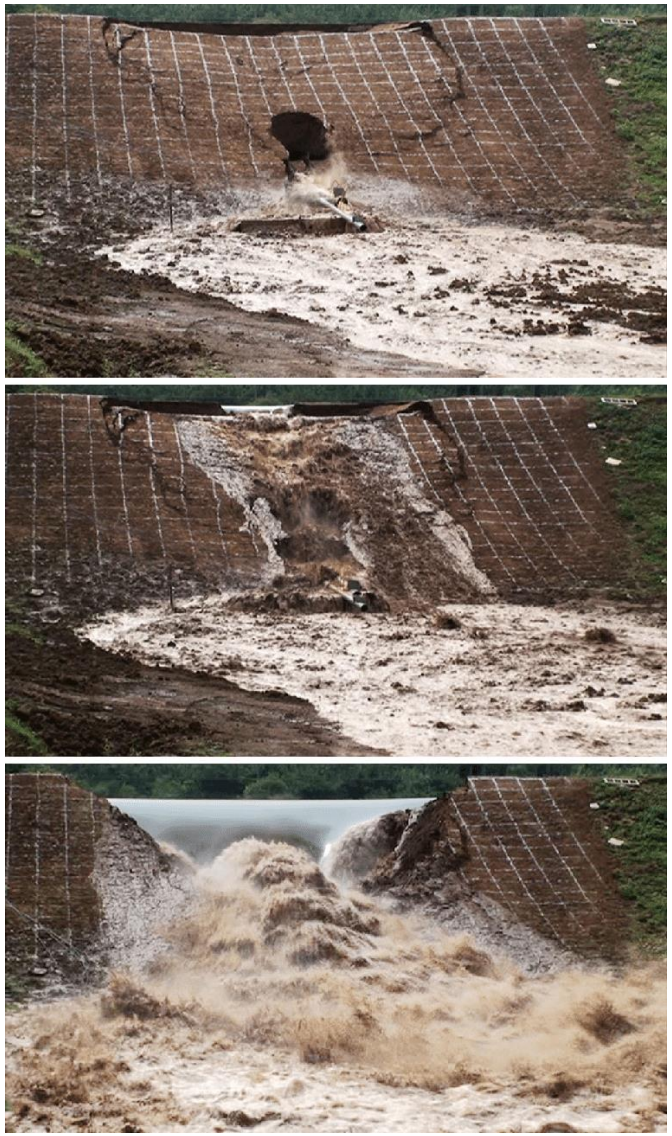
https://youtu.be/09ANN1u0e9Q

Failure Modes – Embankments



High risk: Pipes in gravel bedding through earth bunds

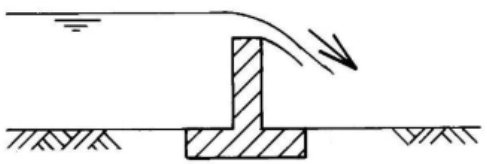
Failure Modes – Embankments



4. Design

Failure Modes – Flood Walls

Box 9.1 Common failure modes for flood defences

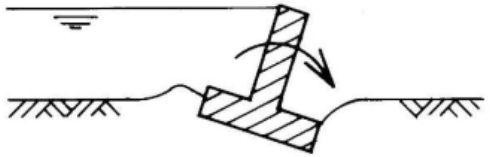


Overtopping leading to failure

Overtopping of a defence does not necessarily result in failure – the defence may have been designed to be resilient if overtopped. However, if the defence collapses during overtopping, the consequences may be more severe than if there were no defence. Overtopping of an embankment can wash away the crest, leading to a breach.

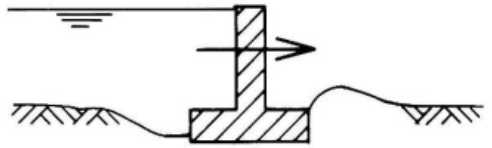
Structural failure

In this case there is a structural failure of part of the defence, leading to loss of ability to retain water. A sudden collapse can be very dangerous, as it can lead to rapid inundation in the defended area without warning. A breach is the equivalent mode for an embankment. Collapse can also result from erosion of the riverbank if the defence is close to the river.



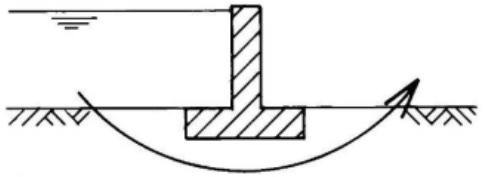
Rotation

Here the defence has rotated under the action of the hydrostatic load, which may include uplift under the base of the wall. A partially rotated wall may remain stable for some time, but the defence level is likely to have been compromised and there remains a risk of collapse under future loading.



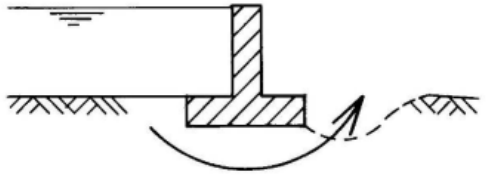
Sliding

This may appear to be a 'safe' form of failure when viewed in cross section. In reality, the sliding may open up cracks between adjacent parts of the defence and the foundations may be compromised.



Seepage

If the quantity is modest, seepage under the defence can usually be dealt with by pumping. Excessive seepage can lead to local flooding and may damage the foundations (see piping below). Seepage can occur through an embankment as well as under it, often as a result of damage by burrowing animals. Local collapse of the embankment may result.



Piping

In extreme cases, seepage flow under a defence can cause the soil on the defended side to become buoyant, creating a void. This can lead to sliding or rotational failure of the wall, or a breach in an embankment. Flow through an embankment can also result in piping failure. The addition of a cutoff to lengthen the seepage path is often the most effective way to avoid piping failure.

[Fluvial design guide - GOV.UK (www.gov.uk)]

Safety Moment

- **Your examples of NFM failure?**

4. Design

Detailed Design – Scheme Summary

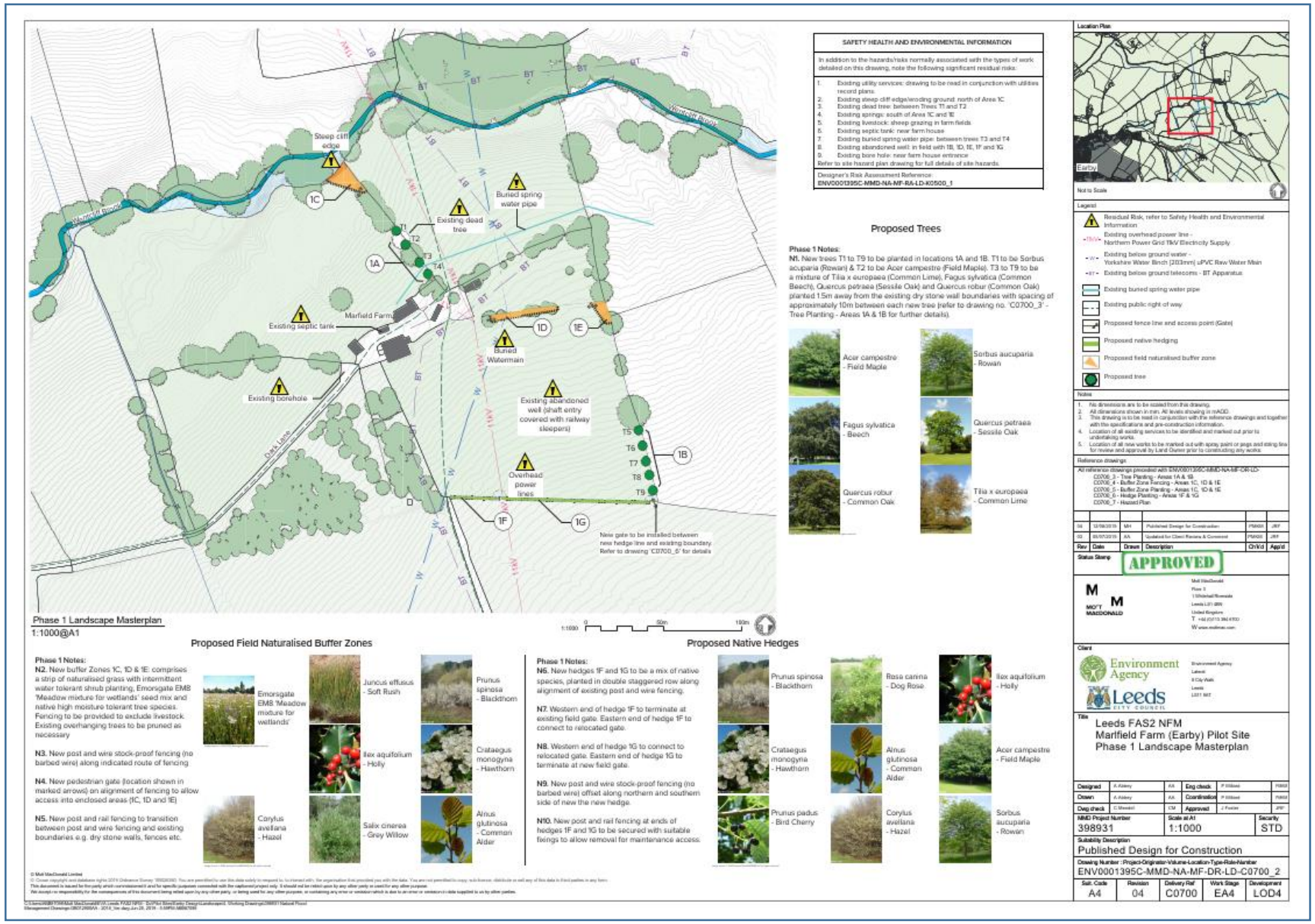
- **Construction seasons** - works split into 2 stages (planting and earthworks)
- **Phase 1:**
  - Hedgerow planting (120 metres)
  - Buffer Zones (3no. total area 368m^2)
  - 9 no. Individual Trees
- **Phase 2:**
  - 11 no. Leaky Barriers (<10m^3 each)
  - 2 no. Seasonal Habitat Ponds (<100m^3 total)
- **Design Drawings:**
  - 26 Drawings issued for Construction

NFM NATURAL FLOOD MANAGEMENT

Shared NFM Community Drawing
Please email comments and suggestions to:
SMO-EVALeedsFAS2NFM@365site.mottmac.com

4. Design

Phase 1 – Masterplan



4. Design

Phase 1 – Individual Trees

1 Image 1: Existing site with indicative locations of new tree positions labelled
Not To Scale

2 Image 2: Existing site with indicative locations of new tree positions labelled
Not To Scale

3 Image 3: Tree guard example
Not To Scale (for reference only)

Table 1 - Tree Specification Sheet

Botanical Name	Common Name	Plant Size (cm)	Root	T1	T2	T3	T4	T5	T6	T7	T8	T9	Total
Quercus robur	Oak (common)	12-14	RB				X				X		2
Quercus petraea	Sessile Oak	12-14	RB						X				1
Tilia x europaea	Lime (common)	12-14	RB			X						X	2
Sorbus aucuparia	Rowan	12-14	RB	X									1
Acer campestre	Field Maple	12-14	RB		X								1
Fagus sylvatica	Beech (Common)	12-14	RB					X		X			2
												Total	9

Note: RB = 'Rootball'. Estimated weight of trees is ~100kg.

Table 2 - Tree guards

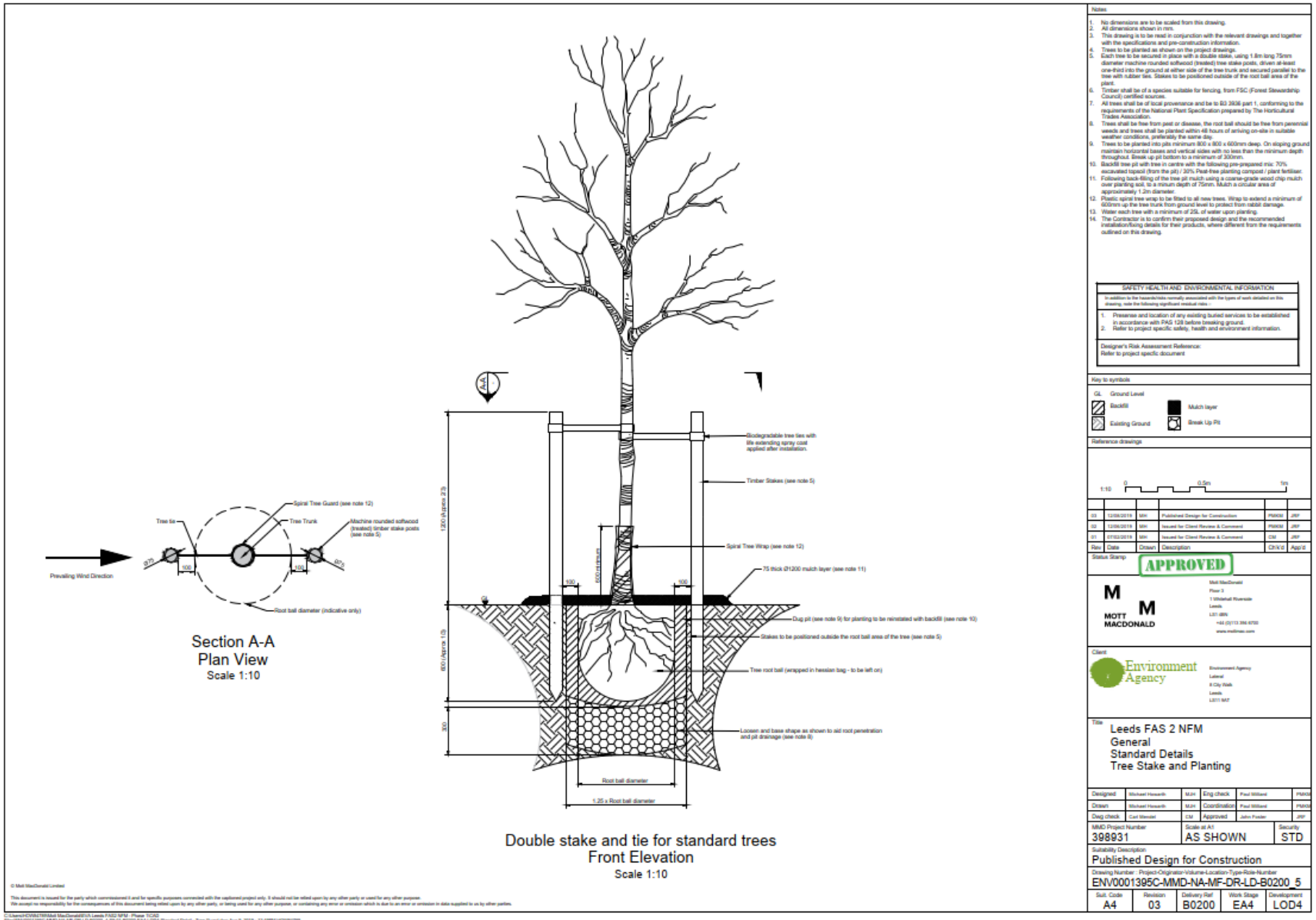
Product	Quantities	Note: For tree guard specification refer to reference drawing 'B0200_4'
Type 1 tree guard	9no.	

Design Considerations

1. Native species (Field Maple, Rowan, Beech, Oak and Lime)
2. Timber tree guards to protect trees from grazing livestock

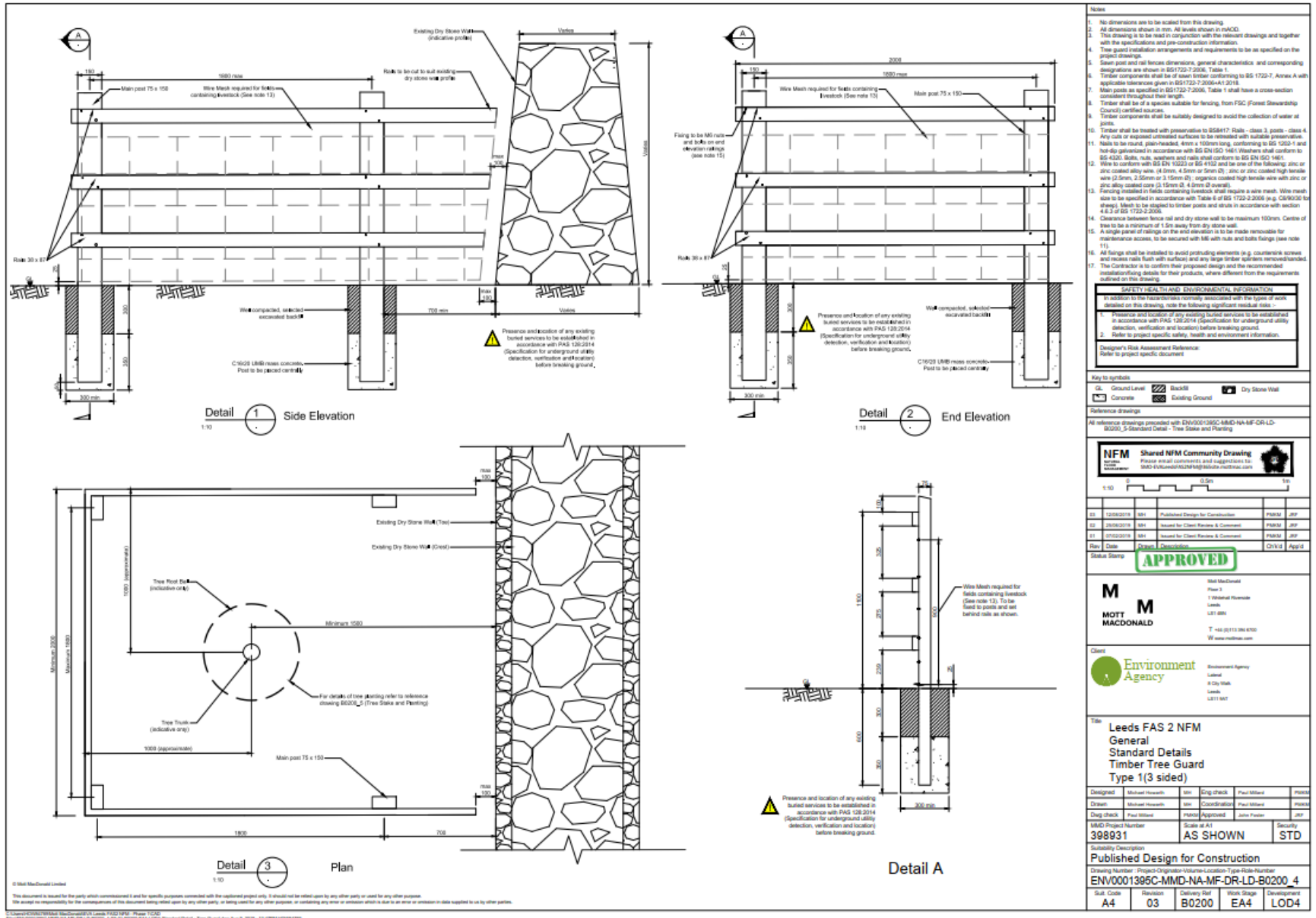
4. Design

Phase 1 – Individual Trees



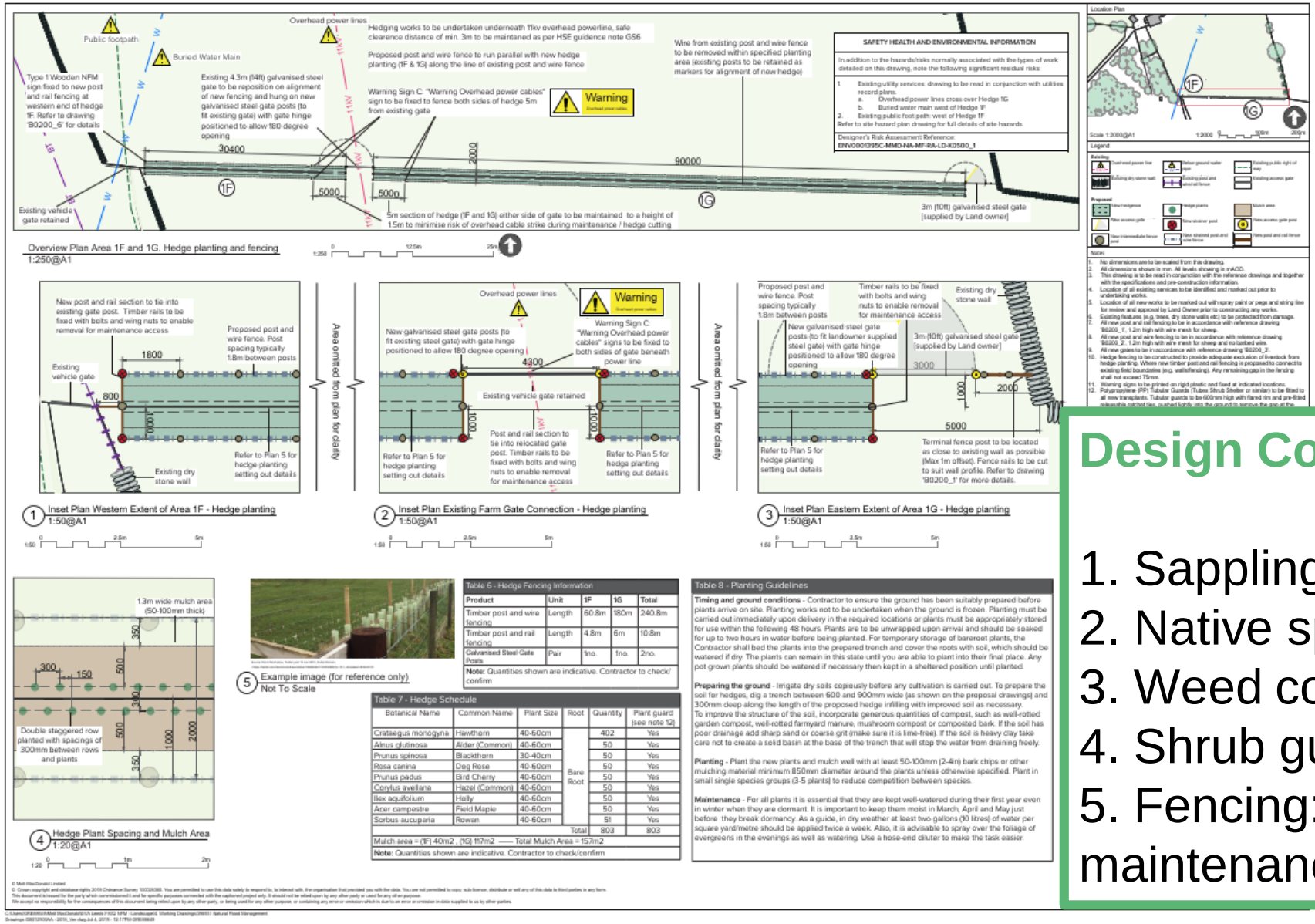
4. Design

Phase 1 – Individual Trees



4. Design

Phase 1 – Hedgerow

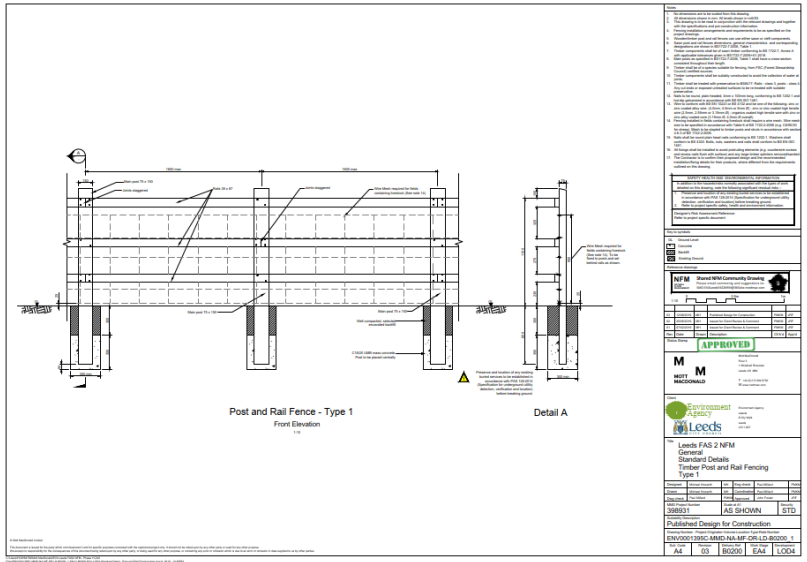


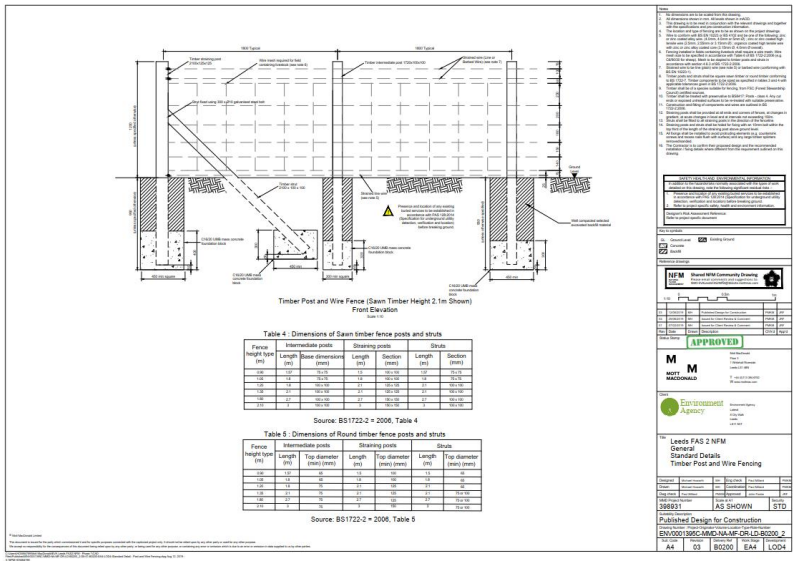
Design Considerations

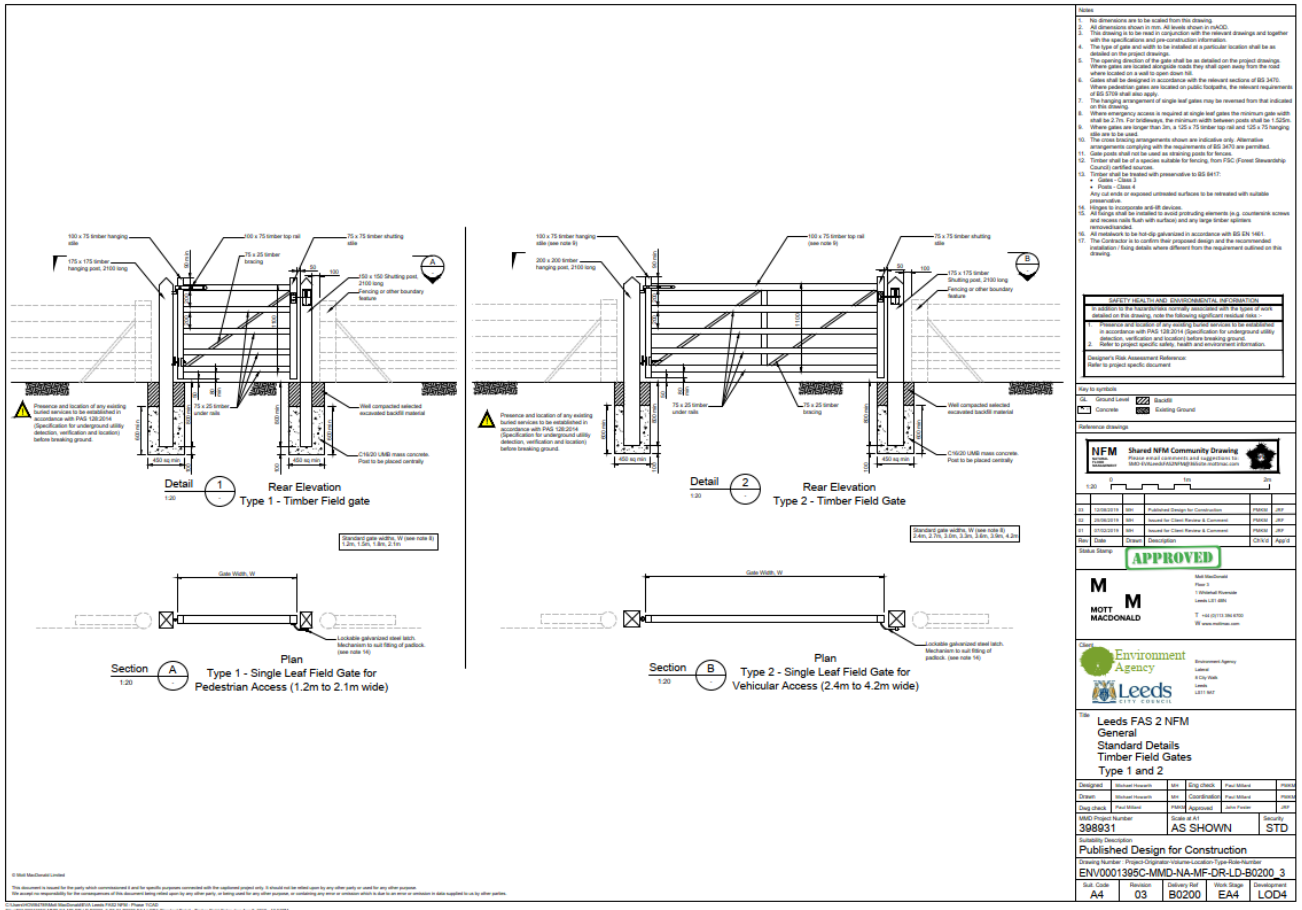
1. Sappling spacing
2. Native species
3. Weed control/mulch
4. Shrub guards
5. Fencing: spacing and maintenance access

4. Design

Phase 1 – Fencing & Gates

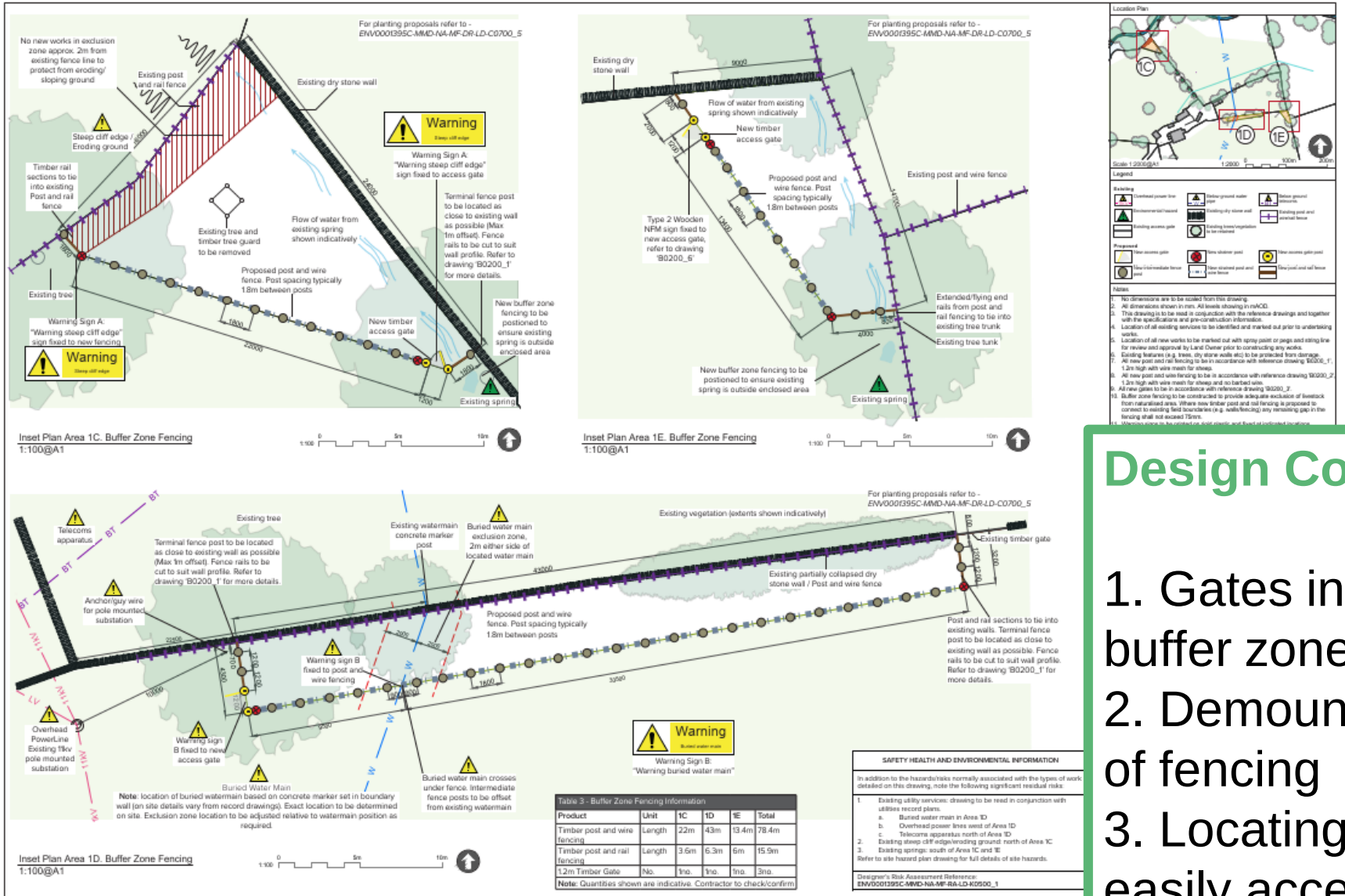






4. Design

Phase 1 – Buffer Zones (Fencing)

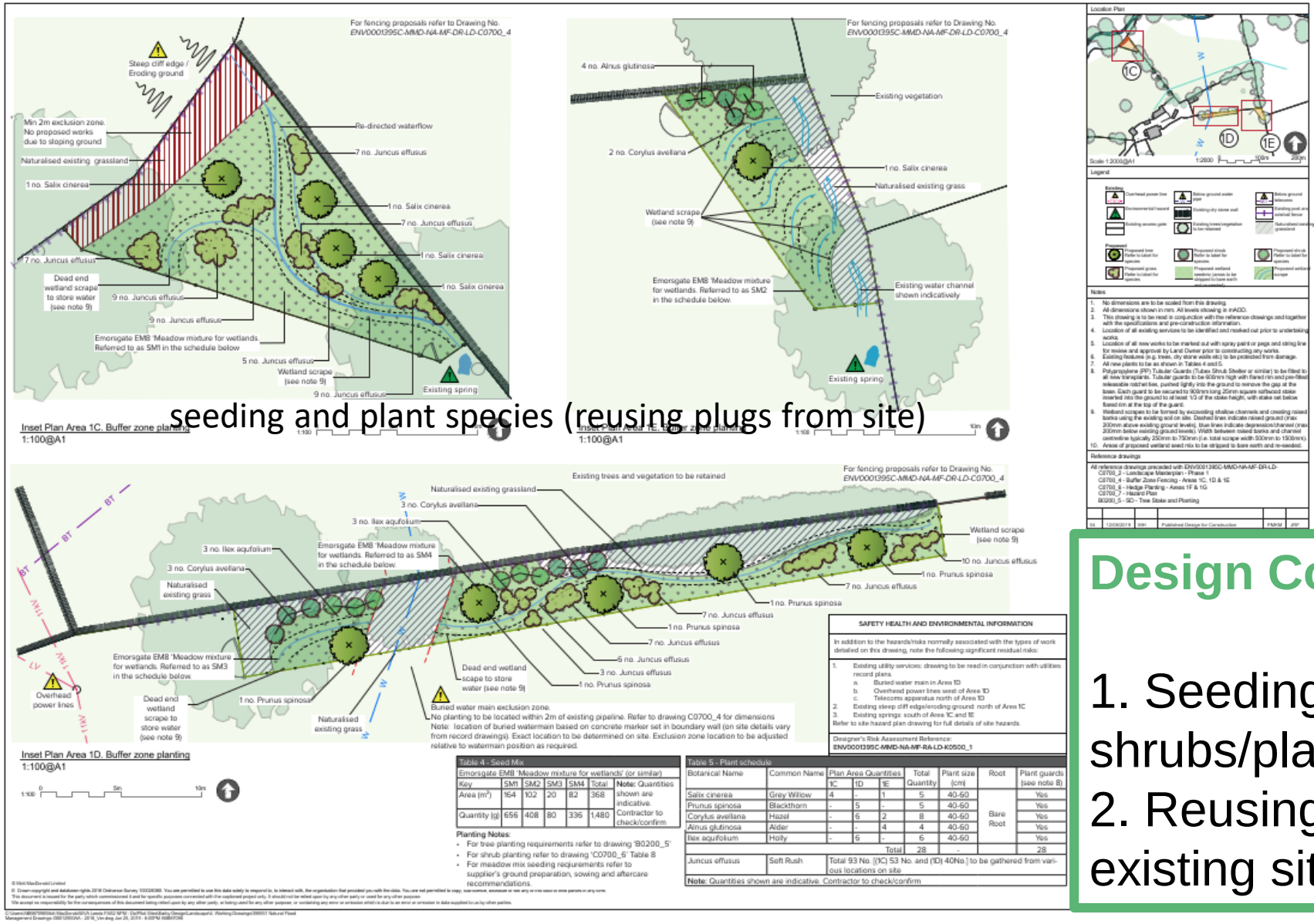


Design Considerations

1. Gates into fenced buffer zones
2. Demountable sections of fencing
3. Locating works in easily accessible areas

4. Design

Phase 1 – Buffer Zones (Planting)



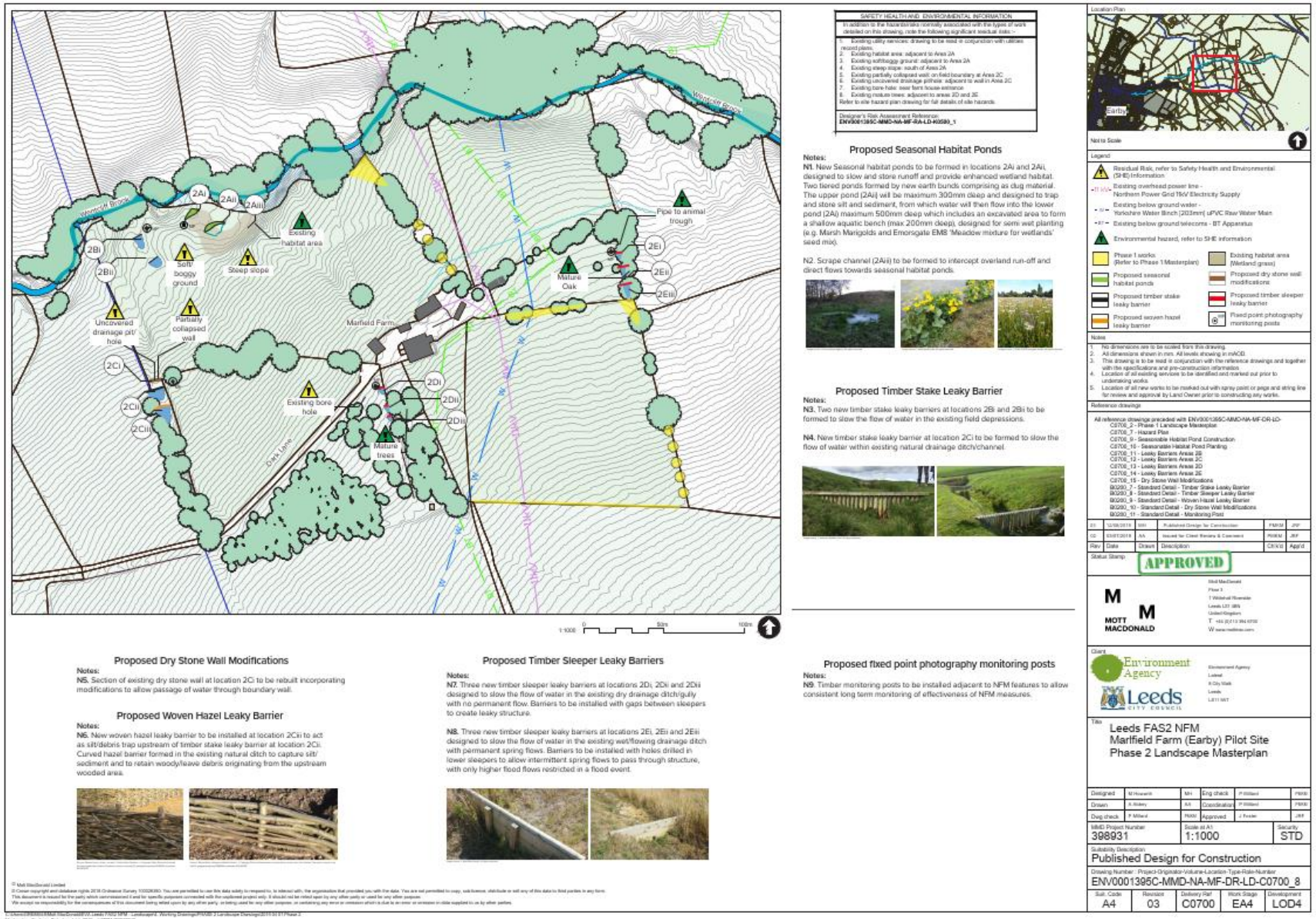
seeding and plant species (reusing plugs from site)

Design Considerations

1. Seeding and native shrubs/plant species
2. Reusing plugs from existing site

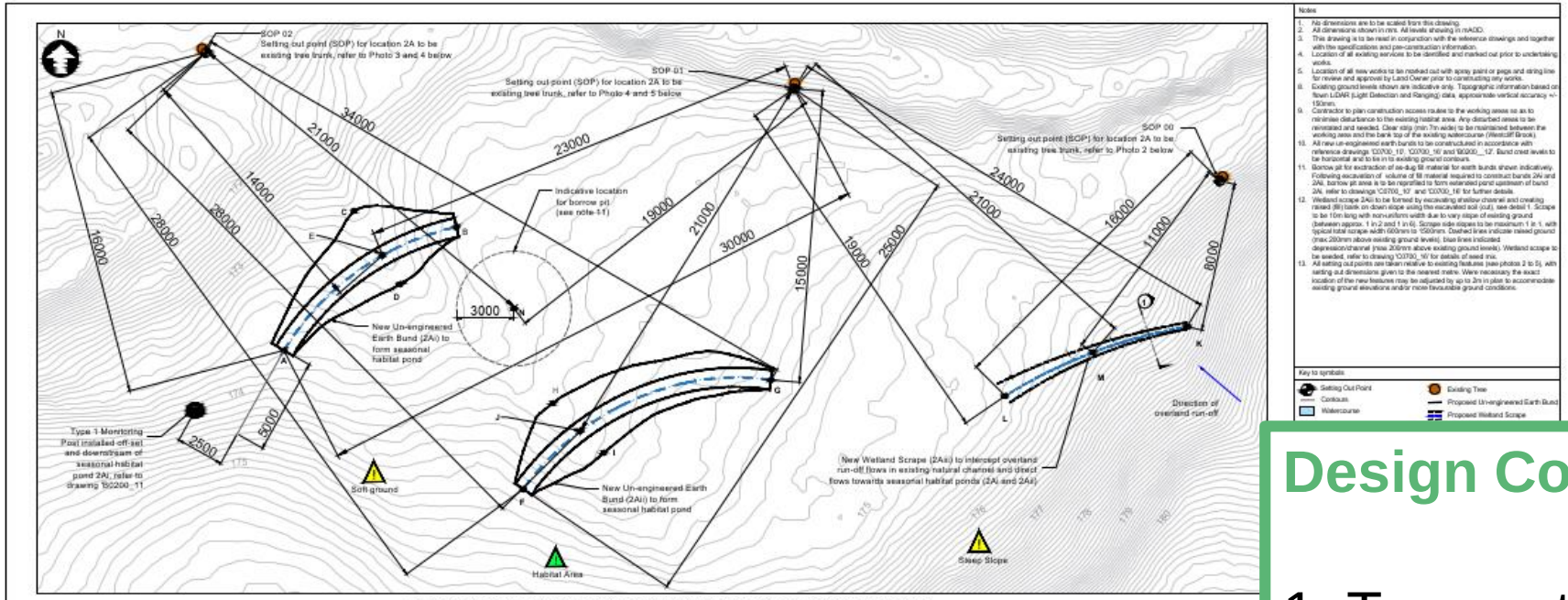
4. Design

Phase 2 – Masterplan



4. Design

Phase 2 – Seasonal Habitat Pond



Seasonal Habitat Ponds (2Ai and 2Aii) and Wetland Scrape (2Aiii) - 2A: Setting Out Plan

Photo 1: Indicative layout of seasonal habitat ponds and scrape

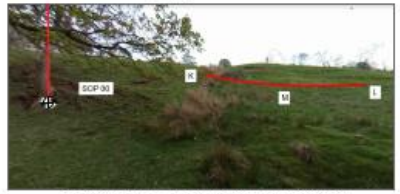
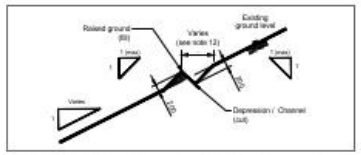


Photo 2: Scrape Setting Out Point (SOP 00)



Detail 1: Wetland Scrape 2Aiii - Typical Cross Section

Photo 3: Area 2A (SOP 02)

Photo 4: Seasonal Habitat Ponds Setting Out Points

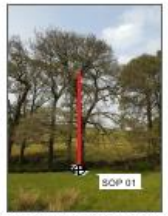


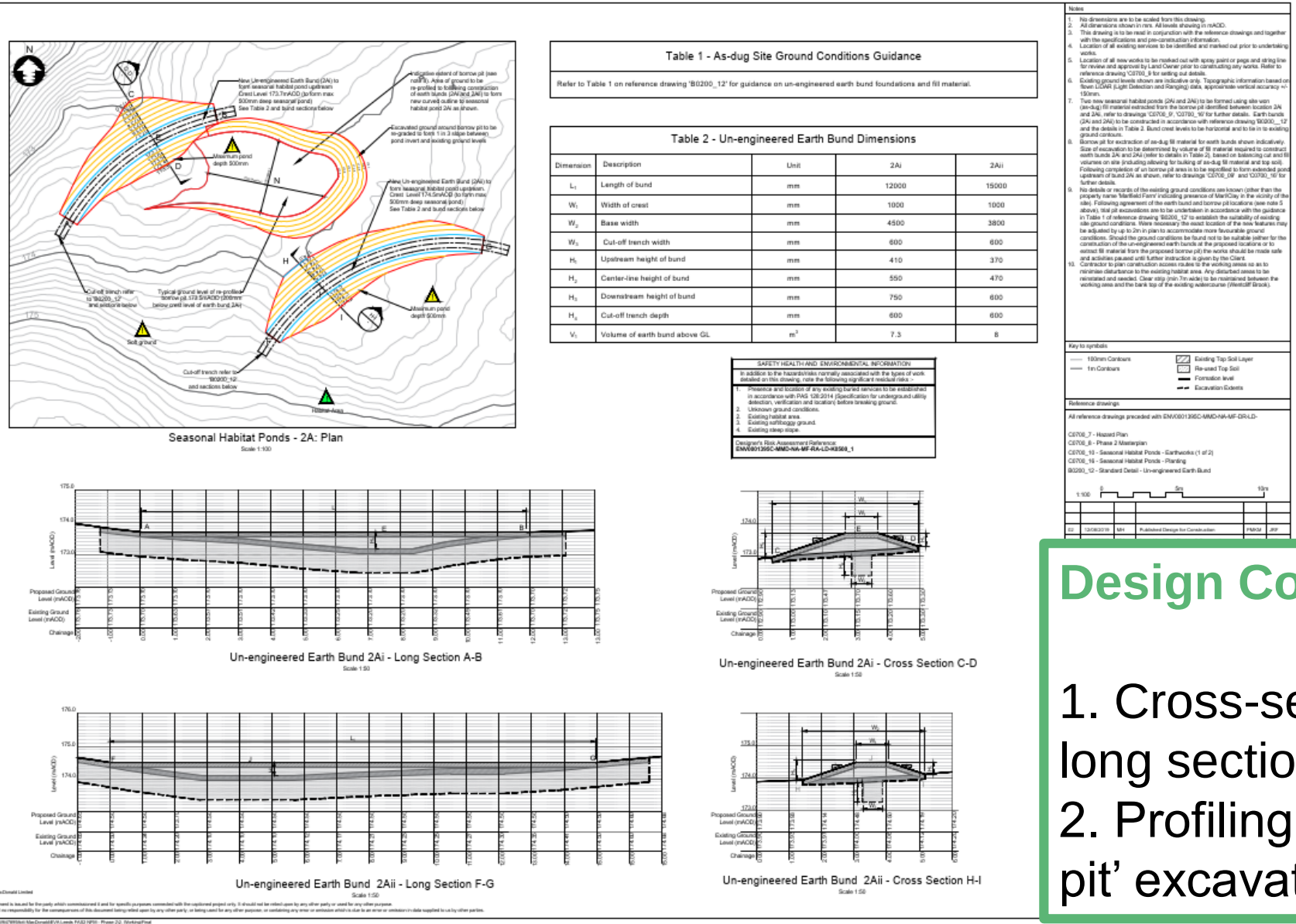
Photo 5: Area 2A (SOP 01)

Design Considerations

1. Two earth bunds (upstream for silt trap)and interception scrape
2. Setting out relative to trees (no fixed features in field)

4. Design

Phase 2 – Seasonal Habitat Pond

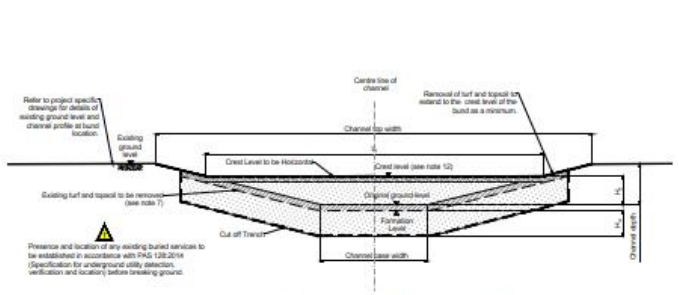


Design Considerations

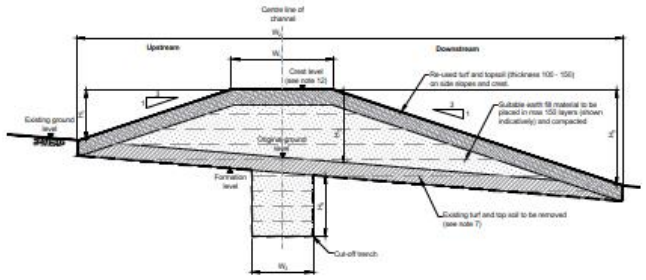
1. Cross-sections and long sections of 2 bunds
2. Profiling for ‘borrow pit’ excavations

4. Design

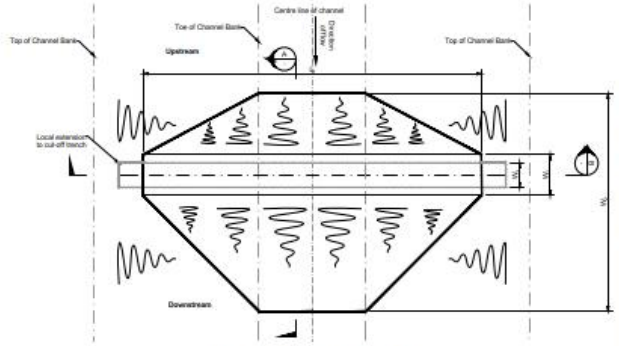
Phase 2 – Seasonal Habitat Pond



Un-engineered Earth Bund - Section B
Scale 1:50



Un-engineered Earth Bund - Section A
Scale 1:20



Un-engineered Earth Bund - Plan
Scale 1:50

Table 1 - As-dug Site Ground Conditions Guidance

Instruction: Contractor to confirm as-dug ground conditions at proposed earth bund location are suitable by trial pit excavation. Trial pit excavation 600 x 600 in plan to be dug at the same depth, and on the line of, the cut-off trench. The acceptability of the site ground conditions for the earth bund and cut-off trench are to be determinedin accordance with the guidance below.

Existing Rock or Soil Type	Condition	Site ground condition observation	Foundation guidance	Fill material guidance
ROCK	Hard	Requires at least a pneumatic or other mechanically operated pick for excavation	Ground conditions acceptable	N/A (Suitable imported material required, see note 9)
GRAVEL, SAND	Compact	Requires pick for excavation. Wooden peg 50 mm square hard to drive more than 150 mm	Ground conditions acceptable	N/A (Suitable imported material required, see note 9)
CLAY, Sandy **CLAY**	Stiff	Cannot be moulded in the fingers. Requires pick or pneumatically operated spade for excavation	Ground conditions acceptable	Acceptable fill material (Follow standard detail)
CLAY, Sandy **CLAY**	Firm	Can be moulded with substantial pressure with the fingers and excavated with a spade	Ground conditions acceptable	Acceptable fill material (Follow standard detail)
SAND, Silty **SAND,** Clayey **SAND**	Loose	Dry lumps may have slight cohesion but easily breaks up in fingers. Readily excavated with spade. 50 mm peg can be easily driven.	May not be suitable (Seek specialist advice)	May not be suitable (Seek specialist advice)
SILT, CLAY, Sandy **CLAY,** Silty **CLAY**	Soft	Easily moulded in the fingers and readily excavated	Ground conditions acceptable	Acceptable fill material (Follow standard detail)
SILT, CLAY, Sandy **CLAY,** Silty **CLAY**	Very Soft	Exudes between fingers when squeezed in fist	Unsuitable	Unsuitable

Example image 1: Naturalised earth bund
(for reference only)

Example image 2: Maintained earth bund
(for reference only)

Table 2 - Un-engineered Earth Bund

Dimension	Description	Unit	Value
L_1	Length of bund crest	mm	Refer to project specific details
W_1	Width of crest	mm	Refer to project specific details (min 1000)
W_2	Base width	mm	Refer to project specific details
W_3	Cut off trench width	mm	Refer to project specific details (min 600)
H_1	Upstream height of bund	mm	Refer to project specific details (max 1000)
H_2	Center line height of bund	mm	Refer to project specific details (max 1000)
H_3	Downstream height of bund	mm	Refer to project specific details (max 1000)
H_4	Cut off trench depth	mm	Refer to project specific details (min 600)
V_1	Volume of earth bund above GL	m^3	Refer to project specific details

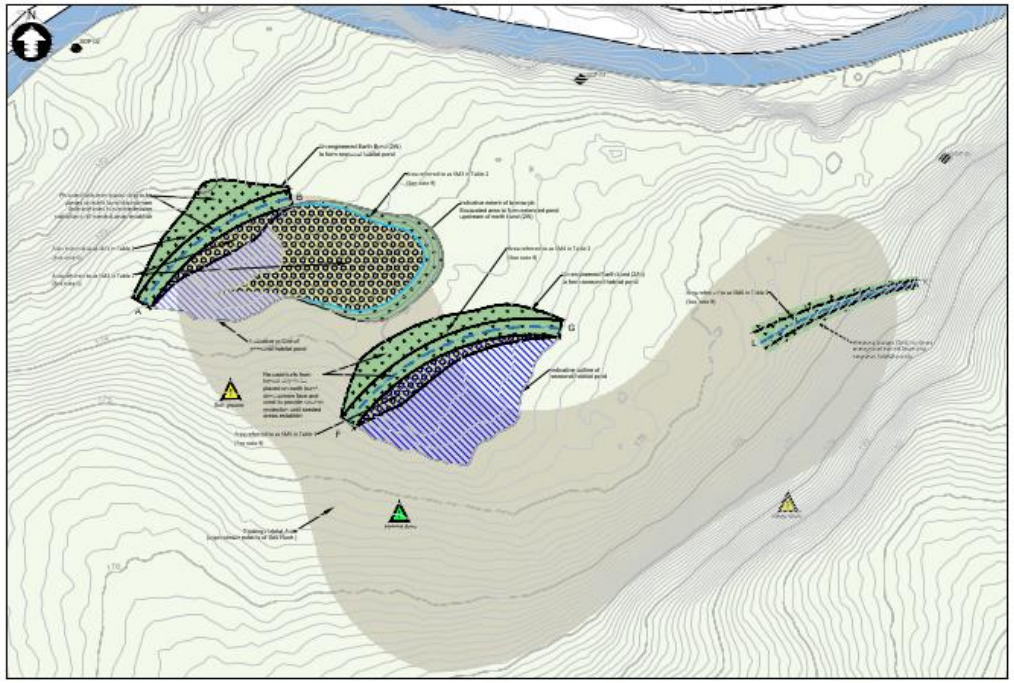
Note: All dimensions for earth bund and cut off trench to be confirmed on site and adjusted as necessary.

Design Considerations

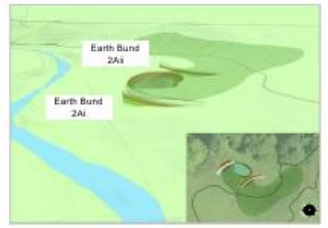
1. Unknown ground conditions (Guidance box) placed in 150mm layers
2. Cut and fill volume / balance uncertainty
3. Gradient of slopes and berm width
4. Grass cover - topsoil strip / turf reuse
5. Cut-off trench, stability key and increases path length for seepage flows

4. Design

Phase 2 – Seasonal Habitat Pond

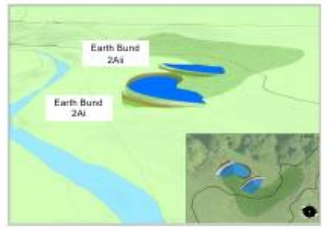


Seasonal Habitat Ponds (2Ai and 2Aii) and Wetland Scrape (2Aiii) - Planting Plan



Visualisation 1: Dry (empty) Seasonal Pond

(indicative 3D illustration only - view point from south west of Area 2A)



Visualisation 2: Wet (flooded) Seasonal Pond

(indicative 3D illustration only - view point from south west of Area 2A)

Photo 1: Marsh Marigolds

Photo 2: Wetland Meadow Mix

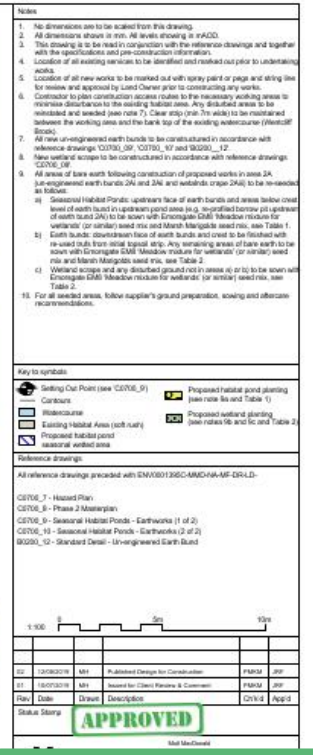


Table 1 - Habitat Pond Seed Mix				
Caltha palustris – Marsh Marigold (sown at 1g/m²)				
Key	SM2	SM5	Total	Note: Areas and quantities shown are indicative. Contractor to check / confirm
Area (m²)	55	9	64	
Quantity (g)	55	9	64	
Emorsgate EM8 'Meadow mixture for wetlands' (or similar) (4g/m²)				
Key	SM2	SM5	Total	Note: Areas and quantities shown are indicative. Contractor to check / confirm
Area (m²)	55	9	64	
Quantity (g)	220	36	256	

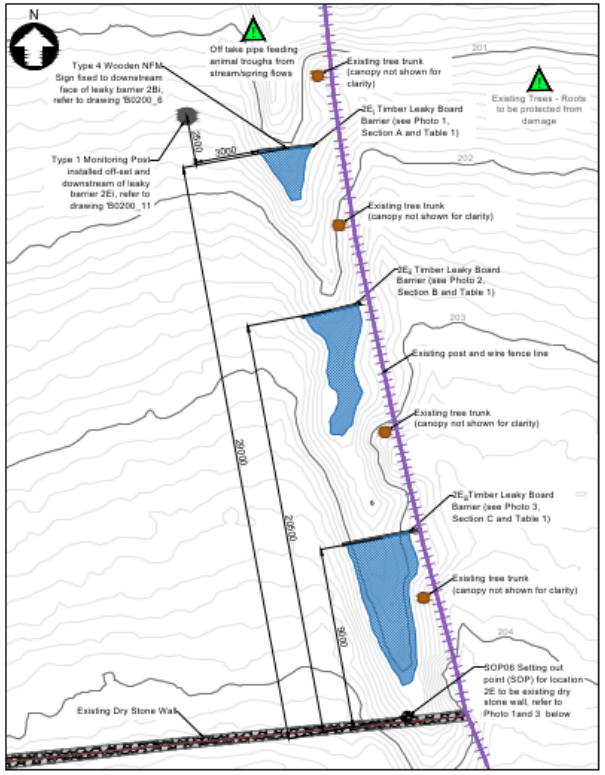
Table 2 - Wetland Seed Mix					
Emorsgate EM8 'Meadow mixture for wetlands' (or similar) (4g/m²)					
Key	SM1	SM3	SM4	SM6	Total
Area (m²)	26	13	31	13	83
Quantity (g)	104	52	124	52	332
Note: Areas and quantities shown are indicative. Contractor to check / confirm					

Design Considerations

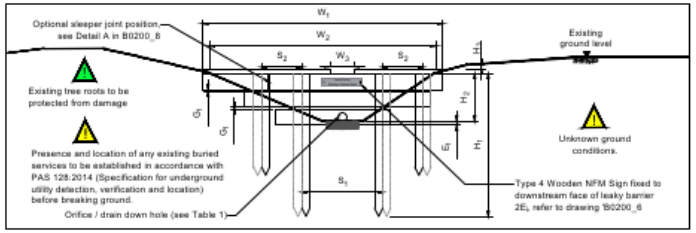
1. Wetland meadow seeding mixes
2. Marsh Marigolds

4. Design

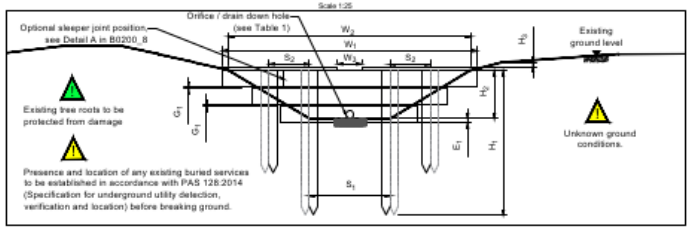
Phase 2 – Leaky Barriers



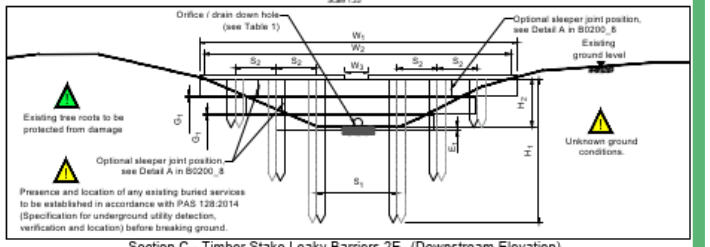
Location 2E - Plan



Section A - Timber Stake Leaky Barriers 2E$_i$ (Downstream Elevation)



Section B - Timber Stake Leaky Barriers 2E$_{ii}$ (Downstream Elevation)



Section C - Timber Stake Leaky Barriers 2E$_{iii}$ (Downstream Elevation)

Photo 1: Leaky Barrier 2E$_i$ Indicative Crest Line

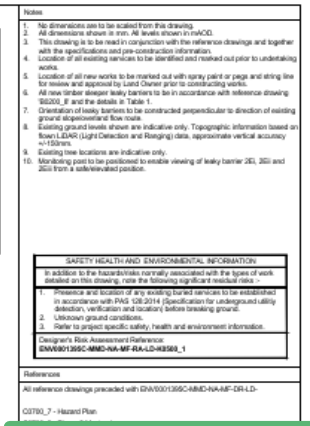
Photo 2: Leaky Barrier 2E$_{ii}$ Indicative Crest Line

Photo 3: Leaky Barrier 2E$_{iii}$ Indicative Crest Line

Table 1 - Timber Sleeper Leaky Barrier Dimensions

Dimension	Description	Unit	2E$_i$	2E$_{ii}$	2E$_{iii}$
W_1	Total width of leaky barrier	mm	3000	3200	4000
W_2	Width of crest in channel	mm	2800	3000	3800
W_3	Width of notch weir	mm	300	300	300
S_1	Spacing between inner face of central stakes	mm	1000	1000	1000
S_2	Spacing between outer stakes	mm	500	500	500
D_1	Diameter of timber stake	mm	100	100	100
N_1	Number of timber stakes	No.	8	8	12
H_1	Maximum stake length	mm	1800	1800	1800
H_2	Maximum stake height above ground	mm	600	600	600
G_1	Gap between timber sleepers	mm	20	20	20
E_1	Embedment depth of bottom sleeper	mm	50	50	50
O_1	Orifice / drain down hole diameter	mm	100	100	100

Note: All dimensions for leaky barriers to be confirmed on site and adjusted as necessary

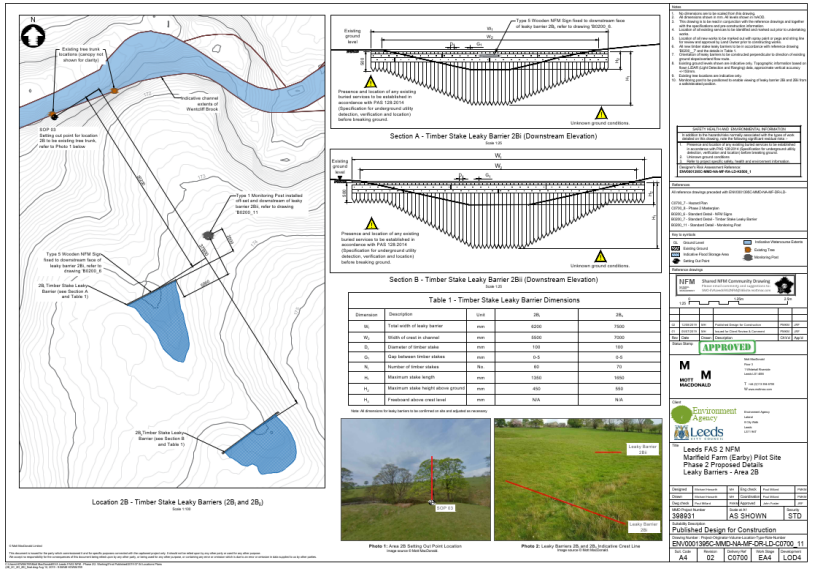


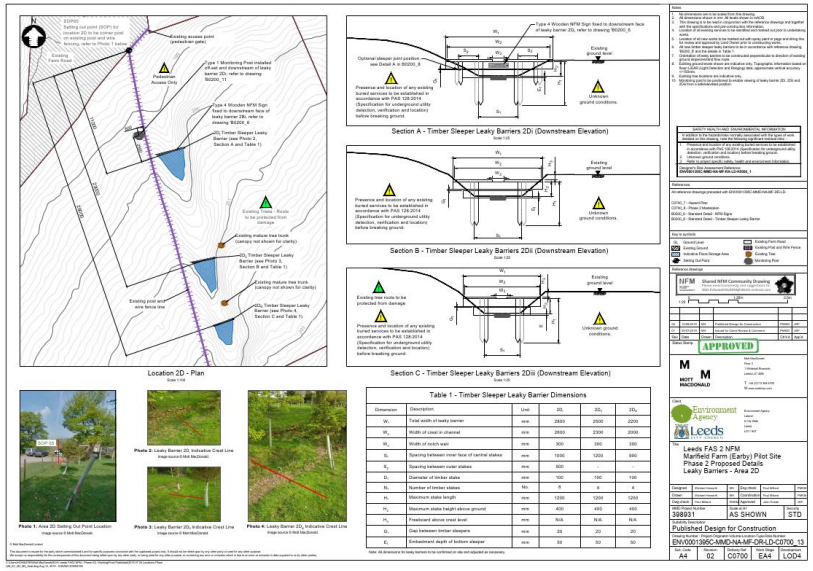
Design Considerations

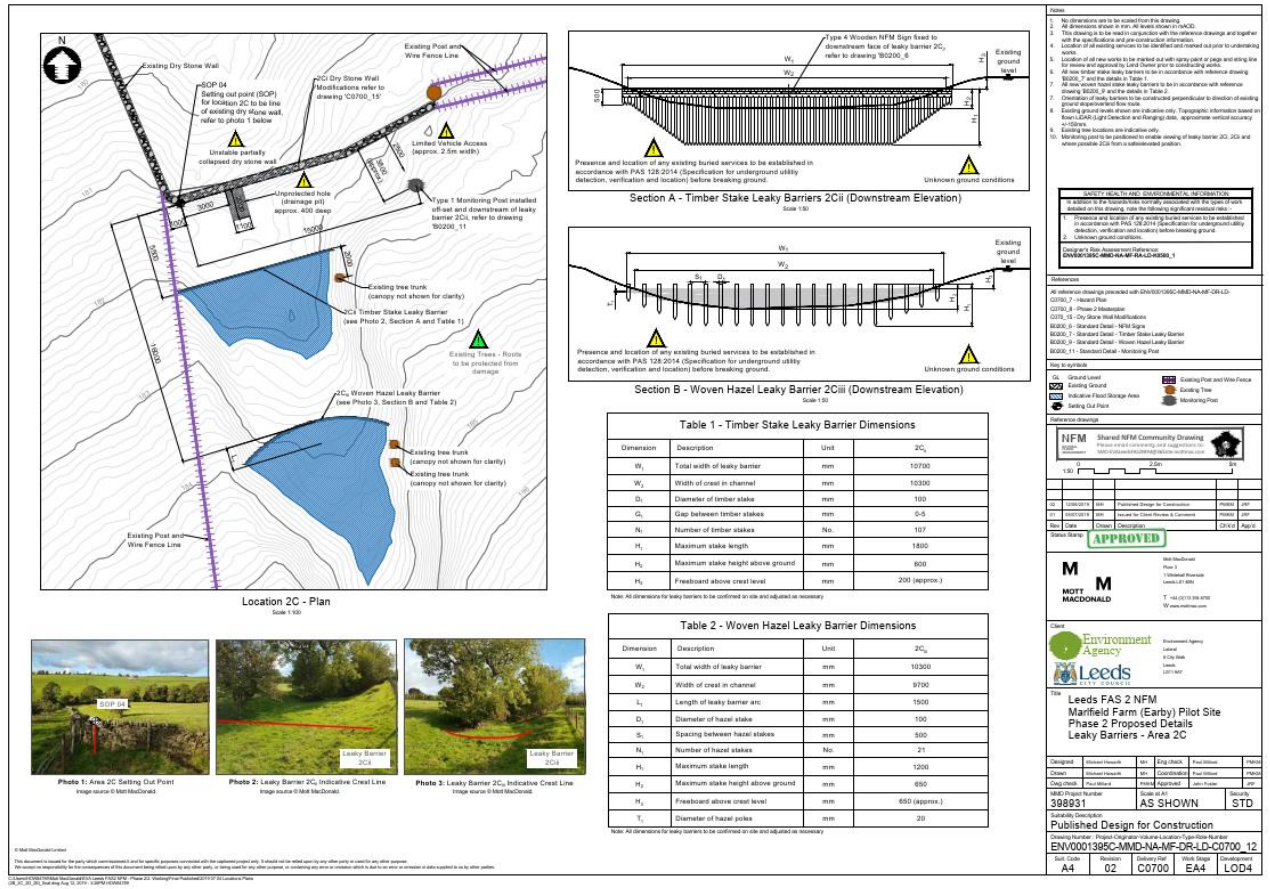
1. Setting out details relative to field boundaries (to avoid existing trees/roots)
2. Dimensions for each structure (referencing standard detail)

4. Design

Phase 2 – Leaky Barriers

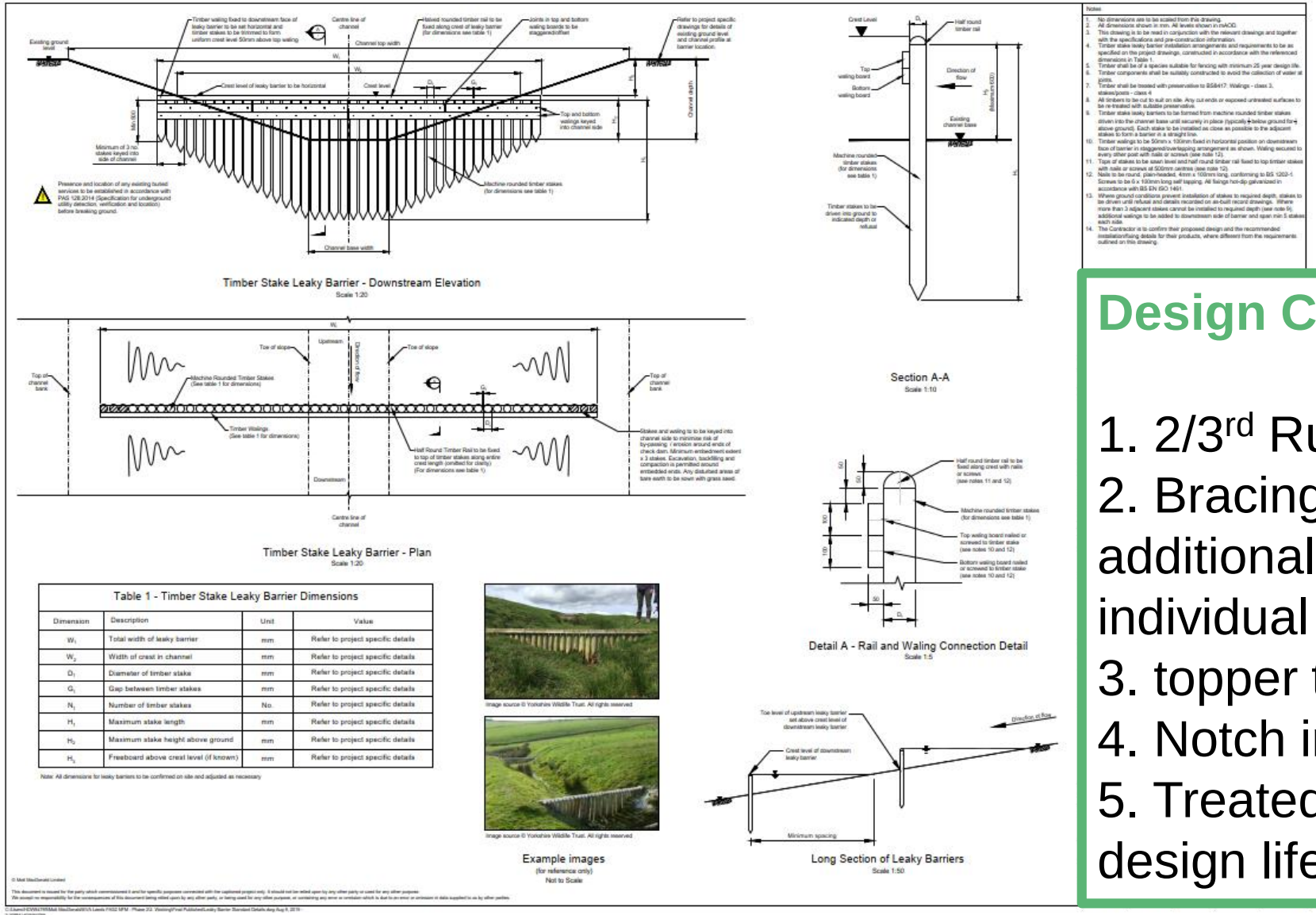






4. Design

Phase 2 – Leaky Barrier: Timber Stake

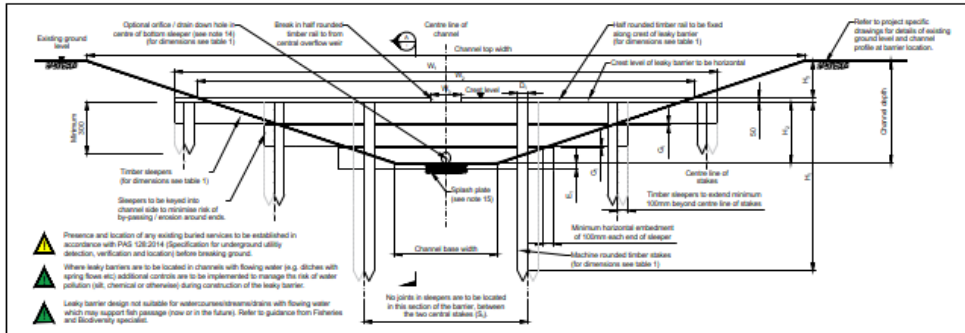


Design Considerations

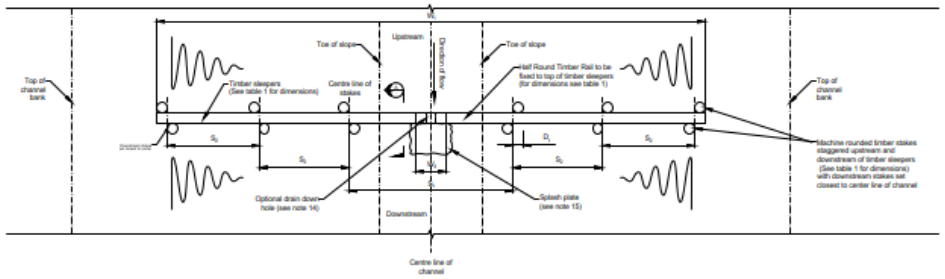
1. 2/3rd Rule
2. Bracing to provide additional stability to individual posts
3. topper to shed rain
4. Notch in centre
5. Treated timber (20+ design life)

4. Design

Phase 2 – Leaky Barrier: Timber Sleeper



Timber Sleeper Leaky Barrier - Downstream Elevation
Scale 1:20

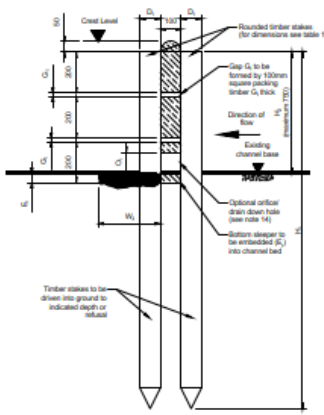


Timber Sleeper Leaky Barrier - Plan
Scale 1:20

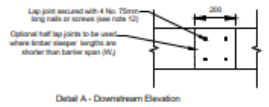
Table 1 - Timber Sleeper Leaky Barrier Dimensions			
Dimension	Description	Unit	Value
W_1	Total width of leaky barrier	mm	Refer to project specific details
W_2	Width of crest in channel	mm	Refer to project specific details
W_3	Width of notch weir	mm	Refer to project specific details
S_1	Spacing between central stakes	mm	Refer to project specific details
S_2	Spacing between outer stakes	mm	Refer to project specific details
D_1	Diameter of timber stake	mm	Refer to project specific details
N_1	Number of timber stakes	No.	Refer to project specific details
H_1	Maximum stake length	mm	Refer to project specific details
H_2	Maximum stake height above ground	mm	Refer to project specific details
H_3	Freeboard above crest level (if known)	mm	Refer to project specific details
G_1	Gap between timber sleepers	mm	Refer to project specific details
E_1	Embedment depth of bottom sleeper	mm	Refer to project specific details
O_1	Optional orifice / drain down hole dia.	mm	Refer to project specific details

Note: All dimensions for leaky barriers to be confirmed on site and adjusted as necessary

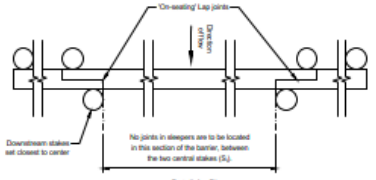
Example images
(for reference only)
Not to Scale



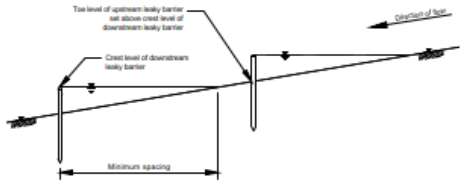
Section A-A
Scale 1:10



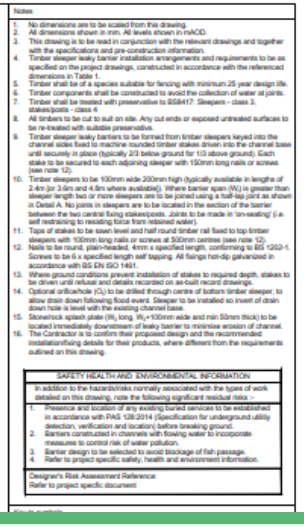
Detail A - Downstream Elevation



Detail A - Sleeper Joint Detail
Scale 1:10



Long Section of Leaky Barriers
Scale 1:50

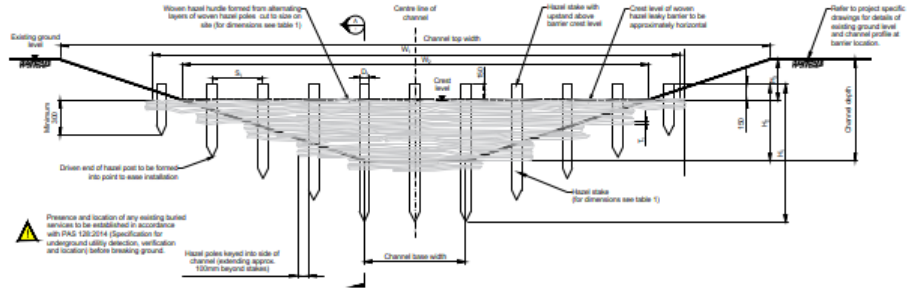


Design Considerations

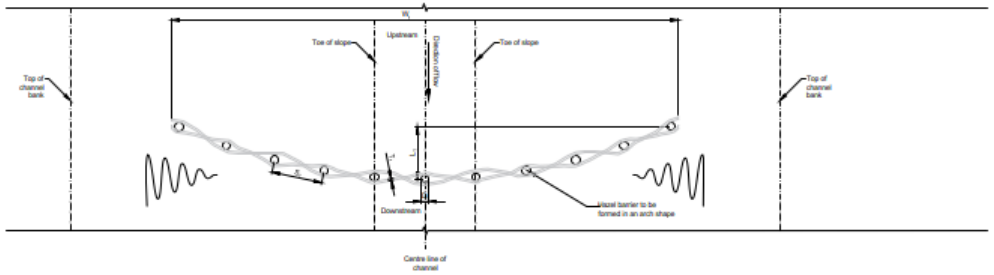
1. Timbers dug into existing channel bank
2. Stakes to provide additional stability
3. ‘Splash stones’ erosion protection

4. Design

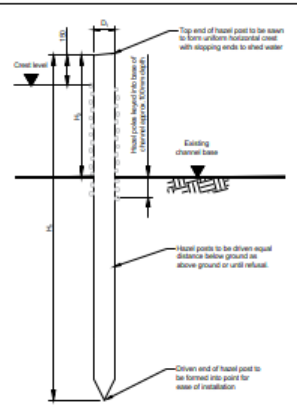
Phase 2 – Leaky Barrier: Woven Hazel



Woven Hazel Leaky Barrier - Downstream Elevation
Scale 1:20



Woven Hazel Leaky Barrier - Plan
Scale 1:20



Section A-A
Scale 1:10

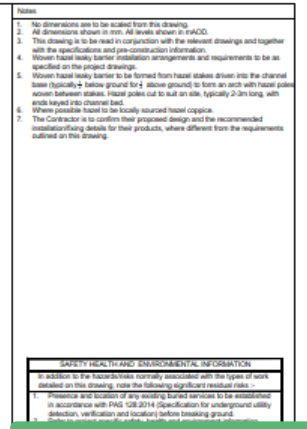
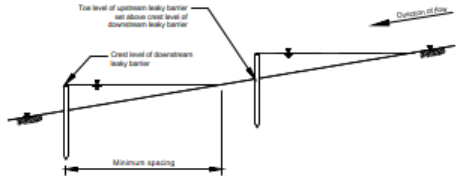


Table 1 - Woven Hazel Leaky Barrier Dimensions			
Dimension	Description	Unit	Value
W_1	Total width of leaky barrier	mm	Refer to project specific details
W_2	Width of crest in channel	mm	Refer to project specific details
L_1	Length or leaky barrier arc	mm	Refer to project specific details
D_1	Diameter of hazel stake	mm	Refer to project specific details
S_1	Spacing between hazel stakes	mm	Refer to project specific details
N_1	Number of hazel stakes	No.	Refer to project specific details
H_1	Maximum stake length	mm	Refer to project specific details
H_2	Maximum stake height above ground	mm	Refer to project specific details
H_3	Freeboard above crest level (if known)	mm	Refer to project specific details
T_1	Diameter of hazel poles	mm	Refer to project specific details

Note: All dimensions for leaky barriers to be confirmed on site and adjusted as necessary

Example images
(for reference only)
Not to Scale



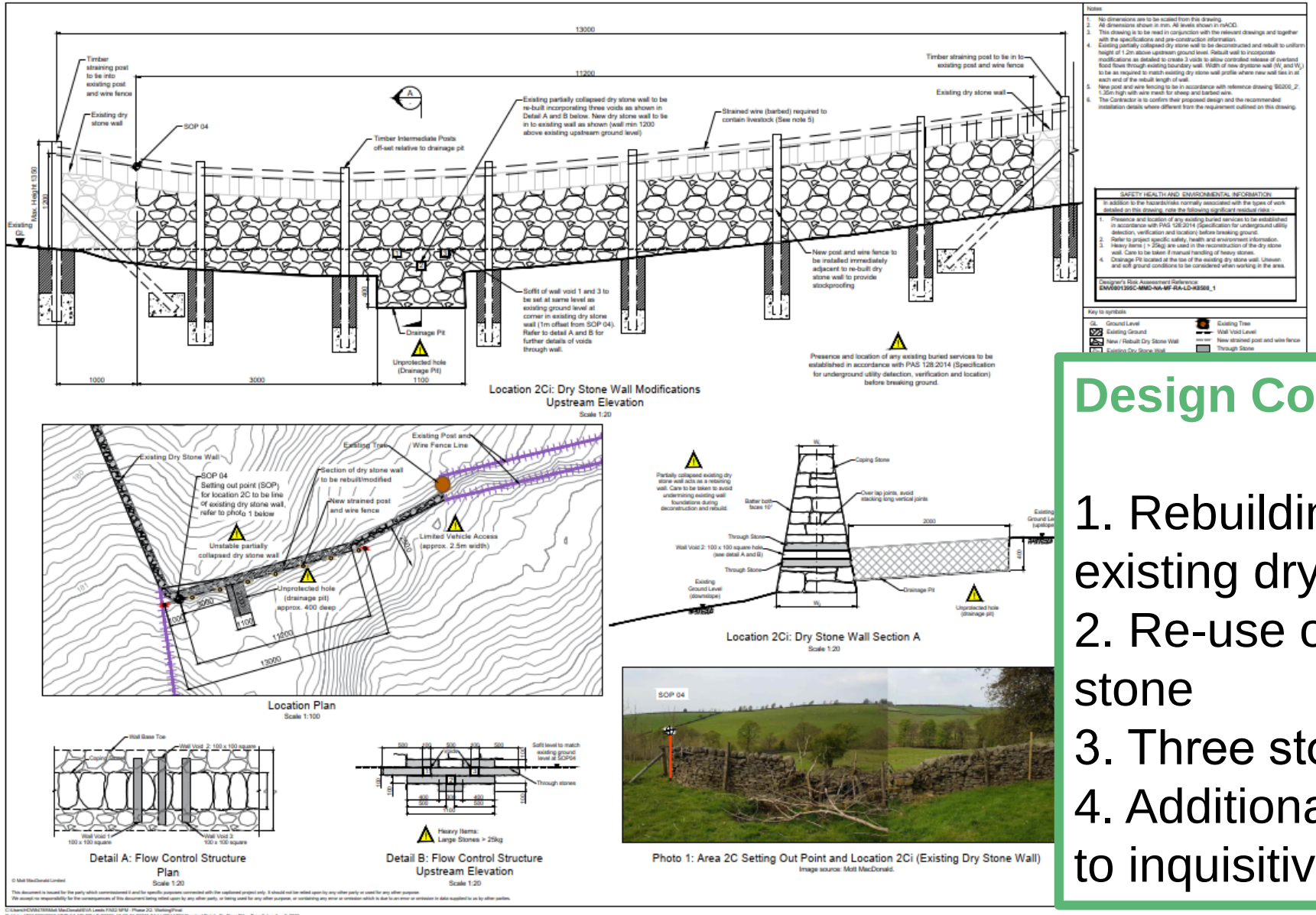
Long Section of Leaky Barriers
Scale 1:50

Design Considerations

1. Debris Collector upstream of ‘storage’ leaky barriers
2. Use of hazel coppice (future repair / replacement using on site hazel planting)

4. Design

Phase 1 – Leaky Dry Stone Wall



Design Considerations

1. Rebuilding/repairing existing dry stone wall
2. Re-use of available stone
3. Three stone ‘pipes’
4. Additional fencing sue to inquisitive sheep

4. Design

Lessons Learned

- **EA CDM Process** – EA sign-off for no GPR (Ground Penetrating Radar) to confirm location of below ground services (Risk to be managed by Contractor).
- **‘Light Touch’ site surveys** – No Topographic survey (used LiDAR and OS Mastermap only) and no Ground Investigations (unknown ground conditions for earth bund)
- **Limited design guidance** – Lack of single source of knowledge/peer reviewed guidance for design criteria/considerations (Pre CIRIA NFM Guide). Led on to developing ‘project specific’ guidance summarising suitable and unsuitable locations for NFM