MORPHUM ENVIRONMENTAL LTD

Engineers & Consultants

Construction Specifications

Groom Creek Wetland

Final

Prepared for Nelson City Council by Morphum Environmental Ltd
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Contents

1.0 Introduction

This specification describes the technical aspects of the construction of the Groom Creek Wetland (herein referred to as the Wetland). The Wetland will divert runoff from an existing modified creek alignment to a vegetated wetland integrated into the existing Maitai River floodplain. This will reinstate the historical alignment of the creek and the approximate location of an original natural wetland. The wetland has been designed to improve the water quality of runoff discharging into the downstream receiving environments (including Maitai River and estuary) whilst providing a high quality, high profile landscape amenity for the park and surrounding community. In particular, the wetland has been designed to reduce existing nitrate loads and suspended sediments. Both of these functions require considered design details to support the mix of physical, biological and chemical treatment processes within the wetland system. In addition the design of the wetland is intended to support improved fish passage through the system to the upper Groom Creek catchment and support resilient biodiversity.

1.1 Site Location of Works

The Groom Creek wetland site is located immediately downstream of the confluence of Groom Creek with the Maitai River on the true left bank (north) of the river. This site is approximately opposite the existing Maitai motor camp with an existing vehicle bridge providing a crossing over the river. The site is entirely within Council owned land but adjoins the large forestry block which is owned and administered by Ngati Koata. This adjacent land is currently being managed as plantation forest and the continued operation of this shall not be impacted by these works. Figure 1 shows the indicative location of the Groom Creek wetland works area.

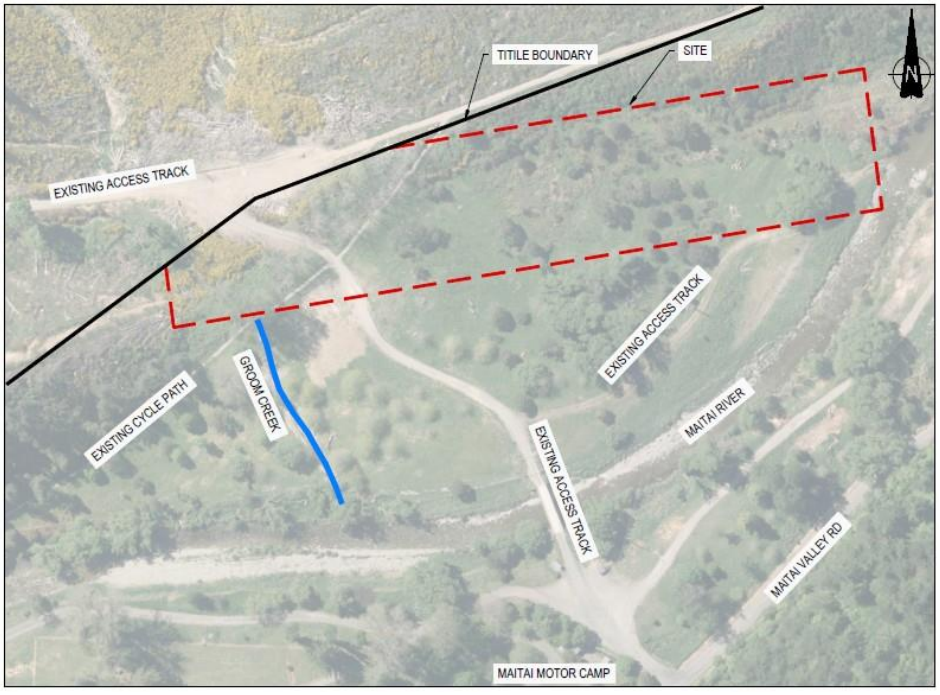

Figure 1: Location of works for Groom Creek wetland

1.2 Construction Drawings

These specifications are based on the construction issue drawings (herein referred to as the "Drawings") which are included as Appendix A. These drawings are to be the basis for pricing and works. Any changes to these drawings due to omissions, errors or design changes shall be communicated to the Contractor as soon as they are noted.

If any discrepancies are noted between this specification and the Drawings, the Drawings shall take precedence. Any discrepancies should be raised with the Engineer to the Contract (herein referred to as the Engineer) as soon as noted to avoid confusion.

1.3 Scope of Works

The works covered comprise the construction of the wetland component including related hydraulic elements and planting of the wetland itself. Landscape elements (paths, viewing decks and/or interpretive signage) are not included as part of this work package but may be included on some concept drawings for context.

Construction works covered in this specification are;

- Establishing secure worksite and site access
- Site clearance including the removal and disposal of grass and other vegetation
- Excavation of upper topsoil/gravel layer and stockpiling for later reuse
- Bulk excavation to form two connected wetland cells with disposal of material to nominated location
- Lining of wetland with approved Geosynthetic Clay Liner (GCL) including all QA requirements
- Placement of cover material (ameliorated topsoil/alluvial gravel mix) over GCL to form bathymetry within wetland footprint
- Construction of diversion forebay connecting to creek channel including concrete high-low bypass weir, throttled culvert beneath forestry access and maintenance access
- Construction of wetland inlet channel from diversion forebay to main wetland
- Construction of hydraulic control and connecting rock chute between two wetland cells and channel at downstream end to connect with Maitai River.
- Construction of compacted rock level spreader 'bund' between inlet and main wetland
- Construction of rock buttresses around identified existing trees to minimise root disturbance
- Planting of wetland vegetation as per planting plan
- Fencing (post and wire for stock exclusion)
- All sediment and erosion control works

1.4 Construction Hold Points

A number of hold points are identified throughout the project where visual inspection by the Engineer to the Contract (or nominated alternative) is required. These hold points will, in places, also require documented survey of critical levels to ensure that the design intent is achieved. A minimum of 48 hours' notice must be given to the Engineer to inform that the Contractor is ready for a hold point inspection.

Specific hold points shall be as follows;

1. At the completion of bulk earthworks

2. During the placement of the GCL liner. Approval of product shall be required prior to procurement and confirmation of installation competence provided.
3. After installation of the required diversion works upstream of the inlet channel. Survey of operating levels will be required.
4. After installation of all hydraulic connection between wetland cells.
5. At the completion of installation of ameliorated topsoil and other cover material prior to planting. Survey of completed levels to demonstrate consistency with design will be required.
6. Following/during planting.

1.5 Tolerances

Tolerances of particular components of the design are especially critical to ensure that the operation of the wetland is as per the design intent. The Contractor shall engage a licenced surveyor to confirm/check particular levels to ensure that these tight tolerances are met. Survey must be taken from a consistent benchmark to ensure that the relative levels are maintained.

In order to get sign off, the following tolerances must be shown.

1. Bulk earthwork levels must be within 50 mm of the design level (i.e. finished level minus 300 mm cover depth).
2. Hydraulic structure levels (e.g. bypass weir, inlet diversion culvert and connecting weir structure) must be within 5 mm of design levels.
3. Extent of lining must be consistent to at least the operating water level (RL 51.5 and 51.0 respectively) and must not be more than 50 mm above this.
4. Finished levels (of all topsoil and other cover material) must be within 25 mm of the design level.

2.0 Site Clearing and Establishment

2.1 Site Establishment

Prior to starting any operations on site, the contractor must submit a marked up site plan showing the locations of any temporary haul routes and stockpile locations for written approval by the Engineer. The Contractor shall ensure that all vehicle access points and temporary site facilities are agreed in writing by the Engineer in advance.

Main access shall be from the existing carpark and bridge across the Maitai River. Access shall not impede the movement of private vehicles or pedestrians. The Contractor shall provide for any traffic management requirements to facilitate safe movement of vehicles into and out of the site and shall not enable unauthorised vehicle movement across the bridge. Clear communication with the owners and managers of the Maitai motor camp and adjacent forestry block will be required throughout to ensure that there are no conflicts with vehicles, workers or stock.

It is the Contractor's responsibility to provide suitable facilities for all workers (including sub-contractors). This will likely include site shed and toilets. All disturbed areas of grass shall be rehabilitated to a fit state prior to project completion.

2.2 Existing services

It is the Contractor's responsibility to check the existence and location of all existing services, buried or otherwise hidden, prior to the commencement of work. Although existing services may be shown on the drawings, no responsibility will be accepted for their accuracy or omission.

Existing services such as drains, sewers, public utility and other services shall be secured and any damage repaired, or attended to satisfy the authority concerned.

The Contractor shall note that there are overhead power lines which transects the site. These must be protected and all works in proximity must comply with the relevant safety guidelines and industry standards.

In the event of a damage being incurred to any existing services, the Contractor shall bear the full cost of repairs required to reinstate the existing services. The repairs may be carried out by the Contractor or by another appropriate agency as directed by the Engineer to ensure the minimum period of interruption to the service.

2.3 Nuisance

The Contractor shall take all reasonable steps to avoid causing nuisance to properties or people in the vicinity of the works including the Maitai motor camp. No work shall start before 0700 hours nor continue later than 1800 hours from Monday to Saturday. Work outside these hours and on Sundays and Public Holidays may be possible subject to specific approval of the Engineer, providing a minimum of seven (7) days' notice is given. Saturdays, Sundays and public Holidays shall not be regarded as normal working days for programming purposes unless specifically required by the Contractor and approval given by the Engineer prior to implementation of the works. Should the Contractor wish to perform any work, including plant maintenance, outside these hours the Contractor shall obtain prior written approval to do so.

The Engineer reserves the right to restrict the Contractor's use of public roads during the hours of peak traffic flows and weekends.

Where dust becomes a public nuisance the Contractor shall take actions to suppress it. This shall be addressed within the erosion and sediment control plan.

2.4 Site Safety

The Contractor shall be responsible for performing the work in healthy and safe manner and shall ensure that works at all times comply with all relevant OHS regulations. The Contractor shall be the Principal Contractor for the purpose of this Contract and shall be responsible for notifying all relevant bodies.

It is the responsibility of the Contractor that they, their employees and sub-contractors are aware of and familiar with safety rules and practices as authorised by the Engineer.

The Contractor shall provide adequate first aid equipment, fire extinguishers and other safety equipment of an approved type and amount, as may be specified (or expected in accordance with good working practices) in connection with this Contract and shall maintain this equipment in good working order.

The Contractor shall also supply its employees and sub-contractors with adequate personal protective clothing and other equipment which shall be maintained in good condition or replaced and shall be worn as indicated by notices, instructions and good practices. These shall include safety boots, hard hats, protective eye wear, hand gloves etc.

The Contractor shall report to the Engineer any accident or incident irrespective of whether injury to personnel, damage to property, plant or equipment, fire and a "near-hit" situation might have led to one of the above mentioned consequences.

2.5 Environmental management compliance

It is the Contractors responsibility to ensure that works do not adversely impact on the downstream receiving environments. The Contractor shall take all such measures as may be required to prevent the discharge of silt, sediment or other deleterious materials such as oil, petrol/diesel fuel, cement etc from the site into any existing drainage system, natural water course or protected area. Provisions must be in place to respond to unintentional leakage of hydrocarbons and all refuelling of machinery shall be undertaken well away from any waterbodies or potential overland flow paths.

Sediment control measures shall be maintained and cleaned so that they function at all times.

Care shall be taken to minimise the area of disturbed land around the area of works. All disturbed surfaces shall be reinstated (seeded with approved grass seed) immediately following works as per the planting plan.

2.6 Temporary Fencing

The Contractor shall arrange for and erect appropriate fencing and signage around the works to maintain a safe environment and to keep people from the construction site. In particular, the Contractor must consider the proximity to the adjacent cycle/pedestrian pathway and the need to restrict any access either during or outside of work hours. The fencing arrangement must consider the need to maintain public access through portions of the work area (i.e. maintain cycle path) and shall be discussed with the Engineer in advance.

All fences, signage and other structures shall be removed at the completion of the construction works.

2.7 Setting out and survey works

All levels shown on the drawings shall be verified against an established site benchmark prior to commencing works. Any discrepancies with relative levels must be raised with the Engineer as soon as identified. The Contractor shall establish or locate permanent bench marks at the site. Any permanent bench marks damaged or disturbed during the works shall be re-established by the Contractor.

The Contractor shall verify all dimensions and levels shown on the Drawings prior to commencement of the works. Dimensions shall not be scaled from drawings. All works shall be set out and pegged with clear marking prior to commencing earthworks. Set out shall be strictly in accordance with the drawings and data provided to the Contractor. Set out shall be inspected and approved by the Engineer prior to commencement with any potential discrepancies and or conflicts raised at the earliest convenience.

The Contractor shall engage a licensed surveyor to carry out the initial survey works for setting out the works, cross sectional surveys, recording existing conditions, levelling works, establishing temporary bench marks necessary for the on-going setting out of the works and final as built surveys. Tolerances for aspects of the design are tight and must be confirmed by the licenced surveyor.

The Contractor shall review the digital terrain model used in the project documentation and agree that this model is to be used thereafter in the calculation of earthworks quantities.

Site set out shall also identify the preferred location for temporary stockpiling of materials and storage of all imported materials including GCL lining. Agreement shall be sought from the Engineer for the location of all temporary storage areas.

2.8 Geotechnical information

Ground conditions at the site have been verified by four excavated test pits (05th July, 2016) along the alignment of the works. The brief summary report of these are included in Appendix C. This confirmed the presence of a matrix of alluvial gravels (well rounded) with alluvial soils and clays in the upper layers and sand at depth. Based on these test pits it is deduced that the groundwater level is variable across the site influenced by substrates, springs and ground undulations. Soils below the groundwater layer remain as alluvial gravels except at the downstream end where bedrock was encountered at approximately RL 40.5.

All proposed batters are considered to be shallow with reasonable gentle grades with minimal risk of slumping anticipated.

2.9 Tree removal and disposal

The design and location of the wetland has been undertaken to minimise the impact on existing mature native trees. In particular the intent is to protect and retain as many of the existing mature kanuka trees and incorporate these into the riparian edges of the wetland. Two smaller kanuka trees are positioned within the wetland footprint and will need to be removed. Other large non-native species require removal (in particular around the diversion forebay) and will require removal and disposal.

All trees to be removed stall be marked (flag tape) before any disturbance and confirmed with the Engineer. The following shall be followed during tree removal.

- All trees to be removed must be felled and processed by an appropriately qualified arborist and must be undertaken in a safe and responsible manner
- All trees must be felled to avoid any damage to other nearby trees which are being retained
- Removal of trees must include the full removal of the root ball and large lateral roots

- All vegetative matter shall be mulched on-site (including branches) and stockpiled in a location identified by Council for later re-use as mulch around planting.
- Up to three large sections of main trunk and limbs shall be identified by the engineer for reuse as part of the wetland construction. These sections shall be movable by excavator and shall be stored on-site until construction progressed for them to be placed on riparian batters to provide habitat. Logs shall be stored off the ground where possible to enable them to dry over summer months without striking new shoots.
- Other sections of large trunks (not suited to chipping) shall be removed off-site and disposed of in an appropriate manner. In the instance that these are to be on-sold to third party (i.e. as fire wood) approval shall be sought from Council.

2.10 General site clearing

Following the removal of large trees, all areas involving earthworks for the wetland construction shall be stripped of grass cover and other vegetation. In the area of the diversion forebay, this includes the area of exotic weeds (blackberry, broom and honeysuckle) which will need to be fully removed including roots and vine sections. Care must be taken to avoid vegetation matter being mixed with topsoils to prevent unintended transfer to other parts of the site. All cleared vegetation shall be disposed of offsite by the contractor. Clearance around the forebay should be undertaken at the outset to works to enable time for any regrowth. Where required, regrowth of aggressive weed species may require herbicide spray before earthworks. The use of any spray must be discussed and approved with the Engineer to ensure that there are no adverse ecological impacts.

Grubbing shall be carried out in all areas to be worked and shall include the complete removal of all stumps, roots and other embedded debris. Care shall be taken to not remove excess surface soils which shall be retained as topsoil for re-use.

2.11 Tree Protection

All trees within proximity to the works area (unless indicated for removal) shall be protected for the duration of works by the Contractor. Temporary fencing and clear marking tape shall be erected around the base of any trees which may be subject to damage through machinery, materials storage, stockpiling or vehicle movements.

Do not drive vehicles, store materials (including stockpiles), carry out earthworks or undertake any other activity (including refuelling of plant), within the drip line of trees which are to be retained. Trees which are located immediately adjacent to the wetland are to be protected through locally steeped batters and rock buttresses to the wetland water level. All batter cuts shall maintain a minimum 2 m clearance from the trunk. Where roots over 50 mm diameter are to be cut, these must be exposed and hand cut with a sharp pruning saw. Cut roots shall be immediately painted with an appropriate wound sealant. Any trees which are significantly damaged shall be replaced at the Contractors expense to the satisfaction of the Engineer.

2.12 Topsoil

All topsoil overlying proposed excavations and underlying areas directly affected by works shall be stripped and stockpiled. Wherever an area is to be excavated, the top 150 mm (or other depth as determined on site) of the natural soil is to be excavated and stockpiled on site for reuse. Topsoil to be reused on site shall have all surface grass material (except fine root matter) removed in advance for disposal.

Based on limited test pit excavations, topsoil is considered likely to include significant alluvial gravels interspersed with silty and sandy soils. This is considered acceptable given the need for topsoil to form a confining layer over the GCL lining and the saturated nature of the wetland soils. Site sourced topsoil shall be ameliorated with imported topsoil at a ratio of 2:1 (site sourced to imported by volume) to provide a suitable growing medium.

Imported topsoil's shall meet the following general specifications;

1. Imported topsoil must be capable of providing an environment for sustaining plant life and growth, constant in volume whether wet or dry, sufficiently porous to ensure drainage of excess water, free of weeds and other noxious organisms, and free of saline deposits.

2. Imported topsoil shall be friable, fertile soil mix, not set hard or become difficult to work as a consequence of drying out and be capable of handling when moist. Soil reaction shall be slightly acidic to neutral with a pH between 5.5 and 7.0 and salinity and must not exceed 600 ppm. The soil must be free from materials toxic to human health or plants and be free of roots greater than 6 mm diameter, clay lumps greater than 10 mm measured in any one direction, stone greater than 20 mm and other elements foreign to the normal composition of soil.

3. Ensure that all imported soil is free from vegetative reproductive parts.

4. If using additives to raise topsoil to the required standard, advise the Engineer and ensure compliance with the relevant test criteria.

5. Composted components: use only decomposed materials that will ensure nitrogen deficiency does not occur.

6. Contamination: where diesel oil, cement or other phytotoxic material has been spilt on the subsoil or topsoil, excavate the contaminated soil, dispose of it offsite, and replace it with site soil or imported topsoil to restore design levels.

7. Topsoil depths: spread topsoil to the following typical depths:-

    - Wetland area (i.e. above GCL liner): 200 mm site sourced alluvial soils placed immediately over installed liner. 100 mm imported topsoil placed over alluvial spoils and trimmed to form final bathymetry

    - Terrestrial planted areas (above level of normal operating water level defined by GCL liner): 100 mm minimum imported topsoil immediately over trimmed in-situ soils.

    - Grassed areas (where reinstatement required): generally trim in-situ soils and hand cast seeds.

8. Placing topsoil - compaction: lightly compact topsoil so that the finished surface is smooth, at the required levels ready for cultivation and planting. Prevent excess compaction from construction plant over the top soiled areas. Particular care required to avoid repeated vehicle movements across wetland area following placement of liner and topsoil, especially where elevated groundwater present.

2.13 Accidental cultural or archaeological discovery protocol

It is possible that existing archaeological sites may be affected by the proposed excavation and wetland construction work. Evidence of archaeological sites may include burnt and fire cracked stones, charcoal, rubbish heaps including shell, bone and/or glass and crockery, ditches, banks, pits, old building foundations, artefacts of Maori and European origin or human burials. The contractor is advised to contact Heritage New Zealand if the presence of an archaeological site is suspected. Work affecting archaeological sites is subject to a consenting process under the Heritage New Zealand Pouhere Taonga Act 2014. If any activity associated with this proposal, such as earthworks, fencing or landscaping, may modify, damage or destroy any archaeological site(s), an authority (consent) from Heritage New Zealand Pouhere Taonga must be obtained for the work to proceed lawfully. The Heritage New Zealand Pouhere Taonga Act 2014 contains penalties for unauthorised site damage.

The Contractor shall allow for an Iwi monitor to be present on-site during earthworks which could potentially uncover materials of cultural/historical significance. In the event of Maori archaeological sites (e.g. shell midden, hangi or ovens, garden soils, pit depressions, occupation evidence, burials, taonga) or koiwi (human remains) being uncovered, activities in the vicinity of the discovery shall cease immediately without any further disturbance. The Contractor must notify Council immediately and arrange for notification to Tiakina te Taiao Ltd (03 546 7842). The Contractor must not recommence works in the area of the discovery until the relevant approvals to damage, destroy or modify such sites have been obtained.

Protocol for the locating and or retrieval of Pakohe (Argillite) must be discussed in advance with the relevant iwi representatives. Allowance shall be made for enabling access for iwi representatives to inspect stockpiles ad open excavations for the purposes of retrieving Pakohe.

3.0 Construction sequencing

3.1 Sequencing intent

Careful consideration of the sequencing of construction activities is required to avoid adverse environmental impacts on the downstream receiving environments or damage to the wetland prior to completion. Because the diversion works require activity within the bed of the current channel there is a risk of mobilization of sediments which could impact downstream reaches of the existing Groom Creek channel and the Maitai River. Therefore, the sequencing is intended to minimize this through maintaining a separation between active work areas and channel flow. The following sections outline a proposed approach to achieve this. In the instance that deviation from this methodology is proposed, approval must be sought from the Engineer in advance of commencing works. The methodology shall be discussed in detail with the Engineer or their representative prior to works commencing.

3.1.1 Wetland construction and channel works

The new wetland and associated inlet/outlet channels shall be constructed off line prior to any work on the upstream diversion. Due to the nature of work, all excavations will result in any rainfall runoff accumulating within the excavation footprint rather than uncontrolled discharge towards the Maitai River. Where significant rainfall occurs, or pump out of groundwater is required for lining, water shall be discharged to an appropriately identified area where infiltration can occur over the existing grassed floodplain rather than overland discharge to the Maitai River.

The wetland, hydraulic structures, inlet channel and outlet channel shall be completed in full prior to any planting. At this point the wetland can be planted (strictly in accordance with Section 10.0). Depending on the time of completion, planting should occur as soon as possible within the wetland. This should not occur between the months of June-August (inclusive) when growth rates are slow inhibiting establishment.

Immediately following planting of the wetland areas water can be pumped from the existing channel into the head of the new inlet channel to fully saturate the liner and soils and raise the water level within the wetland cells.

3.1.2 Wetland diversion forebay

As far as practical, works to construct the diversion forebay shall be undertaken off line prior to any breach into the existing Groom Creek channel. This shall include works to form the forebay (maintaining a stabilised bund between forebay and channel), maintenance access track and culvert beneath the existing forestry access road.

Once the forebay is completed (and when favorable weather forecast permits) the final excavation can connect the forebay with the existing cannel.

3.1.3 High flow bypass weir and channel

Following completion of the forebay (and downstream wetland works), the high flow bypass weir can be constructed. This will be undertaken in an offline condition in accordance with the site management protocol detailed in Section 3.2. The following steps are proposed for the construction of the bypass weir and channel works;

1. Install stable sandbag bund to direct flows preferentially into the diversion forebay and therefore through to the wetland.

2. Prepare the alignment for the diversion weir including a suitably well compacted footing and carefully excavated slots to enable weir to be keyed into both banks.
3. Construct (or crane lift pre-cast) concrete weir structure extending across the full width of the channel. Care must be taken to achieve a consistent level weir crest in accordance with tolerances.
4. Form the batter up to the weir crest and batter slopes on sides in accordance with drawings.
5. Form the batter on the downslope side of weir to tie into existing channel invert and banks.
6. Line all batters above water level with approved biodegradable erosion control matting and plant.
7. Place rock protection around weir in accordance with drawings.
8. Remove upstream sandbags once all sections are completed and stabilised with dense planting and matting. At this point the system is fully online and operational.
9. Temporarily cover the inlet to the diversion culvert at the discretion of the Engineer if it is decided to maintain the wetland in an off line configuration until suitably established.

3.2 High flow site management

Once the wetland and forebay works have been completed, all flows will be conveyed through this route and into the wetland during construction of the highflow bypass weir. Following breaching the forebay to connect with the existing Groom Creek channel the downstream section of this channel shall be bunded with sand bags directing all creek flows into the wetland itself. During this time the existing Groom Creek channel will not receive flows (except in case of flood flows as discussed below), enabling works within the bed to be undertaken. This phase of work is the riskiest in terms of sediment control as flows which exceed the capacity of the diversion culvert will be forced to flow in the channel. Without appropriate site management this could result in the mobilization of sediments.

Contingency must be made for this with preparedness to implement a high flow response. The following outlines the required contingency planning;

1. Install sand bag bund to divert all flows into the wetland forebay. The bund must be stable and able to withstand flow depths up to 500 mm depth. The integrity of the bund shall be checked daily prior to works commencing.
2. Monitor weather forecasts at least twice per day. As a minimum the forecast must be checked prior to leaving the site in the evening and at the start of each working day. Particular attention must be given to weekend forecasts when staff will be off site for one or more days.
3. Reduce the area of open cut at any time to that which can be covered in the event of significant runoff. Construction sequencing should allow for areas to be completed (including planting and installation of erosion matting) before starting on further sections.
4. In the event of inclement forecasts, the entire open cut work area shall be covered with geotextile to reduce scour. The geotextile must be well secured at the upstream end with driven stakes and rock to avoid water getting under and lifting fabric. All edges must extend above the top weir height and be pinned. All overlaps must be perpendicular to the flow direction and be arranged with the upstream panel overlapping the downstream panel by at least 500 mm. Sandbags shall be placed on side batters to prevent wind lift.
5. The diversion sandbags shall be maintained in place for as long as practical to allow vegetation in the transition to the bypass channel to establish. Once sand bags are removed the wetland will become online to design flows with higher flows able to bypass the system.

4.0 Bulk Earthworks and Impermeable Liner

The Contractor shall supply all labour, plant and materials required to complete all earthworks and excavations shown on the drawings and/or specified in the Contract Documents. The work includes all bulk excavation, stockpiling, erosion control, lining (geosynthetic clay liner), placing topsoil/gravel cover material, disposal of excess material off site (or to appropriate disposal location in close proximity), planting and all associated work in accordance with the Contract Documents and as may be directed by the Engineer.

4.1 Extent of Bulk Earthworks

The Contractor is to confine machinery operations to the extent of works as shown on the Drawings. If any deviation from these areas is needed for constructability purposes, agreement must be sought from the Engineer in advance. In particular, the Contractor must ensure that at no times is heavy machinery allowed to operate in obstruction of the existing pedestrian walkway or to restrict access to the Ngati Koata forestry block.

4.2 Excavation - General

Generally, limits for depth of excavation of the wetland shall be in accordance with details on the Drawings and digital terrain model. It is noted that the levels provided on these are the finished levels (including topsoil etc) and do not necessarily reflect the full depth of required excavations. All finished surfaces (prior to any infilling) shall be confirmed through survey and used as the basis for as built drawings.

Excavations shall include the removal of all materials of whatever nature encountered, including all obstructions of any nature that would interfere with the proper execution and completion of the work. The removal of these materials shall conform to the lines and grades shown on the Drawings or ordered by the Engineer. In the instance that hard bedrock is encountered, the Contractor shall raise with the Engineer as soon as identified to discuss the response. It is considered unlikely that rock breaking shall be required.

The Contractor shall supply, place and maintain all supports and shoring that may be required for the sides of any excavation, and all pumping, ditching or other approved measures for the removal or exclusion of water. The walls and face of all excavations in which workers are exposed to danger from unstable ground shall be guarded against by a shoring system, sloping of the excavation, or some other acceptable method.

All bulk excavations shall be inspected by the Engineer or their representative prior to any lining works or infilling with topsoil/gravel. No earthworks shall be covered until written (email) approval is received.

Material shall be stockpiled only in locations agreed with Council. Excess material shall be disposed of as directed by Council. It can be assumed that this will be within the immediate area and will not require transport beyond the road.

4.3 Geosynthetic Clay Liner (GCL)

The wetland will have a continuous geosynthetic clay liner (GCL) installed to minimise water losses into the surrounding soil and support treatment within the wetland. The specification and installation of this liner is a critical component of the wetland which is fundamental to the sustained function of the wetland. All staff involved in the installation of the liner must be aware of this criticality and must either

be experienced in the installation of GCL or have undertaken induction training with an approved supplier representative.

The GCL must be a proprietary product comprising non-woven needle punched geotextile encasing a bentonite clay layer. As a minimum the product must conform with all specifications demonstrated by the Bentofix NSP 4300 product which is included in these specifications. Confirmation of this must be provided in advance of procurement and must be in the form of independently verified performance data. The liner will have a maximum hydraulic conductivity of 2×10^{-11} m/s.

The CCL shall be constructed to the extents shown on Drawings with a continuous lining extending to at least the normal operating water level (51.50 in upper wetland and 51.0 in lower) across the entire wetland area. Installation must be strictly in accordance with the manufacturer's specifications and installation guidelines. In the instance that an alternate product to Bentofix NSP 4300 is used, the Contractor must provide a copy of the supplier's specifications and installation guidelines in advance of works commencing.

The following critical points must be noted and adopted throughout installation;

- All material delivered to site must be stored in a dry sheltered position. Material will be stored on pallets with a tarpaulin cover
- All GCL sheets will be installed perpendicular to the flow direction (i.e. across the wetland) with a minimum 300 mm overlap on all joins, the upstream panel will always overlap the downstream panel. All panels must be securely anchored at crest of batters with either 300 mm lightly compacted overburden or fixing to timber edge boards.
- The base on which GCL is to be laid must be inspected by the Engineer prior to the placement of any GCL and must be reasonably smooth with no protrusions. In the instance that areas are considered excessively rough, a bedding layer of coarse sand may be required
- The GCL shall be covered with the 300 mm confining material either on the same day or prior to rainfall (whichever is shortest timeframe). Failure to cover the GCL will result in the uncontrolled swelling of the clay without pressure to bind bentonite laterally. Where visual inspection by the Engineer is not possible prior to covering, photographic logs of each section shall be required and provided.
- Operators must take care when placing material above GCL. Any incidences of rips or penetrations can easily be repaired with a cut patch and bentonite paste adhesive. Failure to patch any such penetrations will compromise the integrity of the wetland.
- Care must be taken to ensure that the methodology allows the continuation of installation following overnight stoppages without uncontrolled swelling or degradation of the joint section. This could be achieved by wrapping the leading edge of the GCL at the end of each day in polythene to allow the next sheet to be placed onto a clean and dry overlap.
- Care must be taken to ensure that there are no voids beneath the liner caused by undulating ground or stretched liner sheets around structures.
- Where the liner is required to be installed below the standing groundwater level (i.e. open pool area), a manufacturer approved methodology shall be proposed. This must be documented and provided to the Engineer for approval prior to commencing these works. This will require pumping to locally lower the groundwater until such time as the confining layer has been placed.
- Any areas of the completed liner (with confining layer) where positive water pressure is causing ballooning under the liner shall be brought to the engineers attention as soon as possible. Depending on the severity these areas may require additional confining material and will need to be clearly marked to avoid vehicle or foot traffic across area until after water has filled wetland to compensate pressure.

5.0 Wetland Construction

5.1 Wetland Bathymetry

The internal finished levels within the wetland must be strictly in accordance with the drawings (and digital terrain model) to ensure that the flow through the system is controlled in accordance with the design intent. This includes a uniform cross section perpendicular to the flow direction to ensure that velocities are constant across the full width of the wetland and that contact with vegetation and wetland substrates are optimised. Attention to the batter slopes of the sides and uniform long section grades must be given, in particular the 2 m wide safety bench extending from the normal water level. This bench (at 1:8 grade) supports vigorous growth of macrophytes which reduces the risk of unintended ingress by members of the public.

The final wetland levels (bathymetry) can be achieved through the bulk earthworks phase, through placement of topsoil's or a combination of both. All topsoils shall be lightly rolled following placement to prevent settlement or slumping when saturated.

5.2 Submerged Topsoil

The provision of suitable topsoil on the base and batters of the wetland is crucial to ensure successful macrophyte establishment. Aquatic macrophytes typically prefer medium textured silty to sandy loams (sedimentary to sandy loams with clay content) that allow for easy rhizome and root penetration. In this instance there is a preference to utilise as much of the available site sources material as possible to reduce the volume and provenance of any material imported from outside of the immediate catchment area. Therefore the topsoil shall comprise a 200 mm layer of site sourced material from the upper surface levels (matrix of alluvial gravels in silty soil) with 100 mm of imported topsoil above. Topsoil shall be placed over the GCL liner (refer Section 4.3) and shall be won and placed in accordance with Section 2.12.

Most terrestrial topsoil provides a good substratum for aquatic macrophytes. Any topsoil purchased from a soil supplier must be certified by the supplier as suitable for the purposes of landscaping. Where the proposed topsoil does not meet the requirement of the specification above, amendment may be required. This will be guided by a laboratory and may involve addition of fertilizer or organics.

5.3 Base Aggregates/Alluvial Beach Area

The base of the upper wetland outlet pool and the area identified as the 'alluvial beach' adjacent to the inlet shall be covered with a 200 mm thick layer of washed site sourced alluvial gravels extracted during excavations. Gravels shall be washed through sluicing whilst spread in a bunded impoundment or by other means. Care must be taken to ensure that any sluiced alluvial silts are unable to discharge to waterways in accordance with the ESCP.

In the instance that gravels are able to be extracted from the banks of the main Maitai River then these would be consider preferable to avoid the need for washing. No gravel shall be extracted from the Maitai River or its banks unless the activity is fully consented and being undertaken as part of another project at the same time.

5.4 Rock buttresses

Where existing trees are situated close to the required batter edges they shall be protected with hand placed rock buttresses to support steeper batters at the edge of the drip zone. These shall be constructed in accordance with the Drawings.

6.0 Reinstated stream connections

Creek channels are to be created in the following sections;

- between the inlet diversion culvert and upper wetland
- between the upper wetland and lower wetland (short section described as chute)
- at the outlet of the lower wetland (channel works not to continue all the way to Maitai River)

These shall be formed and detailed to replicate a natural, low gradient creek with associated variability and sequences of pools, runs and riffles. This will be achieved through the following specification and instruction on site.

6.1 Bulk channel excavations

The digital terrain model provides the finished surface for bulk excavations. This enables the general stream bed, batters and longitudinal fall to be formed on site. This will provide a 1m wide base, 1:3 side batters and an intermediate pool zone in the inlet channel. The alignment is intended to avoid conflict with all existing mature trees. In the instance that it is considered that realignment is needed this should be raised with the Engineer. Prior to excavation the alignment shall be staked out on the ground for approval by the Engineer.

6.2 Channel form

Based on limited test pits it is considered likely that all channels will be cut into existing alluvial gravel deposits in a consolidated silty soil matrix. These materials have been naturally deposited by the Maitai River and are considered well suited to forming a substrate for the proposed stream connections. Depending on the depth of excavation, and the variable substrate structure, these may be tightly packed or loose. For the creation of a naturally functioning stream system it is important that the base substrates are relatively loose to enable water movement through the upper hyporheic zone (surface gravels where flow is both through the substrate and on top). This is to be achieved through mechanical ripping of the upper 500 mm of alluvial gravels. In the instance that there are only a small proportion of gravel present (not considered likely), the upper 500 mm will require removal to be replaced with 500 mm of site sourced gravels from elsewhere on the site.

The finished form of the channel shall support variability within the stream including pools (including a single formal pool in the inlet and other dispersed micro pools), riffles (sections with uniform grade and dispersed flow profile) and cascades (locally placed larger rocks to create sinuosity of flow path and localised turbulence/eddies. The finished form shall be achieved through the placement of selected larger diameter rocks (large cobbles and boulders) as instructed onsite by the Engineer. Such rocks shall be separated from the bulk excavation material as located and set aside for this purpose. All channel works must ensure that at no point is fish passage impeded by vertical drops or extended sections with narrow constricted flows which increase velocities. These conditions are considered unlikely to occur due to overall grades and in situ substrates.

Washing of channel gravels is not considered as being required as the initial flushes through the system will mobilise these into the wetland areas and disperse them across the surface of the wetland to provide further bed sediments in the wetland itself. Sediment loads will rapidly stabalise following completion.

6.3 Channel engagement

Once the channel work is complete and the wetland cells fully constructed, flows will be conveyed into the channels through either initial pumping from the upstream channel or the removal of sand bags on

the upstream diversion culvert. This will enable initial flows to flush through the hypoheic zone and redistribute some of the smaller gravels and sands. This stage will therefore result in some natural movement and reorganisation of the substrate in response to the flow dynamics. During this time care must be taken to ensure that large flood flows are not able to flush through the channels as these may cause mass movement until substrates are fully settled. Inspection of the channel during this time will be required to monitor velocities and ensure that the form is naturalistic and representative of a tributary of this scale.

6.4 Channel planting

The channel sections shall be planted as soon as possible following construction to enable the side batters to stabilise quickly. Planting shall be strictly in accordance with planting plans and instructions from designers for the set out of individual tree specimens on the batter and upper edges. Edges of the channel base shall be planted as per planting plan with suitable semi-aquatic macrophytes to stabilise the channel form and create a natural form.

6.5 Fish relocation

Once stream channels have been constructed and planted the wetland system will be brought online to enable construction of the high flow bypass. At this time, relocation of any fish within the existing Groom Creek channel may be required in accordance with consent conditions. Where relocation is required, live transfer to the new channels/wetland is supported assuming that trapping and transfer complies with industry best practice relevant to the species present. Macroinvertebrates, natural algae communities and sediments will be flushed into the new channels sections from the upstream catchment.

7.0 Wetland Hydraulic Connections

To respond to the existing site levels and with the intent to integrate the wetland without excessive earthworks, the wetland has been designed as two cells with 500 mm difference in permanent water level. These are connected with a small rock 'chute' which is integrated with a weir which also supports stepping stone access across the wetland. The construction of these connections is critical to ensure that the wetland functions as intended. This includes the coverage of the impermeable lining which must be carefully defined to support wetland function. The detailed specification relating concrete weir elements are covered in Section 9.0. This section covers functional requirements related to elements which influence hydraulic function.

7.1 Liner extents

Geosynthetic Clay Liner (GCL) shall be installed in accordance with Section 4.3 and as shown on the drawings. The edges (upper extent) of the liner are especially important to ensure that the wetland functions as intended and maintains its water level between rainfall events. The liner must therefore extend to the nominated operational water level (51.5 in upper cell and 51.0 in lower) around the entire perimeter with any localised low points increasing the risk of uncontrolled water lose. Similarly the liner should not extend too far above this level to enable peak flows to engage the littoral zones around the wetland edge and contribute to shallow groundwater on the floodplain. As per Section 1.5 the liner shall therefore extend no more than 50 mm above the operational water level. This shall be achieved by taking surveyed levels and trimming to suit prior to covering the liner.

Where the liner abuts structures (weir between wetland cells) care must be taken to ensure that the liner is securely fixed against the structure and supported with hand placed tight rockwork.

7.2 Upper wetland weir connection

The operational water level of the upper wetland is controlled entirely by the weir structure which also forms the support for the stepping stone crossing across this section. The weir must therefore be constructed with attention to the finished level, footing conditions (to avoid settlement) and consolidation of side flanks (to avoid any risk of short circuiting). The weir can be cast in situ or pre-cast with verification of the level required in accordance with Section 1.5. Placement of the stepping stones must not result in further settlement with a need to partially support the stepping stones on rock extending on the downstream side of the weir. The selection of the stepping stones must support this placement.

7.3 Lower wetland outlet

The outlet to the lower wetland is less formalised and does not include any structural elements. Rather it is to be formed by lapping the liner to the required level (RL 51.0) over a bund of compacted basecourse prior to placement of the confining layer. The cannel downstream of this is unlined and water shall be able to infiltrate into the in-situ alluvial gravels over this reach.

8.0 Wetland Diversion Forebay and Culvert

8.1 Forebay construction

The forebay shall be formed strictly in accordance with the drawings including the batters, base grades, maintenance access and transition to culvert. Survey of all as-built levels will be important as the basis for ongoing monitoring of coarse sediment deposition to inform scheduled removal.

8.2 Diversion culvert

The diversion of frequent flows into the wetland system will be controlled by the pre-cast concrete box culvert. The upstream inlet to the culvert shall be throttled with a fitted steel plate to restrict inflows whilst passing frequent flows to support viable fish passage. The steel plate shall be a hot dipped galvanised 5 mm steel plate precision cut to form the required opening. Threaded M10 stainless steel lugs shall be fixed to the culvert surround and fixed with an approved waterproof adhesive. The diversion plate shall then be fitted with M10 stainless steel nuts and washers. Whilst the plate does not need to provide a watertight seal the nuts shall be hand tightened to ensure the plate remains securely fixed.

The culvert shall be installed in accordance with the drawings and based on a 200 mm set down from the finished invert height. A 200 mm high concrete nib shall be cast into the upstream end of the culvert to set the forebay water level at RL 54.50. The invert level of the culvert at this point will therefore be RL54.30 with 200 mm of washed alluvial gravels providing 200 mm of gravel substrate within the culvert. Intermittent larger diameter (~200 mm) alluvial rocks shall be fixed to the culvert floor using an appropriate high strength mortar or adhesive. These shall be at approximately 1 metre centres with the gravels placed around these fixed rocks.

The culvert shall be founded on compacted basecourse in accordance with manufacturer's specifications within a trench cut across the existing forestry road and cycle path (which will need to be closed for the duration of culvert installation). The culvert trench shall be infilled immediately following construction with the track reformed over the top to reinstate the access and cycle path. The upstream and downstream headwalls shall be formed with hand placed angular rock (~350 mm diameter) placed to form a tight matrix to prevent scour and undermining of the culvert structure. Care shall be taken to fill voids with basecourse during placement of the rock protection to reduce the risk of scour behind the rock.

8.3 High flow bypass weir

The high-flow bypass weir supports the conveyance of flows which exceed the treatment capacity of the wetland. The weir is engaged when the water level in the forebay rises in response to the restricted culvert inlet. The bypass weir distributes flows across a broad 7 m weir crest to manage peak flows with minimal backwater impacts upstream. Downstream of the bypass, the channel shall be shaped to concentrate flows back into the existing downstream channel for conveyance to the existing confluence with the Maitai River. The channel downstream of the existing shared path bridge crossing will remain unchanged but shall only be engaged to convey peak flows.

The crest height of the weir is critical and it is important to ensure that the crest is level across the full width at the required elevation (RL 55.0). Following construction the weir crest shall be surveyed and in the instance that it is not constructed in accordance with the Drawings it will require localised levelling which could be achieved by remedial works to form a new crest or the use of a concrete saw to cut/grind back to the required invert.

Flanks of the bypass weir must be well keyed into the sides of the channel to provide a watertight seal and ensure that piping does not result in uncontrolled scour or erosion. Where suitable site sourced material (clay) is not available the use of important bentonite sealant shall be used to form seal.

8.4 Rock protection

Rock protection is included adjacent to hydraulic structures in the forebay. This includes both sides of the bypass weir and entry to the diversion culvert. All rock must be installed as per the Drawings and Engineer's direction. All rock must be hard-wearing angular rock and be hand placed to achieve an interlocking matrix. Care must be taken to key rock into the underlying ground (or 50 mm blanket of course sand) as required to form stable and solid protection.

8.5 Biodegradable Erosion Matting

Biodegradable erosion protection will be used on all batters around the high flow bypass and diversion to stabilise the slopes until such time as plants establish. The proposed product must be approved by the Engineer prior to procurement.

Erosion matting will comprise an open weave jute mat or other approved product and will be manufactured using 100% natural fibre which will biodegrade in no more than 2 years. The matting will comprise open weave to enable rhizomatous plants to spread across the batters and to reduce the risk of the matting lifting off through plant growth which can cause water to pull away large sections.

All matting will be well secured using non-galvanised steel pegs. Pegs will be sized to provide a sound hold in the site materials and will not be subject to movement without considerable force. Pegs will be fixed at 250 mm centres along all joints and the base and at a 1 m grid along the remainder of the face. Panels will always be placed with joins perpendicular to the flow direction with a minimum of 500 mm overlap. The upstream panel will always overlap the downstream panel.

Plants will be planted through the matting with the minimum amount of cutting of mesh fibres to enable the plants to be installed.

9.0 Concrete work

9.1 General

This Specification sets out generally the requirements for reinforced and mass concrete for use in the concrete weir structures. This includes the main diversion weir, then upper wetland control weir and any other concrete placed as part of the construction.

The concrete shall be in accordance with this specification and all relevant New Zealand Standards, in particular NZS 3109:1997 Concrete Construction. The Contractor shall be familiar with these standards and adhere to them at all times. Any uncertainty with any aspects of the specification or design must be raised with the Engineer at the earliest convenience.

9.1.1 Ready Mixed Concrete

Ready mixed concrete will be accepted provided that it complies in all respects with the requirements of this specification and NZS 3109:1997 Concrete Construction. The maximum time between mixing and placing of each batch of concrete shall not exceed 60 minutes in spite of the use of retarders.

Delivery dockets are to be retained by the Contractor for each batch of concrete delivered and be made available to the Engineer upon request.

No water or other materials are to be added to the concrete at site without approval.

9.1.2 Setout & Formwork

All formwork and setout is to be inspected by the Engineer prior to the installation of the concrete weir sections.

Locations for construction joints (including stages in weir construction) are to be confirmed on site with Engineer.

All formwork is to be straight, true to line and free from defects, warping and inconsistencies. Formwork is to be strong and well secured to retain line and level during and after pour.

9.1.3 Formwork

Formwork shall conform to relevant New Zealand Standards so that concrete, when cast in the forms, will have the dimension, shape, location and surface finish required by the Contract.

The Contractor shall be responsible for the sufficiency of the formwork.

If the formwork fails to meet the requirements of the Contract, the Engineer may reject it and any concrete which has been cast in it. In this case the Contractor shall at his own cost remove the rejected concrete, form construction joints, reconstruct the formwork and recast the concrete.

The time determined by the Contractor for removal of forms shall be subject to the approval of the Engineer. The Contractor shall exercise extreme care to avoid damage during stripping operations. Damage sustained to any part of the structure or member shall be repaired or replaced at the Contractor's expense to the satisfaction of the Engineer.

9.1.4 Steel reinforcement

Reinforcement shall be 668 L steel mesh folded to shape and placed with spacers to ensure that a minimum of 50 mm clearance between the mesh and formwork is achieved throughout. All overlapping

mesh sheets shall be securely fastened together with wire. Where the weir is constructed in two stages, reinforcing mesh shall extend beyond the first section by at least 500 mm to enable tie into the second section.

Reinforcement shall be free from loose mill scale, excessive rust, dirt, coatings, pitting, kinks and other defects prior to concrete placement.

9.2 Handling and placing concrete

The placement of any concrete shall not be commenced until the Engineer or their representative has inspected and approved the foundation material, formwork, reinforcement etc., against which the concrete is to be placed. The Contractor shall give 24 hours' notice to the Engineer prior to placement of concrete.

Concrete shall not be mixed or placed if, in the opinion of the Engineer, the existing weather conditions or the forecasted conditions are such that this could have a detrimental effect to the concrete and finished works.

No concrete shall be deposited on a wet subgrade.

In preparation for the placing of concrete, all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the forms in correct shape shall be completely removed from the forms when the concrete reaches a level which renders them necessary.

Concrete shall be conveyed and deposited as quickly and as close as possible to its final point of discharge in one continuous operation without interruptions until completion of the scheduled pour. Concrete shall be placed so as to avoid segregation of the materials and displacement of the reinforcement.

9.2.1 Compaction of concrete in the forms

Concrete shall be compacted using approved concrete immersion vibrators and shall be done subject to the provisions listed below. The vibration shall be internal.

- Vibrators shall be of an approved type, capable of transmitting vibration to the concrete at frequencies of not less than 6000 cycles per minute.
- The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms.
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms. Vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration to thoroughly compact the concrete but shall not be continued so as to cause segregation.
- Vibrators shall not be applied directly, or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration.
- Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with vibrators.

9.2.2 Curing

Curing procedures shall conform to relevant New Zealand Standards. The Contractor shall protect fresh concrete from premature drying and excessive hot or cold temperatures. Maintain the concrete at a reasonably constant temperature with minimum moisture loss for the curing period.

9.2.3 Protection

The Contractor shall protect the finished concrete from damage due to load over stresses, heavy shocks and excessive vibrations, particularly during the curing period.

The Engineer may request the provision of adequate covers to protect the concrete from adverse weather conditions during the curing period.

Any damage to work caused by failure of the Contractor to provide adequate protections shall be rectified to the satisfaction of the Engineer.

All forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods herein after specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete the Engineer shall order work stopped until the defects have been corrected.

9.3 Placement of fill batters

Once the concrete weirs are cured and formwork removed, earthworks can create the required batter slopes and transitions into the existing ground. Fill batters on the transition on either side of the high flow bypass weir shall be constructed with well compacted site soils free from organic materials, rubble or other imported materials. Material shall be compacted in 200 mm vertical layers with a suitable vibrating plate compactor. Care must be taken around the concrete weir structures to avoid any damage. Both sides of the batter shall be constructed at the same time to prevent differential loading on one side of the weir which could cause rotation or failure. Attention to levels must allow for the placement of overlying rock and topsoil on the batter slopes.

10.0 Planting Specifications

The Contractor shall source and supply specified plants which are in a healthy condition at the time of planting. The Contractor is required to liaise directly with the nursery regarding the timing of the delivery to site. Assessment and final approval for planting will be at the discretion of the wetland designer (Morphum). Plants shall be handled and planted to avoid any damage to the plants condition. Plants shall be planted to ensure that the entire root mass is buried and the ground around each stem shall be gently compacted following planting. Soils shall not extend above the base of the stems of the plants.

All plants for the wetland, and areas subject to inundation, shall be supplied as established potted plants and shall not be supplied as large conglomerate clumps to be 'broken up' or as plant material transplanted from other natural or planted areas. Planting shall be in strict accordance with the Drawings and plant lists. Attention shall be taken to ensure that a uniform density of plants is achieved across the entire area with planting zones as documented in the drawings. Distribution of plants is intended to provide ecological structure, diversity and visual amenity. The Contractor must discuss the layout with the Engineer prior to planting. The plants species and numbers are shown on the Drawings and associated planting lists.

All plants shall be hand planted with care taken to ensure that the base of the plant stems is not above the surrounding ground level and that plants are securely in the ground without risk of lifting following planting. An inspection shall be made by the Engineer or their representative following completion of planting to ensure that vegetation has been planted in such a manner as to ensure successful establishment and as per the intended design. Any plants deemed to be unsatisfactorily planted shall either be replanted or replaced.

10.1 Wetland Plants

The shallow and deep marsh sections of the wetland (as shown on the Drawings and planting lists) will be planted with a finished density of 4 plants/m^2. Planting shall be in strict accordance with the planting plan in the Drawings. Attention shall be taken to ensure that a continuous ring of plants are achieved at the normal water level (51.5 in upper wetland and 51.0 in lower).

The wetland shall be filled to 250 mm below the normal water level immediately following the planting to ensure that all plants are within (or have ready access to) water within 6 hours of planting.

An inspection shall be made by the Engineer or their representative following completion of planting to ensure that vegetation has been planted in such a manner as to ensure successful establishment and as per the intended design. Any plants deemed to be unsatisfactorily planted shall either be replanted or replaced at the Contractors expense.

10.2 Littoral edge planting

The immediate edges of the wetland (extending to 500 mm above the normal water level) will be inundated regularly during rainfall events and will remain largely wetted between events when wetland maintained at the normal water level. These variable edge batters are to be planted with a density of 4 plants/m^2 in accordance with the planting plans and lists.

All plants shall be hand planted with care taken to ensure that the base of the plant stems is not above the surrounding ground level and that plants are securely in the ground without risk of lifting following planting. An inspection shall be made by the Engineer or their representative following completion of planting to ensure that vegetation has been planted in such a manner as to ensure successful establishment and as per the intended design. Any plants deemed to be unsatisfactorily planted shall either be replanted or replaced at the Contractors expense.

10.3 Harakeke planting zone

The area on the south side of the upper wetland shall be planted in a mixed palette of Phormium (Harakeke) species selected to provide habitat, amenity and a long term source of suitable weaving material for productive uses. Specific species, provenance and planting details shall be in accordance with instruction from iwi representatives. Harakeke shall be planted at a density of 1/m^2.

10.4 Riparian and terrestrial planting

Areas around the immediate perimeter (above the 52.0 level) shall be planted with terrestrial species suited to the moist conditions. These will provide biodiversity benefits and amenity and will complement the existing regenerating native vegetation in the area. These will include a mix of low sedges/rushes, shrubs and trees. Trees will be positioned to provide shade around the open water pool and the northern aspect of the wetland. The layout must consider the expected growth form of respective species and the importance of maintaining site lines and the principles of CPTED. In general terms these areas will be planted with a density of 4 plants/m^2 (sedges/rushes) with select trees positioned as directed by the Engineer or their representative in accordance with the planting plans and lists.

All plants shall be hand planted with care taken to ensure that the base of the plant stems is not above the surrounding ground level and that plants are securely in the ground without risk of lifting following planting. An inspection shall be made by the Engineer or their representative following completion of planting to ensure that vegetation has been planted in such a manner as to ensure successful establishment and as per the intended design. Where possible the staking of trees shall be avoided to enable the trees to develop a strong and natural form which responds to prevailing conditions.

Any plants deemed to be unsatisfactorily planted shall either be replanted or replaced at the Contractors expense.

10.5 Reinstatement of grassed areas

Disturbed areas not identified for planting shall be reinstated with hand cast pasture grass using Council approved seed mix. Disturbed ground shall be levelled and smoothed off and lightly compacted to prevent uneven settlement and potential depressions and excessive undulations. Seed shall be applied at a rate of 50g/m^2 with an even coverage achieved. Supply and mix of seed shall be confirmed with Council prior to procurement and application. Depending on the timing of seed application, initial watering with water truck may be required to support germination. Allowance shall be made for mowing grass up to two times during initial 12 month establishment to promote vigorous growth.

10.6 Pest control

Protection of plants from damage from pest species will be important. Pests are likely to include rabbits, birds (waterfowl including pukeko, ducks, geese and weka), stock and feral goats. Terrestrial plants (shrubs and trees) will require plastic tree guard sleeves to protect from rabbits. Protection of wetland plants from damage from birds (uplifting or grazing of new shoots) will likely require considered management of birds. This could include the use of bird scarers, overhead deterrents or with approval temporary relocations.

10.7 Permanent fencing

Following the completion of construction works the top edge of the batter to the forebay shall be fenced to reduce the risk to cyclists in this section where the batter is in close proximity to the public path. The

extent of fencing shall be as shown on the Drawings and shall be staked out for Engineer approval prior to construction.

Fencing shall comprise a standard 5 wire 'farm style' post and wire fence comprising H5 treated strainer posts, galvanised 8 gauge wire and H3 timber rails. Allowance must be made for an appropriately qualified/experienced fencing contractor to undertake works.

11.0 Establishment and Defects Period

11.1 Wetland engagement

Following construction and planting of the wetland areas, water shall be diverted through the diversion culvert and allowed to fill the wetlands to normal water level. Once this level is achieved (and held) the culvert shall be temporarily blocked off (sandbags) to prevent further inflows. The water level within the wetland cells shall then be drawn down (pumped or siphon) to 250 mm below the normal water level as directed by the Engineer.

Depending on the size of vegetation at the time of planting and the timing of planting, the inlet culvert shall remain blocked off until such time that the plants establish. The inlet culvert shall not be fully opened until instructed by the Engineer.

11.2 Vegetation Maintenance

Following construction, the vegetation will require additional maintenance for a period of 24 months. Allowance shall be made for regular inspections, initial hand weeding and replacement of any unhealthy plants. It is likely that filamentous algae will initially grow within the wetland in response to the saturation of organics within the submerged topsoil. Whilst entirely natural and harmless, the algae can be manually removed using rakes and nets or alternatively left to naturally subside (generally after first summer).

APPENDIX A; Construction Drawings

APPENDIX B; Bentofix GCL technical specifications

APPENDIX C; Test Pit Investigations