APPENDIX C
EDITH CAVELL REHABILITATION
RESTORATION PLAN

REPORT

Parks Canada Agency
Jasper National Park of Canada

Edith Cavell Rehabilitation
Restoration Plan
2015-3498

February 2017

ISO 9001 and 14001 Certified | An Associated Engineering Company

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1 Introduction

Associated Environmental Consultants Inc. (Associated) has prepared this Restoration Plan for the Mount Edith Cavell Rehabilitation project (the project). This Plan outlines the methods for restoring vegetation at the project site, following construction activities.

Infrastructure at the base of Mount Edith Cavell was damaged in 2012 by a surge of water created by the calving of Ghost Glacier into Cavell Tarn below. Damaged infrastructure includes the parking lot, Cavell Road, and lower trails. With the planned rehabilitation, several long-term upgrades to the area are proposed as follows:

- Expand the parking area by constructing a new parking lot north of the existing parking lot.
- Re-route Cavell Road near the parking lot to avoid the geohazard zone to the west and abandon the portion of road in the geohazard zone; culverts will be required for water drainage.
- Construct a new trail connecting to the existing Cavell Meadows Trail.
- Repair the existing trail network.
- Construct a new scenic viewpoint and access trail.
- Install barricades and site furniture at the existing lookout.
- Construct two to three outhouses at the parking lot.

The area to be disturbed for construction is approximately 1.0 ha. The new Cavell Road will be approximately 0.2 ha, and the new parking lot, approximately 0.3 ha. The remaining area to be restored will be approximately 0.6 ha. Various restoration approaches will be used within the area including: maintenance of existing vegetation (protected tree zones) in areas south of the new parking lot, use of native soils throughout the area, installation of trees and shrubs, and establishment of microhabitats that support native species diversity.

This Plan follows the requirements outlined in the Basic Impact Analysis (Associated 2016a) and the concepts outlined in the Erosion and Sediment Control (ESC) Plan (Associated 2016b) developed for the project.

2 Site Description

The project is located in the Subalpine Ecoregion (Holland & Coen 1982), more specifically, within the lower and upper subalpine. The following habitats were documented by Belland et al. (2001), as arranged from lowest to highest elevation:

- Outwash plain of Cavell Creek
- Moraine
- Moraine/trail
- Subalpine forest
- Upper subalpine/alpine

Trail work is proposed in the moraine and moraine/trail habitats. The moraine includes the lateral moraines that originated when Angel Glacier filled the Cavell Valley, comprising mainly Gog quartzite with variable sized boulders and smaller particles. The moraine is sparsely vegetated except along the Teahouse and Cavell Tarn Creeks, and in seepages dominated by willows (Belland et al. 2001). In some sections, trails traverse the moraine and create a distinct habitat characterized by its snowbeds and seepage.

The parking lot and road improvements will be constructed in the subalpine forest where dominant trees include Engelmann spruce (*Picea engelmannii*), white spruce (*P. glauca*), subalpine fir (*Abies bifolia*), and lodgepole pine (*Pinus contorta*). Shrubs in the parking lot area primarily include Drummond's willow (*Salix drummondiana*), rock willow (*S. vestita*), and grouseberry (*Vaccinium scoparium*). The understory is characterized by moss and lichen covered ground, downed trees, with several forbs and some graminoids.

3 Goals and Objectives

The overall goal of the project is to restore areas disturbed during construction of the parking lot and Cavell Road by establishing native plants and site conditions that allow natural processes to place the site on a trajectory towards native forest and shrub communities similar to the adjacent undisturbed areas. Ecological restoration is the process of initiating or accelerating the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2004). This is achieved by ensuring key components of the natural ecosystem are present such as native plants, topsoil salvaged from the site, and woody debris and by eliminating factors that can inhibit recovery such as weeds and soil erosion.

Revegetation of the site is approached in two ways: 1) active revegetation, which involves the installation of plant materials to establish plant growth; and 2) natural revegetation, which allows plant establishment to recover over time without planting.

This Plan focuses on the new parking lot and Cavell Road as shown in the site plan (**Appendix A**). These areas will be actively revegetated. The moraine is sparsely vegetated and without soils; as such restoration of the trail area will be via natural revegetation and placement of salvaged sod if available and location appropriate.

The objectives for vegetation restoration are as follows:

1. Establish a native forest community with areas of rock landscape.
2. Include whitebark pine (Pinus albicaulis) in restored native forest areas.
3. Establish willows through live-staking in ditches and seeps along slopes.
4. Create a variety of microhabitats to support native species diversity by using locally salvaged topsoil and placing it through restoration area in a rough and loose soil configuration.
5. Prevent the establishment of weeds in restored areas.

4 Restoration Schedule

Timing of revegetation and restoration activities is important due to the short growing season in the Subalpine Ecoregion. Ideal planting windows will be captured to the extent possible and based on the project schedule. Construction activities will be completed over three construction seasons and influenced by regulatory timing windows (i.e., migratory bird breeding period and Delayed Access Period for protection of woodland caribou) and logistical factors including the closure of Cavell Road during winter.

Table 4-1
Restoration Schedule

Restoration Phase	Dates	Tasks
Initial Revegetation	2016 (fall)	· Clearing, grubbing · Topsoil salvage
	2017 (summer and fall)	· Construction of parking lot and Cavell Road · Replacement of salvaged topsoil via rough mounding · Seeding of salvaged topsoil upon replacement
Long-term Restoration	2017 (fall)	· Spread of coarse woody debris over salvaged topsoil
		· Installation of log pond sediment control devices
	2018 (spring and summer)	· Planting of trees and shrubs · Establishment of vegetation from seedbank contained in salvaged topsoil

5 Selection of Plant Materials

5.1 TREES AND SHRUBS

Tree will include species found at the project site where tree clearing is planned. Trees may include Engelmann spruce, subalpine fir, white spruce, lodgepole pine, and whitebark pine.

Recommended species for willow cuttings are Drummond's willow (*Salix drummondiana*) and smooth willow (*S. glauca*), which are present at the project site. The source of cuttings must be approved by PCA.

Other shrub species suitable for planting at the site include dwarf bilberry (*Vaccinium caespitosum*), tall bilberry (*V. membranaceum*), grouseberry (*V. scoparium*), rock willow (*Salix vestita*), green alder (*Alnus viridis*), and common bearberry (*Arctostaphylos uva-ursi*).

All plant material installed at the site will include native species with local provenance. The site includes two seed zones, including Subalpine (SA) 1.2 and SA 2.2. material that does not originate from these seed zones will require approval by PCA.

For any seed collected at the site during 2016 and 2017, the nursery can provide 1 year old seedlings for transplanting during 2018. However, 2 to 3 years is often required to allow sufficient time to collect seed and propagate native species. Therefore, availability of existing seed or nursery stock collected from the same seed zone may dictate the final species list as well as the size of plant material to be installed.

Landscape drawings in **Appendix A** provide a list of species to be installed including their locations and spacing. These draft landscape drawings will be updated, and the contractor will be responsible for ensuring that final approved plans are used during installation.

5.2 GRAMINOIDS AND FORBS

The planting of graminoid (grasses, sedges, and rushes) and forb species is not planned. Topsoil that was salvaged from Cavell Road and parking lot area contains native seedbank and will be placed throughout the restoration areas. Grass seed mixes are widely used in revegetation projects but are known to reduce species diversity. Establishment of a dense grass cover will create significant competition for native forbs and graminoid species in the seedbank, and also has potential to provide competition to planted trees and shrubs.

Maximum species diversity is achieved by allowing the native seedbank to germinate without introducing competition that is not naturally present in this environment. Therefore, a seed mix is not planned for the site. A diverse community of forbs, grasses, sedges, and rushes will become established through the seedbank contained in the topsoil.

5.3 BRYOPHYTES

The presence of bryophyte species (mosses) is strongly influenced by the available microhabitats. As such, transplantation of mosses is not a common practice and relevant research documenting its success is limited.

Specific requirements for each species relevant to microhabitat include attributes such as moisture, slope, light exposure, and growing medium (e.g., fallen trees, coarse woody debris). Transplanting living moss from an undisturbed site to the restoration site may be especially problematic due to the early successional stage that will be initially present throughout restoration areas, and the lack of microhabitats similar to undisturbed areas.

Creating site conditions that allow natural processes to progress towards a diversity of microhabitats will provide opportunities for the establishment of mosses. On June 29, 2016, an Associated bryologist identified 36 moss species in the parking lot area, primarily growing under dense tree canopy on decaying wood. Re establishment of moss species is expected to occur over time through the establishment of

microhabitats similar to pre-disturbance conditions. This includes established trees that will provide shade, and topographic heterogeneity from rough and loose soils that will create a variety of microhabitats

6 Restoration Plan

6.1 TOPSOIL SALVAGE

Topsoil will be salvaged, stockpiled, and preserved for use in re-establishing native vegetation. The local topsoil stripped during initial site operations contain a seedbank of native plant species, and as such is the preferred medium for establishing plant growth on disturbed areas.

Following final grading, topsoil will be spread using a minimum of 100 mm over all ditch surfaces between the new parking lot and existing Cavell Road, the side slope, in areas where subsoil is exposed.

Topsoil will be placed in a rough and loose soil configuration throughout restoration areas following concepts described in the Northern Alberta Institute of Technology – Boreal Research Institute technical note on rough mounding (**Appendix B**). Initial vegetation establishment will rely on the native seed bank contained in the topsoil. Topsoil mounds may range from 100 mm to 400 mm in depth.

6.2 SOD MAT SALVAGE

Plant establishment will be an extremely slow process due to issues such as the lack of topsoil, the short growing season, the minimal number of frost-free nights, and the high exposure to wind. All earthwork on new trails will be done by hand and disturbance will be minimized. Sod mats will be salvaged where possible, when the ground is completely thawed, likely in early summer or later. Storage of the sod mats will be directed by PCA. Sod mats will be installed as available along the new trail sections where grading is required in vegetated areas.

6.3 WILLOW STAKING

Live willow stakes will be installed in ditches and where seeps occur along slopes. Live staking is a soil bioengineering technique that creates a living root mat that will stabilise soil and withdraw excess soil moisture. A guideline entitled Live Staking and Joint Planting, published by the Contra Costa Clean Water Program and Urban Creek Council, includes installation methods (**Appendix C**).

Willow stakes to be installed will be cut locally or from a similar ecosite. Cuttings will be made during the dormant season (i.e., after leaf fall and before bud break). No more than 10% of a plant and no more than 10% of the willows in an area will be harvested (L. Shepherd, personal communication, 2015). For the best chance of survival, willow stakes will be installed during early spring, prior to budding, in thawed soil that remains moist. If stakes cannot be installed immediately, they will be propagated into plugs immediately following collection.

Willow staking will include live silt fences in ditches or other drainage channels where moisture is likely to concentrate. Live silt fencing consists of rows of cuttings installed perpendicular to the direction of water flow and can act to reduce velocity and trap sediment even before they begin to grown.

Willow staking along seeps will include, but not be limited to, log pond sediment control structures, designed to create microhabitats. These structures will be located on the slope east of the new Cavell Road in areas with the greatest groundwater seepage. These features will include coarse woody debris and willow stakes along the base of each structure, designed to create three shrub islands. This will promote shrub communities without creating a continuous shrub cover. Refer to Section 6.6 below and the Edith Cavell Rehabilitation Erosion and Sediment Control (ESC) Plan for additional details.

6.4 TREE AND SHRUB PLANTING

Trees and shrubs will be installed in clumps of the same species in a manner that mimics natural native plant communities. Coniferous trees will be planted in mixed stands throughout the restoration areas. Seedlings will be planted at 2 or 3 m spacing.

Willow cuttings will be installed in ditches and at each log pond sediment control structure, and other locations on slopes or at the toe of slope where groundwater seepage is observed. The methods associated with collecting, soaking, and installing cuttings are critical to their survival. Oversight by personnel with relevant experience is necessary to ensure success. Additional information on willow cuttings is provided in **Appendix C**. Willows for live silt fence and log pond sediment control structures will be installed at 10-15 cm spacing. Other shrub species will be installed at approximately 1m spacing.

6.5 COARSE WOODY DEBRIS PLACEMENT

Coarse woody debris will be placed on the ground within tree planting areas. Downed woody debris is a natural feature of terrestrial and aquatic ecosystems and is an important component of this restoration plan due to its benefits including:

- Creation of microhabitats;
- Ability to improve soil biology;
- Support of nutrient cycling and moisture retention; and
- Function to control erosion.

Woody debris placement will focus on ensuring that downed trees are left intact, and placed on the ground around planted trees. Woody debris will be installed at a minimum quantity of 50 m^3/ha but can include up to 200 m^3/ha. Exact quantity shall be based on material that is available at the site.

6.6 LOG POND SEDIMENT CONTROL STRUCTURES

Log pond sediment control structures will be constructed at three locations on the cut slopes east of the new Cavell Road. These structures will incorporate natural materials (primarily logs) to promote ponding of water in moist areas along the slope. The design of these structures will include cover logs to promote the

development of moist and protected microhabitats similar to those typically found throughout the region under large downed woody debris. Live staking installed as a fence with willow stakes spaced 15 cm apart will also be used to stabilize soils, and biodegradable geotextile will be incorporated to provide additional sediment retention benefits. To maximize the benefit to soil bioengineering, each structure will be field-fit into the local topography to intercept surface drainage. Specific details regarding the design and construction of log pond sediment control structures are shown in the landscape drawings in **Appendix A** and described in the project ESC Plan.

6.7 ROCK PLACEMENT

Boulders made available during excavation at the site will be placed within planting areas around the new parking areas. Details and locations are provided on landscape drawings.

The moraine area located south of the new parking area includes a large rock pile that can be spread out around the vicinity of the reclaimed roadway. Exact quantities and locations of material will be determined on site under supervision of the Environmental Surveillance Monitor.

7 Irrigation

Installed plants will be monitored and watered by the contractor as necessary to reflect normal site conditions. Willow cuttings associated with log pond sediment structures may require watering on a weekly basis during the first growing season if rainfall or natural seeps do not provide necessary soil moisture for cuttings to become established.

The contractor will inspect installed plants several times during the growing season to ensure adequate moisture is available for plants to become established. PCA will routinely monitor plant material following completion of the project, and ensure adequate watering of plant material is taking place.

8 Fertilization

Fertilizing native species is not recommended because of its potential to stimulate growth of non-native species. In some cases, high nutrients favour weed growth, whereby native species are more tolerant of low nutrients than weeds.

While it is not recommended for use, allowance for fertilization can be made. If the contractor responsible for plant installation should deem it necessary to fertilize upon planting, one initial fertilization is permitted by PCA. The product name and safety data sheets should be provided to the Environmental Surveillance Officer prior to use.

9 Soil Stabilization

On slopes and areas not included in the ditch, topsoil will be distributed using a rough mounding technique to promote microclimate zones, erosion control, seed growth, and water retention. Rough and loose surface treatment will take place as described in the technical note on soil rough mounding (**Appendix B**).

Additionally, coarse woody debris will be spread throughout the site as described in Section 6.5 and will consist of logs and branches. Coarse woody debris is beneficial for achieving restoration goals as this debris creates pockets of shade, aids in retention of moisture, and creates microhabitats that support greater biodiversity (Pyper and Vintage 2012). Soil stabilization measures are discussed in further detail in the ESC Plan.

10 Monitoring and Reporting

10.1 MONITORING PROGRAM OBJECTIVES

Restoration activities will be monitored by PCA and the Environmental Surveillance Officer. A post-construction reclamation monitoring plan will address performance indicators, contingency measures, and replacement requirements. An adaptive management approach is necessary to manage risk to plant survivorship and may be based on conditions at the site including weather, post-construction site hydrology, and other unforeseen factors.

10.2 WEED CONTROL

Invasive weed species are a significant concern because non-native seeds or plant material can be brought to site either as a contaminant in soil associated with nursery stock or via vehicles, footwear, equipment, or tools associated with the construction works. All vehicles and equipment must arrive clean and free of soil and vegetative debris to avoid the introduction and spread of weeds.

Tall buttercup (Ranunculus acris) is a noxious weed that was observed near the outhouse at the existing parking lot during a site visit in June 2016. Weed control for the project must include active monitoring and management to avoid the establishment and spread of this species in the newly disturbed area.

A contractor will be responsible for hand-pulling weeds twice in July and twice in August of the first two growing seasons following plant installation. Weeds include any species listed as exotic on the Alberta Conservation Information Management System (ACIMS) [1]. When removing weeds, care will be taken to ensure all parts of the plant including roots are removed. Responsible personnel will have knowledge and expertise to identify plant species.

[1] www.albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-acims/download-data

11 Closure

This Restoration Plan was prepared by Associated Environmental Consultants Inc. for application in the Edith Cavell Rehabilitation project. Following review and comment period, a final version of the Plan will be developed and issued for use.

This Plan was prepared by:

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This Plan was reviewed by:

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Regional Manager, Senior Environmental Scientist
Associated Environmental Consultants Inc.

12 References

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Appendix A – Site Plan

LEGEND

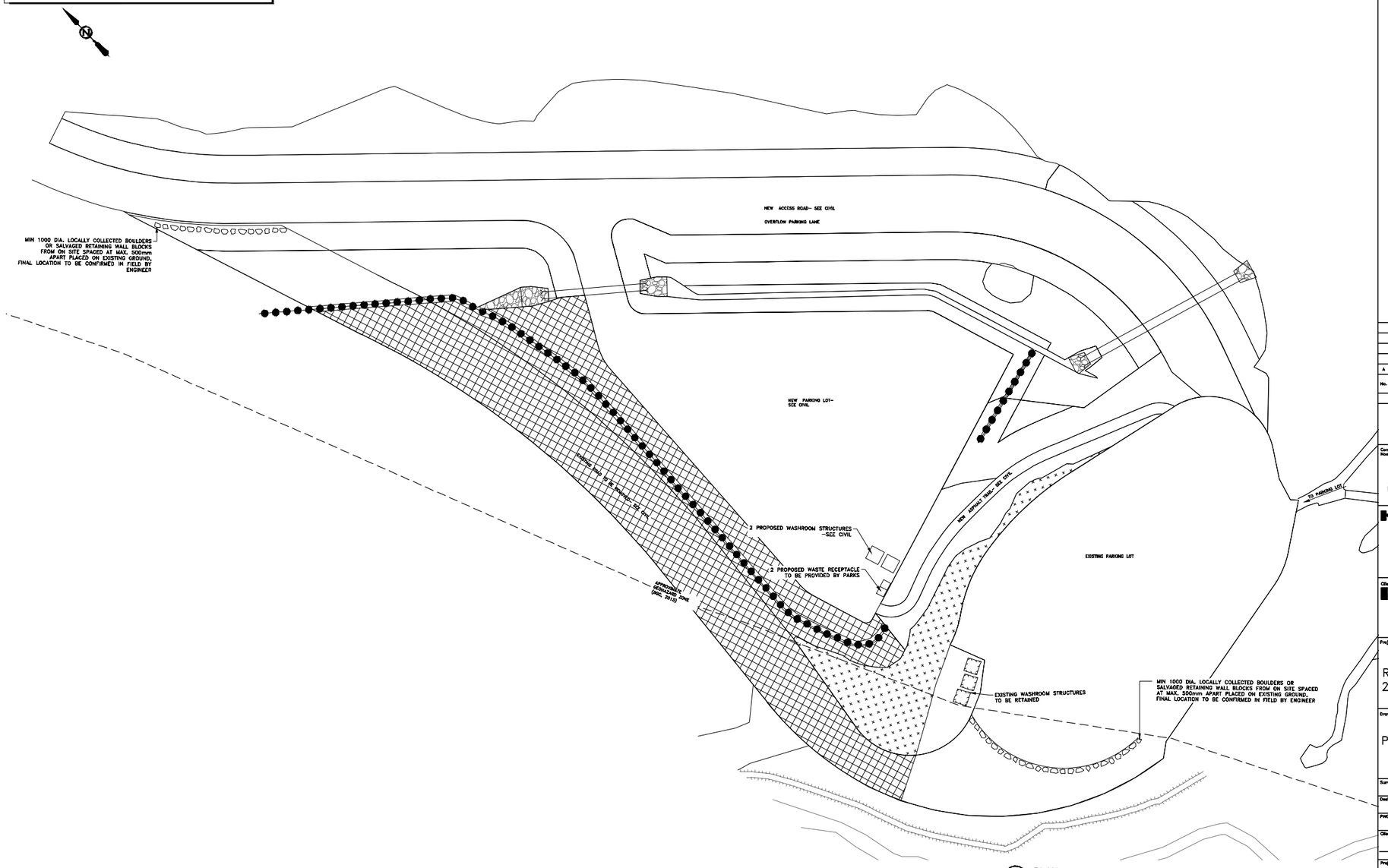
EXISTING VEGETATION TO BE PROTECTED/RETAINED
SEE DETAIL 7 ON SHEET L-07

MORRAINE RESTORATION ZONE- PLACE 100mm DEPTH SALVAGED MORRAINE MATERIAL OVER ENTIRE AREA INDICATED

LIVE WILLOW STAKING/WILLOW SILT FENCE IN DITCH - SEE DETAIL 5/ L-07

LOG POND SEDIMENT CONTROL STRUCTURE- SEE DETAIL 4/ L-07

NOTE:
- ALL LOCATIONS SHOWN ARE APPROXIMATE. ALL FINAL LOCATIONS TO BE CONFIRMED IN THE FIELD BY ENGINEER.
- NO NEW PERMANENT CONSTRUCTION TO OCCUR BELOW GEOHAZARD ZONE. WITH EXCEPTION OF BOULDER ACCESS CONTROL.
- SEE SHEET L-07 FOR COMPLETE PLANT LIST
- NEED MIN. 5m SETBACK FROM ROAD & PARKING LOTS FOR WHITEBARK PINE (RARE SPP. PROTECTED BY LAW) TO AVOID ENCROACHMENT FROM ROAD MAINTENANCE



1 PLAN
1:250
PARKING LOT RESTORATION SHEET 1

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2017TEB08	ISSUED FOR 90% REVIEW	R.R.	D.S.

Revision / Revision

A detail number
numéro de detail
B source drawing no.
de dessin no.
C detail on drawing no.
detail sur dessin no.

Consultant's Name / Nom de l'expert-conseil
Associated Engineering

Eng. Stamp / Sceau de l'ingénieur

Public Works and Government Services Canada
Client Services Team Southern Alberta Operations Branch

Travaux publics et Services gouvernementaux Canada
Le Client Entretient l'Équipe Alberta Méridional Branche d'Opérations

Canada

Client/client
Parks Canada Agency / L'Agence Parcs Canada
Western and Northern Region / Ouest et Nord du Canada

Project title/Titre du projet
MT. EDITH CAVELL
REHABILITATION CONTRACT
2 JASPER NATIONAL PARK OF CANADA

Drawing title/Titre du dessin
LANDSCAPE
PARKING LOT RESTORATION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	R.R.	2017TEB08
Designed by/Concept par	Reviewed by/Revisé par	Scale/Échelle
D.S.	R.O.	AS SHOWN

PWGSC Project Manager/Administrateur de Projets TPSGC

Client Acceptance/Acceptation du client — Name, Responsible Officer/Nom, Responsable
Approved by/Approuvé par — PWGSC Project Manager/Administrateur de Projets TPSGC

Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
718		13
Drawing Reference No./No. de référence du dessin		18
L-01		

A0 1188 x 841

LEGEND

EXISTING VEGETATION TO BE PROTECTED/RETAINED SEE DETAIL 7 ON SHEET L-07

CLOSED FOREST RESTORATION ZONE- SEE 12X12 ENLARGEMENT SAMPLE ON THIS SHEET

CLOSED FOREST RESTORATION ZONE- 5.0m ROADWAY OFFSET - SEE 5X10 ENLARGEMENT SAMPLE ON THIS SHEET

LIVE WILLOW STAKING/WILLOW SILT FENCE IN DITCH - SEE DETAIL 5/ L-07

LOG POND SEDIMENT CONTROL STRUCTURE- SEE DETAIL 4/ L-07

NOTE:
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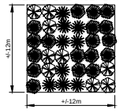
- SEE SHEET L-07 FOR COMPLETE PLANT LIST
- NEED MIN. 5m SETBACK FROM ROAD & PARKING LOTS FOR WHITEBARK PINE (RARE SPP. PROTECTED BY LAW) TO AVOID ENCROACHMENT FROM ROAD MAINTENANCE

CLOSED FOREST RESTORATION ZONE
12X12 ENLARGEMENT SAMPLE



QUANTITY	SCIENTIFIC NAME	COMMON NAME	SPACING
TREES			
9	*Abies bifolia*	Subapline Fir	2m
18	*Picea engelmannii*	Engelmann Spruce	2m
9	*Pinus albicaulis*	Whitebark Pine	2m

SUBALPINE FIR
ENGELMANN SPRUCE
WHITEBARK PINE

* THIS LAYOUT IS REPRESENTATIVE ONLY OF A TYPICAL 12mX12m AREA OF TREE PLANTING WITHIN THE CLOSED FOREST RESTORATION ZONE. QUANTITIES ON THE PLANT SCHEDULE TAKE PRECEDENCE OVER THIS LAYOUT.

CLOSED FOREST RESTORATION ZONE - 5m ROADWAY OFFSET
5X10 ENLARGEMENT SAMPLE

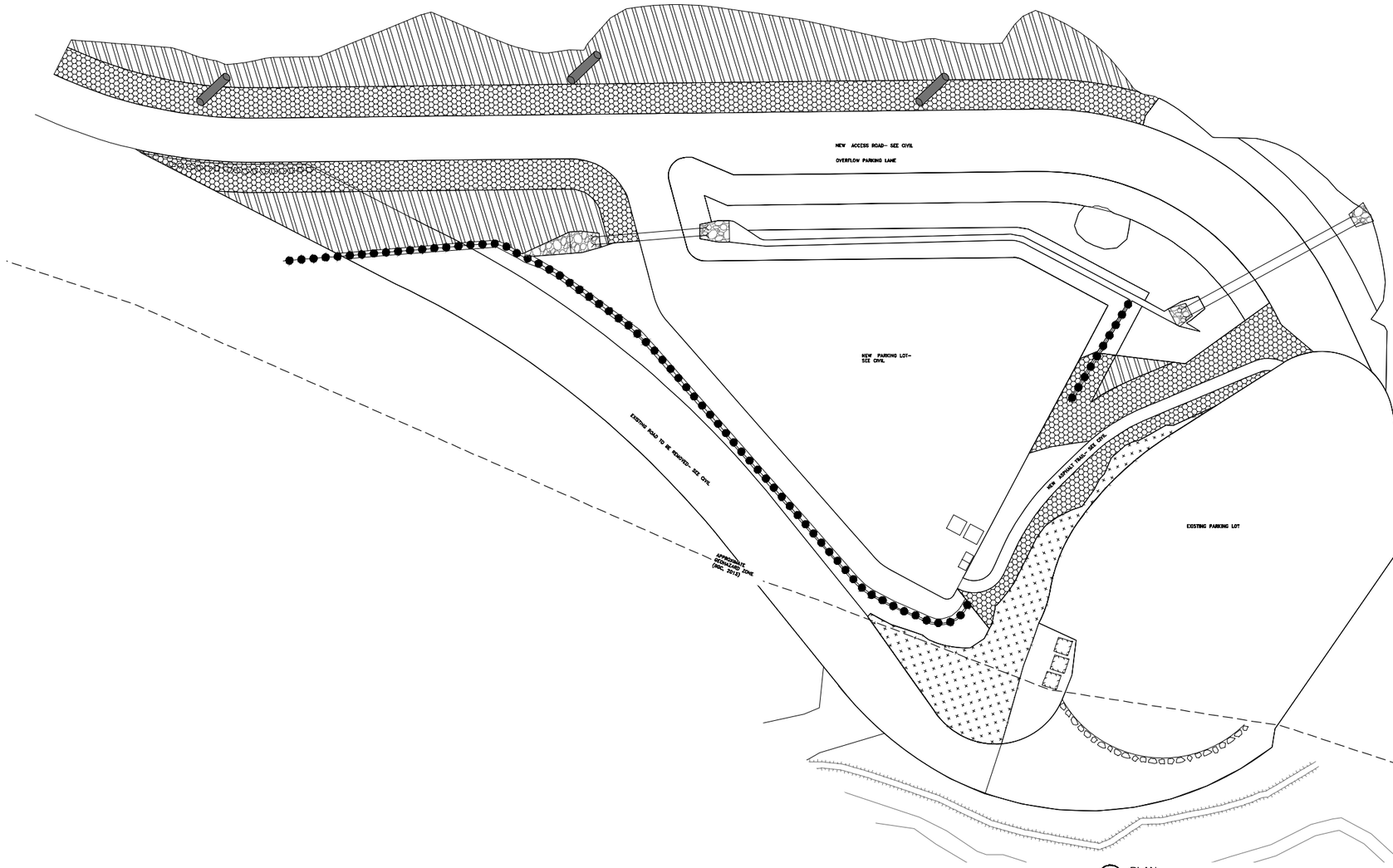
QUANTITY	SCIENTIFIC NAME	COMMON NAME	SPACING
TREES			
3	*Abies bifolia*	Subapline Fir	2m
6	*Picea engelmannii*	Engelmann Spruce	2m
3	*Pinus contorta*	Lodgepole Pine	2m

SUBALPINE FIR
ENGELMANN SPRUCE
LODGEPOLE PINE

* THIS LAYOUT IS REPRESENTATIVE ONLY OF A TYPICAL 5mX10m AREA OF TREE PLANTING WITHIN THE CLOSED FOREST RESTORATION ZONE. QUANTITIES ON THE PLANT SCHEDULE TAKE PRECEDENCE OVER THIS LAYOUT.

CLOSED FOREST PLANT LIST

QTY	BOTANICAL NAME	COMMON NAME	SIZE
Coniferous Trees			
229	*Abies bifolia*	Subapline Fir	Sapling
457	*Picea engelmannii*	Engelmann Spruce	Sapling
112	*Pinus contorta*	Lodgepole Pine	Sapling
117	*Pinus albicaulis*	Whitebark Pine	Sapling



1 PLAN 1:250
PARKING LOT RESTORATION SHEET 2

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2017TEB08	ISSUED FOR 90% REVIEW	R.R.	D.S.

Revision / Revision

A detail number
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REHABILITATION CONTRACT 2 JASPER NATIONAL PARK OF CANADA

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PARKING LOT RESTORATION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
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D.S.	S.D.	AS SHOWN

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Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
718		14

Drawing Reference No./No. de référence du dessin
L-02

18

AS THIS X 841

LEGEND

- EXISTING VEGETATION TO BE PROTECTED/RETAINED SEE DETAIL 7 ON SHEET L-07
- OPEN FOREST RESTORATION ZONE- SEE 10X10 ENLARGEMENT ON THIS SHEET
- SHRUB LANDS- 5.0m ROADWAY OFFSET- SEE 5X10 ENLARGEMENT ON THIS SHEET
- WILLOW STAKING AREA. USE SALIX DRUMMONDIANNA (DRUMMONDS WILLOW) SPACED 300mm O.C
- LIVE WILLOW STAKING/WILLOW SILT FENCE IN DITCH - SEE DETAIL 5/ L-07
- LOG POND SEDIMENT CONTROL STRUCTURE- SEE DETAIL 4/ L-07

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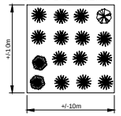
OPEN FOREST RESTORATION ZONE
10X10 ENLARGEMENT SAMPLE



QUANTITY	SCIENTIFIC NAME	COMMON NAME	SPACING
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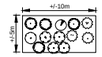
1	*Abies bifolia*	Subapline Fir	3m
2	*Picea engelmannii*	Engelmann Spruce	3m
13	*Pinus albicaulis*	Whitebark Pine	3m

- SUBALPINE FIR
- ENGELMANN SPRUCE
- WHITEBARK PINE

* THIS LAYOUT IS REPRESENTATIVE ONLY OF A TYPICAL 12m×12m AREA OF TREE PLANTING WITHIN THE OPEN FOREST RESTORATION ZONE. QUANTITIES ON THE PLANT SCHEDULE TAKE PRECEDENCE OVER THIS LAYOUT.

SHRUB LANDS RESTORATION ZONE - 5m ROADWAY OFFSET
5X10 ENLARGEMENT SAMPLE



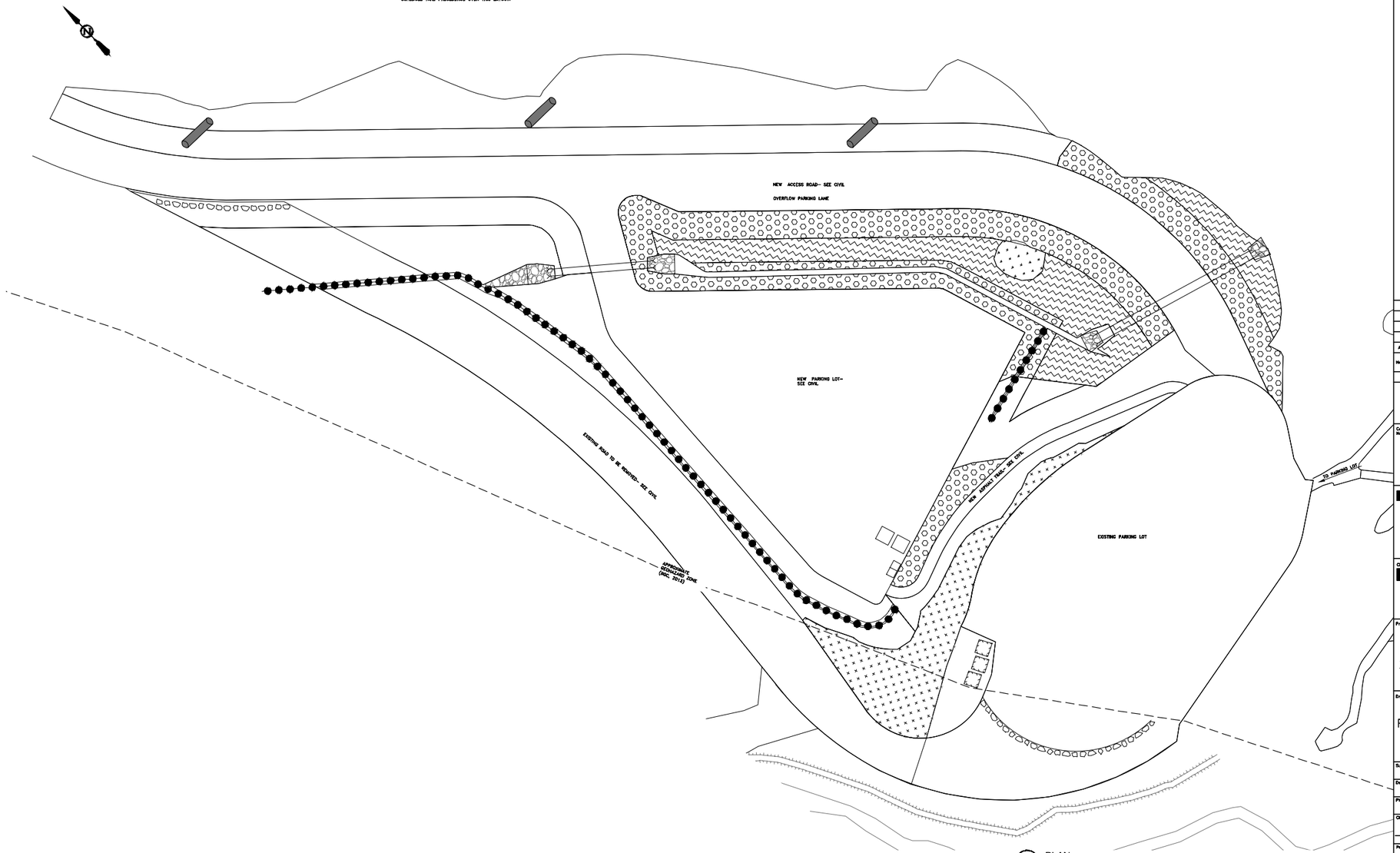
QUANTITY	SCIENTIFIC NAME	COMMON NAME	SPACING
SHRUBS			
4	*Alnus viridis*	Green Alder	2m
1	*Salix vestita*	Rock Willow	2m
3	*Vaccinium caesoitosum*	Dwarf Bilberry	2m
1	*Vaccinium membranaceum*	Tall Bilberry	2m
4	*Vaccinium scoparium*	Grouseberry	2m

- GREEN ALDER
- ROCK WILLOW
- DWARF BILBERRY
- TALL BILBERRY
- GROUSEBERRY

* THIS LAYOUT IS REPRESENTATIVE ONLY OF A TYPICAL 5m×10m AREA OF SHRUB PLANTING WITHIN THE SHRUB LANDS RESTORATION ZONE. QUANTITIES ON THE PLANT SCHEDULE TAKE PRECEDENCE OVER THIS LAYOUT.

OPEN FOREST PLANT LIST

QTY	BOTANICAL NAME	COMMON NAME	SIZE
CONIFEROUS TREES			
4	*Abies bifolia*	Subapline Fir	Sapling
12	*Picea engelmannii*	Engelmann Spruce	Sapling
63	*Pinus albicaulis*	Whitebark Pine	Sapling
SHRUBS			
94	*Alnus viridis*	Green Alder	1 year old collected stock
31	*Salix vestita*	Rock Willow	1 year old collected stock
63	*Vaccinium caesoitosum*	Dwarf Bilberry	1 year old collected stock
31	*Vaccinium membranaceum*	Tall Bilberry	1 year old collected stock
94	*Vaccinium scoparium*	Grouseberry	1 year old collected stock



1 PLAN
PARKING LOT RESTORATION SHEET 3
1:250

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2017TEB08	ISSUED FOR 90% REVIEW	R.R.	D.S.

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Eng. Stamp / Sceau de l'ingénieur

Public Works and Government Services Canada
Client Services Team Southern Alberta Operations Branch

Travaux publics et Services gouvernementaux Canada
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Canada

Client/client: Parks Canada Agency / L'Agence Parcs Canada
Western and Northern Region / Ouest et Nord du Canada

Project title/Titre du projet:
MT. EDITH CAVELL REHABILITATION CONTRACT 2 JASPER NATIONAL PARK OF CANADA

Drawing title/Titre du dessin:
LANDSCAPE
PARKING LOT RESTORATION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	R.R.	2017TEB08
Designed by/Concept par	Reviewed by/Revisé par	Scale/Échelle
D.S.	B.O.	AS SHOWN

PWGSC Project Manager/Administrateur de Projets TPSGC

Client Acceptance/Acceptation du client — Name, Responsible Officer/Nom Responsable

Approved by/Approuvé par — PWGSC Project Manager/Administrateur de Projets TPSGC

Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
718		15
Drawing Reference No./No. de référence du dessin: L-03		16

AS THIS A 24

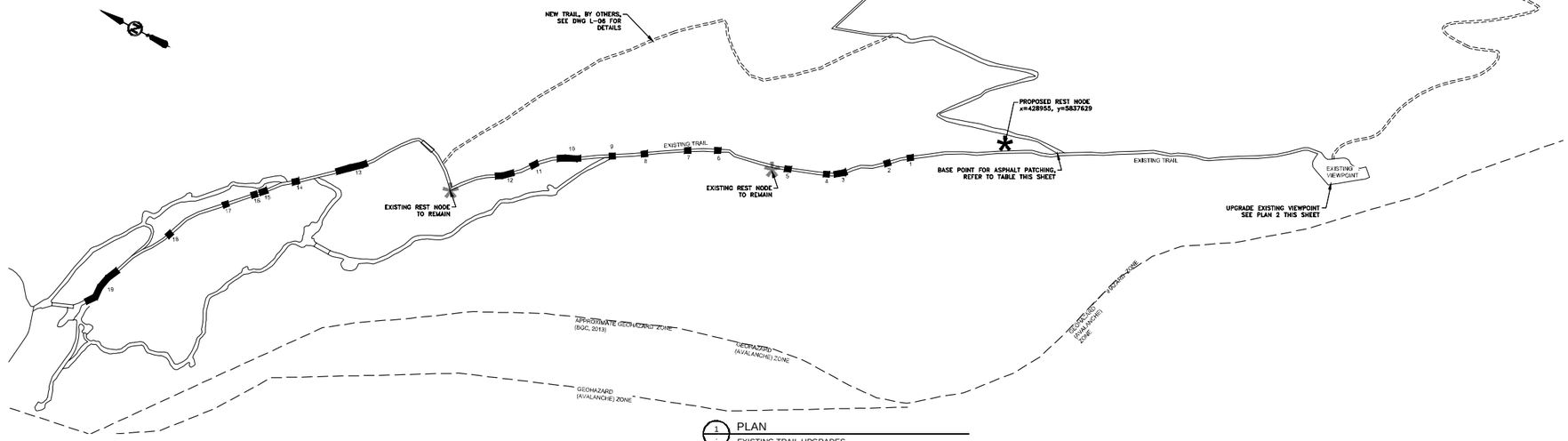
ASPHALT PATCHING SUMMARY

Repair #	Distance from Base Point (m)	Repair Length
1	68	3
2	79	3
3	100	6
4	108	3
5	126	3
6	160	3
7	174	3
8	194	3
9	209	3
10	225	11
11	245	4
12	257	9
13	342	15
14	374.5	3
15	390	4
16	395	3
17	409	3
18	439	3
19	469	24

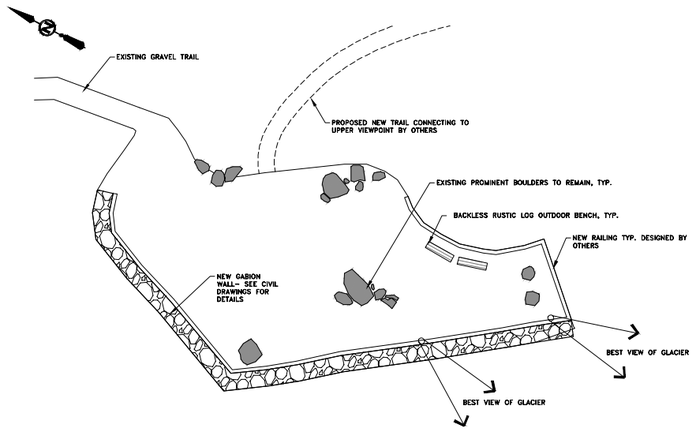
LEGEND

- ASPHALT TRAIL REPAIR. FINAL EXTENTS TO BE CONFIRMED ON SITE. SEE DETAIL 1 THIS SHEET
- EXISTING REST NODE TO REMAIN
- PROPOSED REST NODE. SEE DETAIL 2 ON THIS SHEET
- BACKLESS RUSTIC LOG OUTDOOR BENCH. SEE DETAIL 3 ON THIS SHEET

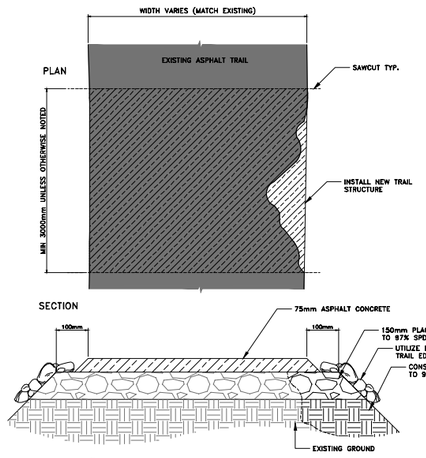
NOTE:
- FINAL TRAIL REPAIR LOCATIONS TO BE CONFIRMED PRIOR TO CONSTRUCTION START IN THE FIELD BY ENGINEER.
- FUTURE INTERPRETIVE SIGNAGE REQUIREMENTS TO BE COORDINATED WITH MFTC.



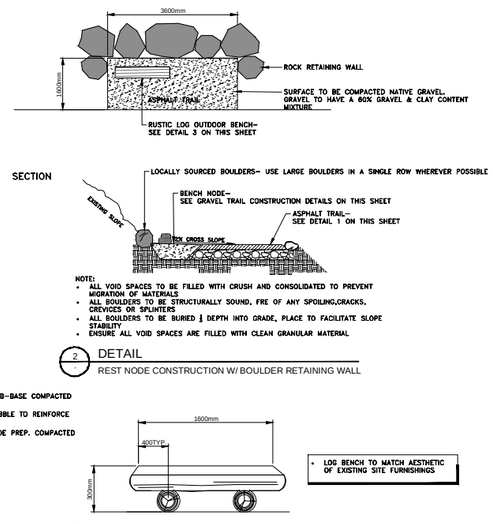
1 PLAN
EXISTING TRAIL UPGRADES



2 PLAN
EXISTING VIEWPOINT UPGRADES



1 DETAIL
ASPHALT REPAIR



2 DETAIL
REST NODE CONSTRUCTION W/ BOULDER RETAINING WALL

- LOG BENCH TO MATCH AESTHETIC OF EXISTING SITE FURNISHINGS

3 DETAIL
BACKLESS RUSTIC LOG BENCH

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2017TE308	ISSUED FOR 90% REVIEW	R.R.	D.S.

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Public Works and Government Services Canada
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Client Services Team Southern Alberta Operations Branch
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Client/client: Parks Canada Agency / L'Agence Parcs Canada

Western and Northern Region / Ouest et Nord du Canada

Project title/Titre du projet

MT. EDITH CAVELL REHABILITATION CONTRACT 2 JASPER NATIONAL PARK OF CANADA

Drawing title/Titre du dessin

LANDSCAPE EXISTING TRAILS AND VIEWPOINT IMPROVEMENTS

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	R.R.	2017TE308
Designed by/Concept par	Reviewed by/Revisé par	Scale/Échelle
D.S.	R.O.	AS SHOWN

PWGSC Project Manager/Administrateur de Projets TPSGC

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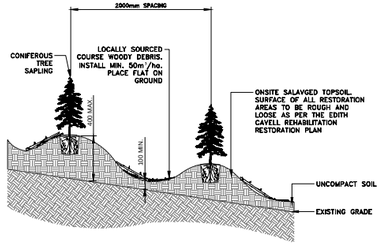
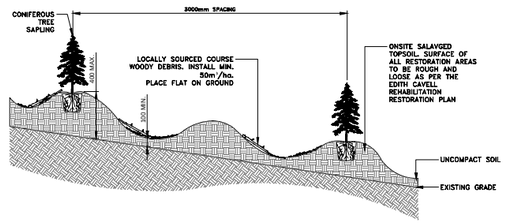
Project No./No. du projet	Asset No./No. de bien	Sheet No./ No. de la feuille
718		16
Drawing Reference No./No. de référence du dessin: L-04		16

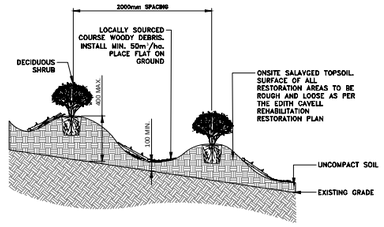
AS 1188 x 841



1 DETAIL
CLOSED FOREST RESTORATION 1:20



2 DETAIL
OPEN FOREST RESTORATION 1:20



3 DETAIL
SHRUB LANDS RESTORATION 1:20

PHOTO
NATURALIZATION SOIL PLACEMENT

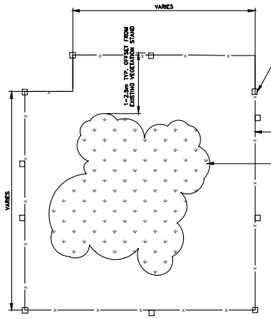
NOTE:
- PLANT MATERIAL TO BE SOURCED FROM THE SURROUNDING AREA (SEED ZONES: SUBALPINE 1.2 OR 2.2) UNLESS OTHERWISE APPROVED
- PLANT SPECIES ARE SUBJECT TO REPLACEMENT BASED ON AVAILABILITY OF PLANT STOCK FOLLOWING APPROVAL BY PARKS CANADA.
- TOPSOIL PLACEMENT IN TREE/ SHRUB PLANTING AREAS WILL BE ROUGH AND LOOSE CREATING A SERIES OF PITS AND MOUNDS RANGING FROM 100 TO 400mm IN DEPTH, AND WILL NOT BE TRACK PACKED.
- LARGE WOODY DEBRIS TO BE PLACED IN CLOSED FOREST PLANTING ZONES AT A MINIMUM OF 50m³/ha.
- WILLOW COLLECTION, SOAKING AND INSTALLATION WILL OCCUR UNDER SUPERVISION OF PERSONNEL WITH TRAINING/EXPERIENCE IN LIVE STAKING.
- WORK SHALL BE CARRIED OUT ACCORDING TO THE REQUIREMENTS OF THE EDITH CAVELL REHABILITATION RESTORATION PLAN AND EROSION SEDIMENT CONTROL PLAN.

COMPLETE PLANT LIST

QTY	BOTANICAL NAME	COMMON NAME	SIZE
Coniferous Trees			
233	*Abies bifolia*	Subapline Fir	Sapling
469	*Picea engelmannii*	Engelmann Spruce	Sapling
112	*Pinus contorta*	Lodgepole Pine	Sapling
180	*Pinus albicaulis*	Whitebark Pine	Sapling
Shrubs			
94	*Alnus viridis*	Green Alder	1 year old collected stock
31	*Salix vestita*	Rock Willow	1 year old collected stock
63	*Vaccinium caesoitosum*	Dwarf Bilberry	1 year old collected stock
61	*Vaccinium membranaceum*	Tall Bilberry	1 year old collected stock
94	*Vaccinium scoparium*	Grouseberry	1 year old collected stock

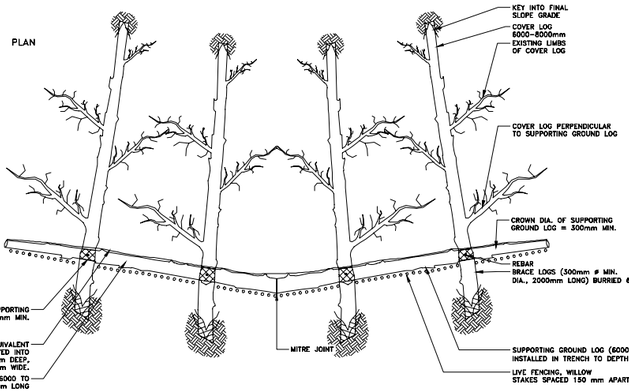
WILLOW STAKES PLANT LIST

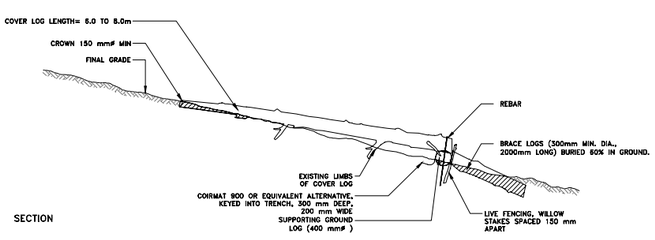
QTY	BOTANICAL NAME	COMMON NAME	SIZE
Shrubs			
400	*Salix glauca*	Smooth Willow	Live Stake
160	*Salix drummondiana*	Drummond's Willow	Live Stake



NOTES:
- A STANDARD "SAFETY ORANGE" SNOWFENCE MUST BE PLACED A MINIMUM OF 2.5m FROM TREE TRUNKS AND MIN. 1m FROM SHRUB TRUNKS, FENCE ZONE SHAPE VARIES AND TO BE DETERMINED ON SITE ACCORDING TO VEGETATION
- ALL EQUIPMENT, SOIL, BUILDING MATERIALS AND OTHER DEBRIS SHALL BE KEPT OUT OF THE VEGETATION PROTECTION ZONE
- IF ANY DAMAGES OCCUR WITHIN THE VEGETATION PROTECTION ZONE, THE PROJECT ENGINEER IS TO BE ADVISED IMMEDIATELY IN ORDER TO ASSESS THE DAMAGES BY A CERTIFIED ARBORIST FOR DIRECT ACTION TO BE TAKEN.

7 DETAIL
PROTECTIVE SNOW FENCING TO EXISTING VEGETATION





SECTION

NOTES:
1. COVER LOG TO REST IN NOTCH OF SUPPORTING GROUND LOG.
2. FILTER FABRIC TO BE BIODEGRADABLE, KEYED IN ON UP SLOPE FACE OF SUPPORTING GROUND LOG.
3. INSTALL THE LOG POND SEDIMENT CONTROL STRUCTURE DIRECTLY ONTO SUBSOIL AT FINAL GRADE.
4. WILLOW STAKES MIN LENGTH = 500 mm, MIN DIA. = 40 mm.
5. COVER LOG TO BE SECURED TO SUPPORTING GROUND LOG USING 1.2 M LONG REBAR (15 mm DIA.) AT EACH JOINT, DRIVEN THROUGH PILOT HOLE.
6. TOPSOIL THROUGHOUT THE LOG POND SEDIMENT CONTROL STRUCTURE TO BE MIN. 100 mm THICK.
7. FINAL LOCATIONS OF LOG POND SEDIMENT CONTROL STRUCTURES TO BE DETERMINED IN FIELD BY ENGINEER.
8. INSTALL LOG POND SEDIMENT CONTROL STRUCTURES AS PER SECTION 4.9 OF THE EDITH CAVEL REHABILITATION EROSION AND SEDIMENT CONTROL PLAN

ALL WILLOW STAKES FOR LOG POND SEDIMENT CONTROL STRUCTURE TO BE SALIX DRUMMONDIANA

4 DETAIL
LOG POND SEDIMENT CONTROL STRUCTURE

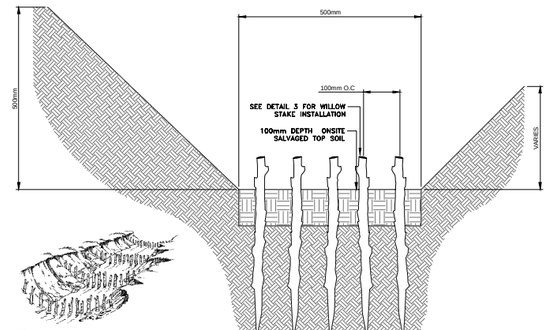
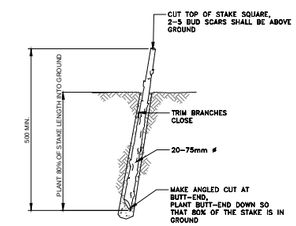


DIAGRAM
WILLOW SILT FENCE

NOTE:
- ALL WILLOW STAKES IN SWALES TO BE SALIX GLAUCA
- MAXIMUM 2.0m BETWEEN ROWS

5 DETAIL
WILLOW SILT FENCE



NOTES:
- USE HEALTHY, STRAIGHT AND LIVE WOOD AT LEAST 1 YEAR OLD
- MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION; USE AN IRON BAR OR PILOT HOLE IN FIRM SOILS
- SOAK CUTTINGS FOR AT LEAST 24 HOURS PRIOR TO INSTALLATION (SOAK 5-7 DAYS FOR BEST RESULTS)
- TAMP THE SOIL AROUND THE STAKE FOR STABILITY

WILLOW STAKES SHALL BE:
- CUT LOCALLY OR FROM A SIMILAR ECOSITE
- CUT DURING THE DORMANT SEASON (AFTER LEAF FALL AND BEFORE BUD BREAK)
- NOT MORE THAN 10% OF A SINGLE PLANT TO BE HARVESTED
- NOT MORE THAN 10% OF PLANTS IN A LOCAL POPULATION BE HARVESTED

6 DETAIL
WILLOW STAKE INSTALLATION

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2017TE30B	ISSUED FOR 90% REVIEW	R.P.	D.S.

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Project title/Titre du projet
MT. EDITH CAVELL REHABILITATION CONTRACT 2 JASPER NATIONAL PARK OF CANADA

Drawing title/Titre du dessin
LANDSCAPE DETAILS

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	R.P.	2017TE30B
Designed by/Concept par	Reviewed by/Revisé par	Scale/Échelle
D.S.	B.O.	AS SHOWN

PWCSC Project Manager/Administrateur de Projets TPSGC

Client Acceptance/Acceptation du client | Approved by/Approuvé par

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Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
718		19 / 19

Drawing Reference No./No. de référence du dessin
L-07

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Appendix B – Log Pond Sediment Control Device Detail Drawing

BOREAL RESEARCH INSTITUTE

BOREAL RECLAMATION PROGRAM



Technical Note, June 2013

Making Sites Rough and Loose: A Soil Adjustment Technique

DAVID POLSTER

Rough and loose surface treatments (Polster 2009) provide an effective way to control erosion and create conditions that promote the revegetation of the site. By creating topographic heterogeneity (Larkin et al. 2008) the rough and loose surface configurations provides increased diversity of habitats therefore improves ecological resilience (Holling 1973). This brief document shows how sites can be made rough and loose to gain these ecosystem benefits and initiate natural successional processes (Polster 1989).

Rough and loose surface configurations (Photographs 1 and 2) can be achieved by using an excavator to open holes on the slope, dumping the material that is generated from the holes in mounds between the holes. The excavator, using a digging bucket (not clean-up), takes a large bucket full of soil and places it to the left of the hole that was just opened, half a bucket width from the hole so it is half in and half out of the hole. A second hole is then excavated half a bucket width to the right of the first hole. Material from this hole is then placed between the first and second holes. A third hole is now opened half a bucket width to the right of the second hole, with the excavated soil placed between the second and third holes. Care should be taken when excavating the holes to shatter the material between the holes as the hole is dug. The process of making holes and dumping soil is continued until the reasonable operating swing of the excavator is reached. The excavator then backs up the width of a hole and repeats this process, being sure to line up the holes in the new row with the space between the holes (mounds) on the previous row.

Photograph 1 (left) and 2 (right). Rough and loose surface configurations can be made using an excavator on slopes up to 2:1 or 26°. Large areas can be treated for a cost of about $700/ha.

Rough and loose surface treatments can be used in confined areas as well as in large open areas (Photograph 3). These treatments are ideal for recovering hydrologic integrity on resource access roads and where unauthorized access by motor vehicles ("quads" and "dirt bikes") is causing ecological degradation. The rough and loose treatments can be used on coarse textured substrates and can be applied in areas where potentially droughty conditions dictates that planting be conducted on north facing slopes (Photograph 4).

Photograph 3 (left) and 4 (right). Forest access roads and other small areas can be treated using the rough and loose technique (left) as well as areas with coarse substrates (right) such as this old dam site with alluvial boulders, cobbles and gravels.

The rough and loose treatment provides ideal conditions for live staking (Polster 2006) as the soils are loose so the stakes can be planted deeply and roots can grow unencumbered by compaction (Photographs 5 and 6). Live staking can be used to establish pioneering species such as Balsam Poplar and Willow. Two meter long cuttings inserted one meter into the substrate allows substantial root systems to develop and fosters successful establishment of these species.

Photograph 5 (left) and 6 (right). Live staking in the rough and loose soils of this tailings pond is easy and allows the cuttings to grow rapidly (right, start of 2nd year growth for cuttings)

The rough and loose surface treatments provide ideal microsites for seeds to lodge in and for seedlings to grow (Photograph 7, 8 and 9). Where local conditions provide ample seed, a diversity of native species will naturally establish. In general, these species will be appropriate for the sites where they establish so that moisture loving species will establish in the bottoms of the holes while species that favour dry sites will be found on the tops of the mounds. This species diversity enhances ecosystem resilience.

Photograph 7 (left), 8 (centre) and 9 (right). A variety of local forest species have established within a year of treatment on a rough and loose forest road on Salt Spring Island.

LITERATURE CITED

Holling, C.S. 1973. Resilience and stability of ecological systems. Annu. Rev. Ecol. Syst. 4: 1-23.

Larkin, Daniel J., Sharook P. Madon, Janelle M. West, and Joy B. Zedler. 2008. Topographic heterogeneity influences fish use of an experimentally restored tidal marsh. Ecological Applications 18:483 – 496.

Polster, D.F. 1989. Successional reclamation in Western Canada: New light on an old subject. Paper presented at the Canadian Land Reclamation Association and American Society for Surface Mining and Reclamation conference, Calgary, Alberta, August 27-31, 1989.

Polster, D.F. 2009. Natural Processes: The Application of Natural Systems for the Reclamation of Drastically Disturbed Sites. paper presented at the B.C. Technical and Research Committee on Reclamation, BC Mine Reclamation Symposium. Cranbrook, B.C. September 14-17, 2009.

Appendix C – Live Staking and Joint Planting

Live Staking and Joint Planting

Live staking and joint planting involves the insertion of live, vegetative cuttings into the ground in a manner that allows the cutting (stake) to take root and grow. Willow stakes are a live "rebar" while willow poles are generally much longer and used more for structure reinforcement (see Pole Planting). Joint planting or face planting involves tamping live stakes of rootable plant material or rooted cuttings into soil in the interstices of porous revetments, riprap, or other retaining structures. **Refer to Manufacturer Directory - Bioengineering**.

Conditions Where Practice Applies

Live stake cuttings can be used to repair small earth slips and slumps. The stakes can help buttress the soil and arching. Gullies and bare gully banks can benefit from live staking. Live stakes or poles can be inserted or driven through interstices or openings in gabions, riprap, articulated block, or cellular confinement systems. Live stakes can be used to anchor and enhance the effectiveness of willow wattles, straw rolls, coir rolls, turf reinforcement mats, coir mats, continuous berms and other erosion control materials.

Poles, which are longer and of a larger diameter than stakes, are generally used for structure reinforcement on slopes and streambanks, in floodplains where they can reach the water table and vadose zone, or in conjunction with riprap, gabions, rock toe protection or other applications when a longer stake is required. Poles generally have a better chance of survival since the pole cutting is planted much deeper (see Pole Planting).

Joint or face planting is useful for adding a cover of vegetation to an otherwise inert bank surface such as rip rap. The purpose might be for habitat value or for erosion control value, or both. The insertion of long stem cuttings provides structural stabilization of the bank. Rooting adds further resistance to the soil below the inert cover, and if soil is present or added around the inert material, rooting will likely occur there, tying the material to the bank below.

The following chart shows recorded shear stress and velocities withstood by live staking.

Bank Material/Protection	**Shear**		**Velocity**			**Reference**
	lb/ft^2	N/m^2	ft/s	m/s		
Sandy Loam	0.0167		1.75	0.53	Design	Temple, 1980
Silt Loam	0.0218		2	0.61	Design	Temple, 1980
Alluvial silts	0.0218		2	0.61	Design	Temple, 1980
Ordinary firm loam	0.0341		2.5	0.76	Design	Temple, 1980
Very light loose sand, no vegetation or protection			1-1.5	.3-.46	Limit	Fortier & Scobey, 1926
Average sandy soil			2-2.5	.61-.76	Limit	Fortier & Scobey, 1926
Stiff clay, ordinary gravel soil			4-5	1.2-1.5	Limit	Fortier & Scobey, 1926
Live stakes in riprap (immediately after construction)	2.04	100			Limit	Schiechtl & Stern, 1994
Live stakes in riprap (after 3-4 seasons)	6.12	300			Limit	Schiechtl & Stern, 1994
Coarse gravel and stone cover with live cuttings (immediately after construction)	1.02	50			Limit	Schiechtl & Stern, 1994
Coarse gravel and stone cover with live cuttings (after 3-4 seasons)	5.1	250			Limit	Schiechtl & Stern, 1994
Willow posts			3.1	0.94	Limit	Schiechtl & Stern, 1994

Willow cuttings / willow stakes	2.1	103	9.8	3	Limit	Gerstgrasser, 1999

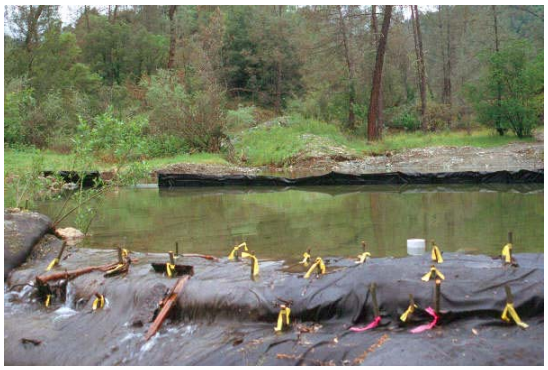
Materials

Live willow cuttings make the best material for live stakes. Willow or cottonwood make excellent poles. Joint planting may require using longer cuttings (poles).

Advantages

Using a system of live stakes or poles can creates a root mat that stabilizes the soil by reinforcing and binding soil particles together. Stake establishment can improve esthetics and provide wildlife habitat. As a temporary measure, live staking performs an important function of stabilizing and modifying the soil, serving as a pioneer species until other plants become established. Stakes can play an important geotechnical function of buttressing and arching.

Joint planting is useful where rock riprap, log cribwalls, rock deflectors, cellular confinement systems, gabions, or other structural practices are required. Eventually, a living root mat grows in the soil upon which the rock or structure has been placed, greatly reducing pull out. The root mat helps to bind the soil and to prevent sediment loss between and below the rocks and the rooted vegetation helps anchor the structure to the slope.



Disadvantages

Live staking and joint planting must be implemented during the dormancy period of chosen plant species, late fall to early spring. If native willows or cottonwood are not

found in the vicinity, live staking may not be a good option. Planting willows, in some cases, can adversely interact with other natural forces, such as water hydraulics. Willows can sometimes deflect currents adversely. Stream banks and steep slopes are highly susceptible to erosion and damage from significant storm events. Live stakes alone provide very little initial site protection during the establishment period. With joint planting, it is sometimes difficult to plant between in-place structural elements and filter fabric. Stakes should be in contact with native ground below structures for best results.

Implementation

Stakes shall be harvested and planted when the willows, or other chosen species, are dormant. When harvesting cuttings, select healthy, live wood that is reasonably straight. Use live wood at least 2 years old. Avoid suckers of current years growth as they lack sufficient stored energy reserves to sprout consistently. The best wood is 2-5 years old with smooth bark that is not deeply furrowed. Trimming the terminal buds on the willow will redirect the plants energy to root growth. Leave the terminal buds on the cottonwood.

Several species of willow will grow from cuttings in less favorable soil conditions such as road fills and gullies in bare denuded land. Even in very unfavorable sites willow cuttings will often grow vigorously for a few years before they die out. Willows have several different growth forms, from shrubs to large trees. Small to medium sized shrub-type and rhizomatous or creeping-type willows are used for planting channel banks. Upland willow species are found in relatively dry areas and should be used on similar sites. Tree-type willows are selected for the upper bank and flood plain area.

Make clean cuts without splitting ends. Trim branches from cutting as closely as possible. The butt end of the cutting shall be pointed or angled and the top end shall be cut square to help identify the top and bottom when planting . The top, square cut, can be painted and sealed by dipping the top 25 -51 mm (1-2 inches) into a 50-50 mix of light colored latex paint and water. Sealing the top of stake will reduce the possibility of desiccation, assure the stakes are planted with the top up, and makes the stakes more visible for subsequent planting evaluations.

Cuttings should generally be 19 mm (¾ inch) in diameter or larger depending on the species. Cuttings of small diameter (up to 40 mm (1 ½ inches)) shall be 0.5 m (18 inches) long minimum. Poles should be 35-90 mm (1.5-3.5 inches) diameter and 2-3 m long. The actual length of cuttings depends on the application but the cutting should be long enough to reach into moist soils in mid-summer or the capillary fringe.

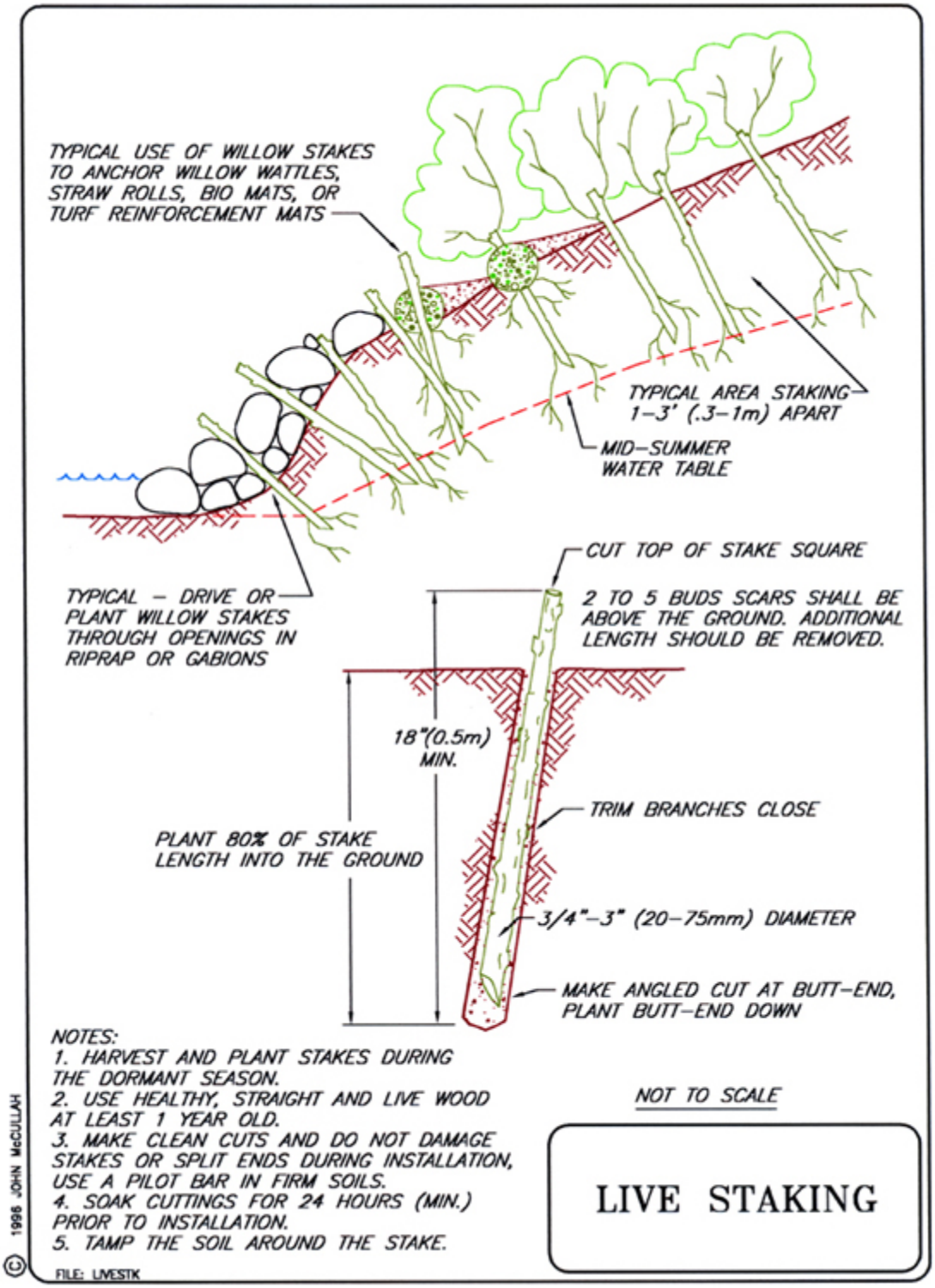
Stakes must not be allowed to dry out. All cuttings should be soaked in water for 5-7 days (a minimum of 24 hours). Soaking significantly increases the survival rate of the cuttings, however they must be planted the same day they are removed from water. Use a iron stake or bar to make a pilot hole in firm soil. Plant the stakes butt-ends into the ground, with the leaf bud scars or emerging buds always pointing up. Be careful not to damage the buds, strip the bark or split the stake during installation. The stakes should

not be planted in rows or at regular intervals, but at random in the most suitable places at a rate of 2-5 cuttings/m^2.

Set the stake as deep as possible into the soil, preferably with 80 percent of its length into the soil and in contact with mid-summer moist soils. The stake should protrude only to a maximum of one-quarter its length above the ground level to prevent it from drying. Stakes should be cut so that cutting extends above competing herbaceous vegetation. At least 2 buds and/or bud scars shall be above the ground after planting. It is essential to have good contact between the stake and soil for roots to sprout. Tamp the soil around the cutting.

The pole plantings shown in the photos above were not planted deeply enough. In the photo on right, notice that only about 20% of the cutting was in the ground. Ideally, about 80% of cuttings should be in the soil.

With joint planting, live stakes are typically installed after the inert cover material is in place. Often a pry bar will have to be used to establish a hole for the stake. Drive or plant willow stakes through openings in riprap, gabions, or other structures.



Typical drawing of Live Staking and Joint Planting

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Costs

The installed cost of Live Stakes typically ranges from $1 - $2 per stake, depending on local labor rates, proximity of harvesting area to site, and other site variables.

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