

**Columbia River Project Water Use Plan
Physical Works Terms of Reference**

**Kinbasket and Arrow Lakes Reservoirs
Revegetation Management Plan**

**CLBWORKS-2 Mid Columbia and Arrow Lakes Reservoir
Revegetation Program Physical Works – Phase 4A**

Revegetation

February 18, 2013

KINBASKET AND ARROW LAKES RESERVOIRS REVEGETATION MANAGEMENT PLAN

1 BACKGROUND

The Columbia River Water Use Plan Consultative Committee (WUP CC) recognized the value of riparian and wetland vegetation surrounding Kinbasket and Arrow Lakes reservoirs for enhancing littoral productivity, providing physical, structural and biological character for wildlife habitat, protecting cultural heritage sites and providing aesthetic benefits (e.g., reduction of dust storms) within the drawdown zones. As a result, the protection and enhancement of high quality riparian and wetland vegetation emerged as a key environmental objective for the Columbia River Water Use Plan.

The WUP CC supported reservoir-wide revegetation programs for Kinbasket and Arrow Lakes reservoirs in lieu of maintaining lower elevations during the growing season than those provided under current operations to maximize vegetation growth in the drawdown zones (BC Hydro 2005). The revegetation approach consists of two programs (CLBWORKS-1 (Kinbasket Reservoir Revegetation) and CLBWORKS-2 (Mid Columbia and Arrow Lakes Reservoir Revegetation) with interventions over multiple years to facilitate growth of vegetative cover in areas that have good potential to become self-sustaining. Key environmental and social objectives of the revegetation programs are to maximize vegetation growth in the drawdown zones to benefit littoral productivity, wildlife habitat, shoreline erosion, dust control, recreation and archaeological site protection. Feedback from public and First Nations was also considered to ensure that the planned approach did not significantly conflict with other land uses (e.g., motorized and non-motorized recreation, beach areas), and that revegetation prescriptions were compatible with First Nation archaeological site protection requirements and incorporate traditional use species, where possible.

1.1 Mid Columbia River and Arrow Lakes Reservoir Revegetation Program

Riparian vegetation in Arrow Lakes Reservoir, and in particular the mid Columbia (Revelstoke Reach), presently extends over an elevation range of about 10 m (430 m to 440 m). Expansion of vegetation into the lower elevations appears to have occurred largely as a result of a fall rye (*Secale cereale*) seeding program that began in the early 1990s, and which may have facilitated the spread of natural vegetation (sedge and grass). A series of low water years from 1990 to 1999 also allowed for the establishment of natural vegetation by providing seedlings sufficient growing time to develop into mature plants that are capable of tolerating subsequent extended inundation. These factors appeared to have worked in concert over the past decade to allow for the establishment and persistence of extensive areas of vegetation, which now dominate the drawdown zone of Revelstoke Reach and smaller areas in the main body of the Arrow Lakes Reservoir (Moody 2005).

Recognizing the importance of riparian and wetland vegetation in the drawdown zone, the WUP CC explored several operating alternatives designed to maintain existing vegetation in the mid Columbia and the Arrow Lakes Reservoir by imposing lower reservoir elevations for longer periods during the early part of the growing season (late spring and early summer). Modeling of these alternatives showed that

stricter elevation constraints would provide varying levels of protection to vegetation, but could incur very high costs in lost power generation in some years. There was also concern around the high level of uncertainty in many of the assumptions used to develop elevation constraints, particularly around the relative importance of timing, duration and depth of inundation on the distribution, biomass and species diversity of vegetation. To address these concerns, the WUP CC recommended a multi-year revegetation program in areas between elevations 434 m and 440 m, and stated that areas below 434 m should continue to be given attention as required by BC Hydro's dust control program (BC Hydro 2005). The final decision of the WUP CC to support a revegetation program for the mid Columbia and Arrow Lakes Reservoir was based on the assumption that the soft constraints operating regime¹ would be effective in maintaining current levels of vegetation, and that revegetation activities would be a more cost-effective means of remediating and expanding vegetation cover for ecological and social benefits than imposing hard constraints on the operation of the reservoir (BC Hydro 2005).

The monitoring components of the mid Columbia and Arrow Lakes Reservoir Revegetation Program include the following Terms of Reference:

- Kinbasket and Arrow Lakes Reservoirs Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir (CLBMON-11B1) – implementation was initiated in 2009 and runs annually until 2019. This program assesses the efficacy of revegetation efforts in increasing the suitability of wildlife habitats in the drawdown zone.
- Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis (CLBMON-12) – implementation was initiated in 2008, and the program runs bi-annually from 2009 to 2017.
- Arrow Lakes Reservoir Inventory of Vegetation Resources (CLBMON-33) – the program was initiated in 2007, and bi-annual monitoring commenced in 2008. The program will run until 2016.
- Arrow Lakes Reservoir Plant Response to Inundation (CLBMON-35) – implementation has been postponed pending the Mid Columbia Interim Review in late 2013.

CLBWORKS-2, a physical works component of the Revegetation program, consists of four phases. The first year (Phase 1) was completed in 2007, and included field verification of revegetation potential, as well as prioritization of revegetation sites and initiation of nursery stock. Phase 2 ran from 2008 to 2010, during which time most areas identified in Phase 1 were treated, and additional potential treatment areas were identified. Phase 3 (2011) was a continuation of the work carried out during Phase 2, with additional refinements to the treatments and methods, based on monitoring results over the past three years.

The final phase of the program (Phase 4) consists of several sub-phases to be carried out over the coming years. These sub-phases were to be implemented

¹ Available at
http://www.bchydro.com/etc/medialib/internet/documents/environment/pdf/wup_columbia_executive_summary_pdf.Par.0001.File.wup_columbia_executive_summary.pdf

exclusively in conjunction with CLBWORKS-30 (Arrow Lakes Reservoir Wildlife Physical Works) to ensure that revegetation efforts target areas where wildlife habitat benefits can be maximized. However, an opportunity recently arose to use additional sedge stock in the revegetation efforts. This stock was made available as a result of unused stock from CLBWORKS-1, which has been temporarily postponed due to poor revegetation success in Kinbasket Reservoir and the probability of high water levels in the Reservoir in 2012 and 2013.

This document provides the Terms of Reference for the implementation of the first sub-phase of the fourth phase of CLBWORKS-2 (CLBWORKS-2 Phase 4-A). Separate Terms of Reference will be submitted for other sub-phases linked to prescriptions implemented under CLBWORKS-30².

Planting prescriptions will be based on results obtained during Phases 1, 2 and 3 of this program (Moody 2007a, b; Keefer et al. 2008; Keefer et al. 2009, Keefer Ecological Services 2011), which were carried out using an adaptive management approach.

The first three phases of the mid Columbia and Arrow Lakes Reservoir revegetation program targeted areas that had a good potential to become self-sustaining after five years of treatment as a cost-effective means of maximizing vegetation growth in the drawdown zone of the Arrow Lakes Reservoir. Phase 4A will continue with this approach, aiming to select areas with a high potential for growth, which have not been treated in previous years.

The program's environmental and social objectives are to:

- enhance littoral productivity;
- improve physical, structural and biological features of wildlife habitat;
- protect cultural heritage sites;
- provide benefits to recreation and shoreline stability; and,
- provide aesthetic benefits (e.g., reduction of dust storms).

The WUP CC agreed that monitoring of the revegetation program would be critical to:

- evaluate the effectiveness of revegetation efforts at enhancing sustainable vegetation cover in the drawdown zone;
- determine effects of the soft constraints operating regime on existing vegetation; and,
- assess benefits of the revegetation program to wildlife habitat, archaeological site protection and shoreline stability.

² The success of prescriptions implemented under CLBWORKS-30 will be assessed through CLBMON-11B4 (Monitoring of Wetland and Riparian Habitat in Revelstoke Reach).

1.1.1 Summary of Results from CLBWORKS-2, 2008 to 2011

This physical works program was initiated in June 2007 with site selection/verification, and continued on a small scale in 2008. Implementation of the physical work was to be carried out over five years.

The major activities in 2008 were the setup and implementation of a fertilization trial at Burton in the Arrow Lakes Reservoir. There were three main treatments: fertilization on silty sand, coarse sand and 3,000 planted lenticular sedge seedlings. These treatments all occurred in June 2008, just prior to inundation. An additional 3,000 seedlings were planted in areas outside of the fertilization treatments in irregular polygons in June 2008. In the fall of 2008, roughly 9,000 lenticular sedge and 400 Columbia sedge seedlings were planted in the drawdown zone near the towns of Burton and Nakusp.

The efficacies of the 2008 spring planting and fertilization activities were hindered by the inundation of all sites within days of the treatments. Seed collection was also hampered as the inundation occurred in conjunction with the ripening of the sedge seed. As a result of water levels remaining near full pool in the fall, the freshly planted seedlings were inundated for the entire fall growing season, giving them little to no time for root establishment prior to flooding.

In 2009, a variety of treatments were implemented based on the findings of the 2008 research trial treatments and results of similar work in Kinbasket Reservoir (CLBWORKS-1): live staking of cottonwood, willow and dogwood, the sourcing and planting of sedge seedlings, the seeding of native grasses and sedges, and fertilization. Monitoring activities were scheduled annually and bi-annually to develop better operational mechanisms.

2009 marked the second year of a seeding and fertilization trial located at Burton. The spring results suggested there was a strong correlation between competing grass vigour and fertilization application. In addition to the trials, a total of 20 tonnes of fertilizer, provided by BC Hydro, was applied operationally to a number of sites covering approximately 50 ha. The monitoring of live stake establishment in the fall of 2009 showed an overall black cottonwood survival of 83% and willow stake survival of 39%.

Seedlings planted in spring 2009 integrated into the existing plant community, as shown by the inability of fall surveyors to discriminate between planted and natural sedges.

The final two years of the revegetation program (Years 4 and 5) were to be implemented in conjunction with CLBWORKS-30 (Arrow Lakes Reservoir Wildlife Physical Works) to ensure that revegetation efforts were targeting areas where wildlife habitat benefits could be maximized. However, the implementation of CLBWORKS-30 was delayed, and an additional year of implementation of CLBWORKS-2 was added in 2011. Approval for this work was received from the Comptroller of Water Rights in October 2010.

The 2011 program planted approximately 266,000 sedge plugs, over 18,000 black cottonwood, 1,000 willow, 1,000 dogwood seedlings, and 4,300 black cottonwood

live stakes over 28.1 ha in nine different sites. It also monitored some previous treatments. Seedling were planted at higher densities than the prescribed maximum (2500/ha) due to contractor error. Live stakes densities were lower in 2011 (1125/ha) than in 2010 (1634/ha).

Seedling survival of previous prescriptions (2010) ranged from 0 to 58%, with survival higher in high elevation bands. Live stakes survival also varied much, from 30 to 80%. Rodent damage (girdling) was observed in some sites and may have accounted for some of the low survival rates. Higher survival rates of live stakes were linked to machine planting instead of hand planting.

2 REFERENCES

- BC Hydro. 2005. Consultative Committee report: Columbia River Water Use Plan, Volumes 1 and 2. Report prepared for the Columbia River Water Use Plan Consultative Committee by BC Hydro, Burnaby, BC. 924 pp.
- Keefer, M. E., T.J. Ross, and T. Ehlers. 2008. CLBWORKS-2 Mid Columbia and Arrow Lakes Reservoir Revegetation Program Physical Works (2008) – Fertilization Trials and Seed Collection. BC Hydro. 50 pp. plus appendices.
- Keefer, Michael E., R. Moody, T.J. Ross, A. Chapman and J. Meuleman. 2009. CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works – Phase 2 Report (2009). Report prepared by Keefer Ecological Services for BC Hydro. 50 pp. plus appendices.
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- Moody, A.I. 2005. Mica-Revelstoke-Keenleyside Water Use Plan: potential areas for vegetation establishment in the Arrow Lakes Reservoir. Prepared for BC Hydro. 49 pp.
- Moody, A.I. 2007a. Mid Columbia and Arrow Lakes Reservoir Revegetation Program – Phase 1 (2007). Report prepared for BC Hydro. 20 p. plus appendices.
- Moody, A.I. 2007b. Mid Columbia and Arrow Lakes Reservoir Revegetation Program – Phase 1 (2007). Addendum to Final Report. Report prepared by AIM Ecological Consultants Ltd. for BC Hydro. 37 pp.

Physical Works No. CLBWORKS-2 Mid Columbia and Arrow Lakes Reservoir Revegetation Program – Phase 4A Terms of Reference

1 Program Rationale

During the Columbia River Water Use Plan (WUP) process, the WUP Consultative Committee (WUP CC) recognized the value of vegetation for improving aesthetic quality, controlling dust, protecting cultural heritage sites from erosion and human access, and enhancing littoral productivity and wildlife habitat. The WUP CC further recognized that the most significant opportunity for accomplishing these objectives lay in remediating and expanding riparian and wetland vegetation in the reservoir drawdown zone, because the drawdown zone is the only area substantially affected by changes in BC Hydro's operation of the reservoir. Based on the success of vegetation treatments for dust control in Revelstoke Reach (mid Columbia River), the WUP CC agreed that establishing permanent vegetation cover in the drawdown zone³ of Arrow Lakes Reservoir and Revelstoke Reach was the best option for achieving the multiple objectives referred to above. The goal of the revegetation program is to maximize vegetation growth in the drawdown zone in a manner that provides benefits to littoral productivity, wildlife habitat, shoreline stability, recreation, dust control and archaeological site protection (see also Section 1.1).

The WUP CC supported revegetation programs in Revelstoke Reach and in the Arrow Lakes Reservoir based on the assumption that the soft constraints operating regime for Arrow Lakes Reservoir (Appendix II) would be effective in maintaining existing levels of vegetation. To verify this assumption, and to evaluate how effectively revegetation efforts are meeting the multiple objectives set by the WUP CC, the Committee recommended these vegetation monitoring programs:

- CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the mid Columbia and the Arrow Lakes Reservoir
- CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis
- CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources
- CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation

These monitoring programs, for which separate Terms of Reference have been prepared, are being implemented in parallel with revegetation efforts, with the exception of CLBMON 35 which has been postponed pending the Mid Columbia Interim Review in late 2013 (Table CLBWORKS 2-1).

³ The operating range of Arrow Lakes Reservoir is between 422 m (1384 ft.) and 440 m (1443 ft.); the revegetation program will treat the upper elevations between 434 m (1424 ft.) and 440 m (1443 ft).

Table CLBWORKS-2-1 Status and Schedule of Columbia River WUP Monitoring Programs and Physical Works Implementation under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan

Monitoring Programs	2007 YR1	2008 YR2	2009 YR3	2010 YR4	2011 YR5	2012 YR6 Interim Review	2013 YR7	2014 YR8	2015 YR9	2016 YR10	2017 YR11	2018 YR12	2019 YR13 Final Review
CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis		✓	✓		■		■		■		■		
CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources	✓	✓		✓		■		■		■			
CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir		✓	✓	✓			■	■		■		■	
CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation in the Arrow Lakes Reservoir			✓	✓	■	■	■	■	■	■	■	■	■
CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis		✓	✓		■		■		■		■		
CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area			✓										
CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources	✓	✓		✓		■		■		■			
CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation							■	■	■	■	■		
Physical Works													
CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works	✓	✓	✓	✓	■	x	■	■	■	■			
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works	✓	✓	✓	✓	■								
Legend:	■	=	Program to be undertaken/initiated in identified year										
	u/w	=	Project is underway										
	✓	=	Program completed for the year										
	x	=	Program started, but encountered operational or hydrological delays										

The WUP CC set out guiding principles by which the revegetation programs should be implemented (BC Hydro 2005):

- Revegetation will be undertaken only in areas that have good potential to become self-sustaining in five years;
- Any revegetation activity must be done in a manner that is respectful of existing First Nation archaeological sites;
- Revegetation efforts on the Arrow Lakes Reservoir are to be directed above elevation 434 m (1424 ft.). Areas below this elevation are still to be addressed as required by the BC Hydro dust control program;
- Above Arrow Lakes Reservoir elevation 434 m (1424 ft.), planting efforts to address erosion and dust control issues are a high priority; and,
- Planting will not occur where efforts will be disrupted by or interfere with other forms of public use. This will require consultation with local stakeholders.

Because development of a long term riparian/wetland cover in the reservoir is expected to involve treatments over several years, the revegetation program is being implemented as a multi-year project requiring interventions over five years. The first

year of the program (Phase 1) was completed in 2007, and included field verification of revegetation potential, as well as prioritization of revegetation sites and initiation of nursery stock. Phase 2 ran from 2008 to 2010, during which time most areas identified in Phase 1 were treated, and additional potential treatment areas were identified. Phase 3 (2011) was a continuation of the work carried out during Phase 2, with additional refinements to the treatments and methods, based on monitoring results over the past three years.

The final phase of the program (Phase 4) will be partly implemented in conjunction with CLBWORKS-30 Arrow Lakes Reservoir Wildlife Physical Works to ensure that revegetation efforts are targeting areas where wildlife habitat benefits can be maximized. Two planting phases are planned in 2013: a) larger scale targeted vegetation enhancement in any remaining high potential areas, where vegetation can become self-sustaining and b) wildlife specific prescriptions, to be implemented in concert with the construction of specific wildlife physical works. This Terms of Reference addresses Phase A; the detailed designs and costs for Phase B will be submitted in separate Terms of Reference.

In accordance with the above guiding principles for the revegetation program (BC Hydro 2005), the specifics of the program as described in these and previous Terms of Reference have been developed through public and First Nations consultation to ensure that revegetation prescriptions are compatible with other land uses (e.g., motorized and non-motorized recreation, beach areas) and requirements for First Nation archaeological site protection. In addition, vegetation types valued for traditional use by First Nations have been incorporated into the prescriptions, where feasible.

1.1 Available Areas for Revegetation

During the WUP process, potential impacts of reservoir operations were modeled separately (BC Hydro 2005) for three elevations in the drawdown zone, due to differences in the characteristics of the vegetation communities that have become established within these zones and their importance to various interests⁴. These elevation zones are:

- 434 to 436 m – Vegetation present, low biomass, low diversity; dominated by perennial sedge and reed canary grass.
- 436 to 438 m – Vegetation present, high biomass, moderate diversity; dominated by perennial sedge and reed canary grass, but supports a number of other species.
- 438 to 440 m – Vegetation present, moderate biomass, high diversity; more terrestrial in nature. The principal differences for elevations 436 to 438 m are a significant component of shrubs and a lower biomass of herbaceous species.

While some vegetation has also become established between elevation 430 and 434 m, the WUP CC recognized that this establishment has largely occurred in recent years, likely as a result of a series of low water years. The WUP CC therefore

⁴ Interests included recreation, wildlife, vegetation, culture and heritage, and erosion control.

agreed that it was not reasonable to expect that vegetation at elevations below 434 m be maintained, given the variability in reservoir water levels across years.

1.2 Scope and Objectives

The scope of the physical works for Phase 4A includes revegetation of suitable sites in elevations between 434 m and 440 m in the drawdown zone of the Arrow Lakes Reservoir and Revelstoke Reach.

The optimal planting locations will be based on the review of CLBMON-33 data (Enns and Enns 2012) and on CLBWORKS-2 (Keefer Ecological Services 2012).

Key environmental and social objectives of the mid Columbia and Arrow Lakes Reservoir Revegetation Program physical works are to:

- 1) maximize vegetation growth in the drawdown zone⁵;
- 2) provide benefits to littoral productivity and wildlife habitat through increased plant species diversity;
- 3) improve shoreline stability and control dust through targeted planting, where possible;
- 4) increase species diversity of native plants, particularly those of interest to First Nations; and,
- 5) provide increased protection for known archaeological sites, where possible.

These objectives will be achieved through application of site-specific prescriptions (see Section 2.2.2) in suitable locations that specifically target the above values.

1.3 Consideration of the Arrow Lakes Reservoir Operating Regime

Development of riparian and wetland vegetation is believed to depend on the duration and timing of inundation of emergent vegetation during the growing season, as well as the maximum full pool level of the reservoir (Moody 2005). In any given year, conditions that favour the growth of vegetation depend on which of the soft constraints can be met, on weather variability in the Columbia Basin, operational load requirements and constraints under the Columbia River Treaty.

Because reservoir water levels will greatly influence the viability of existing vegetation communities and the successful establishment of revegetated areas, they must be explicitly considered in each year of program implementation. A summary of historic levels is presented in Table CLBWORKS-2-1. Projected reservoir levels will be provided to the contractor in early February to assist with planning of revegetation strategies for the upcoming field season.

⁵ Vegetation growth can be defined as the increase in area of self-sustaining vegetation cover

Table CLBWORKS-2-2. Proportion of time (from Apr 01 to Sept 30) that Arrow Lakes Reservoir elevations exceeded a particular elevation band (mASL) for the period 1997 – 2012 (from Hawkes and Tuttle 2012).

Band	Elevation	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average
1	433-434	0.67	0.67	0.58	0.62		0.61	0.68	0.56	0.31	0.63	0.72	0.72	0.67	0.82	0.69	0.67	0.64
2	434-435	0.65	0.65	0.57	0.57		0.54	0.63	0.41	0.14	0.56	0.60	0.69	0.64	0.73	0.64	0.64	0.58
3	435-436	0.62	0.61	0.56	0.55		0.46	0.57	0.22		0.49	0.50	0.67	0.57	0.61	0.62	0.55	0.54
4	436-437	0.60	0.57	0.54	0.49		0.38	0.49	0.10		0.43	0.43	0.64	0.38	0.47	0.58	0.45	0.47
5	437-438	0.52	0.42	0.49	0.42		0.31	0.35			0.38	0.34	0.60	0.11	0.28	0.48	0.39	0.39
6	438-439	0.42	0.24	0.37	0.33		0.25	0.23			0.31	0.21	0.48		0.19	0.36	0.34	0.31
7	439-440	0.29	0.00	0.18	0.16		0.18	0.07			0.19		0.19		0.09	0.26	0.29	0.17

1.4 Integration with other Monitoring Programs and Physical Works

An important aspect of the revegetation program is the integration of the physical works with related studies and other physical works (e.g., debris removal) to be carried out in the drawdown zone. Collaboration and data exchange between the revegetation program and other BC Hydro Water License Requirements programs is an explicit contract requirement.

The following studies are directly affected by, or have the potential to affect, the activities of CLBWORKS-2:

1. **CLBMON-11B Mid Columbia and Arrow Lakes Reservoir Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works:** CLBMON-11B is an 11-year program to monitor wildlife utilization patterns in response to revegetation efforts in the mid Columbia River and Arrow Lakes Reservoir. The program has been broken down into four sub-components (B1-B4) to address specific monitoring requirements. Implementation commenced in 2009.

Coordination between these studies and revegetation efforts is required to ensure that information about treatment goals (e.g., habitat enhancement) and areas treated each year is shared, as well as to ensure that wildlife monitoring sites are not impacted by revegetation treatments.

2. **CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources:** CLBMON-33 is a 10-year program to assess and map the spatial extent, structure and composition of existing vegetation communities, and the revegetated areas at a landscape level within the mid Columbia and the Arrow Lakes Reservoir. Its objective is to determine the inter-community changes over time in response to the soft constraints operating regime. This program also identified riparian wildlife habitat in Year 1. Program implementation was initiated in 2007.

Close collaboration between CLBWORKS-2 and CLBMON-33 is an essential for the success of both programs. The success of CLBMON-33 depends on retaining control sites for each identified community type over the course of the monitoring period. Ensuring that these control sites are unaffected by revegetation efforts is a key requirement of the revegetation program.

3. **CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis:** CLBMON-12 is a 10-year program to monitor the response of existing vegetation communities, at the site level, to the soft constraints operating regime. This program is also intended to evaluate the long-term effectiveness of the revegetation program at expanding the quality⁶ and quantity of vegetation in the drawdown zone. The evaluation will consider ecological and social benefits, and assess the costs and benefits of the

⁶ “Quality” is defined as a measure of how effectively the established/enhanced vegetation meets the interests expressed by the WUP CC.

recommended treatment options. Implementation was initiated in 2008, and monitoring occurs bi-annually, with a commencement in 2009.

Close collaboration between CLBWORKS-2 and CLBMON-12 is an essential component for the success of both programs. During the first year of implementation of CLBMON-12 (2008), work focused on obtaining baseline data and establishing monitoring plots and associated control plots in areas chosen for revegetation. Collaboration between the two programs is critical to ensure that monitoring sites are not adversely affected by revegetation treatments.

- 4. CLBWORKS-17 Arrow Lakes Debris Inventory, Management Strategy and Removal:** CLBWORKS-17 addresses new debris that enters the system from tributaries and sloughing of the reservoir banks during high water events by managing debris stranded in “bathtub rings” around the reservoir that may be re-introduced to the reservoir during high water events.

Debris removal activities, such as debris piling and burning, have the potential to impact revegetation efforts by disturbing previously treated sites, and altering soil chemistry and physical features. Information exchange between CLBWORKS-2, CLBWORKS-17, and archaeologists conducting monitoring in Arrow Lakes Reservoir, which will be coordinated by BC Hydro, is critical to ensure that relevant information about revegetation sites, site sensitivities, and access is provided to the debris program manager.

2 PHYSICAL WORKS PROPOSAL

2.1 Revegetation Approach

2.1.1 Revegetation Site Locations and Available Stock

Physical works carried out in previous years have treated the majority of high priority polygons, leaving primarily medium and low priority sites. It will be the responsibility of the contractor to review the Phase 3 treatment data (maps and tables in Keefer Ecological Ltd. 2011 and Keefer et al. 2010) and identify one or more suitable locations for planting the available stock.

BC Hydro has approximately 67,500 sedge (*Carex spp.*) seedlings available for planting. The breakdown by species is:

Lenticular sedge (*Carex lenticularis*) - 59,920 (mix of cell size 412A, 412B and 512)
Columbia sedge (*Carex aperta*) - 8,100 (cell size 412B)

One suggested treatment area is Renata (Site 13; Keefer Ecological Services 2011), and more specifically the polygon below the 2010 planted area, which treated elevations 436-440 m. It is suggested that the 435-436 m portion of the polygon be planted, as well as any portions of previously treated areas where establishment was sub-optimal and infill planting would be beneficial. Note that this site contains several control polygons for CLBMON-33 that cannot be treated. Coordination with this program is therefore essential.

Other potential areas include the Needles (Site 11) above elevation 436 m; Arrow Park North (Site 7) above elevation 436 m; and the Narrows (Site 6; all sites described in Keefer Ecological Services 2011).

Actual planting locations and suitability of site conditions, including access, must be verified through an on-site assessment.

2.1.2 Planting Workplan

Site and substrate specific prescriptions, using the available stock, will be described in a planting workplan to be submitted to BC Hydro for review and acceptance in early February of 2013. Each prescription must be designed for site and substrate conditions, and must consider elevation and location (e.g., exposure, slope, moisture, etc.) in the drawdown zone.

The planting workplan, to be implemented in 2013, will describe:

- which prescription (or combination of prescriptions) is recommended for each identified site (or combination of sites), how much area can be treated within the site, and an estimate of stock required to treat the area;
- why this prescription is deemed suitable for the identified site(s), substrates and/or elevation ranges;
- which objective(s) the prescription(s) will address (see Section 1.2);
- how archaeological sites, or areas that have a high potential for the presence of archaeological information, will be adequately protected from any intrusive works, and how additional protection from erosion and/or discovery may be provided;
- how potential impacts of implementation of specific prescriptions on control sites will be avoided;
- how the effects of site and substrate conditions, as well as elevation and location (e.g., exposure, slope, moisture, etc.) will be tested for a given prescription or combination, and how requirements for adaptive management will be met; and
- an alternate treatment sequence (contingency approach) in the event that high reservoir levels prevent access to lower elevation sites.

In addition to the above requirements, the planting program should also include detailed planting specifications to facilitate monitoring of planting quality. Criteria should include:

- spacing of seedlings,
- spacing from existing vegetation,
- planting depth,
- planting hole preparation (including tools used, site preparation if any, etc.),
- protection of seedlings from grazing, browsing and other damage; and,
- utilization of microsites to enhance survival.

2.1.3 Control Sites for Monitoring Programs

Under CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources (Enns 2007; Enns et al. 2007; Enns et al. 2008; Enns and Enns 2012), 16 distinct

vegetation communities were identified in the drawdown zone of the Arrow Lakes Reservoir between elevations 433 m and 440 m. The goal of CLBMON-33 is to track changes in the spatial extent, structure and composition of these existing communities over time to determine key factors that influence existing vegetation at the landscape scale. To ensure that effects of reservoir operations and environmental influences can be separated from the effects of revegetation efforts, certain areas that are suitable for enhancement will remain untreated to act as control areas for CLBMON-33 and other monitoring programs under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan (e.g., CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis; CLBMON-11B Mid Columbia and Arrow Lakes Reservoir Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works).

The proposal shall clearly describe how planned revegetation approaches ensure that control areas remain unaffected by:

- a) identifying potential impacts of specific prescriptions on control sites (e.g., ground disturbance caused by accessing sites or treatment mechanisms,); and,
- b) describing how the above impacts may be avoided through targeted implementation of prescriptions.

2.1.4 Archaeological Site Protection and Traditional Use Species

The location of heritage sites for those areas that have been assessed in the Arrow Lakes Reservoir and Revelstoke Reach is available through the Arrow Lakes Reservoir Archaeological Site Overview Assessment (CLBMON-52) and associated maps, as well as additional information obtained under the Reservoir Archaeology Program (RAP), which has assessed a total of 545 ha in the Arrow Lakes Reservoir, distributed evenly from north to south. This information will be made available to the contractor upon contract award.

It should be noted that not all areas identified for revegetation have been evaluated for the presence of archaeological sites. It is BC Hydro's expectation that the contractor's team will include an archaeologist who can assess the potential for archaeological sites for all previously un-assessed sites where intrusive prescriptions are proposed. The proposal shall demonstrate how the development of specific treatments and selection of planting mechanisms will be linked with available archaeological information to ensure that identified sites or areas considered to have a high potential for the presence of archaeological information are a) adequately protected from any intrusive works, and b) additionally protected from erosion and/or discovery, where possible.

2.1.5 Wildlife Habitat Enhancement

The fundamental wildlife objective of the Columbia River WUP was to maximize wildlife abundance and species diversity in the Columbia River system. The WUP CC made recommendations for physical works in lieu of operational changes to enhance wildlife habitat in the mid Columbia River (Revelstoke Reach; BC Hydro 2005), and these physical works will be implemented under CLBWORKS-30 (Arrow Lakes Reservoir Wildlife Physical Works). To ensure that the wildlife habitat benefits of these physical works are maximized, revegetation efforts will take into account the

construction of these physical works. Plans for these physical works will be communicated to the contractor.

While revegetation in Phase 4A will not occur in conjunction with wildlife physical works, it is nevertheless important that prescriptions maximize the amount of riparian habitat created to improve wildlife values. Revegetation prescriptions will therefore incorporate species beneficial for wildlife⁷, where feasible, and the proposal shall outline:

- a) which plant species may be utilized;
- b) which habitat values are expected to be addressed; and,
- c) which wildlife species will benefit.

Detailed prescriptions will be provided in an annual planting workplan, which will be submitted to BC Hydro for review and acceptance in early February of 2013.

2.2 Methods

2.2.1 Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which will include, but not be limited to: 1) budget management, 2) program team management, 3) logistics coordination, 4) technical oversight in field and reporting components, and 5) facilitation of data transfer among other programs under the Kinbasket and Arrow Lakes Reservoirs Revegetation Management Plan.

A safety plan must be developed and submitted to the BC Hydro contract manager for all aspects of the program involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required.

2.2.2 Task 2: Implementing Recommended Prescriptions

The proponent shall indicate which prescriptions may be developed to address the objectives in Section 1.2. Specifically, the proposal shall include information on:

- a) which treatment (or combination of treatments) is recommended for each identified site (or combination of sites) and/or elevation ranges;
- b) why this treatment is deemed suitable for the identified site(s) and/or elevation ranges;
- c) which objective(s) the treatment(s) will address;
- d) the approximate cost of each identified treatment by hectare, and total cost of all treatments per year.

The planting workplan will provide additional site specific details on how individual prescriptions meet the WUP CC objectives. If the proponent feels that not all values

⁷ I.e., species that provide forage, cover, nesting opportunities, etc.

can be addressed, the proposal shall describe how the current prescriptions meet each of the objectives listed in Section 1.2.

2.2.3 Task 3: Reporting

A technical report will be prepared at the conclusion of the 2013 implementation year, and will include:

- an executive summary;
- a description of the methods employed;
- a data summary;
- an assessment of priority sites for revegetation for the current year, and the rationale for their selection or their omission;
- an assessment of revegetation prescriptions and their suitability for different elevations, substrates and geographic locations;
- a discussion of the objectives which were met by implementation of specific prescriptions in target areas; and,
- any recommendations.

The report and field memo will follow the standard format that has been developed for WUP program physical works. All reports will be provided in hard-copy and in Microsoft Word and Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files. All map data, including meta data, will also be provided electronically in ARC GIS compatible format.

2.3 Schedule

The revegetation program physical works will be implemented between February and June 2013, as dictated by snow and water levels. Table CLBWORKS-2-3 provides a detailed task schedule.

Table CLBWORKS-2-3 Proposed Schedule for the Arrow Lakes Reservoir Revegetation Physical Works – Phase 4A

Task	Date
Submission of draft Planting workplan	February 15, 2013
Site assessment/verification	February – March 2013
Submission of Final Planting workplan	March 22, 2013
Planting of seedlings	March – May 2013
Post treatment monitoring	June 2013

2.4 Budget

The average annual cost for the implementation of Phase 4A of the revegetation program physical works in 2013 is estimated at \$119,872 (including inflation and contingency).

3 REFERENCES

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APPENDIX I – SOFT CONSTRAINTS OPERATIONS FOR THE ARROW LAKES RESERVOIR (BC Hydro 2005)

Consensus agreement was reached around developing soft operating constraints for Arrow Lakes Reservoir to meet the interests and stated objectives of the CC. In supporting soft constraints for the reservoir, the Committee recommended a 5-year review period upon implementation of the Water Use Plan to evaluate the effectiveness of the soft constraints.

The CC agreed that there are a number of conflicting interests, which will vary in degree according to water year. The Committee acknowledged that BC Hydro would need to balance these trade-offs internally when selecting its water management strategy. This balance would be informed by the expressed values of the Committee members, the performance measures calculated to date, the efficacy of the physical works, and the evolution of knowledge arising from the monitoring programs to guide operational decisions.

Following is a summary of the soft operating constraints for Arrow Lakes Reservoir.

Interest	Constraint
Vegetation	<ul style="list-style-type: none">• Maintain current level of vegetation in the drawdown zone by maintaining lower reservoir water levels during the growing season. No specific operating targets were identified to meet this general objective.• If vegetation is showing signs of stress as a result of inundation during the early part of the growing season (May to July), target lower reservoir levels in the fall to allow exposure of plants during the latter part of the growing season.• Preservation of current levels of vegetation at and above elevation 434 m (1424 ft.) is considered a priority.
Wildlife	<ul style="list-style-type: none">• Ensure that inundation of nesting bird habitat by rising reservoir water levels in early summer is no worse than that which occurred on average over recent history (1984 to 1999). Match operating levels to inundation statistics for elevations 434 m (1424 ft.) and above over the 1984 to 1999 period, which were used to produce the average historic performance measure score for spring/summer nesting short-eared owl habitat.• Ensure that availability of migratory bird habitat in the fall is as good as or better than that which has been provided on average over recent history (1984 to 1999). Draft the reservoir quickly after full pool is reached, targeting a reservoir level of 438 m (1437 ft.) or lower by August 7.
Fish	<ul style="list-style-type: none">• Ensure appropriate reservoir elevations for tributary access during the kokanee spawning period (late August to early November). Reservoir levels of or below 434 m (1424 ft.) could cause tributary access to be restricted in some streams

under certain conditions. Proposed monitoring study aimed at determining reservoir level thresholds under a range of tributary stream flow conditions below which spawner access becomes a problem.

Recreation

- Target reservoir water levels between 437 m (1433 ft.) and 439 m (1440 ft.) from May 24 to September 30.
- Flexibility to achieve lower reservoir levels of 434 m (1424 ft.) during the recreation season would be acceptable with proposed construction/upgrade of boat ramps for recreation interests served by these formal access points.

Culture and Heritage

- Maintain reservoir water levels at or below 436 m (1430 ft.) for as long as possible.
- First Nations are willing to accept water levels above this 20% of the time (or for 2.5 months) provided that it is timed in accordance with the vegetation efforts. First Nations would be willing to relax this constraint if the archaeological site protection plan is underway.

Erosion

- Minimize duration of full pool events. Reservoir water levels of 439 m (1440 ft.) are ideal.
- Avoid sudden drawdown once full pool has been reached (particularly if high runoff has saturated the reservoir banks) to avoid slumping of the shores.

Power Generation

- Optimize power values