

Removing the Wellsite Footprint Phase II: Wetland Reclamation

Interim Report

Revegetation and Ecohydrologic Responses After Removal of Fill From Roads and Pads in

Fen Peatlands

(GL 13-AU-ERPC-06)

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21 September 2015

Background

We previously completed an investigation of present knowledge regarding wetland reclamation (Graf, 2009). We also produced a gap analysis of past, presently ongoing, and anticipated research, which prioritized the identified these gaps to inform a research program to address them and accelerate the development and use of construction and reclamation practices leading to restoration of wetland ecosystem function (Osko, 2010).

The major gaps identified were classified into the following categories:

- a) Practical techniques for construction and restoration of roads and well pads,
- b) Effects analysis and documentation to more clearly define the hydrologic and ecologic effects of roads and pads so that construction and reclamation practices are more effective at minimizing these impacts,
- c) Landscape assessment and planning that addresses issues of cumulative effects and how to manage for them. In addition, such an assessment should be used to set landscape-scale goals and to tailor individual construction or reclamation projects to a broader landscape picture rather than having uniform targets for all individual projects.

The present work focuses primarily on first category, with some emphasis on the second. Specifically, we conducted a road reclamation study examining partial removal of road fill to re-establish hydrologic function and peatland vegetation to the affected fen, as well as a well pad reclamation study examining fill removal, surface microsite variation, and revegetation practices for restoration of functioning peatland vegetation to the affected fen. The basic challenges these projects address are questions surrounding the amount of fill required to be removed to adequately restore hydrologic function on and offsite; promote conditions for peatland revegetation onsite; practices for revegetating to a peatland community, including sources and application of plant propagules, microsite variability, and moisture regime; and influences of any remaining fill material on soil and water chemistry both on and offsite.

Objectives/Purpose:

We studied two sites, a pad (CNRL) and a road (JACOS), constructed within fens in northeastern Alberta from which clay fill had been removed to near the water table. We applied a mix of site preparation and revegetation strategies to each site. Surface roughness; transplants of graminoid,

shrub, and tree species; and introduction of live peat fragments were applied to the pad. Surface roughness was not applied to the road, but transplants of graminoid, shrub, and tree species, as well as introduction of live peat fragments were applied with and without amendment of soil with stockpiled peat. Our first hypothesis was that surface roughness would increase overall survival and growth of transplanted species because variation in surface elevation would increase the microhabitat diversity for plant establishment, thus enhancing resilience to water table fluctuation. Similarly, we hypothesized that species richness and diversity from natural recolonization would be greater on a rough surface than smooth for the same reason. Third, we hypothesized that introducing live peat fragments would increase species richness and diversity, particularly of wetland species. Fourth, we expected that amending soil with a stockpiled peat substrate would improve both transplanted and naturally occurring plant responses. Finally, we questioned whether live peat fragment introduction would also have a soil amending effect on transplanted vegetation.

As effects of the road and its reclamation are not restricted to the physical boundaries of the road, but also to the surrounding fen, we completed ecohydrologic studies on the fen adjacent to the road, which examined the following:

1. Whether partial road removal reduced the hydrologic gradient between the upstream and downstream sides of the road,
2. Effects of the hydrologic gradient on fen vegetation,
3. Spatiotemporal variability in nitrogen and phosphorus dynamics (nutrient pools, supply rates and mineralization rates) and CO₂ dynamics (net ecosystem exchange, respiration and gross ecosystem production),
4. Relationships between nutrient and CO₂ dynamics and their environmental controls,
5. Effects of the road on nutrient and CO₂ dynamics, and
6. How the “disturbed” fen adjacent to the road compares to undisturbed fens along naturally occurring hydrologic and vegetation gradients in northeastern Alberta.

Preliminary results:

Revegetation Studies:

Results from the two study sites were more insightful when considered together, rather than examining each of them on their own. Given that seasonal and year-to-year water table elevations

can vary considerably, drainage management is an important consideration for establishment of peatland vegetation on an excavated mineral surface within a peatland. There was no difference in transplanted species survival and growth between rough and smooth treatments overall on the CNRL pad, but survival and growth differed among planting positions within the rough treatment. This observation, combined with high mortality due to flooding on the road at the JACOS site implies that introducing surface roughness as a hedge against fluctuating water table for improvement in transplant survival is a reasonable approach in the absence of direct drainage management. Providing a varied micro topography increases options for both planting site and species selection, thereby increasing site resiliency to seasonal or year-to-year moisture variations. The same concept applies to improving diversity of naturally colonizing species. Again, although not definitively conclusive from the CNRL site alone that surface roughness improved species diversity, taken in conjunction with JACOS observations, it appears that surface micro-topographic variation does improve potential for diverse recolonization due to increased number of establishment microsites varying in soil moisture, soil temperature, insolation, and wind.

Our application of live peat fragments was a not very fruitful for revegetating the road or pad with peatland vegetation. However, the little positive evidence we did observe was consistent with positive results reported by others. There may have been factors peculiar to the CNRL site, such as too much mineral substrate, or to our procedure for collecting and distributing the peat fragments that led to the failure of this practice to be effective on our site. Given that others have had good success with this method, we believe it to be sound, but may require more precise management in application than we were able to achieve.

Similarly, it was difficult to determine whether the peat amendment contributed to success of natural colonizers because of the persistent flooding at JACOS. However, there was some indication that the combination of composted peat amendment with live peat fragment application produced positive results in terms of increased plant diversity, indicating that these treatments could be successful if used in combination, primarily to provide an organic substrate on which to establish mosses and other peatland plants.

Finally, there did appear to be some benefit of live peat fragment application to transplant survival and growth. While this was not the intended purpose of the peat fragment application, the added benefit is welcome.

Ecohydrologic Studies

The JACOS road produced a hydrologic gradient between the upstream and downstream sides of the road. Soil moisture was lower and depth to water table was greater on the downstream side than the upstream side, which resulted in subtle but measurable differences in vegetation species composition between the two sides of the road. Lowering the elevation of the water table did not improve water flow between the two sides of the road sufficiently to reduce this gradient.

While we expected differences in nutrient biogeochemistry and CO₂ exchange in response to the moisture gradient, few differences were observed. While there were no significant differences in nutrient dynamics between the two sides of the road, there were pronounced hotspots of elevated nitrogen in the groundwater on the drier side. These may have been associated with proximity to well pads or shallower peat. There was no significant difference in overall carbon exchange between the two sides of the road, probably because environmental factors controlling flux rates such as Photosynthetically Active Radiation, peat temperature, air temperature, and Leaf Area Index were uniform across the road. However, there were subtle differences in Gross Ecosystem Productivity (gross photosynthesis) between the two sides of the road, likely due to small differences in overall vegetation biomass and species composition between the two sides.

In comparison to other wetland sites, the moisture gradient across the road at JACOS was less than natural gradients observed among the sites, likely explaining the minimal differences observed in nutrient and carbon dynamics at JACOS road site. Of note regarding the five sites compared along the natural moisture gradient, was that there seemed to be a lower soil moisture threshold that was not breached despite increasing depth to water table. The soil moisture threshold may have been maintained by the common sub-humid climate and high evapotranspiration rates among the sites coupled with differences in capillary rise associated with different species occupying sites. The JACO road site did stand out among the others in terms of nitrogen cycling however, due likely to external nitrogen sources associated with greater industrial activity on this site compared to the others.

Anticipated Recommendations:

Based on our observations from the two sites, roughening the surface of mineral substrate that is to be reclaimed to peatland vegetation in order to increase microsite variability should be considered in the absence of direct or active surface drainage management. If available, the excavated mineral surface should be capped with stockpiled peat or similar organic matter to provide an organic substrate for peatland plant (especially moss) establishment. The cap should be deep enough to provide some buffering capacity from the mineral soil chemistry, as well as to have a moderating effect on water table fluctuations. The surface can then be revegetated with the peat fragment transfer technique, planting of appropriate peatland vegetation, or both.

Partial fill removal did not remove the damming effect of the road, which can have consequences on nutrient cycling and carbon cycling on the downstream side of the road due to differences in soil moisture between the upstream and downstream sides of the road. While such differences were subtle at the JACOS road site because the gradient caused by the road was not severe to begin with, simply lowering the road surface to near the water table will probably be insufficient as a general strategy for restoring hydrologic connectivity across a road and additional drainage strategies will be required.