Building Tomorrow's Society
Bâtir la Société de Demain

Fredericton, Canada
June 13 – June 16, 2018/ *Juin 13 – Juin 16, 2018*

MAJOR CIVIL ENGINEERING PROJECTS BOOST LOCAL WORKFORCE COMPETENCIES

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Abstract: Major civil engineering projects provide opportunities to develop new competencies through strategic government policies and corporate mindfulness. The experiences gained on two such recent projects in Atlantic Canada are examined. The projects are: the "Tar Ponds Project", a major environmental remediation and cleanup of the Sydney Tar Ponds and Coke Ovens site after 100 years of steel-making in Sydney, Nova Scotia, and the "Muskrat Falls Regulatory Compliance Project" for the 824 MW Hydroelectric Development on the Lower Churchill River in Labrador. Both multi-year heavy civil engineering projects shared challenges of large footprint on the land, multiple regulators and government levels, and very engaged stakeholders, including Aboriginal communities. This paper compares these projects to extract and consolidate practical project management insights gained to meet benefits agreement requirements through incorporating and coordinating local community workforces with specialist consulting engineers and scientists. These practical lessons learned inform civil engineering managers responsible for managing similar heavy civil and environmental engineering projects.

1 INTRODUCTION

It is good business for large complex engineering projects (major projects) to build in and incorporate mechanisms for sharing needs, understandings and boosting competencies: from job entry to highly specialized and skilled workers, to the professional development and evolution of engineers, scientists, and managers. Major projects can be a factor in community sustainability through improved "job-worthiness".

Local workforce competencies are enhanced on two levels on major projects—Leadership and Community Workforce. Leadership: engineers and engineering project managers develop leadership capabilities on major projects where there is uncertainty, ambiguity, and high-risk potential (financial and/or reputation). Many levels of leadership must coalesce individuals, teams, organizations, and environment. Leaders in these projects need to be different, flexible, responsive, adaptive, inclusive, and communicative. (Remington 2011) Sense and Kiridena discuss current theories of project management competencies for managing complex projects noting the "greater recognition of the significance of human, behavioural and social dimensions of contemporary project-based undertakings" (Sense and Kiridena 2014). From a practitioner's perspective, both Remington and, Sense and Kiridena provided useful insights during the lifetime of their major projects. Community Workforce: Benefits to local communities has been seen by governments as key to the long-term sustainability of the communities affected by major projects. Legislation at provincial/state and federal government levels provides a catalyst for change by project

owners and their contractors. The strategy and legislation are evolving. The United Nations 2030 Sustainable Development Goal #8: “Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all” is a lofty one (United Nations 2018) and one response invites governments to rethink local economic development for major projects (Ovenden 2018). From labourers to highly skilled personnel, major projects offer employment and financial stability. They are also rich training environments presenting individuals with new ways of knowing and behaving in the workforce. The insights the authors’ project teams gained on two major, transformative projects in Atlantic Canada, were to get involved early before the major project starts, to partner with training and community employment interest organizations, to provide internal training, to embrace diversity, to build individual competencies, resilience, and retention, and to build job awareness with opportunities offered to expand career capabilities for local workforces. It starts with people first. Providing local workforces with opportunities and experience in large transformational projects appears to have benefits that last beyond the project. Governments can provide leadership and incentives through enabling legislation and training programs available to project owners and developers to encourage engagement of local workforces, provide appropriate training, and operate in a manner that transfers and retains expertise to local workers.

2 TWO MAJOR ENVIRONMENTAL / HEAVY CIVIL ENGINEERING PROJECTS

The two projects discussed in this paper are both transformational projects in building communities and infrastructure that are liveable and sustainable. The projects technically transformed areas, through the engineering and construction that occurred there, and they impacted workforces in communities with sensitive culture and traditions by implementing programs to attract, train and hire local workers at all levels. This paper considers two major engineering projects with similarities and differences that supported competency augmentation in the surrounding communities.

2.1 Tar Ponds Project

The Sydney Tar Ponds and Coke Ovens Remediation Project (Tar Ponds Project) was an environmental clean up of a tidal estuary and lands impacted by 100 years of steel-making and coke production in Sydney, Cape Breton, Nova Scotia. The funding for the cleanup was split between the Canadian federal government (70%) and the Nova Scotia provincial government (30%) under a cost-sharing agreement. Together these two levels of government formed the “Owners” of the project. In 2004 at $400M, it was the largest remediation project active in Canada. The project affected local workforces in the First Nations communities of Cape Breton including Membertou and Escasoni as well as non-aboriginal communities of Sydney centre, the Pier, and Ashby. (Ingraham, McNeil and Burke 2014)

Figure 1 Sydney Tar Ponds Location (Ingraham, McNeil and Burke 2014)

The governments of Canada and Nova Scotia used the Sydney Tar Ponds Agency (STPA), a Special Operating Agency of the government of Nova Scotia, to manage and implement the remediation. The remediation plan, which underwent an environmental assessment (EA) required by the Canadian Environmental Assessment Act and the Nova Scotia Environment Act, described the project and served to determine the need for an environmental assessment and to promote efficient coordination of the environmental assessment. (AMEC 2004) The authors Ingraham (as STPA's Quality Contracts Manager) and McNeil (as Independent Quality Assurance Consultant - Manager) were responsible for quality compliance of work performed by the remediation contractors as mandated by the Environmental Assessment commitments for the project.

Composition of Local Workforce and Initiatives: The area boasts a diverse heritage of English, Scottish, Acadian, African Canadian, Mi'kmaq and Eastern European people. It has been economically depressed since the decline and eventual closure of the coal mining industry, steel making industry and the commercial fishery. While the workforce was well trained in specific aspects of commercial and industrial roles, initiatives relating to engaging and developing workforce competencies were a requirement to train and engage the appropriate employees to work on the remediation project. Some of the initiatives undertaken to engage and prepare the work force and the outcomes are listed in Table 1.

2.2 Muskrat Falls Regulatory Compliance Project

The Muskrat Falls Regulatory Compliance and Environmental Effects Monitoring Project (Muskrat Falls Regulatory Compliance Project) is a part of the larger Nalcor Energy Lower Churchill Project (LCP) Hydroelectric Power Development in Newfoundland and Labrador that was sanctioned in December 2012 (Government of NL 2012) by the provincial government (NL). The LCP is located within the traditional lands of Innu Nation. Locally, it has direct impacts on the communities of Happy Valley – Goose Bay, Sheshatshiu, Mushuah, North West River, Mud Lake, and influences Inuit, Métis, Settler and other surrounding communities and peoples. The area around the project is remote and sparsely settled. (Ingraham and Tucker 2017)

The LCP obtained agreement for Government of Canada guaranteed debt (through long-term (>35 years) bonds) and various other debt vehicles, and equity agreements (Nalcor, Government of Newfoundland and Labrador, and Emera) (Nalcor Energy 2018a) (Nalcor Energy 2018b). The LCP has a Regulatory Compliance Plan for Generation that includes Environmental Compliance (Nalcor Energy 2014) which outlines the framework covering environmental regulatory requirements and permitting required during construction as well as Environmental Assessment (EA) and Joint Panel (CEAA 2018) commitments. As part of the Consultant's team, the authors Ingraham (Senior Project Manager) and Tucker (Project Manager) were responsible for the overall planning and design leadership for the Environmental Compliance of three Muskrat Falls Regulatory Compliance Project programs: Avifauna Management, Historic Resources Management, and Environmental Effects Monitoring.

The Muskrat Falls Regulatory Compliance Project inherited the various requirements of the larger LCP, including compliance with the commitments made regarding employment, procurement, gender equity and diversity and monitoring and reporting. These are consistent with the Impact and Benefit Agreement (IBA) between Nalcor, NL government and Innu Nation ratified June 2011 and LCP's collective agreements set up as a part of the Construction Benefits Strategy (Nalcor Energy 2015). The Muskrat Falls Regulatory Compliance Project also inherited commitments made under the *Tshash Petapen* Agreement ("New Dawn" Agreement) with Innu Nation (ECNL 2008).

Table 1: Some Initiatives on Tar Ponds Project

Initiative	Outcomes
Local Economic Benefits (LEB) requirement for local employment	Tenders specified targets with defined priorities: Cape Bretoners first, Nova Scotians second, and others third); requirement for employment of African Nova Scotians; a built-in 15% weighting in the evaluation scores; LEB statistics were reported monthly to the STPA by every company working on the project.
Nova Scotia's first **Aboriginal Set-Aside** Procurement Strategy (from October 2005 Protocol Agreement with First Nations) (Collier MacDonald 2005)	Allocated $20M for Mi'kmaq First Nations owned companies for capacity and skills development. First Nations businesses received a total of $71.1M out of $323.5M as the experience gained on smaller works generated opportunities for partnering with other firms on larger works.
$1M **Funding** for Unama'ki Economic Benefits Office	Funding provided to upgrade skills of First Nations individuals in Cape Breton and identifying business opportunities for First Nations firms now has expanded operations to all of Nova Scotia and changed its name to Mi'kmaq Economic Benefits Office of Nova Scotia (MEBO)
Training programs – **Diversity and Inclusion:** African Nova Scotians; Older Workers program and skills gap program; women in non-traditional careers directly or through the Anne Terry Project, a local women's employment and development support centre	Organization: Involvement with Nova Scotia Community College (NSCC), Cape Breton University (CBU), Building Environmental Aboriginal Human Resources (BEAHR), Aboriginal Skills and Employment Partnership (ASEP); portfolio development program (24 participants); 14-week career decision-making program in trades and technology; leadership and sexual harassment awareness workshops (78 participants); 6 student scholarships ($18K); Sydney African Nova Scotian Employment Centre (ANSEC); *Women in Trades*; *Techsploration* for high school women; *Women Unlimited* training
Training Programs – Engineering Consultant Initiative: Work in Partnership with NSCC to develop a customized project training program: Construction-Enviro Worker Training Program	Course Purpose: A 1-year fast-tracked accredited program to train up to seventeen students from the five First Nation communities within Cape Breton in specifically identified areas of heavy civil construction and site remediation. This met the objective to provide inclusion opportunities and the necessary training to assist learners in obtaining supervisory or oversite positions within the project.
OVERALL	First Nations: 85 persons employed (70 Full Time Equivalents - FTEs) (5.4% of total workforce); 2.6M person hours (1301 FTEs) of which 89% were in Cape Breton. Contractors: 28 out of 32 contractors were from Cape Breton. Local Project Expenditures (as at March 31, 2013) 52% Cape Breton, 11% other Nova Scotia, 93% to Canadian firms or individuals. Women: $409K – women in trades and technology; 1-day annual Career Course for Young Women (38 participants) (offered 3 years). African Nova Scotians: $241K – ANSEC; 10 student jobs; tours and presentations to students; $25K for tuition of a NS engineering student/intern of African descent. The Economic Development Officer obtained outside funding for training, including an Older Worker program (36 participants) and skills gap training (16 participants); 28 bursaries
While these initiatives were successful in terms of participation, overall, African Nova Scotians did not maximize opportunities, due to capacity issues and conflict in the community. The African Nova Scotian Employment Centre struggled with communication, building awareness, recruitment, and responsiveness to businesses. A few interviewees felt more initiatives/opportunities should have been provided. It was noted that for women and African Nova Scotians, transforming acquired skills into employment was a challenge. (PWGSC 2014)	

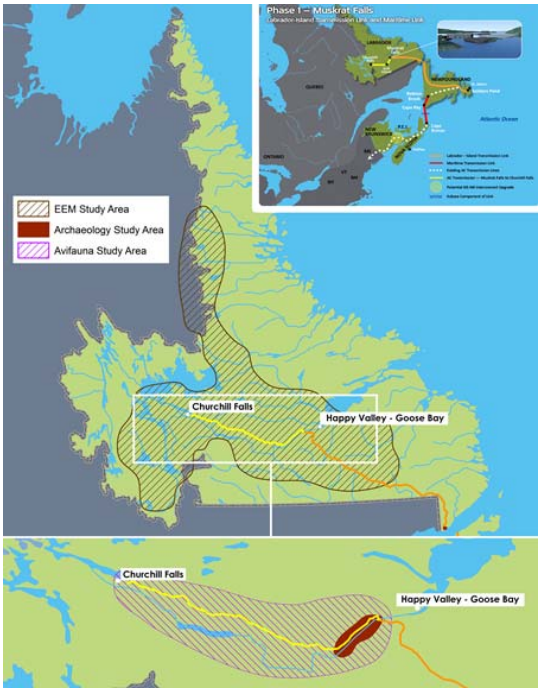

Figure 2*:* Muskrat Falls - Project Site Location (Ingraham and Tucker 2017)

Composition of Local Workforce and Initiatives: The local area had limited availability to meet the demands of the project. Using local people wherever possible, supported by training programs to prepare them was a requirement. Human resources were drawn locally, regionally, and beyond with professionals, technical staff, and skilled labourers employed. The make-up of the workforce was self-identified Aboriginal (Innu, Inuit, Mi'kmaq), Métis, and forces drawn from corporate resources mostly from Atlantic Canada. The gender ratio was an approximately even split. (Ingraham and Tucker 2017)

Table 2: Muskrat Falls Regulatory Compliance Project: Composition of Human Resources

Year	Male	Female	Aboriginal	Non-Aboriginal	Labradorean	Non-Labradorean
Employee Numbers						
2013	21	22	26	17	28	15
2014	36	26	25	37	34	28
2015	23	19	24	18	31	11
2016	29	20	31	18	36	13
2017	20	11	20	11	20	11
Total	129	98	125	101	149	78
% Ratio*	57%	43%	56%	44%	66%	34%
Employee Total Field Hours						
2013	6894.0	6,929.0	8,196.0	5,627.0	9,057.0	4,766.0
2014	13,122.5	11,153.5	12,134.0	12,142.0	15,437.5	8,838.5
2015	9,295.0	6,424.5	8,633.0	7,036.5	10,471.0	5,248.5
2016	13,160.5	7,629.0	13,314.0	7,475.5	15,156.0	5,633.5
2017	9,328.5	5,056.5	10,431.5	3,953.5	9,896.0	4,489.0
Total	51,800.5	37,192.5	52,708.5	36,234.5	60,017.5	28,975.5
% Ratio*	58%	42%	59%	41%	67%	33%

*Ratios are determined for pairs - Male:Female; Aboriginal:Non-Aboriginal; and, Labradorean:Non-Labradorean

Table 3 Muskrat Falls: Field Team and Field vs. Project Hours Breakdowns for all Components

	Field Team Breakdown				Field vs. Project Hours Breakdown			
Year	Tech Hours	Team Lead Hours	Total Field Hours	Lead vs. Total	Field Hours	Non-Field Hours	Total Project Hours	Field vs. Total
2013	9,668.5	4,145.5	13,823.0	30%	13,823.0	10,408.2	24,231.2	57%
2014	17,731.0	6,545.0	24,276.0	27%	24,276.0	18,560.5	42,836.5	57%
2015	9,874.0	5,845.0	15,719.5	37%	15,719.5	13,764.3	29,483.8	53%
2016	16,552.5	4,237.0	20,789.5	20%	20,789.5	11,834.5	32,640.0	64%
2017	11,203.5	3,181.5	14,385.0	22%	14,385.0	8,076.3	22,461.3	64%
Total	65,029.5	23,954.5	88,993.0	27%	88,993.0	62,643.8	151,652.8	59%

This resulted in several initiatives relating to developing workforce competencies and their outcomes summarized in Table 4.

3 PRACTICAL CIVIL ENGINEERING PROJECT MANAGEMENT INSIGHTS

Major projects offer engineers, scientists, and managers the chance to develop practical skills and behaviours that enhance their abilities as leaders. Globally, the technical professions are moving to be relevant and to be forces for change. Publicly visible major projects cannot be planned, designed, constructed nor maintained without considering the communities they affect. Major projects need the "social license" to proceed, which can be earned through generating new learning opportunities and increasing the public understanding of overall long-term community benefits and the environmental safeguards. Engineering companies should set up projects from the start to improve competencies for Aboriginal or First Nations persons, women, visible minorities, and youth. These projects provide opportunities for mentoring, role modeling, direct training to improve skills and fill gaps, to build individual and community resilience, and to have a diverse workforce free from paternalistic and out-moded policies and practices. (For more about individual resilience in the construction industry, see (Chen, McCabe and Hyatt 2017).) Mandatory local benefits programs and agreements may still be needed in the short term with Special Projects Legislation (Oakley 2012), Local Economic Benefits, (e.g. (STPA 2018)), Impact and Benefit Agreements (e.g. (Nalcor Energy 2015)), and Set-Asides (e.g. (Nova Scotia 2018)). Major projects help develop a culture of inclusion, respect and understanding. The engineering profession and practice can enhance these opportunities and local benefits to garner further support for projects, sustain their local workforce, and potentially deliver projects at lower costs through a locally trained and available workforce.

Figure 3 The "Pyramid Model" of Social License (adapted from (Thomson and Boutilier 2011))

Government and corporate mandates for local benefits: The Social License to Operate (Boutilier 2011) (Colton, et al. 2016) (Gehman, Lefsrud and Fast 2017) (Thomson and Boutilier 2011) has gained some momentum as communities, governments and consultants evolve relationships that are sustainable and where major projects, such as the Tar Ponds Project and the Muskrat Falls Regulatory Compliance Project have legitimacy, credibility and trust (Figure 3). The Government of Canada has been referring to Corporate

Social Responsibility (Government of Canada 2018) and the Social Licence for energy and extractive projects as well as projects determined to be of National interest. These relatively new components to decision-making (loosely interpreted as policy changes) necessitate the need to approach projects differently than in the past. In addition, many rural and First Nation communities recognize that they have not always maximized local benefit from projects, and are requiring a more meaningful means of engagement. Corporations also recognize the need to maximize economic efficiencies. Pulling together these three aspects (policy, community benefits and sustainability, as well as project economics) makes good sense for major projects.

Good sense for management: Projects are successful for numerous reasons, but in the end, capable, well-trained, affordable workforces are critical. Through investments and partnerships with local training institutes, hiring agencies, and meaningful trustworthy community relationships, the two projects in our study have shown both local and project benefits in longer term employment, higher than normal retention and a trained and experienced workforce to support the project. A trained workforce that evolves with the project reduces new annual investments for seasonal staff by companies, increasing productivity and reducing annual start-up training costs. Partnering experienced staff with new staff has increased ownership and on-site leadership skills to empower further growth and led to greater staff retention. In the longer term, higher staff retention not only adds to project stability and efficacy, but also to social stability from predictable and meaningful work. These staff become local advocates for the project and the company.

Table 4: Some Initiatives and outcomes specific to the Muskrat Falls Regulatory Compliance Project

Initiative	Outcomes
Innu-owned business	Stassinu Stantec Limited Partnership holds the contract.
Culture and Heritage – strong historical, cultural and spiritual significance	In support of the NL *Historic Resources Act* – Innu Elders are included in reviews of historic and archaeologic findings; school children are exposed in special presentations and activities.
Training Programs:	Site Orientation and Cultural Awareness Training: Innu cultural awareness for all employees – 389 Innu Awareness Orientations; on-the-job training for Avifauna Management and Historic Resources Management for both the project team as well as for other contractors of the LCP, cross-training (field work: Avifauna Management, Historic Resources and Environmental Effects Monitoring for economic and responsiveness gains), field supervisory training, mentoring and coaching that enhanced retention and development of field team leads from year-over-year returning field staff
Gender Equity and Inclusion	Hired 98 women, 125 Aboriginal people, 227 total hired to date
Community networking	Through the Consultant's longstanding office presence in the community of Happy Valley - Goose Bay and the involvement of their partner – Stassinu Services Inc. (an Innu-owned and operated local company) they were able to access the local community through various means and established relationships. These longstanding relationships allowed them to leverage local suppliers and human resources (staff) in effective ways.
OVERALL	Training and employment are welcomed opportunities in a region with some of the highest unemployment and poverty rates in Canada. The legacy is almost 100 local staff trained in new techniques related to biological field studies, archaeological excavations, and historic resource conservation techniques. The Innu-owned business strengthened ties in the entire community; increased understandings of the biophysical environment, as well as expanded the cultural and heritage knowledge the lower Churchill River over the past 3,500 years.

Collaboration Benefits—one example (from the Tar Ponds Project): The composition of the material which required remediation was a very unique product which consisted primarily of the combined by-products of steel making, coking and sewer outfall discharge into the same receiving environment. Given this product's unique nature, it created workability challenges for the proposed Remediation Action Plan (RAP). To address these challenges, extensive bench scale testing for solidification/stabilization was completed to optimize the test results which included specifications associated with compressive strength of the material, permeability, and leachability. One discovery of the bench scale testing and subsequent Phase I field testing was that sample preparation processes and conditions had a large impact on test results. The initial quality control and quality assurance test results from Phase I revealed significant variability in test results. Workability and preparation of the material and test sample preparation caused costly variations in results. The Consultant collaborated with the STPA, the design engineer, and the solidification/stabilization contractor and their quality control consultant to refine the material preparation and sampling process by **creating Standard Operating Procedures (SOPs)** for preparing the solidified/stabilized material and its subsequent test sample collection, handling, preparation, and storage. Once the SOPs were refined and tested, the process (considered unique to the characteristics of the material being solidified and stabilized) was shared by the Consultant with all stakeholders through several half-day **"Sample School"** training sessions. Sample Schools were provided to all those involved in the project including Consultant personnel, STPA personnel, the Independent Engineer (IE), the Design Engineer, and the prime Contractor and their Quality Control Consultant. After completion of the SOP collaboration and the Sample School training, significant improvements in the homogeneity of the processed material and subsequent test samples resulted in testing consistencies that were achieved immediately. The **benefit of collaboration** in this project was to build competence and improve results, which led to improvements in schedule and decreases in costs due to reduced re-working and re-testing of material (which saved many thousands of dollars to rework a cell realizing there were potentially hundreds of cells that might have required rework without this collaborative effort).

3.1 Key Lessons Learned and Opportunities for Improvement

Long-term Investment in Community: Both projects were successful because the Consultant was invested in the community and had its physical office embedded there for decades prior to start of the major project. Thus, the Consultant was able to leverage long-established relationships with local businesses, educational institutions, service providers and community workforces. **Long-term investment in Client:** Consultant and client were known to each other for decades prior to start of the major project and had an established understanding of each other. **Stable, predictable work**: Consultant invested in individuals to build skills and understandings about the nature of major projects and the availability of secure work over the project lifespan. In both projects, there was good staff retention and for the Muskrat Falls Regulatory Compliance Project there was no field staff turnover in the final year—a significant cost savings. **Open communications**: Transparent, honest, and frequent communications with staff, contractors, suppliers, clients/owners are a necessity. Both formal (reports, change orders, field instructions) and informal (conversations, observations, information sharing) communication pathways kept the projects current for those who needed to know information for decision-making. At times, shedding the hierarchical approach expedited solutions on the ground by making use of knowledge held by individuals and teams in the field. Highlighting issues immediately was followed up through more formal mechanisms later. **Adaptable and fluid processes**: Processes that are prescribed on paper at the start of the project must be adaptable to, and realistic for, evolving conditions and situations in the field in real time with direct and immediate communications. More efficient processes and collaborations arose from knowledge exchanged between management and field staff in real time. **Get early buy-in**: Understanding project goal(s) as early as possible benefited outcomes and deliverables of the project and the teams evolved with collaborative and cooperative goal setting and problem-solving. Trust developed early reduced costs of mindless and repetitive rework of tasks. Open communications between ground crews/teams reduced or eliminate suspicions and resistance to work in the field amongst different contractors/consultants. **Interpersonal relationships and experience**: mis-alignment of teams within a company or between a company and the client can negatively impact the progress of the project through withholding of vital information, delayed decision-making, higher costs, slipped schedules and pressures on staff. The project management team must constantly adjust to effect alignment and to communicate assertively the impacts that can result from failure to do so.

4 CONCLUSIONS

The insights that the authors' project teams gained were to get involved early, to partner with training and community employment interest organizations, to provide internal training, to embrace diversity, to build competencies and retention, and to build job awareness with opportunities offered to expand career capabilities for local workforces. It starts with people first. Providing local workforces with opportunities and experience in large transformational projects appears to have benefits that last beyond the project. Governments can provide leadership and incentives through enabling legislation and training programs available to project owners and developers to encourage engagement of local workforces, provide appropriate training, and operate in a manner that transfers and retains expertise to local workers. Long before either of the projects mentioned were awarded, strategic local relationships were well established. Working in the local communities on smaller scale projects built sustainable offices and networks which were heavily leveraged through trusted relationships as major projects in both areas were released. The success was realized not from 'fly by night' organizations looking just to maximize profits, but through working with neighbours as existing community members. Applying this local first approach proved to be both economically more sustainable through high retention and lowering travel associated costs, and potentially increasing community sustainability and resiliency by having a trained and experienced local workforce. Both project areas have historically had seasonally depressed workforces, and although these projects were also seasonal, they allowed for a level of security for workforces in anticipation of the next season of work. This allowed families to invest and settle more fully into their local communities. By having professionals identify the types of skills required to successfully deliver projects, Consultant worked with human resource staff, training agencies, and community resources to find and train local staff who were subsequently fairly compensated and valued throughout the project. Both the company and the individuals mutually benefited from this relationship, further embedding the company into the community and ensuring it is poised to work together building on these meaningful relationships on other projects in the future. As described in (Sense and Kiridena 2014), the projects highlighted in this paper benefited and they support the finding of the value of the human, behavioural and social dimensions of contemporary project-based undertakings.

Acknowledgements

The authors would like to thank the support of their teams and colleagues as well as their colleagues in the former Sydney Tar Ponds Agency (now NS Lands Inc.) and on the Nalcor Energy Lower Churchill Project.

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