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How Provincial and Local Discourses Aligned Against the Prospect of Dam Removal in New Brunswick, Canada

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ABSTRACT: In 2013, the state-owned electrical energy utility in New Brunswick, Canada, announced that a problem with concrete expansion was shortening by 40 years the expected life of the 660 MW Mactaquac Generating Station on the Saint John River. Its construction late in the 1960s, and the subsequent inundation of 10,000 hectares (ha) was part of a regional modernisation programme. Locals lost homes, agricultural land, communities and landmarks and a new mill changed livelihoods and attracted new people. In the intervening decades, the reservoir has become locally cherished for waterfront living and pleasure boat recreation. Since 2012, independent social science research about the fate of the dam and headpond has been undertaken in parallel with stakeholder engagement and public relations by the electricity utility. The final decision was delivered late 2016. The chosen option was to extend the dam's life through repairs *in situ*, not one of the options formally under consideration. This paper presents provincial-scale discourses on the Mactaquac decision, using a 2014 energy survey of 500 New Brunswick residents which included questions about the Mactaquac decision. Analysis reveals how provincial preferences aligned with local qualitative research (summarised in an Appendix), revealing preferences for ongoing headpond amenity and the avoidance of further trauma associated with major landscape change. Preferences of First Nations to remove the dam may yet prove disruptive to the announced option. The discussion summarises aspects of the case study relevant to other instances of dam removal and landscape transition, as well as exploring options for further theoretical development, testing or application. These opportunities include: why males and females demonstrated different scales of concern around Mactaquac; the implications of different framings of hydroelectricity development (e.g. sacrificial landscape or local energy) on removal debates; and, how public decision-making can usefully engage with rather than dismiss uncertainty and path dependency.

KEYWORDS: Amenity, energy, gender, hydroelectricity, multifunctionality, path dependency, sacrificial landscapes, social imaginaries, stakeholder engagement, uncertainty, New Brunswick, Canada

INTRODUCTION

Increasing numbers of dams are being removed in the United States each year for reasons of aging infrastructure and environmental concerns (Ryan Bellmore et al., 2016). Comparable documentation is hard to come by in Canada, yet a similar pattern of dam removal is not yet evident. In fact, the period of large dam construction may not yet be over in Canada (Environment Canada, 2004). The Site C Dam in Northern British Columbia and Muskrat Falls Dam in Labrador have both started construction in the last few years. Relatively small numbers of dam removals have taken place in Canada, compared to the number of dams, which are also poorly inventoried but approximated by the Canadian Dam Association to be 10,000, 933 of which are considered 'large' by the International Commission on Large Dams (ICOLD). British Columbia started in 2003 with the removal of the Coursier Dam for safety reasons (constructed in 1963) and has since undertaken at least 20 other small dam removals ("To remove or not to remove?", 2013). Ontario has removed many small dams, largely for environmental reasons, and is currently considering the removal of one of Canada's oldest hydroelectric dams at Chaudière Falls in Ottawa.

Not all dams are the same and those differences have important implications for dam-removal discussions. Indeed, "every dam removal is a singular experiment" (Fox et al., 2016: 96). Many dams that have been removed, or proposed for removal, linger from 19th century or early 20th century resource and industrial purposes that no longer exist, such as water supply for log runs or water power for textile mills. The headponds impounded by these dams have been present for many decades, sometimes centuries. Such a long presence in local landscapes seems to generate strong attachment for nearby populations, which start to see them as natural (Fox et al., 2016). Other dams are not obsolete in function but are no longer fit-for-purpose due to risk of failure, poor function due to sedimentation, or simply net water loss from evaporation if the damming was for irrigation purposes (Saurí and del Moral, 2001). Dam-removal discussions in such settings pitch local landscape connection against environmental restoration in fairly binary ways. Dams that continue to generate electricity, or that have multiple functions (energy production, recreation, irrigation, flood control) being variously well met, inspire a more complex discussion. These might include debates between green and blue environmental trade-offs: 'green' energy from a renewable water resource, versus 'blue' hydrologic connectivity and integrity. As recently shown, hydroelectricity remains broadly acceptable to Canadians as a source of energy (Comeau et al., 2015), perhaps in part because most of that infrastructure is far from centres of population.

Very little social science research has been undertaken in advance of any of these removals, in Canada or elsewhere (Born et al., 1998; Tullos et al., 2016). Rather, the arguments for and against removal have played out in the media, often pitching local residents and their real-estate values and recreational activities against conservation organisations interested in river restoration and fish populations. As Babbitt (2002) observed, the arguments against dam removal are often very similar to those used to protest dam construction. There is some evidence that path dependency is part of such problems of landscape change. Path dependency describes the tendency of new investment to follow and reinforce past investment, thus narrowing the set of options perceived as viable (Marshall and Alexandra, 2016). A decision made once makes it easier to make again (or alternatives harder to make, known as 'lock in' (Wilson, 2014)), whether it is taking a short-cut, participating in a social norm like sending kids to school, or building a particular kind of energy infrastructure to meet needs. This is reminiscent of Giddens' (1979) theory of structuration, which described the recursive reproduction between systems (individual and group practices) and structures (institutions that enable those practices through roles and resources). Path dependency explains, for instance, why the Site C Dam under construction on the Peace River was described by BC Hydro as an efficient decision: the first two dams upstream made Site C more powerful while reducing its marginal environmental impact (Loo, 2016). Moreover, BC Hydro's promise that building Site C will prevent other rivers being dammed suggests the environmental history language of 'sacrificial landscapes' for public good (Black, 2000),

which is a relatively new idea for renewable energy. Diversity of experience within these concepts, such as gender and indigeneity, have largely gone unexplored.

This paper elucidates a case study in New Brunswick, Canada, where the future of the prematurely failing Mactaquac Dam and Generating Station has been in discussion since 2012. The dam had started construction 20 km upstream from the capital city of Fredericton in 1966, the third, newest and furthest downstream dam on the Saint John River (called Wolastoq by local First Nations), becoming operational in 1968. The headpond flooded 10,000 hectares of farms, settlements and infrastructure; further expropriations were made for a pulp and paper mill, and several parks adjacent to the water (Si, 1993; Bourgoin, 2013). The dam further blocked the migration of salmon as well as other species already affected by the older Beechwood Dam 100 km upstream. Salmon transported above the dam were further decimated by the stocking of the headpond with species that compete better in lake environments such as bass and muskellunge. Dam removal was one of the three, and later four, options under consideration during that period, but was very much a minority preference. Instead, a range of interests aligned quickly and eventually successfully in favour of maintaining the dam and its associated headpond. In this paper, we present the results of a 2014 survey of New Brunswick residents about the Mactaquac decision. Reflecting on these data, along with parallel qualitative social science work in the region (Keilty et al., 2016; Sherren et al., 2016), we reveal how and why the dam removal option came to be rejected, and what that means for other dam-removal cases.

Only a few independent researchers – i.e. not paid by the utility or advancing a preferred outcome – followed this case. Our team covered its entire duration (2012-2016). We undertook numerous qualitative and quantitative research projects over that period (Appendix A), as well as following media and attending public events. This is 'critical instance' case study research in that it does not set out to make generalisations, or test theory (Flyvbjerg, 2006). Instead it takes advantage of the rare occurrence of a dam-removal discussion happening amidst many of the same people who participated in the dam-construction discussion. Mactaquac reached the end of its useful life 50 years prematurely, which puts it at the front end of a wave of similar decisions that will need to be made all across North America and beyond as 20th century dams come up against similar issues of replacement, refurbishment, and removal, all in the context of carbon pricing, other renewable alternatives, and the like. Moreover, had dam removal been the option chosen, Mactaquac would have been the largest dam removal of its kind in the world. We appreciate this special issue explicitly welcoming such cases.

The first goal above – understanding how and why the dam removal option came to be rejected – requires two things to be fully achieved. This has implications for the paper structure that bear explaining up front. First, we feel posterity would benefit from us giving substantial space in the paper to document this particular instance of public interest decision-making. Second, we seek to understand the outcomes of that process using empirical results. In doing that we are problem-driven rather than theory-driven. This paper is transparent about our lack of a theoretical framework at the outset. Such an approach is consistent with grounded theory, though we do not claim to have adhered to any such protocols (Knigge, 2017). Theory is discussed here consistent with where it was leveraged in the research. We intentionally do not reverse engineer a theoretical frame into our introduction to suggest we knew where we were heading. We offer this rich case study with the confidence that such a fully 'worked' example will provide an adequately vicarious experience to allow use and perhaps even generalisation by others (Ruddin, 2006). In the discussion we provide some theoretical implications that the results raised for us.

THE CASE AND THE DECISION

In April, 2013, New Brunswick Power (NB Power), the Crown Corporation¹ electricity utility, announced that the future of the Mactaquac Dam and Generating Station was in question. Structural issues with the dam had begun to emerge as early as the 1980s. An aggregate was used in the concrete powerhouse and spillway that led to a chemical reaction called Alkali-Aggregate Reaction (AAR) that causes the concrete structures to swell, requiring constant maintenance and suboptimal power generation. The dam was engineered to provide approximately 12% of the province's power, but it is generally used for daily peak loads rather than base load and is reported to generally operate at 28% of its capacity (Cronin, 2016). The 2013 announcement was an admission after 45 years that the predicted 100-year lifespan could not be achieved without significant reinvestment. Furthermore, a solution would need to be in place by 2030. NB Power committed to a fulsome conversation with residents of New Brunswick about the options then on the table: (1) rebuilding a new powerhouse on the opposite side of the river, (2) removing the power-generation infrastructure but leaving the earthen dam and headpond intact, or (3) removing the dam and headpond. In New Brunswick, important estuarine sites have recently been restored (e.g. removal of a dam on the Eel River after 47 years, in 2010-2011; the opening of the gates at the Petitcodiac Causeway in 2010, projected for full removal in 2017), as well as several smaller structures removed, but none of these structures produced electricity for the grid.

The announcement came at a difficult time for the small (750,000 population), aging (median age 43.7) and indebted Atlantic Province. The Province had committed to a renewable portfolio standard of 40% by 2020. This was not too high a bar to achieve. At the time of that commitment, as much as 36% of the province's electrical energy was coming from renewable sources. However, the removal of the 12% of the province's electrical energy supply able to be supplied by the Mactaquac Generating Station would make that 40% target much more difficult to achieve. Furthermore, as a daily peaking facility, Mactaquac was an excellent asset for backstopping other renewable sources of energy that suffer from intermittency (e.g. solar when the sun does not shine or wind on calm days). More recently, the Canadian Federal Government announced carbon pricing for the provinces starting in 2017.

NB Power had made a number of costly infrastructure decisions over the prior decade which lowered public confidence in the utility: refurbishing the Coleson Cove Generating Station to use low-quality bitumen-based fuel without properly securing a reliable supply; doing the first refurbishment of a CANDU-6 nuclear reactor at Point Lepreau at great cost and time overruns. Elsewhere in the energy sector, oil and gas were not exempt from controversy: violent protests over shale gas development led to an indefinite moratorium on the technology; citizens worried about accidents with trains transporting oil; and debate raged about the proposed Energy East pipeline to move Alberta crude oil to a deep-water port at Saint John, NB. Amidst all this was the abandoned attempt to sell NB Power's assets to Hydro Quebec. This idea was proposed in 2009 and abandoned in 2010 when Hydro Quebec pulled out, anecdotally in part because of the risk presented by the flawed Mactaquac Dam. In general, New Brunswick residents believe that provincial decision-makers are biased towards industry (Sherren et al., 2016), particularly J.D. Irving Ltd.; which, in addition to dominating forestry, food, oil and shipbuilding, controls all the newspapers of the Province (Poitras, 2014).

The province has not distinguished itself with regard to open, frequent or genuine public engagement in the past decade (Beckley, 2014). Perhaps as a reaction to concern over this fact, NB Power carried out an almost unprecedented amount of public engagement in the region over the Mactaquac decision. The public utility hired consultants to undertake a standalone stakeholder engagement with six NB Maliseet (First Nations) bands. This process excluded the Wolastoq Grand

¹ A Crown Corporation is a company-like organisation, such the Canadian Broadcasting Corporation (CBC), owned entirely by the Government of Canada. Simply put, Crown Corporations are state-sanctioned monopolies constituted when government believes the public interest is served by such a structure.

Council (the traditional government), the Houlton Band of Maliseet within the Saint John River catchment in the neighbouring US State of Maine, and the significant number of members of the First Nations living off-reserve. The utility also hired a public relation and a market research firm to undertake separate engagement processes with local and provincial residents. According to the final report, those opportunities to engage included "open houses, community dialogue sessions, stakeholder workshops, a custom online survey, formal submissions, and public opinion research conducted by telephone" between 22 September 2015 and 31 May 2016 (National Public Relations & Corporate Research Associates, 2016: 3). Their methods did not adhere to social science standards in either collection or analysis: preferring simple response volume over representativeness, self-selection over stratification, and without controls on completion allowing the equivalent of ballot box 'stuffing' by particular interests. NB Power committed millions of dollars in biophysical research related to the options for Mactaquac, none of which had been published publicly or in peer-reviewed journals before the decision, but clearly did not understand or trust the potential of rigorous social science.

At the beginning of the month that public comment was to be closed prior to a decision (31 May 2016), NB Power added a new option to extend the life of the dam through repairs. Information on this option and its technical feasibility were elusive: it was first mooted in October 2014 but was not formally included among the options under consideration later (CBC News, 2014). It was ruled out on 29 March 2016 (White, 2016a), and then reappeared on 6 May 2016 (White, 2016b). In July 2016 an article reporting on a spill of lubricating oil at the dam limited the options under consideration to two: "whether to extend the life of the current dam beyond 2030, or remove the dam and allow the river to return to its natural state" (Hazlewood, 2016). An email to the journalist about whether this was an error went unanswered.

The final decision-making process was extremely opaque. On 20 December 2016 the chosen option was to prolong its life to the originally expected lifespan of 2068. During that announcement, the CEO of NB Power said that they were choosing the cheapest option, but neglected to 'show their work', explicitly saying it would not share the studies it used in making the decision. The final report of the public engagement programme reported on grouped and counted expressed concerns, and determined that the primary concerns were environment, cost, energy prices and local jobs (National Public Relations & Corporate Research Associates, 2016). They never asked participants to express a preference for a particular option. Rather, they limited their solicitations to values of concern. Notwithstanding the flawed methodologies of this research, NB Power did not even carry through by demonstrating how the options aligned with these and other variables of interest. Nor did they explain the relationship between values expressed by various publics and stakeholders and the preferred option they put forward. A community advisory group was provided indications in mid-2016 that a Multi-Criteria Decision Analysis model was under construction to guide the decision, but no other evidence was provided of a systematic approach to the decision that combined ecological, economic and social data. The next few years will involve formal approvals and environmental reviews, before starting on what is now called the 'Mactaquac Life Achievement Project'.

Many people feel that dam removal was never genuinely 'on the table'. Removal was never described in similar detail to the other two options in the comparative reviews released in August 2016 (Dillon Consulting Ltd.; 2016; Stantec Consulting Ltd.; 2016), including inadequate detail in landscape visualisations (Sherren et al., 2016). Many questions about the dam-removal option that arose during public engagement were never answered. The public engagement final report included copies of some communications as an appendix, but did not make them public as they were submitted. Among these were: Who will own that land exposed by draining the headpond? Will present residents with access to water retain that right? What will environmental remediation of exposed land involve and who will pay those costs? Do the sediments present any environmental risk (given historical, contaminants from upstream potato farming and pulp and paper industry)?

Finally, the expressed preferences of one critical local group that did want the dam removed seemed to be buried. Six Maliseet bands were engaged in a separate, closed consultation process with the Dillon Consulting Group, the outcomes of which were never publicly released. When, in July 2016, the Grand Chief of the Wolastoq Grand Council made a press release that the Council preferred the dam be removed, it was only carried by the non-Irving *NB Media Co-op* (Tremblay, 2016). No newspapers picked up the story, though it did appear as a single line in that CBC (i.e. non-Irving) coverage of an oil spill at the dam (Hazlewood, 2016).

METHODS

In fall 2014 we conducted a survey in the field with a representative sample of New Brunswick residents ($n=500$) via online panels. This was a year before the formal stakeholder engagement, but a year and a half after the initial announcement of the problem and well within the period of local speculation and debate. Although local perspectives were clearly important for the Mactaquac decision, the cost of all three of the options was significant (2-5 billion CAD), and would likely have to be carried by New Brunswick taxpayers.² The survey explored energy literacy, exposure to energy infrastructure, energy source preferences, and engagement in energy issues, as well as levels of trust in various organisations and overall world view. The survey design was largely the same as was implemented for an associated national survey (Comeau et al., 2015; Parkins et al., 2017), in which the proportional share for New Brunswick was only 72, but it included four specific questions on the Mactaquac Dam.

After extensive pre-testing, our survey was administered across New Brunswick from 15 to 28 October 2014, by polling firm *Corporate Research Associates* (the same as used by NB Power for their public opinion survey). Participants were recruited from a diverse database of over 450,000 Canadians managed by the firm *Research Now* who agree to do surveys in exchange for points redeemable for small rewards. These so-called 'online panels' are used to select stratified samples for research purposes. In our case, given the status of New Brunswick as officially bilingual in English and French, a bilingual email solicitation was sent to a sample representative of the provincial population. Online panels are often biased toward overrepresentation of younger female respondents. We managed this potential bias by establishing quotas to ensure that region, age and gender sample proportions were representative of the New Brunswick population as measured by Statistics Canada. Income, education and urban/rural distribution data were also collected and tracked for alignment with Statistics Canada national proportions.

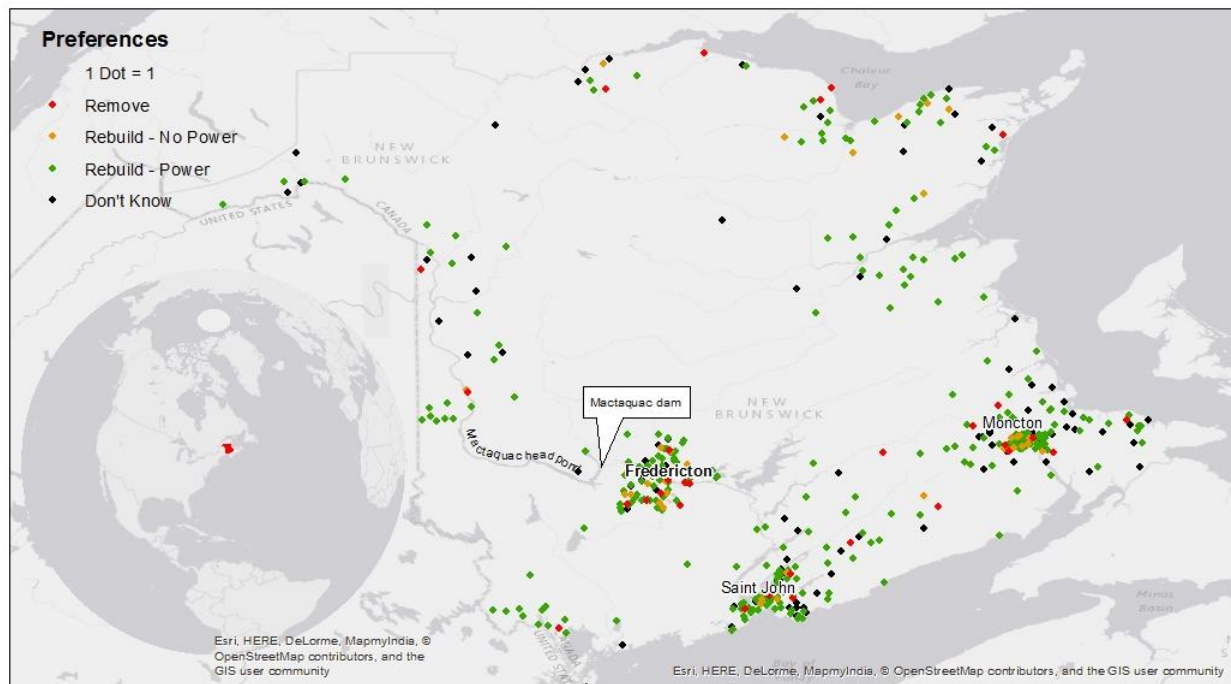
In general, methods and response rates for this survey are consistent with the industry norm for online panels. To secure 500 completed surveys, 5154 email solicitations were required. Of these, 829 began the survey: 109 did not complete, 28 were terminated because they were ineligible, and 192 because the proportional quota for their demographic had been reached. The subsequent response rate of 16% fell within the average of 15 to 20% for *Corporate Research Associates'* online panels and was also consistent with average response rates for random sample telephone surveys. This survey took an average of 25 minutes to complete (excluding those who took more than an hour, who likely left the terminal idle for some time). The completion rate was 82% (somewhat higher than the industry average of 75% for online panels). By coincidence, the random selection, when mapped using postcodes, included very few respondents from the area of the headpond itself (Figure 1).

Qualitative survey responses were thematically coded and are summarised in prose, using anonymous verbatim excerpts to illustrate the language employed. Quantitative results were statistically analysed using descriptive statistics, cross-tabulation, tests such as chi-squared and finally

² Current rumours and legislative changes suggest a public-private partnership is pending, perhaps with Nova Scotia-based Emera Inc., which has recently bid to supply power to New England via cable from NB.

multinomial linear regression to predict the preferred Mactaquac outcome. In this paper, we consider five-point Likert scales as symmetrical, continuous measures, and calculate means for use in regression. We developed separate regression models for each gender, and classified quotes that way, rather than other possible analytical categories such as age or first language, because of the outcomes of parallel work at a national scale and in other case studies and perceived gaps in energy infrastructure research more generally.

Figure 1. Map of survey respondents within New Brunswick.



Note: The province is identified in red on the inset locator. Points are randomly distributed within postal codes volunteered on the survey, coded by expressed preference on the Mactaquac Dam.

Decades of research have been undertaken into scientific knowledge, risk perceptions and environmental values and behaviour across genders. Results have been mixed on gender differences in environmental orientation (Hayes, 2001; McCright and Xiao, 2014; Zelezny et al., 2000) and support for 'hard' (i.e. oil and shale) or 'soft' energy paths (i.e. conservation and renewables) (Longstreth et al., 1989). Females appear less risk-tolerant (Weiner et al., 2013), though researchers in carnivore and lethal wildlife management have found gender difficult to disentangle from other demographics within models (Dougherty et al., 2003; Agee and Miller, 2009; Johnson, 2014), such as lower likelihood of a strong political orientation (Davidson and Haan, 2012). In a recent Canadian survey ($n=3000$) women had lower tested energy literacy, as well as confidence in their knowledge on energy, and were more inclined than men to hold neutral views on energy development (most neither supporting nor opposing individual sources) (Comeau et al., 2017). In nearby climate adaptation work females emerged as the protectors of place, even when that place was an anthropogenic landscape, rejecting the restoration of abandoned agricultural dykelands back to salt marshes (Sherren et al., 2016). We saw an opportunity with our stratified sample to understand if men and women preferred different outcomes on the Mactaquac Dam, and if they held the same preference, if it was associated with different explanatory variables.

RESULTS

Quantitative analysis

In general, respondents did not feel well-informed about the Mactaquac issue at the time of the survey. Only 7% said they knew 'a lot' or 'quite a bit' about it, a mere five persons opting for the former. Males were twice as likely to choose 'quite a bit' or 'a moderate number' than females (105 compared with 54), and females commensurately more likely to choose 'not much' or 'nothing' (208 compared with 128). Despite a general lack of self-assessed knowledge, most respondents (63%) preferred to see the dam rebuilt with the same or more electric generation capacity. The next most common answer was 'Don't know' (23%). Only 6% believed at that time that the dam should be removed. As might be expected, a higher-than-expected proportion of those who said they knew nothing about the discussions around the Mactaquac Dam said they did not know what should be done with the dam (Single-cell chi-squared = 11.1, see * in Table 1). Those who said they were regularly exposed to hydroelectric installations were less likely to be uncertain about the decision (chi-squared=5.2 and 11.4 compared with 25.5% for those not exposed to hydro).

Table 1. Perceived knowledge of Mactaquac Dam discussions and opinions on the dam's future, by number and proportion.

Option/Knowledge	Nothing	Not much	A medium amount	Quite a bit	A lot	Total
Rebuild the dam with the same or more electrical generation capacity	71 (14%)	130 (26%)	90 (18%)	22 (4%)	4 (1%)	317 (63%)
Retain the dam and the reservoir (head pond) behind it, without electricity generation capacity	10 (2%)	15 (3%)	11 (2%)	2 (0.4%)	0 -	38 (8%)
Remove the dam	3 (1%)	13 (3%)	10 (2%)	3 (1%)	1 (0.2%)	30 (6%)
Do not know	49* (10%)	45 (9%)	19 (4%)	2 (0.4%)	0 -	115 (23%)
Total	133 (27%)	203 (41%)	130 (25%)	29 (6%)	5 (1%)	500 (100%)

Note: Asterix (*) denotes a significant chi-squared result.

There were various drivers of preferences about the future of the Mactaquac Dam. Potential benefits to the province, economy and consumers had the highest mean score, while the assessments of risk (e.g. the potential for dam failure, or the trustworthiness in general of hydro technology) was most often assessed as 'extremely important' (Table 2). The other drivers were most often assessed as 'important', least among these landscape impacts, which only 56% considered important or extremely important. The rest were assessed by 69 to 80% in that range (Table 2).

We used multinomial linear regression to try to identify the predictors of each preferred opinion. Females were twice as likely to say they did not know what should be done with the dam (61 females compared with 32 males), leading all three options to be more likely to be preferred by males. Knowing that gender is a knowledge gap in terms of energy issues, as discussed earlier, separate models were developed for each option as well as for each gender (Table 2). These models predict each combination of preference and gender by a range of demographic, knowledge, and experience variables (described fully in Appendix B). In order to include income as a variable, models exclude respondents who preferred not to share their income, and thus comprise 215 males (LR $\chi^2 = 146.8$, Pseudo $R^2 = 0.3305$)

and 223 females (LR $\chi^2 = 151.29$, Pseudo $R^2 = 0.3832$). All models compare against those who state they do not know what should be done with the dam.

Table 2. Respondent rating of the importance of various issues associated with their position on the Mactaquac Hydroelectric Dam.

Score	When thinking about the province's options for the Mactaquac hydroelectric generating station, please indicate how important the following were in influencing your answer				
	Benefits (to the province, economy and/or consumers)	Risk to human health and safety	Impact on the environment	Costs (to the province, economy and/or consumers) to develop or maintain	Impact on the landscape
Not very important (1)	5 (1%)	21 (4%)	17 (3%)	13 (3%)	43 (9%)
Somewhat important (2)	21 (4%)	37 (7%)	34 (7%)	35 (7%)	53 (11%)
Moderately important (3)	74 (15%)	84 (17%)	84 (17%)	105 (21%)	122 (24%)
Important (4)	232 (46%)	163 (33%)	194 (39%)	215 (43%)	170 (34%)
Extremely important (5)	168 (34%)	195 (39%)	171 (34%)	132 (26%)	112 (22%)
Mean score	4.07	3.95	3.94	3.84	3.51
Standard deviation	0.86	1.11	1.04	0.98	1.20

The most common preference stated was for the dam to be rebuilt with power generation. Both males and females were significantly motivated toward this option by the benefits it represents (z-scores of 4.71 and 2.68 at 99% confidence) and not by its cost (-3.25 and -3.44, 99%). Risk, however, divided the genders: risk was negatively correlated for males (-2.73, 99%), as it was for men around all three options, and positively for females (1.74, though only at 90% confidence). For males, opting for rebuilding with power was associated with self-reported knowledge of hydroelectricity (2.19, 95%) and conservatism (2.02, 95%). For females, preferring rebuilding with power was positively associated with self-reported high knowledge about the Mactaquac issue (2.03, 95%) and tested energy literacy (2.09, 95%), and negatively associated with formal education (-2.19, 95%).

Of those in this model who had a preference (i.e. did not select 'don't know'), options 3 (remove the dam) and 2 (remove the powerhouse but retain the dam and headpond) were less commonly preferred by both genders, both at about a tenth of the rebuild-with-power option (26 and 33, respectively, compared with 286). Despite the small n , these options revealed very different stories by gender.

Those preferring dam removal were unified by environmental motivations for their choice, though for males this was much stronger (2.88 with 99% significance) than for females (1.65, 90%). As with other options, risk perceptions were strongly negatively associated with the choice for males (-3.26, 99%), and a lack of support for hydroelectricity in general (-2.02, 95%). Males preferring this option were also somewhat significantly more conservative than those who did not know what should be done with the dam (1.92, 90%). Female respondents preferring dam removal, by contrast, tended to assess their knowledge of the Mactaquac issue as high (2.72, 99%), and both benefits (-2.52, 95%) and landscape implications (-1.71, 90%) were negatively associated as motivators of the removal option.

The choice to remove the hydroelectric facility but replace the dam without power generation is a complex mix: according to NB Power this option would be cheaper to undertake than a full rebuild, yet maintain the status quo landscape. Males and females had completely different models for this option.

For males, this preference was motivated by its landscape implications (2.3, 95%), but not risk (-3.11, 95%; consistent with other options), and it was positively associated with their reported knowledge of hydroelectricity in general (2.85, 99%). For females this preference was not positively associated with any of the listed motivations. A benefits motivation was significantly negatively associated with this option for females (-2.13, 95%). For females, preferring this option was associated with scoring high on ecocentrism (3.17, 99%), although environmental motivations were slightly negatively associated (-1.51). Preferring this option was also negatively associated with age for females (-2.17, 95%), as well as with formal education (-2.66, 99%), and with their self-assessment of their energy knowledge (-2.11, 95%), although income was somewhat positively associated (1.92, 90%).

Table 3. Multinomial linear regression predicting preferences for three Mactaquac options, by gender, compared to 'don't know'.

Variable	Rebuild with power		Rebuild without power		Remove the dam	
	Male (n=151) Z- score	Female (n=135) Z- score	Male (n=17) Z- score	Female (n=16) Z- score	Male (n=15) Z- score	Female (n=11) Z- score
Age	+0.48	+1.22	+0.76	-2.17 (**)	+0.58	+0.84
Political views (Conservatism)	+2.02 (**)	-0.49	+0.65	+0.68	+1.92 (*)	-1.18
Income	+0.72	-1.04	+0.14	+1.92 (*)	+0.58	-0.16
Education	-0.65	-2.19 (**)	+0.4	-2.66 (***)	-0.15	-1.53
Ecocentrism ^	+1.22	+1.62	-1.18	+3.17 (***)	-1.05	+0.08
Support for renewable energy ^	+0.53	+0.65	-0.09	-1.26	+1.35	+1.55
Support for hydroelectricity ^	+0.11	+1.43	-1.14	+1.03	-2.02 (**)	-1.25
Regular exposure to hydroelectricity ^	+0.57	+0.41	+1.61	-0.36	+1.55	-0.82
Self-reported knowledge of hydroelectricity ^	+2.19 (**)	-1.16	+2.85 (***)	+0.46	-0.17	+0.01
Tested energy literacy ^	+1.41	+2.09 (**)	-0.01	+1.51	+0.29	-1.03
Self-reported energy knowledge ^	+0.82	+1.11	-0.74	-2.11 (**)	+0.04	-0.91
Knowledge of Mactaquac issue	-0.4	+2.03 (**)	+0.16	+0.48	+1.54	+2.72 (***)
Environment rationale	+1.31	-0.52	+1.02	-1.51	+2.88 (***)	+1.65 (*)
Cost rationale	-3.25 (***)	-3.44 (***)	+0.18	+1.46	-0.28	+1.27
Risk rationale	-2.73 (***)	+1.74 (*)	-3.11 (***)	+0.01	-3.26 (***)	+0.95
Landscape rationale	-0.4	-0.87	+2.3 (**)	+1.16	+1.32	-1.71 (*)
Benefits rationale	+4.71 (***)	+2.68 (***)	+0.2	-2.13 (**)	+0.25	-2.52 (**)

Note: with coefficient (+/-), Z-score (sig), where asterixes (*) indicate confidence: 99% (***) , 95% (**) and 90% (*). Variables marked ^ explained further in Appendix B.

Qualitative survey analysis

Only eight survey respondents included the Mactaquac issue in their comments when invited to describe what they thought the largest energy issue was in their province. Rather, shale gas – recently controversial – was most commonly considered the most significant issue. But there were two other locations on the survey where respondents could express more fulsome views on Mactaquac. One option was when they were invited to provide up to two additional drivers for their preferences on Mactaquac beyond the five provided. The second was when they were asked to provide any additional thoughts on the Mactaquac issue in an open-ended way. Only a quarter (27.4%) of participants opted to do any of these. Nonetheless the comments give a much more nuanced sense of what we see in the quantitative models. In this section, some of the key themes are described with direct quotes from the surveys. Those who expressed that they did not know what should be done, and those who opted for rebuilding without power, wrote very little (2 or 3 words per person on average, respectively, often with content of little salience). Females were much more likely to express ignorance, rather than just leave the comments area blank. The following draws more from the other two preferences, those who preferred rebuilding with power (7 words each, on average) and dam removal (12 words).

The damage is done

There were numerous comments including the idea that the damage is done – environmental, social and financial – and that it only made sense to continue to invest in it. From an affected pro-dam respondent:

My family lost 25 acres of farm land to Mactaquac in 67. This land will never be able to be used again it would be cheaper to rebuild than not to have it anymore (female).

This discourse was connected to quite emotional expressions of the sacrifice of the original residents, including "displacement", and "ancestors' graves [that] were moved": "enough devastation and heartache was caused by building the dam in the first place now we are accustomed to it and the landscape the way it stands" (female).

Even one person who did not have a preference said, "It seems to me that the environmental damage has been done, so there may be no benefit to abandoning the dam" (female). In remarkably similar language, two males agreed:

It is already there so rebuilding it won't, or at least shouldn't affect surrounding people, property or environments (male).

The dam already exists, so rebuilding it in the same place should have little, if any, environmental impact (male).

Of course, pro-removal voices assessed that environmental impact as ongoing rather than over and done with: "Hydro electric dams block off the natural flow of rivers and the animals that reside in them. We should be protecting our waterways not blocking them off" (male), and then "salmon might return" (male).

Words like "keep" and "already" were very common with pro-dam respondents, as well as the decision being described as a 'no brainer': "it is a no brainer, just refurbish it and get it over with" (male); "This is a no brainer – 50+ years ago we displaced people and their properties, built new roads to create this dam. The water is there now and in the future" (female). In a similar way, the fact of the existing investment seemed to validate further investment inevitable, the so-called 'sunk cost' fallacy: "We put a lot of money into it. We don't have a choice to keep it" (female); "rebuild the dam; it won't get any cheaper" (male). Those pro-removal saw that investment in the opposite way:

Ce poste hydroélectrique deviendrait un fardeau financier trop important pour la province et pour la population. [This hydroelectric dam is becoming too significant of a financial burden for the province and the population] (male).

Pro-dam respondents also voiced concerns about what damage a removal could do to the headpond environment: "If they remove it that will be doing more damage to area" (female), and "It would be a big mess if the dam were removed" (female). One female wrote, "after 40+ years, good luck with lawsuits having all those "waterfront" property owners losing their shorelines! (anecdotally, lots of politicians)".

Local energy and local jobs

There was also strong support among pro-dam respondents for using water to generate electricity because it is a local resource, and thus better than relying on imported fuel, such as oil or nuclear, or buying electricity from Hydro Quebec. For instance:

It makes no sense to destroy it or just let it sit there; make the upgrades and increase our province's ability to produce its own energy... and increase it! It's got to be better than relying on Irving for everything (female).

One male respondent said, "we need the dam to help with the infrastructure and keep our power local". One female felt "that having the hydro dam makes use of our natural resources and causes little to no harm to the environment", and another agreed "with using our own resources – water". Quotes like these included a sense that local resources were being underutilised, and thus economic development is less than it could be. For instance, a female observed, "New Brunswick is a resourceful province and I feel the government is not doing enough to help out its citizens".

This resource development concern was strongly linked to a general concern around jobs, and – for females – those jobs that might keep their young people working close to home. One female respondent was pleased about "keeping life in our now dying province", which another described as "where jobs are scarce and more being lost due to shut-downs and closures". Another wrote, of the spectre of dam removal:

The people we have employed at Mactaquac would be laid off affecting our economy possibly in many ways such as not having money to spend locally, an increase in unemployment and possibly even causing them to have to move from our area (female).

Many pro-dam respondents described how more and better jobs, in terms of number and duration, will come from rebuilding than from removing the dam. Concern about removal impacts were reflected in many other comments about risk to real estate and tourism values, particularly from females. For instance, the dam was described as a "tourism opportunity" and as an accepted "part of the scenery of NB". This was countered by a few pro-removal respondents who felt that an improved recreational salmon fishing opportunity might make up for the loss:

This could be a great tourist area if the river is then stocked with salmon. The Americans are doing it successfully so I think we should try (female).

Energy system investments

Many respondents clearly saw dams as 'green'. Those who preferred rebuilding with power felt that refurbishing the dam represented a more environmentally friendly solution than its removal. In general, pro-dam respondents felt that hydroelectricity was "environmentally friendly", "pollution free", "natural", "low impact", "clean", "renewable" and "sustainable". Respondents also expressed fears that any replacement energy source was likely to be more environmentally harmful than the dam. For instance, from one male respondent, "If the dam is decommissioned, where will the missing energy

come from? Perhaps from a more polluting source!", and from one female, "If this energy source is discontinued what source will take its place and how much of a negative impact will it have"?

Some of the respondents gave quite sophisticated assessments of the role the current dam, or a potential 'new and improved' dam, could make to the overall energy system. For instance, one female respondent noted Mactaquac's "cold start" capability, sometimes also called 'bootstrapping', meaning the ability to restart itself without using power and thus to be used to 'boot up' other sources. A male endorsed rebuilding Mactaquac to ensure the "diversity of [the] energy portfolio; flexibility of production output to meet the fluctuations in demand level". Only a few mentioned the need of improving energy conservation, for instance: finding "new ways to conserve or save the energy produced and to efficiently distribute it" (male). Another questioned whether the dam was needed, or at least in this location, given decreasing population.

Many pro-dam respondents saw the dam refurbishment as an opportunity to improve ("upgrade", "update") the dam: its production, efficiency, and sustainability. A number of respondents suggested that building the new dam downstream of the last, which one female described as in 'dry dock', would be easier and less costly.

Pro-removal respondents saw much more opportunity in making an equivalent investment in newer renewable technologies:

The expense involved in building a new dam would, I believe, be more than the cost of replacing it with wind power, which for the same money would produce more than the 12% of the energy of the dam (female).

Money can be better spent developing solar or wind power or other possibilities (female)

Remplacer l'énergie hydroélectrique produite de ce barrage par de l'énergie renouvelable moins couteuse à construire (i.e. éolienne) [Replace the hydroelectricity produced by this dam by renewable energy, which is less-expensive to build (i.e. wind)] (male).

They could, in place of the dam, use solar and wind plus geothermal all together to create an unlimited source of energy at a low cost to NBers and create new jobs for the province (male).

There were grave concerns about the cost of the project to the government, and ultimately to citizens. For instance:

If the costs they threw out earlier to fix or replace are correct I have no idea how NB will be able to pay for it. Maybe call Quebec and see if they still want to buy NB Power but don't mention that the dam needs fixing (male).

In the end, for pro-dam respondents, particularly males, the significant financial investment that rebuilding involved was seen as a good long-term investment, balancing costs, impacts and benefits:

...the costs involved are totally immaterial; especially when it comes to renewing the dam and the turbines it will recover much of the cost whereas destroying the dam or letting it simply self-destruct [will not] (male)!

Updating and upgrading an existing generation station can be costly upfront but the long-term indirect benefits to health and other impacts should be costed before making a decision based on the financial implications (male).

Some tensions were evident between long- and short-term thinking:

Regardless of which alternative is chosen now – to remove, repair, alter, or replace the dam – eventually the current structure in place at Mactaquac will have to be removed. Plan for that removal sequence now, BEFORE the thing is too damaged for a controlled event (pro-dam female).

Contrasting this, but predicting the outcome, one male respondent presciently wrote, "strengthening without a complete rebuild would seem to be the best option".

A dearth of trust and knowledge

Finally, lack of trust was an oft-mentioned issue: in the government, which is seen to regularly sell out to industry at the cost of (as several put it, "ripping off") citizens; in the utility, for their "poor project management history" (male); and in engineers who originally caused the AAR problem. In some cases, respondents saw the consultation process as expensive "dilly-dallying" (male), and wished they would spend the money on the work rather than talking about it. Several male respondents also noted the dearth of facts available at that time for citizens to make decisions on the options.

Respondents were uncertain about possible environmental improvements from dam removal. Male respondents hoped for better flood control from a new dam, as well as improved fish passage. There was clearly division on the issue of whether the dam improved or exacerbated river flooding such as during spring melt; however, for instance, "As I understand it – some of the serious flooding on the St. John River started after the dam was built. Would not removal of the dam reduce this problem?" (female); and, "Need to ensure that this dam doesn't continue to cause floods up-river" (male).

DISCUSSION

We set out to document and reflect upon citizen perceptions of the options for the prematurely failing Mactaquac Dam, after five years of debate, research and consultation, with the hindsight of the recent announcement by the utility of a preferred option. We presented new quantitative and qualitative analysis of a 2014 survey of New Brunswick citizens on the topic. That survey demonstrated low awareness of the issue within the province at the time, and the extent to which dam removal was a minority viewpoint. It also helped explain some of the reasons that a preference for dam removal was so rare. Previous to administering that survey (2013-2014) we engaged in qualitative research with Mactaquac locals, which presented other reasons for the rarity of that perspective, including some of the social pressures in the region to have the 'right' position (Keilty et al., 2016; Sherren et al., 2016) (Appendix A). Subsequent to our data collection, we followed the progress of NB Power's official stakeholder process during 2015-2016 using media monitoring and attendance at public events. We also continued to hear from locals informally. This discussion focuses on the dam removal option in contrast to the alternatives – all of which retain a dam and headpond – in relation to the literature and all of the above. It also presents several opportunities that we see for theoretical development, testing or perhaps even application in similar contexts.

The Mactaquac decision and its implications for dam-removal debates

Despite an imperfect process, NB Power arrived at a decision to extend the dam's life that seems congruent with the priorities we heard at local and provincial scales: safe, local renewable energy involving local jobs and the persistence of the headpond's associated amenities (Table 4). Respondents who argued for dam removal asserted that investment in renewables such as wind and solar would more than make up for Mactaquac Dam power generation at less cost than its refurbishment. For this small cohort, hydroelectricity was seen as an old technology, with environmental and social damage that was, 1) not over, and 2) not offset by its benefits. However, the survey showed that provincial priorities rank jobs and other economic benefits over uncertain environmental benefits and that most believed that refurbishment of the dam was least likely to result in any new environmental damage. This section describes some key findings and how they relate to dam-removal debates.

The overwhelming sense in this process is that the Mactaquac structure is seen to still serve a purpose; indeed, it is seen to serve multiple purposes. This is unlike situations around the potential

removals of dams that served erstwhile early-industrial roles (Born et al., 1998; Fox et al., 2016). Mactaquac was seen by citizens to contribute importantly to the energy mix. Though Mactaquac is not the only hydroelectric dam in New Brunswick, it produces more than twice as much power as all the other dams combined, and was seen as a clean source of that energy as well as being valued for its unique attributes (backstopping other renewables which have intermittency problems and its potential to bootstrap the entire electrical system for the province). It is clear, however, that the amenity value of the headpond was not considered any less of a 'use' for locals: these recreation and aesthetic values enabled a certain lifestyle and also attracted family visitors and tourists. In how locals expressed strong resistance to losing such engineered amenity, this case is very much like other contentious dam removal proposals in the literature (Born et al., 1998; Fox et al., 2016), as well as a recent ecosystem service assessment of the Mactaquac decision (Reilly and Adamowski, 2017), and other regional infrastructure decisions (Sherren et al., 2016).

Table 4. Key dimensions of the Mactaquac discourse against removal.

Energy System	Environment	Lifestyle	Employment
Plays important role; an opportunity to upgrade	Damage is already done	Investments already made to exploit headpond landscape	Local energy and amenity means local jobs
Replacement energy might be worse	Removal would harm with uncertain benefit	Removal would cause new losses for locals; negate original sacrifice	Removal a poor investment; no jobs

Associated with the above, dam removal and river restoration were not seen as a safe investment, for the province or for local residents. In cash-strapped New Brunswick, it was felt that investment of several billions of dollars should get you *something*. More and longer-lasting jobs were seen as coming from dam refurbishment than from removal. Many survey respondents described what they saw as an opportunity to upgrade the facility during refurbishment, to make more benefit from the infrastructure with new technology while at the same time making it more environmentally friendly (e.g. better fish passage). The investment was even considered a good one in light of the increasingly aged demographic of the province, and the shrinking energy needs with industrial decline, perhaps because of opportunities to sell surplus power to the New England states of the US. Tina Loo wondered, while questioning the persistence of such old technology in the context of the Site C Dam, whether Canada is becoming an "energy colony" of the US, "soiling its own nest" to serve that market (Loo, 2016). Massachusetts has recently opened a Request for Proposals for clean power supply, and the Nova Scotia-based power company Emera proposes to build an undersea cable from Coleson Cove, NB, to supply 900 MW of that energy (Ingram, 2017). NB Power holds an option to participate as a minority investor in that venture. Whether such opportunities are seen as entrepreneurial or colonial, New Brunswick residents seem to welcome them.

As in many other studies of dam removal (Born et al., 1998; Fox et al., 2016), residential waterfront real estate values were perceived as at risk if the Mactaquac headpond was to be drained. Tourism businesses such as campgrounds and houseboat rentals were also seen as dependent on the dam. No evidence was provided by NB Power about the potential impacts of dam removal on either real estate or tourism. A recent meta-analysis of dam construction projects in numerous other countries has sought to quantify the positive and negative effects of dams beyond electricity and jobs. Such effects are experienced by different stakeholders in asymmetric ways and are difficult to measure and thus compensate for (if negative) or distribute fairly (if positive). In fact, much of the lingering local trauma associated with the Mactaquac Dam derives from what are locally seen as inequities in compensation

back in the 1960s. The meta-analysis showed that while there is public aversion to the domestication of river landscapes through impoundment, and the subsequent impacts on aesthetics and environment, this aversion was not so high that people would be willing to pay to avoid it (Mattmann et al., 2016). Getzner (2014) has recently shown that free-flowing rivers are preferred to hydroelectric headponds for recreation in Austria, and importantly that visitors spent more per visit to free-flowing reaches. No comparable data are available for the Mactaquac. While the dam has been given credit for the recreational boom on its headpond, the braided reaches below the dam between Fredericton and Saint John also hosts significant recreational boating and tourism. River recreation was likely not as prevalent in either reach before the dam. That change may be easier to attribute to a shift from agricultural to service/industrial employment than to the dam: long hours with no clear holidays or retirement changing to careers with set shifts/hours with holidays and retirement.

It is likely that the reason for Mactaquac refurbishment to receive such support is simply that it is already there. Such path dependency is evident in much infrastructure and resource decision-making (Marshall and Alexandra, 2016). Questions have been asked about whether Mactaquac would even be built today, as the river has a relatively small slope at that point and provides little 'head' and thus potential energy. But despite the dam's damaged state, survey respondents used terms like "already" and "keep" (rather than replace). They also suggested that the damage was "done" (rather than ongoing, as ecologists might argue), and saw the only real option as investing further as a result of sunk financial, social and environmental costs. Interview research suggested that dam removal would be seen as a backward move, and possibly negate the value of the original sacrifice (Keilty et al., 2016). It is evident that the distaste for dam removal is not purely a resistance to landscape change (i.e. NOOMBY, not out of my backyard (Fox et al., 2016)) by the fact that the option of rebuilding without power (i.e. keeping the headpond intact for landscape and recreational reasons) was such a minority preference, despite its cost being lower than rebuilding. Of course, path dependency means that dam removal is even more unlikely to be considered later, even if engineers are able to achieve a full hundred-year lifespan for the dam via repairs. As a local resident recently emailed, about the trajectory of privatisation of the headpond's amenities:

...development around the headpond will have proceeded, and at a fast pace. Small cabins and farmhouses will have been replaced by McMansions, the remaining shoreline in natural cover will have been cleared, and the property owners will be sufficiently numerous and wealthy that restoration of the river won't even be an option.

Despite the fact that the final decision has not been controversial in the region – in general citizens seem relieved at the status quo outcome and it is relatively low cost – there are some lingering issues of trust and process that deserve discussion. In general, a lack of trust is not necessarily a bad thing as it inspires public engagement (Parkins et al., 2017). Because of the strong majority message, however, some of those who advocated for dam removal felt negative impacts from doing so. Qualitative interview and focus group work demonstrated that, while nostalgia was strong among those who lived in the area pre-dam and a few privately said they "wouldn't mind" removal, almost everyone had come to cherish the dam and its amenities (Keilty et al., 2016; Sherren et al., 2016). Many used the word trauma in relation to dam construction and spoke of wishing to avoid a similar dramatic, traumatic change from the dam's removal. The Mactaquac area is increasingly an ex-urban commutershed for the nearby capital of Fredericton, but there remains close social and family networks among residents. In this context, there was significant social pressure to have the 'right' opinion (Keilty et al., 2016). People watched opinion leaders closely. One research participant who did not publicly reveal their preference for removal recently wrote to say they were glad they did not speak out to advocate it, given the social risks. One who did speak out for removal wrote to describe negative social and professional outcomes as a result, what Born et al. (1998) refer to as "residual hostility". The relief and bitterness, respectively,

of these two individuals were only strengthened by their expressed beliefs that dam removal was never genuinely on the table.

Finally, the alignment we describe here between public preferences and the final outcome does not include First Nations communities, because our research failed to adequately engage them. This should not be understated or ignored. Six Maliseet bands had been engaged in a separate consultation process with NB Power consultants, which has not been reported publicly. Whilst ostensibly being done to comply with 'duty to consult' mandates, that process seemed to sideline the Maliseet in other research and public engagement opportunities, and render their voices invisible to other citizens. The decision reached by NB Power fundamentally ignores the fact that the local Wolastoq Grand Council, representing the Wolastoqewiyik (Maliseet People) along the St. John River, have publicly called for the dam's removal:

Today, dams separate our people, so in return we carry broken spirits because of this separation ... It is crucial that Wolastoq must be set free again to reconnect our nation, plus to cleanse and revive herself so the salmon and other fish species can return to their natural home (Tremblay, 2016).

There are significant environmental justice issues at play: the Kingsclear First Nations Reserve is a strip of land directly below the dam. The dam and headpond affected traditional use of the landscape for fishing and canoeing, as well as flooding many cultural sites (Holman and Sherren, 2014). Dam spill has eroded the banks along the Reserve, requiring restoration and armouring work in the summer of 2016 funded by the utility. The Maritime Provinces are unceded territory. NB Power thus may not be permitted to simply ignore preferences that First Nations collectively express. In Canada, the Truth and Reconciliation Commission was created to right historic injustices against First Nations. The Commission report includes 94 'calls to action' for decolonisation, including adopting the UN Declaration on the Rights of Indigenous Peoples (United Nations, 2008) which has much to say about justice in natural resources decision-making. Mactaquac may be an interesting test case of the duty to consult. What might it mean to 'ensure free, prior and informed consent' around resources development in the context of infrastructure that is already in place?

Theoretical offerings for landscape transitions

As explained in the introduction, we did not set out to test theory, and this is not a requirement of case study work. It is often the role of case studies, however, to generate new theory, particularly in combination with other cases. We have identified several opportunities for further theoretical development on the basis of this work, whether within dam removal debates or broader research on public good landscape and infrastructure change such as climate adaptation.

First, the only *a priori* analytical position we engaged was gender, and this produced insights that need further exploration. Our survey results indicate that males and females had significantly different drivers of their preferred Mactaquac option, though their overall preferences were not that different. In general, for men, taking a position (i.e. not opting for 'don't know') was more likely to be associated with large-scale thinking: general conservatism, and self-reported knowledge of – or lack of – support for (in the case of those preferring dam removal) – hydroelectricity. Consistent with the literature, men were almost stereotypically opposed to the idea that risk might be driving their preferences (Weiner et al., 2013). For women, taking a position to remove or – less so – to rebuild with power was positively associated with self-assessed knowledge of the specific issue at Mactaquac. Females were much less likely than males to claim such knowledge, and unlike males they wrote comments about their lack of knowledge. If a respondent expressed knowledge of the Mactaquac issue at this early stage in the process they likely had a local connection. There seems little doubt in the commentary associated with the survey, as well as our focus groups (Sherren et al., 2016), that women are thinking of their families – the opportunity to keep kids working in the region (rather than relying on fly-in resource work 'out west'), and to attract summer visitors – as important spinoffs of an investment to rebuild or refurbish

the dam. This may suggest a different scale of drivers in place of protection or climate-relevant behaviour for women and men, which has not been previously much explored (Scannell and Gifford, 2013; Sherren et al., 2016).

Second, we see an interesting tension here in the framing of dams: between the ideas of a landscape being 'sacrificed' to hydroelectricity and hydroelectricity being embraced as 'local energy'. Sacrificial landscapes have been described in the context of many ostensibly public good activities, or at least 'necessary evils' (e.g. oil and gas exploration and refinement, ranges of military weapons, etc. (Black, 2000)). The idea of a hydroelectric landscape as sacrificial is novel, given the additional amenity often associated with dams that few of the other technologies described by environmental historians as creating 'sacrificial landscapes' can claim. In this context, the St. John River was more easily sacrificed than restored because of the low marginal gain the dam removal represented. This may be because the St. John River system has three other hydroelectric dams upriver, including one at a natural falls (Grand Falls) that already served as a natural barrier to Atlantic salmon and other species. As such, the ecological benefits of removing one dam were unclear. The river system would remain compromised in the dimensions that dam removal proponents defined it as damaging. One survey respondent even suggested adding more dams downstream of Mactaquac, sacrificing the St. John for electricity generation to allow conservation elsewhere. This anomalous statement echoed language around the Site C Dam, which was described as helping to concentrate impact by reusing water that has already been used twice upstream to generate hydroelectricity (Loo, 2007; Clarke, 2014).

Contrasting the idea of hydroelectricity as sacrificial, many respondents expressed a clear support for hydro as a safe, green and importantly local energy source. The 'local food' movement has gained traction in Atlantic Canada, as elsewhere, for the environmental and social benefits of knowing that food has been produced in ethical ways that support local ecosystems and/or communities (Lim and Hu, 2016). Yet there has not previously been a commensurate desire expressed for local energy, despite the clear uncertainties, impacts and risks associated with reliance on distant or overseas fuels or transmission of other hydroelectric power over long distances (e.g. in this region from Quebec or Labrador). The recent shale gas debate in New Brunswick, which led eventually to a moratorium on fracking for natural gas in the province, is a good example of a local resource being shunned in preference for importing fuel from elsewhere. In many places renewables like wind are vulnerable to opposition before installation (Wolsink, 2007; Devine-Wright, 2009), during which residents express clear preferences not to be exposed to the means of their energy production. This is an easy option to choose if the alternative option to meet energy needs imposes remote impacts on others, rather than being felt locally. Most survey respondents and locals indicated, by contrast, that they are happy to see their local water resource being used for hydroelectricity. The drivers, limits and utility of this idea of 'local energy' need further exploration, particularly in the context of energy exports. Will people come to see the infrastructure or landscape change associated with electricity export the same way as they are used to seeing other resource exploitation such as forests or agriculture? Or will energy projects designed for exports remain anathema in many places? A renewable energy transition may require citizens to develop a 'local' ethos about other technologies like wind and solar. The physics of renewable technologies means that such infrastructure will have to be more numerous, more visible, and often more proximal to populations than conventional sources (Wüstenhagen et al., 2007).

The last opportunity for theoretical development or testing presented by this work is how to engage with path-dependency and uncertainty in public decision-making. These are often diagnosed as emblematic of flawed logic, ignorance or fear. Yet dismissing them will not ease them as barriers to landscape change. For example, uncertainty came from many sources in the Mactaquac case. First, it is important to remember that few provincial survey respondents felt well informed about the Mactaquac issue. This is a source of uncertainty that is relatively easy to deal with, and according to NB Power research this had improved by the end of the stakeholder campaign (National Public Relations and Corporate Research Associates, 2016). Even at the end of the process, however, the environmental

benefits of the dam removal at Mactaquac were considered highly uncertain. Few participants in our work made a strong case for river restoration, but neither did NB Power or the scientists or consultants they were funding. NB Power funded the Canada Rivers Institute (CRI) at a cost of millions (CAD) to examine the biophysical implications of each of the options. CRI provided some findings at open houses, but had not yet published any of its results in peer-reviewed literature pre-decision. The most oft-mentioned potential benefit of dam removal was the return of migrating salmon, in part because of advocacy by groups like the Atlantic Salmon Federation, but those messages were countered by those who enjoy fishing the small-mouth bass now thriving in the headpond. The likelihood of salmon returning was clearly doubted by our interview participants (Keilty et al., 2016), who cited salmon populations elsewhere also declining, perhaps due to warmer water temperatures associated with climate change and aquaculture in the Bay of Fundy. In the end, it was perceived as a risky proposition to restore this section of river at a cost to the grid and renewable energy commitments. Implications for waterfront landholders were unclear. Uncertainty also persisted about the potential impact of dam removal on spring flooding. Dams like the Mactaquac – branded by NB Power as 'run-of-the-river' but with a significant impoundment – cause variable flow levels (called 'hydrologic peaking') as well as disconnecting fish habitat (Mattmann et al., 2016). Spring flooding was the biggest environmental concern mentioned in survey responses, but respondents were unclear about whether the dam helped or hindered the regulation of flows during the spring freshet. While the findings of Born et al. (1998) suggest that even a clear picture of environmental benefits may not have been a significant factor for residents, the implications of this information vacuum for public debate are clear.

It is similarly easy to dismiss the Mactaquac decision as a product of path dependency, but this minimises the power of the phenomenon. There are many ways that this phenomenon blocks our way to a sustainable future. Path dependency lives partly in spreadsheets and infrastructure, i.e. economic or structural lock-ins (Wilson, 2014). That drives us to do more of what we already know how to do, and continue to invest where the 'damage is done'. For instance, despite recent costly investments in nuclear energy during the refurbishment of Point Lepreau, and patchy performance since, current rumours suggest that NB Power may be prepared to build an additional reactor at that site. All such investment, for Mactaquac and Lepreau among others, will likely drain energy budgets and make investment in alternatives ever more unlikely.

Yet what we learn here is that path dependency is also a manifestation of the 'social imaginary' (Castoriadis, 1987), what we collectively perceive as possible and desirable. Thinking of it this way expands path dependency to include the heart and mind i.e. socio-psychological lock-ins (Wilson, 2014). Extending beyond ideas of status quo bias, simple fear of change (Samuelson and Zeckhauser, 1988), it seems here that path dependency has more to do with track record. This is why installation and removal of Mactaquac met similar public opposition: we learn best by sensory experience and are loathe to discard what we learn this way for more abstract options. What was particularly novel in all our work was not only the aim to avoid further trauma, but the fact of past trauma being reason enough to stay the course: as if changing paths would negate the original sacrifice and effort. This sort of 'social infrastructure' needs further exploration, as well as the limits of our duty to honour such investments.

Instead of uncertainty fuelling path dependency, certainty may be in the driver's seat. Experience leads people to adapt their norms and expectations (e.g. around coastal protection in the Netherlands; see van Staveren and van Tatenhove, 2016), and the realm of the possible narrows. Path dependency is likely also to be blamed for how respondents perceived alternative energy sources as having low benefit. Wind and solar are working against history in this respect: both are new and rare enough in New Brunswick that the region may not yet have experienced an experiential or economic bump from them. The perception of local benefits may simply be lower with unfamiliar technologies. Additional research is needed to further explore this 'shock of the new' (to borrow from art historian Clive James) and how familiarity influences the imaginary and path dependency.

CONCLUSIONS

Research and public deliberations between 2012 and 2016 about the fate of the prematurely aging Mactaquac Dam in New Brunswick, Canada, revealed a majority preference for keeping the dam and its associated headpond. Provincial-scale discourses around the issue revealed a strong path dependency in thinking, including 'sunk costs' justifications and confidence in the economic benefits of dams, as well as support for local energy: using local resources for local jobs. These provincial discourses worked together with local ones, investigated more qualitatively, which were dominated by fear of losing the amenity the headpond has come to represent and the possibility of new trauma from dam removal. For females in particular, the Mactaquac Dam and its headpond represent family: summer visitors and jobs for their kids. No strong case was made for the benefits of dam removal: environmental benefits were uncertain and ownership and remediation issues remained unresolved. The final decision to extend the life of the current dam through repairs was not formally part of the stakeholder process, but has largely not been controversial given the above discourses and local concerns about project cost and taxpayer burden. Yet the decision contravenes the expressed preferences of local First Nations, violating some of Canada's recent commitments toward decolonization. Further research is suggested around emergent theoretical links: how genders differ in the scale of issue that drives their responses to landscape change; how hydroelectricity can be framed as sacrificial or 'local energy' to different ends; and how public decision-making can engage with rather than dismiss uncertainty and path-dependency.

APPENDIX A: SUMMARY OF QUALITATIVE INSIGHTS FROM PREVIOUS WORK AROUND MACTAQUAC

In the absence of plans for investment in rigorous social science around the Mactaquac decision, we carried out parallel, independently funded research. Most of this research was qualitative in methodology, and is fully described elsewhere. In the summer of 2013, we carried out landscape elicitation and focus groups with three groups of local residents while floating on the Mactaquac headpond on a houseboat (Sherren, 2016). A short documentary produced from boat footage (<https://vimeo.com/87082790>) has received 7200 views to date. A second set of interviews, this time on land using maps as interview prompts, was carried out a year later (Keilty et al., 2016). These studies demonstrated that landscape baselines in the Mactaquac have been malleable with experience, that is, over time and the accrual of good memories the headpond has become for locals more desirable than either the original pre-dam landscape or what it could become after dam removal. In fall 2014, we were inspired by some of the misinformation revealed in those land-based interviews to create a storymap (<http://energytransitions.ca/storymap>) to show the pre-dam landscape to those without first-hand experience (Holman and Sherren, 2014). It has been used 9000 times to date.

Our prior qualitative research in the area, comprising interviews and focus groups (Keilty et al., 2016; Sherren et al., 2016), confirmed that dam removal was rarely the preferred option among residents around the headpond. Dam removal was certainly opposed by participants in that research that moved to the area as adults, taking advantage of affordable waterfront prices and rural lifestyles close to the capital city, particularly after the new Trans-Canada Highway construction routed heavy traffic away from the area in the mid-2000s. Dam removal was also largely opposed by participants who grew up with the dam and headpond in place. Even those who had personally experienced some loss of land or home with the expropriations associated with the dam were largely supportive of keeping it in place, to benefit their families or others who had come and built new lives there.

The dam was part of a rural modernisation scheme that included a new pulp and paper mill, new town (and commensurate infrastructure), two provincial parks and a historical re-enactment settlement. The rural modernisation ethos remained surprisingly strong for many older participants, who never forgot their pain and sacrifice, but saw that their families had adapted to new realities, if not directly benefited. One female respondent told us that 600 of her father's 1200 acres was appropriated, but in the long run, the value of those 600 acres increased dramatically. Her family land happened to be

on an inlet and the flooding created the potential for a great number of shorefront lots. There was a place for nostalgia but few wanted to try to return the landscape to what it had been. In the map-elicitation interviews participants discussed the idea of dam removal as a retrograde folly – trying to turn back time – and demonstrated huge information gaps as to what dam removal would require in terms of remediation and how long it would take (Keilty et al., 2016). Participants in these interviews also doubted whether salmon would come back as predicted.

As the survey indicated, of the broader population, participants in this qualitative work who did want the dam removed were few. Even fewer were those willing to say so in the context of a closely knit rural community which had largely unified behind keeping the dam and headpond. The few contrary-minded individuals were strong-willed and their views were well-known to some of the other research participants. Some even expressed that such people were 'trouble-makers' who had a reputation for taking every opportunity to speak against dam refurbishment. In some cases, by the language used it was clear that participants sought to distance themselves from these divisive individuals, a sort of *ad hominem* rejection of the person and their position as one, and it may be that their expressed preference on the dam was part of that distancing. On the headpond tours we ran in 2013, only one person – a local medical doctor – openly expressed a desire to see the dam removed, to heal personal trauma as well as for environmental and economic reasons. In a recent email exchange this participant wrote, explaining their desire to stay in the area despite the recent decision to extend the dam's life, "I am intensely territorial, this is my HOME, and I ... feel bound to it as a healer to a patient". Another participant in the headpond tours, however, emailed after the event to say that they had been intimidated by the weight of opinion on the boat, but would also like to record interest in seeing dam removal fully considered among the options. In a recent email this participant was circumspect: "River restoration had no support. Mothballing the dam was expensive. And rebuilding the generating station was even more costly ... Option 4 [life extension of the dam] kicks the can down the road".

APPENDIX B: SUPPLEMENTARY STATISTICAL ANALYSIS ON DEMOGRAPHICS AND PERCEPTIONS OF HYDROELECTRICITY

This appendix includes demographic analysis of survey respondents that is supplemental to the main text. Additionally, this appendix includes supplemental analysis of respondent perceptions of hydroelectricity as an energy option. Finally, this section explains in more detail some of the variables used in the Mactaquac-related multinomial linear regression (marked with ^ in Table 3). These variable names are highlighted in italicised text below to make them easier to locate. The excision of this content from the main body streamlines the text for those less interested in empirical detail.

First, a caution. Several of these variables are based on questions in the survey that included multiple statements about which participants expressed their views, often rating the degree to which they agreed or disagreed with each statement, or rating the importance of each statement. Factor analysis and other statistical tests were used to determine the statements that collectively measured a single concept. In some instances, statements from more than one question were combined, as a summed scale, to represent a single variable. New Brunswick residents, like most Canadians, often opted for the mid-point on scales, which means the options are more categorical than ordinal. As such, caution must be taken in interpreting the 'averages' we have calculated from these responses.

As in the overall New Brunswick demographic, survey respondents were dominated by those aged from 55 to 64. Of the respondents 80% beyond high school, about half taking the college/apprenticeship route (41%) and half university (39%), with three-quarters of each group having completed those credentials. The most frequent income group amongst those who answered the question was CAD26,000 to CAD51,000, but the median was CAD51,000 to CAD76,000. In aggregate, respondents saw themselves as politically moderate, with two-thirds of the respondents placing

themselves between 3 and 5 (a third exactly in the middle at 4), where 1 is very liberal and 7 is very conservative: of the remainder, 32% leans toward liberal (23%) rather than conservative (10%).

Generally, respondents agreed that humans are connected to and reliant upon nature, rather than superior to it, and that human interference can be harmful. Four statements within a list of paradigmatic value statements to which respondents were asked to respond on a Likert scale clustered together in a strong scale we called '*ecocentrism*' (Cronbach's Alpha = 0.7966; Supplemental1). This scale is used in our multivariate modelling to approximate respondent environmental values.

Supplemental Table 5. Statements used to generate the '*ecocentrism*' scale.

Statement	Mean	SD
I believe that humans, along with all other species, are dependent on the environment and one another to live well	4.31	0.80
I believe that humans are members of the earth's community of life along with all other living things	4.19	0.83
When humans interfere with nature it often produces disastrous consequences	3.92	0.93
I believe that all life should have a chance to pursue its own good in its own way	3.80	0.86

Respondents were asked to assess their own overall knowledge about 'how energy is used in Canada', relative to friends and family, which was used as the measure of '*self-reported energy knowledge*' in multivariate modelling. Then they were presented with five multiple choice questions about energy to see how well they understood key concepts (see full questions at Comeau et al., 2015). For each of these test questions they were also asked how certain they were about their answers. In general, respondents did poorly in the test (57% got less than half correct). Success was somewhat related to self-assessments of knowledge: only 42% of those who thought they knew a lot about energy 'failed', compared with 52% of those who thought they knew a medium amount, and up to 73% of those who thought they knew very little. The '*tested energy literacy*' scale used in later regression is a simple score on the above test.

In general, respondents felt knowledgeable about and supportive of renewable energy, whereas knowledge and support were negatively correlated, however, for non-renewable sources (Supplemental Table 2). Respondents assessed their knowledge of all energy sources as less than 'a medium amount', but hydroelectricity was the most understood (at 2.87 on a five-scale Likert, where 3 is 'a medium amount'). Individual scores on hydroelectricity were used as a measure of '*self-reported knowledge of hydroelectricity*' in the multivariate modelling. Hydroelectricity was only ranked third on the most supported technologies, however, with an average score of 3.96 (on a five-scale Likert) for support (compared with 4.37 for solar, and 4.33 for wind), and only 42 people nominating it as the one they most support (compared with 130 for wind and 123 for solar). The '*support for renewables*' index used in later multivariate modelling comprises an average support score for all the renewable technologies (noted with asterixes in Supplemental Table 2). The '*support for hydroelectricity*' includes simply the score for hydroelectricity (1 to 5, strongly oppose to strongly support).

In general, when respondents supported a technology they did so because of benefits to the province, economy and/or consumers, but impact on the environment was a close second. Impact on the landscape and costs to develop or maintain were the least important drivers. The rankings of reasons for support changed by energy type, suggesting that respondents variously see and balance trade-offs. Of the 42 respondents whose preferred technology was hydroelectricity, their primary reason was the low risk associated with the mature technology (Supplemental Table 2). When respondents failed to support a technology, in general they did so because of environmental impacts or

risks for humans; landscape impacts were third. Only one person suggested their least supported technology was hydroelectricity, largely because of its cost to develop and maintain.

Supplemental Table 6. Self-reported knowledge about various Canadian energy sources.

Energy Source	Knowledge		Support			
	Mean	SD	Mean	SD	# most supported	# least supported
Hydroelectric*	2.87	0.95	3.96	0.75	42	1
Solar*	2.82	0.82	4.37	0.78	123	0
Wind*	2.79	0.82	4.33	0.78	130	3
Nuclear	2.51	0.95	2.98	1.07	14	35
Coal	2.50	0.91	2.61	0.96	0	24
Bioenergy*	2.44	0.87	3.74	0.85	16	2
Oil (non-tar/oil sands)	2.41	0.91	3.22	0.83	3	0
Oil from tar/oil sands	2.39	0.90	3.06	0.91	15	16
Shale gas	2.38	0.88	2.79	1.13	26	60
Natural gas (non-shale gas)	2.37	0.86	3.51	0.86	6	1
Geothermal*	2.19	0.87	3.82	0.83	29	1

Note: (1 = nothing, 5= a lot), along with support or opposition to the further development of energy sources in Canada (1= strongly oppose, 5= strongly support), including the number of respondents who listed each energy source as their most or least supported. Asterixes (*) denote renewable sources.

Supplemental Table 7. Reasons for rating the highest rated energy source for development in Canada.

	Support				Oppose			
	All sources		Hydroelectric n=42		All sources		Hydroelectric n=1	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Potential impact								
Benefits/Costs to the province, economy and/or consumers	4.22	0.86	4.17	0.76	3.22	1.33	2	NA
Impact on the environment	4.19	0.96	4.14	0.87	4.68	0.70	3	NA
Risks to human health and safety	4.11	1.08	4.26	1.11	4.63	0.79	2	NA
Costs to develop or maintain	3.79	1.01	4.00	1.04	3.55	1.29	4	NA
Impact on the landscape	3.60	1.15	3.71	0.99	4.15	1.07	2	NA

Note: (1= not very important, 5= extremely important), for all sources, and then for those choosing hydroelectricity as their most preferred, and the same for most opposed.

Exposure to hydroelectricity was associated (as it is for solar and wind, but not nuclear) with increased support for the technology (Supplemental Table 4). Only 18% of respondents volunteered that they were frequently exposed to (regularly seeing, hearing or smelling) hydroelectric dams. Such self-reporting is questionable, given that 11% also said they were regularly exposed to a nuclear plant: Point Lepreau Nuclear Facility (the only one in the province), is not visible from any commonly travelled road, being located on a remote peninsula into the Bay of Fundy. It is possible that individuals confuse the nearby Coleson Cove thermal plant for Point Lepreau. We used the binary '*self-reported exposure to hydroelectricity*' score in our multivariate modelling.

Supplemental Table 8. Support for development of energy types by regular exposure to those energy types. Asterixes (*) indicate significance confidence levels of 99% (***) and 95% (**).

Energy type	Mean support for development – Exposure (n)	Mean Support for development – No exposure (n)	T-stat	Significance
Solar	4.53 (118)	4.32 (382)	-2.52	***
Wind	4.42 (148)	4.29 (352)	-1.66	**
Hydroelectric	4.25 (88)	3.90 (412)	-4.08	***
Nuclear	3.47 (53)	2.92 (447)	-3.60	***

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