A report regarding the relicensing of the Ellsworth and Graham Lake Dams, Union River, Maine (FERC Project No. 2727)

Prepared by

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Executive Summary

The Ellsworth and Graham Lake Dams, on the Union River near Ellsworth, Maine are among many dams in the region entering or approaching their FERC relicensing processes. As part of these decisions, it is critical to quantitatively and qualitatively evaluate the impacts of relicensing in light of changing social priorities, in the face of technological progress in the energy sector and elsewhere, and incorporating improved information regarding the ecology of rivers and the potential social benefits of robust riparian ecosystems. FERC oversight of dams is required because while some dams are critical to our energy markets and provide other benefits to society, others compromise the ecology, aesthetics, and recreational potential of waterways to the point where they are fundamentally incompatible with evolving social priorities.

Purchased by Brookfield Renewable Energy Partners (henceforth "Brookfield") in 2013 as a necessary component of a bundled set of hydropower generation facilities, the Ellsworth Dam and Powerhouse ("Ellsworth Dam") is an aging structure that would likely require significant repairs and other capital improvements during a subsequent license term. The asset value of the dam–estimated by purchase price, capitalized net revenues, or replacement cost–is far below the ~$50.6 million figure proposed by Brookfield to FERC; in fact, the facility is assessed at only $10 million by the City of Ellsworth for tax purposes, a remarkable disparity.

The Ellsworth Dam generates a modest amount of energy that could easily be replaced by solar or wind power, and partially offset by retrofitting the upstream Graham Lake Dam with generation capacity. The Ellsworth Dam currently provides very little in the way of recreational benefits; the Leonard Lake impoundment upstream of the dam sees little recreational use and has a sparsely populated shoreline. There has been virtually no defense of the dam as a recreational asset by local stakeholders. Removal of the Ellsworth Dam would leave a waterway that would continue to provide most of its current recreational value and would offer a topology and water flow regime with great appeal to recreational canoers, kayakers, and rafters in a region of Maine that is already attractive to this constituency.

It is increasingly clear that the presence of the Ellsworth Dam is a major impediment to the ecological function of the Union River and its upstream tributaries; this reduced ecological

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health has far-reaching implications for human stakeholders, particularly in commercial fisheries (bait for lobster, nourishment of nearshore groundfish that feed on anadromous river herring, potential harvest of American eel/elvers) and recreational angling (American shad, sea run brook trout; and in the long run, potentially a revitalized Atlantic salmon fishery). There is also ample evidence in the literature that functioning river ecosystems and augmented fish stocks *per se* provide benefits to local stakeholders; these values are sometimes reflected in increased property values near healthy rivers, or can be ascertained through survey-based studies.

It is difficult to precisely quantify all of the pros and cons (i.e., "benefits and costs") of relicensing decisions. However, it is not essential to distill all of these impacts into dollarized or other quantitative metrics. Instead, regulators must rely on the combined weight of qualitative and quantitative evidence to determine a "socially optimal" course of action regarding the continued operation (or not) of a dam. This is the case in the context of the Union River dams. In essence, there are three qualitative options at the time of dam relicensing:

1. *Status Quo.* A dam deemed to have large social benefits (in terms of power generation, flood control, and/or provision of recreational services) can be relicensed as is.
2. *Incremental changes.* If conditions have changed significantly since the last relicensing period, the regulatory agency (i.e., FERC) can mandate modification of an existing dam to better reconcile its energy generation with other social priorities. For example, upstream and downstream anadromous fish passage can be improved, and/or flow management can be altered.
3. *Denial of relicensing; requirement of dam removal.* When a dam's flow of benefits has sufficiently declined, its capital value has depreciated, and/or the social opportunity costs of its existence are perceived to have risen dramatically, the dam is no longer compatible with social priorities and should be removed. It is often possible in such a case, as with the Edwards Dam removal on the Kennebec River, to partially or completely replace lost power generation with other hydropower generation (in particular at the Graham Lake Dam) or other renewable energy sources. A shifting of hydropower generation was, for example, a key part of the Penobscot River Restoration Project, with almost no loss of hydropower capacity.

The following considerations should factor into the decision regarding the relicensing of the Ellsworth hydro project:

- The Ellsworth Dam is aging and less efficient than its more modern counterparts (including those purchased concurrently by Brookfield), and its asset value is far below the estimate provided by Brookfield.
- The financial viability of the Ellsworth Dam – i.e., Brookfield's estimate of its productivity – depends on its ability to operate as a "peaking station" through water storage and releases in response to market conditions, a practice that is unlikely to be allowed to continue.

- The shape, technology, and position of the Ellsworth Dam make it all but impossible to improve fish passage other than through amplification of the existing “trap & truck” alewife operation or construction of a modern fish lift. Either would be very costly and would still fail to adequately address the needs of species such as American eel, American shad, and Atlantic salmon.
- The Ellsworth Dam provides little in the way of recreational benefits in the Leonard Lake impoundment, and there are few property owners who would be adversely affected by its removal; on the contrary, the potential recreational benefits of a free-flowing river to the City of Ellsworth and its economy likely far exceed those emerging from the river in its current state.
- The current benefits of the Ellsworth Dam to society in the form of low-carbon energy production could be replicated using increasingly efficient and economic solar and/or wind-based generation, as well as by retrofitting the Graham Lake Dam with LIHI-certifiable[2] generation capacity and effective volitional fish passage for the species native to the Union River.

[2] http://lowimpacthydro.org/

Introduction and Background

The following is an assessment of the value and impacts of the Ellsworth Powerhouse and Dam (henceforth "Ellsworth Dam") and Graham Lake Dam, both on the lower Union River with terminus near Ellsworth, Maine. These dams were purchased in 2013 by Brookfield Renewable Energy Partners (a subsidiary of Toronto-based Brookfield Asset Management) from Black Bear Hydro Partners for an undisclosed sum. These dams were part of a nine-dam package with a total capacity of 70MW (of which the generation of the Ellsworth Dam constitutes roughly 13%). The other dams in this package have been more recently relicensed than the Ellsworth; most have FERC licenses valid through at least 2029.

Originally constructed in 1922, the Ellsworth Dam is the locus of actual power generation – one of the first hydropower facilities built in the state of Maine. It has a generation capacity of 8.9MW, producing approximately 30,000 MwH/yr with an approximate market value[3] (at $0.065/KwH) of $2M/year. The Graham Lake Dam controls the flow out of the Graham Lake impoundment into Leonard Lake and subsequently through the Ellsworth turbines. The Ellsworth Dam has required extensive capital repairs: The original dam failed in 1923, approximately one year after its initial construction, causing $8 million[4] in damages to the town of Ellsworth and environs -- the largest anthropogenic disaster in Maine's history at the time. The hollow Ellsworth Dam was later filled with concrete due to concerns about its stability.

The age of the Ellsworth Dam suggests that further major capital repairs will be necessary in the near- to medium-term. The bearings in the generators of the Ellsworth powerhouse are made of a rare and now-protected species of wood. While designated as "historic"[5], the Ellsworth Dam is by other measures an archaic structure nearing the end of its useful lifespan.

It is incumbent upon FERC at this juncture to assess whether continued operation of the Ellsworth hydro project is in the public interest. As such they should strive to ascertain the value of the dam(s) as a financial asset to its owner (and the resultant benefits to the community in terms of property tax revenues) and compare this estimate qualitatively and quantitatively to the ecological and economic opportunity costs of continued operation. This report primarily addresses these two key components of the decision process.

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[3] The market price received by Brookfield for power generated at the Ellsworth is not transparent; the figure given here is an approximate regional average. The price could be slightly higher given the current "peaking" operation of the facility.

[4] This is equivalent to roughly $486 million worth of damages in 2016 dollars.

[5] The Ellsworth Dam was placed on the Register of Historic Places in 1985.

Asset Valuation

The value of the dams as corporate financial assets is clearly of interest to the FERC proceedings. The sale of hydro generating facilties previously owned by Maine's monopoly utilities, CMP and Bangor Hydroelectric (BHE), was mandated by legislative decree in 1998. When Pennsylvania Power & Light (PPL) purchased BHE's assets, including Ellsworth, the buyer had to accept the *entire* generating portfolio, as-is; terms of the sale prohibited cherry-picking, or the differentiated valuation and selection of preferred components of the asset bundle (a subset which would likely *not* have included the Ellsworth Dam). The subsequent sale of these hydro assets to Brookfield in 2012 was similarly constrained. As such, the two Union River dams in question have *never* been sold, or correspondingly individually “valued,” since they were first built and acquired by BHE in the 1930s.

A recent filing by Brookfield[6] gives an estimated “net undepreciated investment” (i.e., the illiquid asset value that would presumably be lost, or “stranded,” if relicensing were to be denied) of approximately $50.6 million for the Graham Lake and Ellsworth Dams. While the exact methodology used to arrive at this estimate is not clear, I strongly feel this to be a dramatic overestimate of the value of this asset. This opinion is based on four distinct methodologies that can be used to estimate the value of such an asset:

- *Cost basis* (asset price at time of most recent market transaction)

  A reasonable estimate of the embodied capital costs in the dam can be drawn from the cost basis of the asset, i.e., the price paid at the time ownership was initially assumed. Without transparent revelation of the total price paid by Brookfield to Black Bear Hydro Partners, and an apportionment of this total figure across the nine dams purchased at that time, it is in fact difficult to ascertain the “cost basis” of the Ellsworth and Graham Lake Dams. One can only conclude that Brookfield feels it in their interest to have this figure remain opaque. I am confident that if a ~$50.6M share of the total purchase price were assigned to the Union River dams, the implied valuation of the other dams – more recently relicensed and less environmentally and legally problematic – would be implausibly low (or, conversely, the implied total price of the bundled dams would be implausibly high). If valuation is indeed based on purchase price, Brookfield’s estimate needs to be supported by (a) a transparent itemization of the total purchase price of the package of nine dams and (b) an explanation of the rubric whereby this cost is apportioned, or distributed, among these nine fundamentally independent assets.

- *Comparative sales*

  Since the purpose of hydro dams is to generate power, a reasonable metric for their value would be their $/KW of capacity. For other dams recently sold in Maine (and for which,

[6] May 12, 2016, Licensee Brookfield Assets Management’s response to FERC’s Jan. 29, 2016 AIR for the Licensee's Application for New License for the Ellsworth Project.

notably, the purchase price was made public), the cost per MW of capacity was approximately $2M. Since generation capacity only constitutes the gross benefits of dam operation, use of this figure to extrapolate the asset value of other dams implicitly assumes that operational, legal, and other cost ratios are similar across dams.

Related to the apportionment of purchase price: How do the other dams in the recently acquired package compare in terms of implied cost per MW of capacity? If there is a large variation in this metric across dams, what explains these divergent valuations?

In several recent dam transactions in Maine, sale prices were disclosed. These prices implied an average value of roughly $2MM/MW of capacity–and hence an approximate value for the Ellsworth of ~$18MM[7]. In addition, these other dams were much further from their next relicensing process, and faced fewer contentious issues regarding fish passage etc. – all factors suggesting that *the Ellsworth Dam has a value significantly lower than even $18MM*.

- *Capitalized net revenues from power generation*

  The value of an asset can also be estimated as the capitalized stream of net earnings (i.e., net present value) it can be expected to generate. Using this metric and a conservative discount rate of 5%, the $2M of *gross* electricity generation would have a gross present value in perpetuity of $2M/0.05 = $40M. A number of factors suggest a far lower capitalized value of *net* earnings:

  - *Finite lifespan*

    The revenues above will not continue in perpetuity. It is not immediately clear what the lifespan of this dam is, but the stream of revenues will be truncated at some point in the finite future.

  - *Annual operations and maintenance costs*

    There are significant costs of operation not reflected in the $2M/yr revenue figure: Property taxes paid to the City of Ellsworth; labor costs for standard operation; administrative and legal fees; and ongoing/chronic maintenance. If these costs total roughly $C/year, then the proper valuation of the dam is more correctly calculated (again, using a 5% discount rate) as (2MM - C)/0.05 = 40MM – 20C. A higher discount would significantly reduce this value. Without more information regarding Brookfield's cost structure, it is difficult to ascertain a precise value for capitalized annual net revenues, but it is clearly far below $50MM.

  - *Discrete repairs or capital improvements*

    Given the age and construction of the dam, it is very likely to require major repairs or updates in the foreseeable future. In addition, requirements of fish passage installations

[7] See letter to FERC from Dwayne Shaw, Executive Director of the Downeast Salmon Federation, dated May 31, 2016.

(e.g., a lift) could imply large capital expenditures. The estimated asset value of the dam should be reduced by the expected present value of these costs.

- *Change in generation practice (away from peak power market)*

  Brookfield has used the Ellsworth Dam as a "peaking dam," i.e., an operation in which water is stored and strategically released so as to align production with heightened demand and higher prices for electricity. This type of operation is widely held to be ecologically costly and to increase the possibility of dam failure and flooding and is unlikely to be allowed to continue. So the dollarized market value of the power generated at the Ellsworth Dam is likely to decrease from its current level.

- *Muncipal property assessment and tax obligation*

  The values of taxable assets are routinely assessed by municipalities for the purposes of deriving tax obligations[8]. While there is inevitably a slight lag in one direction or another of the assessments (which are carried out annually or slightly less often) and real-time market value, the discrepancy between these two avenues of valuation is rarely significant. The municipality's assessment can be seen as a good-faith estimate of the real value of the asset. Table 1 below indicates that there is a *five-fold* discrepancy between the assessed value of the Ellsworth Dam according to the Ellsworth Assessor's office and the $50.6 million figure proffered by Brookfield. These assessments present a puzzling inconsistency: either the Ellsworth Dam is worth $10 million, which should influence FERC's assessment of the relative benefits and costs of its continued operation, or it is worth closer to $50.6 million, in which case the taxes paid by Brookfield should be commensurately higher. The tax on the full Brookfield valuation would be $918,630 using 2016 Ellsworth tax (mill) rates, a tax liability that would severely compromise the profitability of the Ellsworth Dam's operation.

Table 1. Annual tax assessments for the Ellsworth Dam; public domain data from the City of Ellsworth Assessing Department.

Fiscal Year	Assessment	Tax
2016	$10,000,000	$177,000
2015	$10,000,000	$164,500
2014	$10,000,000	$160,500
2013	$10,000,000	$154,500
2012	$10,000,000	$145,300

[8] From the Mission Statement of the City of Ellsworth Assessing Department: "The mission of the Assessing Department is *to accurately determine the value of property located within the City of Ellsworth for the purpose of taxation*."

- *Comparison of reported NUI for other hydro projects*

  Stated asset values for dams in Kennebec Basin during their 1997 relicensing process brings into sharp focus the extreme nature of Brookfield's valuation of the Ellsworth project. Table 2 below shows, for each of the projects evaluated by FERC in Kennebec Basin Final EIS, the generation capacities ("Cap") and the accepted estimates of Net Undepreciated Investment (NUI). For purposes of comparison, the table also includes the NUI per MW of generation capacity, and the factor by which Brookfield's valuation of the Ellsworth project (i.e., $50.6MM/8.9MW = $5.68MM/MW) exceeds the stated NUI per MW for the Kennebec facilities.

Table 2. A comparison of the valuation (Net Undepreciated Investment per MW of nameplate capacity) of Kennebec basin dams relative to Brookfield's estimate of the Ellsworth project NUI.

Project	Cap (MW)	NUI ($MM)	NUI/MW ($MM)	Rel NUI per MW of Ellsworth
Wyman	72	5.637	0.0783	72.6
Sandy River	3	0.08	0.0267	213.2
Weston	14.74	1.326	0.0900	63.2
Halifax	1.5	0.177	0.1180	48.2
Messalonskee	6.2	1.808	0.2916	19.5
Edwards	3.5	6.374	1.8211	3.1

Brookfield's stated NUI per MW of generation capacity for the Ellsworth project is more than three times that of the Edwards Dam, the Kennebec basin facility with the highest $/MW rating. The current valuation of the Ellsworth Dam (again, in $ of NUI per MW of capacity) is between roughly *20 and 200* times that of the other dams in the Kennebec basin.

Similarly, Table 3 shows a comparison of Brookfield's stated valuation of the Ellsworth project to the same owner's recent stated valuations of the Mattaceunk Project on the Penobscot River (FERC No. 2520) and the Williams Project on the Kennebec River (FERC No. 2335). As in the 1997 Kennebec basin analysis, the NUI/MW estimate put forward by Brookfield for the Ellsworth project is far higher–between 4 and 10 times that of these comparison cases. The fact that the Mattaceunk and Williams dams are also owned by Brookfield makes this contrast all the more striking; one would assume that the valuation rubric, or the asset valuation relative to generation capacity, would be more or less similar across dams with a common owner.

Table 3. NUI/MW from Brookfield's Mattaceunk (Penobscot) and Williams (Kennebec) relicensing applications, relative to Brookfield's NUI/MW estimate for the Ellsworth project.

Project	Cap (MW)	NUI ($M)	NUI/MW ($M)	Rel NUI/MW of Ellsworth
Mattaceunk	19.2	25.119	1.308	4.3
Williams	13	7.365	0.567	10.0

All five of the methods outlined here suggest a value for the Ellsworth Dam far below the estimate provided by Brookfield. While there is some legitimate variation in the NUI/MW metric across dams, the Ellsworth figure is so clearly an outlier in all of these cases that it raises serious doubts about the validity of Brookfield's valuation in this case. Certainly, there is no compelling reason why the Ellsworth project would be valued *more* highly than these other cases, while there are several compelling reasons (its age, its problematic fish passage issues, and its imminent relicensing process) why it might be valued *less* favorably than other dams relative to its generation capacity. To the extent that this asset valuation is important to FERC's decision in this relicensing application, I urge the Commission to employ an impartial and verifiable methodology for valuing the dams in question.

Power Generation and Potential Substitutes

A benefit of the Ellsworth Dam is its generation of electrical power. Hydropower – requiring little or no fossil fuel combustion or greenhouse gas emissions – is doubtless a critical part of the regional and national energy production portfolio going forward. However, hydropower must be evaluated in light of growing awareness of the ecological costs of some hydropower generation technologies, concurrent with enhanced efficiency and reduced cost of alternative low-emission technologies. A recent report by Energy.gov (the online presence of the U.S. Office of Energy Efficiency and Renewable Energy)[9, 10] suggests a positive but qualified future for hydropower generation in the U.S.: while we should take advantage of some of the untapped potential of hydropower generation, we should do it in a way that is compatible with ecosystem function and other social values. The report further suggests that "the future of hydropower is not in the building of new dams," but rather by increasing or adding generation capacity in existing dams with low ecological opportunity costs, by using hydrological

[9] "Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source." Energy.gov, July 2016 [http://energy.gov/eere/water/articles/hydropower-vision-new-chapter-america-s-1st-renewable-electricity-source]

[10] Moody, C. and B. Dennis. "The surprisingly bright future of America's forgotten renewable energy source: water". *Washington Post*, July 26, 2016. [https://www.washingtonpost.com/news/energy-environment/wp/2016/07/26/the-surprisingly-bright-future-of-americas-overlooked-renewable-energy-source-water/?utm_term=.08a5c7faa9e9]

technologies to store potential energy in the form of pumped water, and by seeking out low-impact hydropower generation technologies such as tidal kinetic generation. Implicit in this report is that – if some new hydro operations are not worth building–it clearly follows some existing hydropower generation facilities impose too high an ecological cost to justify their continued operation.

It is critical to note that removal of an ecologically costly dam does not necessarily imply an outright loss of its generation capacity. If hydropower is viewed holistically, or in a "basin-wide" context, it is possible to move some or all of the generation capacity of an undesirable dam to one with substantially lower ecological costs, thus achieving ecological gain with little opportunity cost in terms of generation–or even, in some cases, a "win-win" across these two dimensions. The Penobscot River Restoration Project's transfer of hydro capacity, combined with improvements to fish passage, exemplify this sort of system-scale optimization[11]. In the case of the Ellsworth Dam, a significant portion of its generation capacity could be moved to the Graham Lake Dam, which could also be relatively easily retrofitted with volitional fish passage. In addition to the recovery of the Ellsworth's MWh *per se*, power generated at an improved Graham Lake facility could readily qualify for LIHI certification and be sold at correspondingly higher prices.

Production at the Ellsworth Dam is modest. Aside from transferring a substantial portion of its hydropower potential to an improved Graham Lake Dam, its production could be replicated using other green (low/zero-carbon) technologies. Current trends in local energy markets in Maine favor wind and particularly solar energy as increasingly efficient and cost-effective alternatives.

For example, the Town of Sanford, Maine has recently approved a lease for a 226-acre, 50MW solar installation that will be the largest in the state and produce approximately 90% of the power produced at the Ellsworth Dam[12]. Bowdoin College's 1.2MW solar facility in Brunswick, Maine has proven profitable and meets 8% of the institution's electricity demand. Solar energy costs are rapidly decreasing as production technologies improve and panel efficiency increases[13]. Storage technologies are also improving and promise to mitigate issues with volatile solar generation. In addition, solar-powered electricity generators are able to sell not only the electricity *per se*, but also the solar renewable energy credits (SRECs) associated with the generation.

Large wind generation projects in Maine could also replace the generation capacity of the Ellsworth Dam. Approximately 13% of Maine's electricity needs are currently met by wind

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[11] Opperman, J.J., et al., 2011. The Penobscot River, Maine, USA: a Basin-Scale Approach to Balancing Power Generation and Ecosystem Restoration. *Ecology and Society* 16(3):7-24.

[12] "Plan for Maine's largest solar energy farm moves ahead as Sanford approves lease", *Portland Press Herald*, May 4, 2016. [http://www.pressherald.com/2016/05/04/sanford-approves-lease-for-maines-largest-solar-farm/]

[13] Photovoltaic System Pricing Trends Historical, Recent, and Near-Term Projections 2015 Edition. U.S. Department of Energy (energy.gov). [https://emp.lbl.gov/sites/all/files/pv_system_pricing_trends_presentation_0.pdf]

power[14], a fraction that is growing steadily over time. For example, the Kibby Wind Farm in Franklin County produces 132MWh/year, or roughly 15 times the generation of the Ellsworth Dam; a relatively small wind power operation could replace the Ellsworth Dam's capacity.

In addition to the large-scale solar and wind generation operations in Maine, small-scale generation is on the rise as well; communities are coalescing into "Solarize" campaigns to achieve economies of scale, and the possibility of "net metering" renders household-scale investments cost-effective. Licensing of hydropower must take these trends in renewable generation technologies and institutions into account.

Impoundments and Impacts on Property Values

Once installed for their primary purposes of power generation and/or flow control, dams can in some cases provide ancillary recreational benefits in their impoundments and elicit investments in infrastructure by municipalities and by abutting private landowners. It is therefore important to consider the implications for the associated impoundments of changes to water flow, or of removal of a dam. However, restoration of riparian ecosystems to their "free-flowing state" has been shown to have a broader, if somewhat more diffuse, positive impact on local stakeholders; this latter value can be at least partially embodied in property values in the vicinity of the restoration.

Situated just above the Graham Lake Dam, the ~9400-acre Graham Lake impoundment is the basis for an established residential community with a large group of stakeholders. While no quantitative assessment was undertaken of the prospective loss of property value, it is clear that dramatic alterations of the Graham Lake impoundment (via removal of the Graham Lake Dam) would be highly detrimental to these property owners. Furthermore, and in contrast to the Ellsworth Dam, the Graham Lake dam is conducive to the installation of volitional fish passage that would allow many species of anadromous fish to pass into and out of Graham Lake and it could be retrofitted with hydropower generation capacity.

The 184-acre Leonard Lake impoundment created by the Ellsworth Dam is only ~1.5% the size of Graham Lake, and provides little in the way of waterfront property or recreational amenities. There are currently only 10-12 dwellings with an immediate relationship to Leonard Lake[15]. Topological analysis suggests that, in the absence of the Ellsworth Dam, Leonard Lake would change to a rapid-flowing gorge-like channel amenable to rafting and whitewater kayaking; these benefits would not only be more broad-based, but would also likely exceed the current benefits to adjacent landowners. In fact, it is likely that properties (houses and vacant land) along the bounding Shore Road would benefit from slightly increased acreage and proximity to a restored free-flowing river.

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[14] *"Wind power's growth in Maine, 2007-2016", Portland Press Herald.*
[http://www.pressherald.com/interactive/wind-power-growth-maine/]
[15] Ascertained using Google Earth imagery

There is ample evidence in the economics and policy literature regarding the impact of dams, and their removal, on property values. Most of this research suggests that, while impoundments may provide a highly focused set of recreational benefits to abutting landowners, the net impact of dams on nearby property values is largely negative. Provencher et al.[16] show empirically that free-flowing rivers convey more benefits (embodied in local housing prices) than dammed rivers, even those with associated recreational impoundments. A hedonic analysis of the impact on property values removal of the Edwards Dam on the Kennebec River[17] found that removal of the dam (i.e., the promise of a restored riparian ecosystem) was sufficient to flip the river from a disamenity (with property values decreasing with proximity) to an amenity (where proximity to the river contributes positively to the value of homes). The estimate provided by Lewis et al. of the immediate positive impacts of river restoration on property values is likely to be quite conservative due to the time frame of the analysis; the real estate market is slow to recognize and embody the benefits of improved ecosystem function, and many of these values require learning as well as infrastructural investments to reach their full potential. While it is not feasible to carry out, *a priori*, an analogous hedonic analysis of a prospective dam removal on the Union River, it is reasonable to extrapolate from the Kennebec case and predict a similar positive impact on property values in the vicinity of the Ellsworth Dam site subsequent to its removal or other significant ecosystem restoration.

The Union River is well-regarded for its recreational boating amenities[18]. While flow through the lower Union is currently curtailed by the Ellsworth and Graham Lake Dams, restoration of more natural flows, and recovery of the geological channel of the river would offer the possibility of some highly valued recreational activities, the benefits of which would be amplified by their close proximity to the City of Ellsworth.

Ecological Effects and Related Economic Impacts

Given its height of approximately ~70 ft. and a technology that predates cognizance of the ecological impacts of dams, the Ellsworth Dam is a nearly insurmountable obstacle to upstream and downstream passage of anadromous fish. The Union River is native habitat to numerous species; the most important to human stakeholders are alewives and other species of river herring (e.g., bluebacks), American shad, Atlantic salmon, and American eel. The disruption of the Union River's ecological function has substantial economic consequences–both direct and indirect–that should factor prominently into the relicensing decision.

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[16] Provencher, B., H. Sarakinos, and T. Meyer, 2008. Does small dam removal affect local property values? An empirical analysis. *Contemporary Economic Policy* **26**(2):187-197.
[17] Lewis, L.Y., C. Bohlen, and S. Wilson, 2008. Dams, dam removal, and river restoration: A hedonic property value analysis. *Contemporary Economic Policy* **26**(2):175-186
[18] "Union River watershed offers whitewater and much more". *Ellsworth American*, September 5, 2016. [http://www.ellsworthamerican.com/featured/union-river-watershed-offers-whitewater-much]

Alewife (*Alosa pseudoharengus*) are a small and prolific anadromous species capable of colonizing Leonard Lake, Graham Lake, and the tributaries and ponds upstream of Graham Lake. Alewives are valuable to humans when extracted directly (primarily for use as lobster bait, but also with a limited market for human consumption and as fertilizer). They also form the basis for much of the riparian and coastal marine food web, serving as prey for cod and other groundfish; striped bass, bluefish, and other recreationally important species; bald eagles, osprey, and other raptors; marine mammals; and others. Thus the restoration of alewife runs directly leads to restoration and invigoration of the entire coastal ecosystem, a change that can have large benefits to human stakeholders.

Even a cursory look at the size of alewife runs in the Union River upstream to Graham Lake (~7,900 acres) and the roughly analogous Sebasticook River above Benton (~10,800 acres) shows that the management of the alewife population–both in terms of access to habitat and the harvest mortality–is far from optimal, representing a large opportunity cost to local communities and the larger population of stakeholders concerned with ecosystem function. The average estimated run size in the Union River from 2009-2015 has been 671,500 (or 85 fish per acre), compared to the Sebasticook's 2,255,760 (208 fish per acre). Both of these are below the DMR target of 235 fish per acre, though the Sebasticook has achieved this target run size in two out of the seven years in this range. Improving habitat access in the Union to the level of the Sebasticook would increase the Union River run size to 1,643,000. This would be infeasibly costly to achieve through an augmentation of the trap and truck program.

The 7,900-acre figure used above is conservative, as it assumes access only to Leonard and Graham Lakes. If additional habitat restoration and fish passage projects were carried out, 27,558 acres[19] of potential/historical alewife spawning habitat upstream of the Ellsworth Dam (including Leonard Lake) would become available and would be capable of supporting a population of approximately 6.5 million fish (using the widely-used figure of 235 fish per acre). This is approximately ten times the alewife run currently supported by trap & truck relocation into available habitat past the Ellsworth Dam; an *increase* in the herring population of 0.9*6.5M = 5.85M would result if all habitat were made available. Some portion of such a restored alewife run would have value to society in the form of direct harvest for lobster bait, human consumption, and other uses. As a conservative lower bound, 5/7 of these fish[20], or ~70%, of these fish, could be harvested and used, e.g., for lobster bait. At a weight of approximately 0.5lb/adult[21], and a current price of approximately $0.40/lb.[22] for alewives used as lobster bait, the increase in the sustainable annual harvest would be worth

$$0.7 * (5.85\text{M fish/yr}) * (0.5\text{ lb/fish}) * (\$0.40/\text{lb}) = \sim\$800{,}000/\text{year}.$$

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[19] Watts, D. "Lacustrine Habitat -- Union River Watershed, Maine." Unpublished report, January 2013.
[20] This figure of 5/7 is the mean of two commonly used heuristics for sustainable harvest of alewives: A 35 fish/acre escapement target – constituting 1/7 of the pervasive 235 fish/acre figure; and a 3 day/week hiatus in alewife harvesting during the spawning run, which would allow harvest of the other 4/7 of the biomass.
[21] [https://www.fws.gov/gomcp/pdfs/alewife%20fact%20sheet.pdf]
[22] Personal communication with Jeff Pierce, Alewife Harvesters of Maine; this $0.40/lb figure is a conservative estimate of the current price of fresh alewives for lobster bait, corresponding to approximately $24/bushel.

This should be thought of as one component of the opportunity cost of business-as-usual practices (i.e., inadequate fish passage) at the Ellsworth hydro project.

Note that the price of bait has been increasing due to global scarcity, a trend that is widely expected to continue; mitigation of this price increase is an important regional policy issue[23]. In addition, the market for alewives is expanding and evolving beyond the bait market. If alewives (historically popular as food for human consumption) were to increase in popularity, and in particular if a roe fishery were to be developed for this species[24], the value of this sustainable harvest could be higher than the coarse estimate given here.

It is harder to quantify the indirect and non-market value of a restored alewife run to society. One important component of such value lies in the commercial groundfish industry, as alewives are a lipid-rich food supply critical to the potential re-establishment of groundfish stocks and an associated groundfish industry in Frenchman's Bay and the larger Penobscot Bay coastal region. Ted Ames et al.[25] have reconstructed historical fishing records and provided compelling evidence that removal of anadromous fish has been an important driver of the decline in coastal groundfish stocks–with associated loss in earnings and participation in this historically important industry. The National Marine Fisheries Service and other regulatory bodies increasingly view forage fish as critical to effective holistic/integrated management of predatory species[26], and river herring have recently been listed as a "Species of Concern" by the National Marine Fisheries Service[27]. Recent advances in fishery regulation–in particular the formation of "sectors" as regulatory units in federal waters[28], increased collaboration between fishermen and regulators in understanding localized population dynamics[29], and expansion of comanagement paradigms in the Gulf of Maine[30]–provide optimism about society's ability to sustainably capture the benefits of increased forage fish populations.

Secondary to their direct harvest and their role in the food web of important commercial species, anadromous river herring stocks will benefit their avian predators, with value to tourists and birders; they nourish predatory gamefish, with benefits to anglers; and they

[23] Overton, P. "Maine regulators intervene to mitigate shortage of lobster bait." *Portland Press Herald*, July 8, 2016. [http://www.pressherald.com/2016/07/08/maine-regulators-intervene-to-mitigate-shortage-of-lobster-bait/]
[24] Hongoltz-Hetling, M. "As alewife populations recover, a new economy emerges." *Kennebec Journal*, August 10, 2013. [http://www.centralmaine.com/2013/08/10/as-alewife-populations-recover-a-new-economy-emerges/]
[25] Ames, T., 2010. Multispecies Coastal Shelf Recovery Plan: A Collaborative, Ecosystem-Based Approach. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 2:217–231.
[26] "NOAA proactively Protects Commercial Fishing on Several Species of Forage Fish." NOAA, April 4, 2016. [http://www.westcoast.fisheries.noaa.gov/newsroom/2016/01_noaa_proactively_protects_commercial_fishing_on_several_species_of_forage_fish.html]
[27] [http://www.nmfs.noaa.gov/pr/pdfs/species/riverherring_detailed.pdf]
[28] Labaree, J.M., 2012. *Sector management in new england's groundfish fishery: dramatic change spurs innovation.* Gulf of Maine Research Institute, August 2012.[https://www.gmri.org/sites/default/files/resource/sector_management_in_new_england.pdf]
[29] [http://www.penobscoteast.org/research/groundfish-science-and-fishing-communities/]
[30] e.g., [http://www.penobscoteast.org/research/ecosystem-co-management-pilot/]

facilitate the transport of scarce nutrients from the marine system into inland waterways[31]. In addition, survey-based work has indicated a significant positive non-use value of local residents for the potential restoration of alewife populations.

The potential alewife run in the Union River cannot cost-effectively be achieved using the existing trap and truck program. To reach 35 fish per acre in the upstream habitat, this program would need to increase to (35 fish/acre) * (27,558 acres) = 965,000, i.e., more than triple the currently estimated 100,000-350,000 fish/yr transported past the Ellsworth Dam into Leonard and Graham Lakes. And, as noted above, the construction of effective fish passage beyond the Ellsworth would be prohibitively expensive.

American shad (*Alosa sapidissima*) are a highly valued recreational species with demonstrated potential to recolonize the Kennebec and restored rivers in Maine, through natural establishment and stocking programs[32]. If upstream and downstream passage were made possible, the Union River offers habitat for an estimate run of 20,000 adult fish. According to a recent report[33] by the Pennsylvania Fish & Boat Commission (with reference to the Schuykill River), a run of this size would support approximately 4,000 angler days, worth $200,000/year at an estimated value of $50/angler day. The overall impact of such angling activity could in fact be significantly higher than this estimate, given expenditures of anglers on meals, lodging, and complementary recreational activities. In particular, the potential of the Union River as a destination fishery for angling could allow the local economy to capitalize on the presence of visitors to nearby Acadia, for whom a side trip to the Union River would involve a relatively low investment. Travel to Acadia has hit record highs over the past three years, with approximately 2.8 million visitors in 2015[34].

Atlantic salmon (*Salmo salar*) are currently protected under the Endangered Species Act, and as such do not offer any immediate value in the form of commercial harvest or angling. But the Union River is well within the natural habitat range of this species (a small number of salmon have been observed below the Ellsworth Dam, but with no prospects of passing beyond it), and the Union River could constitute an important part of a coordinated regional recovery plan for Atlantic salmon. To be sure, recovery of Atlantic salmon is a worthy objective of river restoration in its own right, if only to improve the prospects of species survival for this iconic fish; indeed, the spirit of the Endangered Species Act suggests we should do everything reasonably within our abilities to bolster this species' chance of recovery. But beyond this moral obligation, there is the potential for significant use value for human stakeholders, though this cannot happen at the Union River in isolation: If – given restoration efforts elsewhere in

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[31] K. Norris, 2012. *The influence of anadromous alewife on Maine lakes and streams: using nutrient limitation assays and stable isotopes to track marine-derived nutrients*. M.Sc. thesis, U. of Maine.
[32] Latti, M. "Ready for another fight". *Portland Press Herald*, May 18, 2013. [http://www.pressherald.com/2013/05/18/ready-for-another-fight_2013-05-19/]
[33] Pennsylvania Fish & Boat Commission. *Schuylkill River American Shad*. [http://fishandboat.com/shad_schu.htm]
[34] "Acadia National Park visitor level hit 20-year high in 2015". *Bangor Daily News*, Feb. 2., 2016. [http://bangordailynews.com/2016/02/02/news/hancock/acadia-national-park-visitor-level-hit-20-year-high-in-2015/]

addition to those on the Union – salmon were to recover to a point where recreational angling is possible, there could be very large economic benefits. To realize these "use values," FERC should holistically view the Union River as a part of a larger (Gulf of Maine-scale) ecosystem in which restoration of individual components have synergistic, or super-additive, benefits.

American eel (*Anguilla rostrata*) form the basis for a relatively new, and highly lucrative commercial fishery. It is well known to FERC and others that juvenile American eel, or elvers, command a very high price in Asian markets–well in excess of $2,000/lb[35]. The Union River constitutes important habitat for this species and could be the locus of a substantial commercial elver fishery–an industry that (due to its recent development) has been proactively and effectively managed. Yet the Ellsworth Dam has been clearly implicated[36] in substantial mortality of outmigrating adult eels (who leave the Union River to spawn at sea). It would be extremely expensive for the Brookfield to re-engineer the Ellsworth Dam's flow so as to avoid similar incidents in the future.

A restored river system has value far beyond that manifested in commercial fishery harvests and recreational angling. As mentioned above, there is strong empirical evidence that restored rivers have value capitalized into real estate prices (and hence in the resulting tax base). But there is also significant value to local industry of such restoration projects, especially in the medium- to long-term as municipalities and firms make infrastructural investments, and as local employers capitalize on the local environment to attract high-productivity workers. Ellsworth is already the locus of a significant creative and artistic economy, one that is likely to embrace a restored river and leverage its improved aesthetics and recreational access into economic development. The proximity of Ellsworth to Bar Harbor and Acadia National Park make it even more likely that prospective visitors are already self-selected from a population interested in natural beauty and functioning ecosystems; this should make it easier for Ellsworth to effectively capitalize on river restoration.

Summary and Conclusions

The evaluation of the Ellsworth and Graham Lake Dams for relicensing comes at a time of rapid technological change in solar and wind-powered electricity generation, along with current and projected low prices for natural gas. The evaluation also takes place against a backdrop of heightened awareness of the economic and ecological benefits that can emerge from a restored riparian habitat: river-based recreation and other forms of tourism, increased values of proximate properties, and the indirect value of an invigorated trophic web. While it is challenging to quantify many of these effects with a great degree of confidence, their collective qualitative weight is great. Furthermore, there is every reason to believe that the value of a

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[35] "Expectations high for 2016 elver catch, prices". *Bangor Daily News*, March 19, 2016. [http://bangordailynews.com/2016/03/19/business/expectations-high-for-2016-elver-catch-prices/]

[36] "FERC blames Ellsworth Dam owner for autumn fish kills". *Ellsworth American*, Feb. 3, 2015. [http://www.ellsworthamerican.com/featured/ferc-blames-ellsworth-dam-owner-autumn-fish-kills]

restored ecosystem will continue to increase over time as these systems and their connectivity to other parts of regional ecology and economy are better understood.

FERC's is a weighty decision: long-lived, and with impacts on a range of stakeholders. Relicensing is a largely unchangeable binary choice that has to be made at a time in which technologies and social priorities are rapidly evolving. As such, the responsibility of FERC is not to make the decision that looks optimal given current conditions, but to conduct a good-faith appraisal of what the *ex post* optimum will be. It is admittedly hard to predict the future, but if given the choice, it is preferable to be several years ahead of the curve than stuck many years behind it by the end of the license term.

It is now well understood that dams present significant tradeoffs to society: while they provide power generation and potentially useful impoundments, they disrupt the biogeophysical system and curtail the ecosystem services the waterway is capable of providing. Many dams – in Maine and elsewhere – are effective at achieving a healthy, equitable, and efficient balance between electricity generation and the role the river plays in the broader socioecological system. These dams that do make sense to maintain (a) are modern and efficient generators of electricity; (b) are structurally sound and unlikely to require major capital repairs over their remaining lifespan; and (c) are constructed in such a way as to minimize their impact on natural populations dependent on access to upstream spawning and feeding habitat.

The Ellsworth Dam, by contrast, is antiquated, vulnerable to failure, and susceptible to major maintenance issues. This is an anachronistic hydropower generation facility, built at a time when rivers were treated as tools of industry at best–and sewers at worst–and when there was very little appreciation for social values other than power generation (i.e., formal and informal "economic" value) that could otherwise emerge from these systems. Such a dam would not pass existing environmental criteria if it were built today. The augmentation of an insufficient and expensive trap-and-truck system aside, it is virtually impossible to retrofit the Ellsworth Dam to allow it to function harmoniously with the Union River ecosystem, i.e., to allow effective upstream and downstream fish passage, especially for salmonids, American shad, and American eel, all of which potentially have very high economic value through commercial harvest and/or recreational angling. The Leonard Lake impoundment above the Ellsworth Dam is of very limited recreational, residential, or flood-control value – whether measured in terms of aggregate value of waterfront property or in terms of the number of stakeholders that would advocate for its continued existence. On this latter point, removal of the Ellsworth Dam would be far less contentious, in terms of its impact on owners of property abutting the impoundment, than was the Kennebec's Edwards Dam.

FERC has an important qualitative decision to make in the case of the relicensing of the Ellsworth Dam: one between (a) the status quo of marginal and replaceable energy production coupled with substantial adverse ecological and economic impacts; and (b) the restoration of the Union River below Graham Lake to its free-flowing state, and a substantially different, but potentially much-improved, economic paradigm surrounding the river. This is not an easy choice, as the potential benefits are unknown, and there will inevitably be some short-term resistance to moving to this new paradigm. But the mandate of FERC in such long-run relicensing decisions is clearly to be as foresightful as possible, and to consider the broader set of social benefits that emerge from the waterways over which it has jurisdiction. As suggested in the Energy.gov report referenced above, FERC's objective should be to foster power generation at the facilities that can provide it with relatively low social cost, while recognizing the unsuitability of some dams for continued operation.

It is challenging to provide quantitative estimates of the many dimensions and costs and benefits of FERC's decision, but the preponderance of evidence in this case is against relicensing of the Ellsworth Dam at the lower terminus of Leonard Lake. This dam cannot feasibly be modified to allow for adequate upstream and downstream passage of the key species inhabiting the Union River, and its removal would spark an important paradigm shift in the surrounding economy, a shift that would have large benefits in the medium- to long-term. By contrast, the Graham Lake Dam serves an important purpose in maintaining the Graham Lake impoundment; it is important in controlling the level of water so as to optimize the recreational and aesthetic benefits, and therefore the value of the lakefront properties, in this impoundment. Furthermore, the Graham Lake Dam is far more amenable to the construction of volitional upstream and downstream fish passage, as well as perhaps some modest power generation capacity. I therefore recommend that FERC decline to relicense the Ellsworth Dam, instead recommending its removal. Concurrently, the Graham Lake Dam should be retrofitted with volitional fish passage and LIHI-certifiable power generation capacity, so as to bring it in line with recent and prospective social priorities.

Respectfully submitted,

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