Universities Council on Water Resources
Journal of Contemporary Water Research & Education
Issue 134, Pages 34-38, July 2006

Dam Removal: A Taxonomy with Implications for Economic Analysis

Mark Griffin Smith

Department of Economics and Business
Colorado College

Casual observers of dam removal activity in the United States are most likely familiar with the three most widely publicized removal or proposed removal projects—the Edwards Dam on the Kennebec River in Maine (removed), the Elwah and Glines Canyon Dams on the Elwah River in Washington (planned) and the proposed removal or breaching of dams on the lower Snake River along the Oregon-Idaho border. While these removal projects involve medium to large scale dams, most of the actual removal activity involves small, run-of-river dams whose economic usefulness has long past (American Rivers et al. 1999). Thus, dam removal involves projects ranging from those with small removal costs and clear, local benefits to high removal costs and uncertain benefits ranging over an entire river basin.

In 2004, the Environment and Water Resources Institute of the American Society of Civil Engineers initiated a series of workshops aimed at the civil engineering community, to address the major issues associated with dam removal (Environmental and Water Resources Institute 2004). As the speaker on the economic aspects of dam removal at one workshop in this series, it became apparent that clarifying dam removal's economic issues would make an important contribution to the dialogue among economists, civil engineers, biologists, environmentalists, state officials, and others involved in the dam removal process.

This paper proposes a taxonomy of dam removal projects—from the simple to the complex. The dimensions of this dam removal taxonomy extend over a range from: (1) small to large dams; (2) single purpose to multipurpose projects; (3) positive to negative impacts of sediment movement; (4) dam is a liability rather than an asset; (5) removal benefits are certain rather than uncertain; (6) removal generates market benefits versus non-market benefits; (7) removal generates positive versus negative externalities; (8) the scope is local versus national; and (9) removal benefits occur sooner rather than later. Dams at one end these scales are easy to evaluate while those at the other are far more complex.

By explicitly identifying the dimensions that complicate dam removal decisions, this paper aims to clarify how these project parameters affect economists' estimates of net benefits and thus improve understanding of economic analysis among the many disciplines involved in such projects.

Physical Taxonomy

Dam removal can be characterized into a taxonomy along two dimensions—physical and economic. The physical dimension includes those characteristics related to the size, location and function of the dam itself and its direct impacts on the hydrologic regime and riparian environment. The economic dimension concerns translating those physical and biological impacts into economic values. The physical characteristics of dams and their removal will be considered first; I will then turn to economic issues.

Size

The physical size of a dam has a number of important impacts on a river system (Collier et al. 1996). First, small dams are generally run-of-river whereas larger dams are capable of at least annual and, often, over-year storage.

Thus, dam size influences the extent to which a dam has modified the natural hydrograph. Second, larger dams generally inundate a larger area. Dam removal thus creates a smaller or larger restoration area depending upon size. Third, smaller dams are cheaper to remove than more massive dams. Finally, the depth of the reservoir and the placement of outlet works determine temperature impacts on the downstream reach.

Single Purpose or Multi-Purpose

Related to size, a dam can have the single purpose to provide sufficient head and storage to produce power for a single plant to the multi-purposes of storage for municipal, industrial and irrigation water, hydropower, flood control, and flat-water recreation, as well as collaterally creating a productive downstream sport fishery. Clearly, it is easier to evaluate the loss of one output versus many.

Sediment Movement

By creating an impoundment that reduces stream velocity, dams prevent the movement of sediments downstream. When a dam is removed, sediments are again set in motion. Will this sediment movement have positive or negative consequences? In some cases, dams have been removed or are proposed for removal to restore sediment movement. Removing the Matilija and Rindge Dams in Ventura County, California, will eventually help replenish beach sand, though the immediate cost of removing the accumulated trapped sediments will be considerable (American Rivers 2006). Proponents of the removal of Glen Canyon Dam seek to return sediments downstream to the Grand Canyon to provide for both endangered species habitat and beaches for river runners (Glen Canyon Institute 2000). On the other hand, sediment movement may impose significant costs. The reservoir behind the San Clemente Dam under study for removal on the Carmel River in California has nearly filled in with sediments. While dam removal is seen as desirable to restore the river and steelhead run, there is concern that downstream movement of these accumulated sediments will constrict flows and flood expensive homes built in the area subsequent to the dam's construction in 1921(Mussetter and Trabant 2005). Similarly, there is concern that the sediment banks exposed after removal of the Glines Canyon Dam on the Elwah will be unstable and impose a safety hazard for some time after removal.

Liability or Asset

Much of the dam removal activity involves small, low, obsolete structures built to create millponds in the last century or earlier (Aspen Institute 2002). In many cases, these dams generate no benefits to the owner, while they present a potential liability as a hazard to recreational navigation. In California, modifications to address seismic risk may involve significant expense on larger dams. In some cases, dam owners will save by removing a dam by either reducing insurance costs or avoiding expensive retrofitting (Heinz Center 2002). This is an easy economic decision for the owner. However, many dams produce significant water supply, hydropower, recreational or other benefits. Economic analysis must weigh the loss of these benefits against new benefits generated by removing the dam.

Economic Taxonomy

Given the predicted changes in the physical and biological system, it is then the economist's challenge to attempt to "value" them; that is, to transpose these physical changes into a common metric (dollars) and then evaluate whether the sum of these changes results in either a positive or negative value (cost-benefit analysis). Placing a dollar value on the physical and biological changes to the river confronts economists with five distinct challenges:

1. uncertainty associated with predicted changes in the physical and biological system resulting from dam removal;
2. the non-market character of many of these changes especially those likely to be the benefits of removal;
3. the presence of positive and/or negative externalities;
4. the scope of the analysis;
5. the time horizon over which the physical and biological system recovers.

Uncertainty

Dams are built to alter the hydrologic regime of a river. Depending upon their size, function and length of time in existence, dams will have a smaller or larger effect upon this regime. For the reasons discussed above, significant changes may

have occurred in both the physical and biological character of the river system. The fundamental question is: to what extent will removing a dam return this system to its pre-dam, free flowing state?

This uncertainty has three dimensions. First, there is uncertainty about which of the functions of a free-flowing river will return. For example, while dam removal may restore the annual hydrograph to its historic annual pattern, that does not guarantee that an endangered species will re-establish itself in this reach or that accumulated sediments will dissipate downstream. Second, there is uncertainty about the magnitude of these outcomes, i.e. a salmon run returns, but neither at historic, pre-dam levels nor at the levels predicted by ex-ante modeling. Third, there is uncertainty about the rate of recovery. While, from an ecological perspective, the fact that the river ultimately achieves the desired state may be sufficient, but for reasons that will be discussed more fully below, the realization of positive outcomes further into the future diminishes the economic value of restoration.

Non-Market Values

Dam removal aims at restoring positive ecosystem functions to a river system. While the values of these functions may be readily quantifiable in physical terms—numbers of fish, miles of riparian habitat, flow levels, etc.—translating these physical changes into economic values is more difficult. Four issues are paramount.

First, the social welfare framework of economic cost-benefit analysis is not concerned with the value of fish, per se, but the value of fish to human beings. Fish are valued in economic cost-benefit analysis because fishing is valued as a recreational activity or they have value as food. In these ways, fish have use value for human beings. Once these use values have been identified, the second challenge arises —what is the quantity and quality of these outputs after restoration? As the ex-post conditions do not exist at the time of the analysis, values for these changes will be based on the expectation that they will be similar in character to resources for which values are known, e.g. the value of a recreational visitor day (RVD) on a river that we expect this river to be like after restoration. Actual conditions after restoration may be better or worse, thus increasing or decreasing their economic value. Third, a significant aim of river restoration may be to create non-use values such of the recovery of endangered species. A bottom dwelling fish that lives in a turbid river will not even have what economists call passive use value, such as watching a bald eagle's nest or a flock of whopping cranes. Its value is intrinsic and intrinsic value is difficult to measure as well as a controversial concept to many (Diamond and Hausman 1994). The final, over-arching problem is that these non-market values may represent the bulk of the positive outcomes associated with river restoration, while costs such as loss of power revenue, loss of water supply, loss of flood protection and the removal cost itself, can readily be determined as market values. Thus, in performing cost-benefit analysis on dam removal projects, economists are frequently put in the position of justifying "hard" costs with "soft" benefits.

Positive or Negative Externalities

An externality occurs when either a positive or negative effect on an outside party results from a market transaction. An example of a positive externality is the creation of an outstanding trout fishery downstream of a major reservoir in the western U.S. resulting from the release of cooler, clearer water from the outlet works. A negative externality may result from dam removal if upstream landowners are left with a barren, dry lake bottom rather than an attractive riparian shoreline. These effects, whether positive or negative, must be accounted for in determining the full cost of dam removal and river restoration. Moreover, they are important to understand as interest groups such as trout fisherman or riparian landowners will likely mobilize around these externalities to either support or oppose dam removal.

Scope

In principle, benefit-cost analysis should be conducted from a national perspective, that is, how do the benefits and costs of removing a dam affect the national welfare (Howe 1987)? Nevertheless, dam construction has historically been used as an instrument of regional development. Federally subsidized projects under the Reclamation Act, for example, concentrated benefits to a region while spreading the costs over the nation's taxpayers. Dam removal can do just the opposite. Local benefits are lost while elsewhere ocean salmon stocks rebound from restoring this salmon run. Moreover, perhaps

we should begin asking whether national welfare is sufficient scope? In particular, should hydropower losses be measured only in terms lost power revenues or should the costs associated with increased CO_2 emissions be weighed in the balance? At this point, these global externalities are not considered.

A final note on scope—whether policy makers ultimately define scope as local, regional, state, national or global, you can be sure that someone is always tracking the costs and benefits at the local level and arguing that it is the proper scope for analysis. As Tip O'Neal said, "All politics is local."

Time Horizon

The costs associated with dam removal and benefits generated from river restoration extend out over time. Putting these costs and benefits on a comparable basis requires discounting. As value received further in the future is worth less in present value terms, dam removal projects in which the site requires a costly or extended period of restoration and a concomitant delay in use will be less attractive (Stokey and Zeckhauser 1978). In measuring the economic benefits created by dam removal, it matters not only that these changes occur, but also when they occur.

Conclusion

Dams alter river systems. Their removal aims at restoring important natural functions of these altered systems. Engineers and natural scientists focus on the physical changes resulting from dam removal and river restoration. Economists attempt to translate these physical changes into economic value. A misunderstanding between these two approaches arises for two principle reasons. First, the uncertainties associated with predicting physical and biological changes resulting from restoration are only exacerbated by multiplying them by estimated non-market values that similarly have a range of uncertainty. Second, in comparison with "hard" numbers like physical movement of sediments or growth in fish stocks, non-market values are "soft". Issues of what should be counted and when these changes occur further complicate economic cost-benefit analysis. Therefore, it is imperative that we vigorously pursue the ex-post assessment of removal projects to better understand both the physical and economic changes resulting from river restoration.

Acknowledgment

I would like to thank Kyle Schilling and the Environment and Water Resources Institute of the American Society of Civil Engineers for conducting the superb series of workshops, "Dam Removal: Lessons Learned" and giving me the opportunity to hear many different perspectives on this issue.

Author Bio and Contact Information

Mark Griffin Smith is a Professor of economics at Colorado College. His research interests span a range of water resources issues including water markets, instream flow protection, water supply reliability and water quality management in Central and Eastern Europe. From 1994 to 1996 he was project manager and research scholar with the Water Resources Project at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. In 1999 he was appointed the first John L. Knight Chair for the Study of Free Enterprise. Economics and Business Department, Colorado College, 14 E. Cache la Poudre St., Colorado Springs, CO 80903. msmith@ColoradoCollege.edu

References

American Rivers. "Matilija Dam" American Rivers 29 March 2006 <http://www.americanrivers.org/site/PageServer?pagename=AMR_content_7a3e>.

American Rivers, Friends of the Earth and Trout Unlimited. 1999. *Dam Removal Success Stories*. American Rivers: Washington, DC.

Aspen Institute. 2002. *Dam Removal: A New Option for a New Century.* The Aspen Institute Program on Energy, Environment and the Economy: Washington, DC.

Collier, M. R., R. H. Webb and J. C. Schmidt. 1996. *Dams and Rivers: Primer on the Downstream Effects of Dams.* U.S. Geological Survey Circular 1121, U.S. Geological Survey: Denver, CO.

Diamond, P. A. and J. A. Hausman. 1994. Contingent Valuation: Is Some Number Better than No Number? *Journal of Economic Perspectives* 8(4):45-64.

Environmental and Water Resources Institute. 2004. *Dam Removal: Lessons Learned*. Environmental and Water Resources Institute of the American Society of Civil Engineers: Reston, VA. <http://www.ewrinstitute.org/damremoval04/>.

Glen Canyon Institute. 2000. *Citizens' Environmental Assessment (CEA) on the Decommissioning of Glen Canyon Dam.* Glen Canyon Institute: Salt Lake City, UT.

Heinz Center. 2002. *Dam Removal: Science and Decision Making*. The H. John Heinz III Center for Science, Economics and the Environment: Washington DC.

Howe, C. W. 1987. Project Costs and Benefits from National and Regional Viewpoints: Methodological Issues and Case of the Colorado-Big Thompson Project. *Natural Resources Journal* 27: 5-20.

Mussetter, R. A. and S. C. Trabant. 2005. Analysis of Potential Dam Removal/Retrofit Impacts to Habitat, Flooding and Channel Stability in the Carmel Valley, California. In Glenn E. Moglen (ed.) *Managing Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges* – Watershed 2005. <http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=ASCECP0001780407630000340000001&idtype=cvips&gifs=yes>.

Stokey, E. and R. Zeckhauser. 1978. *A Primer for Policy Analysis*. W.W. Norton: New York.