Economies of Scale & Scope in River Basin Management

Gary Wolff, P.E., Ph.D.

Principal Economist and Engineer

The Pacific Institute, Oakland California

gwolff@pacinst.org and 510 251 1600

Introductory Remarks

Water management in most parts of the world has long followed a pattern of functional specialization (FS). Water agencies, companies, or departments of government supply water. Other agencies, companies, or departments supply wastewater services. Yet a third group is charged with flood control and storm runoff management. Of course some water utilities supply both water and wastewater services, and some government departments include all three branches of the water sector. These may appear to be exceptions, but the internal organization of these departments is usually along functional boundaries with planning documents and capital improvement budgets separated by function.

In contrast, many view River Basin Management (RBM) and its close cousins, Integrated Water Resources Management (IWRM) and Watershed Management (WM), as the emerging and better paradigm for water management. The World Bank (1993) has long urged the adoption of a comprehensive, cross-sectoral approach to water management. Serageldin (1995) labeled the French system of stakeholder-governed water institutions organized into six hydrologic basins, created in 1964, as a "model" to be emulated by others, and offered the 1984 reformation of the Murray River Commission in Australia into the Murray-Darling Basin Authority as another successful example of this approach. Since then, Mexico and China and other countries have revised their laws to promote and strengthen integrated approaches to water management. The US Agency for International Development advocates integrated approaches in the water sector (AID, 2002), and solicited proposals in 2004 to spend at least $3.75 million for IWRM.

The most ambitious attempt to implement the integrated approach began in 1991. New Zealand reorganized its entire environmental governance structure to eliminate more than 800 governmental and quasi-governmental agencies, replacing them with 12 regional stakeholder councils based on watershed boundaries that were to coordinate among three central government agencies and 74 territorial authorities at the district or city level. Over 55 statutes and 19 sets of regulations were eliminated or replaced by a single legislative enactment, the Resource Management Act (RMA) of 1991, encompassing environment, natural resources, and land use beneath one umbrella for the purpose of promoting the "sustainable management of natural and physical resources." Nonetheless, "numerous unanticipated shortcomings, both in the design of the legislation and the performance of the stakeholder groups … have hindered implementation and inhibited full realization of the vision and purpose of the RMA." (Sumits and Morrison, 2001, p. vii)

The integrated approach has succeeded less often and clearly than its early proponents expected. One reason is that there are underlying value conflicts and financial resource limitations that have prevented or slowed progress in water management for decades under all governance structures (see Moss, et.al., 2003, for a lengthier discussion of these issues). And the RBM approach does not necessarily make management easier; indeed the greater complexity of trying to solve numerous problems at once creates "transaction costs" that can be larger than the benefits that are sought. As the World Bank said in a revision of its water strategy (2004): "The main management challenge is not a vision of integrated water resources management, but a pragmatic but principled approach." (p. 2)

This paper provides one pragmatic principle for more effective water management. It argues that the RBM component of an effective structure should: 1) identify specifically how and when collaboration between FS organizations will be socially beneficial, and 2) mobilize sufficient political will to force FS organizations to collaborate when they should. The economic insight this paper offers is that collaboration between FS agencies is socially desirable when economies of scale or scope exist that cannot be captured by any one FS organization. Successful integration – in contrast with attempts to integrate too much that either fail or crawl along at a snail's pace -- occurs when these economies are identified and captured, and when FS organizations are allowed to manage projects that do not involve such economies.

This paper defines economies of scale and scope, describes economies of scope in more detail since this is a phrase that non-economists are unfamiliar with, provides a few examples of each in the US setting, and provides some concluding remarks on implementation challenges. A later paper will provide some Japanese and Chinese examples, and provide policy recommendations for Chinese decision-makers.

River Basin Management in the US

Water in the United States (US) is managed primarily through FS. The RBM approach is formally used in only a few of the dozens of river basins and thousands of small watersheds[1] in the country (Delli Priscoli, 2004). The most comprehensive RBM structure in the US governs the Tennessee River, the fifth largest river system in the US, spanning parts of seven States.[2] The Tennessee Valley Authority (http://www.tva.gov/), created in 1933 by the US Congress as a public corporation governing this hydrologically defined area, has a mandate – regional development – that is far broader than water management. Although the Authority has been very successful in numerous ways, it is not without its problems. Among these are a difficult balance between local initiative and centralized planning, a tension between hydropower (which provides 98% of TVA's revenue) and other objectives, and incomplete stakeholder representation and involvement processes (Miller and Reidinger, 1998).

The Delaware and Susquehana River Basin Commissions (DRBC and SRBC, respectively) are the only other entities in the US with wide regulatory authority over their respective river basins (see http://www.state.nj.us/drbc/drbc.htm and http://www.srbc.net/ respectively). [3] Yet the Susquehana Commission's authority does not seem to have been fully utilized. The DRBC website includes regulations affecting

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[1] A watershed is the land area that drains to any point on a surface water channel (e.g., a creek or river). A river basin, by contrast, is the land area that drains to a point where a river discharges into a body of water such as a lake or ocean, or larger river. River basins are at least as large as the watersheds within them, but the reverse is not true.

[2] Tennessee, Mississippi, Kentucky, Alabama, Georgia, North Carolina, and Virginia.

[3] The DRBC was created by a compact between the States of Delware, Pennsylvania, New York, New Jersey, and the US government; the SRBC by a compact between the States of New York, Pennsylvania, and Maryland,

extraction for water supply, discharges for water quality, and land use practices affecting runoff management and flood control. In contrast, the SRBC website contains regulations only for extraction of water, although the legal compact creating it grants wider regulatory powers.

The DRBC and SRBC are two of seven interstate agreements approved by the US Congress. Two others -- the Interstate Environmental Commission (http://www.iec-nynjct.org/)[4] and the Ohio River Valley Water Sanitation Commission (http://www.orsanco.org/)[5] -- have regulatory authority over water quality but not other aspects of water management within their territories. They are FS organizations working on water pollution at the watershed scale, which allows them to capture economies of scale, but they are not full RBM agencies with a mandate to identify or capture economies of scope.

Three more federally approved interstate entities -- the Interstate Commission on the Potomac River (http://www.potomacriver.org/),[6] the Great Lakes Commission (http://www.glc.org/),[7] and the New England Interstate Water Pollution Control Commission (http://www.neiwpcc.org/)[8] -- have little or no regulatory power. They

[4] This Commission was created by a federally approved agreement between the States of New York, New Jersey, and Connecticut.
[5] This Commission was created by a federally approved agreement between the States of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia.
[6] This Commission was created by a federally approved agreement between the States of Virginia, West Virginia, Pennsylvania, Maryland, and the District of Columbia.
[7] This Commission was created by a compact between the States of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, New York, and Pennsylvania. The Canadian Provinces of Ontario and Quebec are associate members of the Commission.
[8] This Commission was created by a federally approved agreement between the States of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

coordinate voluntary action and encourage collaboration across state (or international) boundaries. The Commission on the Potomac River and the Great Lakes Commission cover hydrologically defined areas (the Potomac River watershed, and the Great Lakes Basin), whereas the New England Commission covers a politically defined, seven state region. The work of the New England Commission is restricted to pollution control.

Other river basins in the US are sometimes partially managed at the river basin scale. For example, water rights, flood control, and hydroelectric power production are regulated on the Colorado and Columbia Rivers by the US Department of the Interior and the Colombia River Treaty Organization,[9] respectively. Comprehensive flood control planning for much of the Mississippi River Basin is performed under the direction of the Mississippi River Commission (http://www.mvd.usace.army.mil/mrc/index.php), composed of representatives from several federal agencies.[10]

RBM efforts at smaller scales (e.g., watershed management) are underway in many parts of the US. They are usually voluntary efforts that join together stakeholders across the boundaries of a FS management regime. These efforts have been supported by the US Environmental Protection Agency (http://www.epa.gov/owow/watershed/index2.html) in order to see whether the newer "integrated" paradigm can solve environmental problems that the FS paradigm has not been able to solve, historically.

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[9]The US Army Corps of Engineers and the Chief Executive Officers of the Bonneville Power Administration and British Colombia Hydro manage this organization, created by a Canadian-Us treaty.

[10] This Commission is the US entity most like the newly created River Basin Commissions in China. As noted by members of the Haihe River Water Conservancy Commission during a site visit by the author in June 2004, the Chinese Commissions are staff of the Ministry of Water rather than external stakeholders or politicians representing the jurisdictions that contain portions of the River Basin.

Economies of Scale and Scope Defined

As noted in the introduction, this paper argues that a critical driving force and economic justification for integrated approaches like RBM is the existence of, and potential to capture benefits from, economies of scale and scope. An economy of scale exists when making a facility or program larger will lower the cost per unit of the product or service[11] being delivered. If we can represent the cost of production via a cost function (C)[12] that depends on the amount of product or service produced (Q#), a simple mathematical representation of an economy of scale is:

$$(1) \qquad C(Q1 + Q2, 0) < C(Q1, 0) + C(Q2, 0)$$

Economies of scale often exist in water systems. Dams and reservoirs are often sized based on this concern. For example, a smaller dam and reservoir might cost less, in total, but would have higher costs per unit of water storage. Similarly, the additional cost of sewer pipes to bring sewage from large areas to a single wastewater treatment plant rather than to two or a few smaller plants has often been justified by the lower per unit cost of treating sewage at a larger plant.

[11] The services delivered by water systems are numerous and can be defined in a variety of ways. For example, flood control services are often defined based on protection against flooding from a specified duration (e.g., 1 hour) and frequency (e.g., once every ten years, on average) of precipitation event. Flood protection in practice uses several or more duration-frequency objectives. Another example is water supply, which can be of potable or less than potable quality. Or one could enumerate the services provided by the water (e.g., human consumption, waste removal, irrigation) rather than the service of delivering water of a specified quality. Focusing on the ultimate services for which water is desired is essential when considering options for managing water demand (see Wolff and Gleick, 2002). Simpler "aggregate" categories (e.g., delivery of potable water) are sufficient, however, for the purposes of this paper.

[12] This function represents the cost of delivering services without specifying the inputs (e.g., labor, capital, water, energy, knowledge) required to deliver them. There may be and often are numerous combinations of inputs that would deliver a specified level of services at a specified cost. For example, programs to promote water use efficiency often substitute knowledge for physical water while maintaining the same level of end-use services to customers.

Diseconomies of scale are also possible. That is why some water systems are horizontally fragmented. For example, sewer systems in flat terrain are often smaller in area than in sloping terrain because it is more difficult to move water over large distances when terrain is flat. Discharge to natural watercourses at many rather than a few locations makes more sense, and administrative boundaries tend to conform to the boundaries of the underground pipe system. Also, small management units may have administrative cost advantages over larger units, especially when systems are simple, neighbors are relatively far away, or have different management priorities and objectives.

An economy of scope exists when a facility or program that produces more than one kind of product or service is less expensive than two separate facilities or programs that produce the same quantity of these products or services. If we can represent the cost of production via a cost function (C) that depends on the type and amount of two services produced (Q1 and R1), a simple mathematical representation of an economy of scope is:

$$(2) \qquad C\,(Q1, R1) < C\,(Q1, 0) + C\,(0, R1)$$

Economies of scope in water systems are the least well-recognized economic force behind the growth of RBM as a management paradigm. In the past, the failure to coordinate across functional disciplines was either not very costly or less than the perceived cost of coordinating across functional boundaries. But today, failures to coordinate are very costly and cannot be ignored in most parts of the world. For example, a new dam and reservoir that will destroy significant biological resources and displace thousands or millions of people will be politically opposed, and the trade-off between water supply and goods or services that depend on a free-flowing river will be considered. Similarly, one can no longer relocate water supply intakes upstream of wastewater discharges every few decades, as was done many times in the past. Water supply and wastewater planners have been forced by population and urban growth to consider raw water supply and wastewater discharge issues at the same time.

If a solution exists that provides additional water supply while also enhancing another type of service (e.g., ecosystem services or local economic development), that solution captures an economy of scope. Wastewater recycling is this type of solution, because it provides additional physical water supply, although perhaps not of potable quality, while also reducing wastewater discharges and their environmental impacts. Similarly, combined (storm and sanitary) sewer systems deliver both runoff management and waste removal services that can be more expensive to deliver separately than together.[13]

Solutions that capture economies of scope are increasingly available, both because crowding creates more opportunities for integration of water management functions, and because technological progress makes some economies of scope easier to capture. For example, membrane bioreactors have made satellite wastewater treatment plants that supply irrigation water for local landscaping much more feasible. In some cases, these satellite facilities not only allow one to capture water supply and environmental benefits,

[13] Overflows from combined systems are a serious water quality problem in some locations, affecting recreational and other benefits of clean ambient waters. Saving money by combining functions should not be confused with inadequate designs that save money but also fail to perform adequately.

but also reduce the expense of capital improvements in the wastewater collection pipes or treatment plants downstream as population and wastewater flows increase. Similarly, advances in techniques for rainwater harvesting create opportunities to integrate across water supply and runoff management functions.

Diseconomies of scope are also possible. Sanitary sewer collection systems and wastewater treatment plants are often managed by different entities in the US (e.g., the first by each municipality, the second by a special district that serves a group of municipalities). The skills and facilities required for these systems differ enough that combining their management creates few benefits, but creates an additional level of administration.

It is also worth noting that economies of scale and scope are only one aspect of facility or program design decisions. Paying more per unit of output than the lowest that could be obtained does not mean a project is undesirable. After all, our ultimate concern is that the benefits of a facility or program exceed its costs. If the cost of production is more than it could have been, but is still less than the benefits provided, the project is still desirable.

Facilities and Programs That Capture Economies of Scope

Capturing economies of scale across organizational boundaries is straightforward in concept: agencies or entities share larger facilities or programs than they would implement individually. But capturing economies of scope across organizational boundaries is a less familiar concept. This section provides generic categories of services related to the water sector, and the types of facilities or programs that can be used to capture economies of scope. A few examples of economies of scope and scale that have been captured in the US are provided in the next section.

The ultimate aim of water management is to provide water-related services such as quenching thirst, cooking food, cleaning objects, removing wastes in a healthy and environmentally sound manner, or keeping property dry during large precipitation events. As noted above, there are many ways to categorize these services. For simplicity, consider the following categories of services: 1) services that require delivery of some amount of potable water, 2) services that require delivery of some amount of irrigation quality water, 3) waste removal services, which usually require water of some quality level, but can be provided “dry” (e.g., composting toilets, or night soil removal), and 4) removal of excess surface water during and after precipitation.

Table 1 shows various combinations of the four services listed above and the types of facilities or programs that can be used to capture economies of scale between them.

Insert Table 1 here

Potable water systems nearly always involve an economy of scope. One could deliver water of various qualities through separate piped water systems; e.g., potable water for drinking and critical washing purposes, non-potable water for watering plants and less critical washing. Historically, the cost of dual piping systems far exceeded the cost saving from not having to treat all water to potable standards. That is, satisfying all urban water supply needs with a single – rather than dual – potable water distribution system captured an economy of scope. Another way to capture the 'single quality of water delivered economy of scope' would be a system that delivers water of suitable but lower quality for most end-uses, which can be treated to potable standards at the point of use, reliably and at lower cost than centralized treatment of all distributed water. Such point of use treatment technologies did not exist until recently.

However, so called "purple pipe" systems to convey recycled or lower quality water are being installed along with potable water piping in new subdivisions and office buildings in parts of the world where water of potable quality is sufficiently scarce (e.g., in parts of California). Installing a single potable water distribution system in these settings would incur a *diseconomy of scope*, which cost-conscious designers and managers are avoiding (although they do not use this economic terminology).

Similarly, combined sewer systems (rainwater and wastewater) are common in older Cities in the US (e.g., Boston, Milwaukee, San Francisco) because the cost of separate systems to convey these types of water was prohibitive. An economy of scope was involved, although again the managers involved probably did not use this terminology. A variation on this system, reportedly used in South Korea, is to collect storm and wastewaters combined, but to exclude human body wastes from the sewer system by requiring dry sanitation facilities in homes, businesses, and neighborhoods.

There are more categories of services related to water management than the four listed above. For example, there are a wide range of services related to ambient water such as fishing, bird hunting or watching, recreational boating, swimming, and tourism. There are also land use services related to the water sector, such as the transport benefits of well-drained roadways and parking surfaces. Table 2 provides examples of facilities or programs that capture economies of scope between two categories of water related services outside the water sector: 5) habitat dependent services, and 6) services from roads and parking lots.

Insert Table 2 here

Tables 1 and 2 are not comprehensive descriptions of the potential for economies of scope within the water sector or between the water and other sectors (e.g., environment, transport, energy, farming, buildings). For example, there are economies of scope between the energy and water sectors, such as dams and reservoirs that supply hydroelectric power and water supply or flood control.[14] Wolff, et.al., (2004) describe and quantify some of the not so obvious economies of scope between the water and energy sectors in California.

US Examples

As noted above, most people are familiar with the concept of economies of scale. When physical facilities are involved, an economy of scale means a larger facility. The first

[14] Dams and reservoirs can also support recreational services, both open water above the dam and rafting or boating below the dam if flows are managed to support these activities, and may provide lake habitat or enhance the value of adjacent real estate.

example, however, demonstrates that economies of scale can exist in programs[15] as well as facilities.

Water Supply Operations in the Potomac River Basin

The Interstate Commission on the Potomac River Basin (ICPRB) is one of the seven interstate water commissions in the US. It has no regulatory power but provides valuable fact finding, research, education, and coordination activities.[16] Its principal work areas are water supply, water quality, and living resources. In the water supply area it provides coordination among FS water utilities, some of which own and operate water supply reservoirs. At present there are four reservoirs, two on-stream and two off-stream, that provide storage used to maintain a minimum river flow of about 100 million gallons per day (about 0.379 million cubic meters per day) that support essential habitat and allows water utility intake pipes along the river to function properly.

As early as 1963, drought contingency plans for water supply of the utilities in this River Basin called for as many as 16 dams to be built. As of today, only two dams have been built (one large, one small). By the mid 1970s, combined withdrawals from the River frequently exceeded the lowest flow on record, implying the river would become dry in the event of a severe drought. In response, Washington area utilities, along with state and federal agencies, signed the Potomac River Low Flow Allocation Agreement (LFAA).

[15] Another simple example of a programmatic rather than a facility economy of scale is the cost savings achieved by water utilities that either individually or working with other utilities purchase water-efficient devices such as showerheads, faucet aerators, and toilets in bulk (wholesale). Cost savings to consumers, after programs have been paid for through water rates, anecdotally range from 10-25%. Some private water company staff claim they capture economies of scale in purchasing when they have contracts with several small to medium sized municipalities in one state or region.

[16] The information in the example was provided in personal communications by Carlton and Delli Priscoli (2004), and .

The LFAA binds the utilities to an allocation of available flow during low flow periods, and establishes an unbiased moderator to resolve disputes and enforce the agreement.

During the same period of time, research demonstrated that innovative operational procedures could meet anticipated water demand through the year 2030, including maintaining adequate flows in the River, even with a repeat of the most severe drought on record. Changes in operational procedures were capable of increasing basin-wide system yield by 50% and individual project yields by as much as 200% without infringing on the autonomy of local water suppliers. This non-structural approach involved cost savings of at least $200 million and as much as $1 billion compared with previously proposed structural (new dam) solutions.

Although it may not be apparent, because fewer and smaller dams were built, this is an example of an economy of scale. That is, the left side of equation (1), applied in this case, was between $200 and $1 billion less than the right hand side. The economy is operational and informational in character. By managing water supply on a daily basis at a larger scale – the basin as a single entity – better drought-period water supply services and environmental flows were provided at much lower cost. The work tasks that allow the system to function so well are real-time flow monitoring and data sharing in the basin, yearly joint contingency simulations, and reservoir operations. Through its section for Cooperative Water Supply Operations, the ICPRB plays a pivotal role in the first two of these tasks. The responsibility for these cooperative tasks was formally given to the

ICPRB in 1982 under agreements with the independent water supply utilities. Prior to that time ICPRB was much less involved with water supply issues.

Reclaimed Wastewater for Irrigation Water Supply and Habitat Restoration[17]

The San Jose/ Santa Clara Wastewater Pollution Control Plant is a regional facility operated by the City of San Jose. It serves over 1.2 million residents and businesses in the Santa Clara Valley of California. In 1997, it discharged about 135 million gallons per day (mgd) (about 0.511million cubic meters per day) of tertiary treated effluent, during dry weather, at a near-shore discharge point in the South San Francisco Bay.

Decades of study of the biological impacts of wastewater discharge in the South Bay eventually lead the San Francisco Bay Regional Water Quality Control Board to order a restriction of dry weather discharge at the near shore location to 120 mgd (about 0.454 million cubic meters per day). The tertiary treated water was converting salt marsh to freshwater marsh, reducing habitat for two endangered species: the salt marsh harvest mouse and California clapper rail (a bird). The owners of the regional wastewater treatment plant found that the lowest cost way to meet this regulatory objective – with the participation of the local water wholesaler -- was to develop an extensive water recycling distribution system for landscape irrigation.

The South Bay Water Recycling program was created to plan, finance, design, construct, operate, and maintain this system. The program is a joint effort of three cities, five sanitation agencies, and two private water companies, and receives financial assistance

[17] This example is taken from Wong (1999) and personal knowledge of the author.

from the water wholesaler in the area, the Santa Clara Valley Water District (SCVWD). The program captures an economy of scope between the services provided by irrigation water and the services provided by salt marsh habitat.[18] One facility – the distribution system for recycled water – provides both categories of services.

A critical financial motivator for the recycled water program, rather than relocation of the effluent outfall away from salt marsh habitat, was the decision of the SCVWD to offer a $93 per acre-foot (about $0.075 per cubic meter) payment to the program[19] because they would need to spend at least that much to obtain additional water supply from another source. Without this payment, a relocated outfall would have been less expensive than the recycled water program. In the format of equation (2), this means that the estimated cost of a recycled water system to deliver irrigation water and protect habitat on the left hand side was less than the estimated cost of a relocated wastewater outfall plus $93 on the right hand side.

Groundwater Recharge for Flood Control and Water Supply

The Chino Basin, located in the Upper Santa Ana River Watershed, is the largest river basin in Southern California and the most rapidly urbanizing watershed in the Western US. Projected population growth in the next 20 years is 500,000; current population is 700,000. The groundwater aquifer contains about 5 million acre-feet (about 6 billion

[18] It might also be possible to use recycled water to maintain or enhance stream flow and habitat in the Guadalupe River and Coyote Creek. These waterways are dammed upstream for water supply and flood control purposes; which means that releasing more natural water for dry season habitat purposes would reduce water stored for eventual treatment and distribution through the potable water system. Using recycled water instead would capture a second economy of scope: that is, an economy between the services that depend on potable water supply and the services from healthier river and creek habitat.
[19] Later increased to $115 per acre-foot (about $0.093 per cubic meter).

cubic meters) of water and has unused storage capacity of another 1 million acre-feet. Current and projected water needs far exceed sustainable yield from the aquifer. At present, about 60,000 acre-feet per year (af/yr) (about 72 million cubic meters per year) of imported water from Northern California is used in the Basin. Water import is projected to increase to 150,000 af/yr (about 180 million cubic meters per year) by the year 2020 under a business as usual scenario.

Recent analysis, summarized in Wilkinson (2003), shows that an average of 41,000 af/yr (about 50 million cubic meters per year) of stormwater does not recharge groundwater, but instead runs off, with peak runoff as high as 174,000 af/yr (about 215 million cubic meters per year). Average and peak runoff are expected to increase dramatically as population growth leads to construction of more impervious surfaces (e.g., roads, parking lots, roofs). However, non-structural flood control techniques, such as pervious pavement, grass- and rock-lined drainage swales, small percolation basins near the inlets of storm drains, and so forth, can prevent these increases in runoff and recharge to the aquifer some of the water that currently runs off. Modeling shows that imported water demand can be prevented from rising between2000 and 2020, and imported water demand during drought years (when imported water is in high demand throughout the state) can be reduced to 1/5 or 1/6 its current average annual level. Achieving these results involves phased implementation of a "Recharge Master Plan" for the Basin.

The facilities and activities in the Master Plan provide two types of services:[20] flood control and water supply. These facilities and activities capture an economy of scope between these service categories. Again equation (2) represents this situation: the estimated cost of implementing the Recharge Master Plan (left hand side) is less than the sum of the estimated cost of additional imported water and the estimated cost of traditional flood control for projected development.

Concluding Remarks

Integrated approaches to water governance – e.g., river basin management, integrated water resources management, watershed management – offer benefits that cannot be captured by functionally specialized (FS) organizations. This is an important motivator for the attention that integrated approaches have received in the last decade. On the other hand, integration is hard and time-consuming work. It involves wide stakeholder participation and innovative thinking that is difficult to finance and sustain unless participants and funders receive payoffs that are sufficiently large and frequent.

The practical principle this paper advances is that political will to participate in and fund integrated approaches to water management are strengthened when economies of scale and scope are identified and captured.[21] Why? Because mutual benefit is a powerful motivator.

[20] These facilities also generate multiple benefits, discussed in detail by Wilkinson (2003). For example, large amounts of energy will be saved, and associated air pollution reduced, by recharging with rainwater rather than imported water.

[21] Or inversely, diseconomies of scale or scope that exist are identified and reversed, yielding net benefits.

In at least some and perhaps many cases, the integrating process or agency does not need to have sole or even any authority to actually capture the identified economy of scale or scope. Existing or new FS organizations can plan, finance, design, construct, operate, and maintain facilities that capture these economies. But FS organizations rarely identify and usually cannot capture these economies on their own. They do not have the legal authority, motivation, or skills (on their own) to do so. Identifying and capturing economies of scale and scope, or other mutual benefits across organizational boundaries, is the role that river basin or watershed scale organizations must fill, and that FS organizations need to understand and respect, and often finance and facilitate. Until then, the integrated approach will be seen as a threat by better-established, historically more powerful, FS organizations, and will as a result continue to be under funded and involve "too much talk, too little action."

Unless river basin and watershed scale organizations fill this role, economies of scale and scope will be captured in a haphazard fashion. The US examples provided were discovered by an organized watershed effort only in the case of the Interstate Commission on the Potomac. In the other cases, a FS organization saw the potential economy and then developed the partnerships with other FS organizations required to capture it. In the South Bay Water Recycling example, this "seeing" only took place after a regulatory action forced action to be necessary. In the Chino Basin example, a very creative outside researcher obtained the financial support of a third party and the "ears" of a senior manager, which lead to a study that proved that a financially significant economy of scope could be captured. The need for integrated water management is too severe, worldwide, to rely on haphazard and fortuitous processes like these.

A structured implementation strategy for the insight in this paper would begin with the creation of a forum for dialogue across a watershed or river basin, populated by all water stakeholders. Participants from non-profit community groups should have their expenses of participation paid from whatever sources are feasible, at first, such as government budgets, contributions by FS organizations, affected corporate entities, or charitable foundations. A process-management entity and some amount of technical support should also be funded. Stakeholders will need some help identifying and quantifying in a preliminary way the potential benefits of possible integration actions. Although these services can be provided in part by participating FS organizations, it is important that these organizations either have little self-interest in the outcome of the technical analysis, or that their self-interest be kept in check by an independent third party technical review at one or more places in the discussion and investigation process.

To be judged successful, dialogue of this type must solve problems and thereby demonstrate its value. In some cases, value will be measurable; e.g., the US$0.2 to US$1.0 billion saved in the Potomac River Basin. In other cases, the value will be intangible, but evident to participants and interested parties. Ultimately, the perception that River Basin Councils or similar entities provide as much value as FS organizations, but of a different kind, must be achieved and sustained if these Councils or entities are to become successful institutions that help solve our pressing water problems worldwide.

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Table 1: Economies of Scope Internal to the Water Sector

Categories of Services Provided	Example Facility or Program
1 and 2	A potable quality, piped water system An irrigation quality, piped water system with point of use treatment to potable quality
1 and 3	Potable water distribution with sewage collection and treatment Reclaimed wastewater for potable use
1 and 4	Percolation basins to recharge groundwater
2 and 3	Reclaimed wastewater (with or without treatment, direct or indirect reuse, centralized or decentralized facilities, all or some wastewater (e.g., graywater systems))
2 and 4	Rainwater harvesting systems
3 and 4	Combined sewer systems with conventional wastewater treatment. Combined sewer systems with simpler treatment, but dry sanitation for body wastes.
Service categories: 1) dependent on potable water, 2) dependent on irrigation quality water, 3) waste removal, and 4) removal of excess water during and after precipitation.	

Table 2: Some Economies of Scope Between the Water and Other Sectors

Categories of Services Provided	Example Facility or Program
1 and 2 and 5	Percolation basins
2 and 4 and 6	On-site or neighborhood scale cisterns
3 and 5	Wastewater treatment in constructed natural systems Stream flow augmentation with reclaimed water
2 and 3 and 5 (and potentially 1)	Water reclamation facilities
4 and 5 (and potentially, 1 and 2)	Flood easements Grass lined drainage swales Filter and buffer strips Storm water treatment in constructed natural systems
4 and 6	Pervious concrete and asphalt pavements Crushed stone pavements (e.g., decomposed granite) Paving tiles or blocks
Service categories: 1) dependent on potable water, 2) dependent on irrigation quality water, 3) waste removal, and 4) removal of excess water during and after precipitation, 5) services from aquatic habitat, and 6) services from roads and parking lots.	