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Cities and Water – Dilemmas of Collaboration in Los Angeles and New York City

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1. Introduction

This chapter examines the different ways megacities manage water by comparing how Los Angeles and New York - two U.S. metropolises that divert water from distant sources - have worked with their surrounding regions to acquire, allocate, and manage public supplies. Early in their histories these cities, in their quest to acquire water, adopted a hegemonic relationship with their neighbors. In effect, they sought to control regional sources that could satisfy current as well as projected water needs (Hundley, 2001; New York City, 2011; Koeppe, 2000; 2001). Over time, and under external pressure, both cities embraced collaboration with adjacent communities to address water supply and quality issues whose scope and impact required regional accommodation and sharing of authority. What they have done to achieve accommodation in light of water stress, and how they have done it, may afford lessons for megacities across the globe that face comparable challenges.

New York and Los Angeles diverged in their motives for and methods of collaboration, in part because their water challenges differ. New York's central challenge currently revolves around managing water quality and the safety of its drinking water. Meeting this challenge is virtually impossible without cooperation with non-governmental actors in other political jurisdictions from whence its water supply comes - and who would be severely burdened financially if the city had to build a large regional water filtration plant. For Los Angeles, by contrast, water (and air) quality issues in the Owens Valley - the source, since 1913, of one-third of the city's water - have driven efforts to partner with valley stakeholders to negotiate gradual reductions in flow and restoration of the watershed. While both cities were initially concerned with water supply, however, over time they both became increasingly worried over water quality and the need for integrated approaches to managing supply and quality.

2. Method and approach

Our approach is four-fold. We: 1) analyze the hydrological and political factors influencing water decisions; 2) compare these cities' water policy histories; 3) examine their current collaborative challenges; and, 4) draw out their most important similarities and their lessons for other cities. For Los Angeles, we focus chiefly upon the Owens River with briefer discussion of newer (i.e., mid 20th Century) issues, including the *State Water Project* which diverts water from the Sacramento-San Joaquin - Bay Delta, and the Colorado River

Aqueduct, completed in 1940. While the Owens Valley case revolves around a powerful, growing city initially diverting water from a modest agrarian region in order to support future growth, and then restoring a portion of that region's water under federal order, the latter cases revolve around endangered species protection and climate variability, respectively, as factors that compel change in urban water policy.

For New York City, the chief focus of our discussion is the Croton and Catskill watersheds - the former is the city's original regional water source, dating to the 1840s, while the second was developed in the late 19th Century. In more recent years, both watersheds have been part of the so-called *New York City Watershed Protection Plan* designed to protect the city's water supply from sewage and runoff-induced contamination through adopting cooperative land use controls and other measures. These watersheds are the source of fully one-half of the city's water supply. Additional case material from the Delaware River, an interstate stream which New York relies upon for the other half of its water supply, is also discussed.

Section 3 sets the stage for comparison by first considering two vital questions: 1) how do megacities affect water supply and quality in their nested regions; and, 2) why are Los Angeles and New York good cases for studying these issues? Despite being located in a highly-developed society, and perceived as having safe, well-managed water systems, this was not always the case. Beyond this, as we shall see, Los Angeles and New York share important challenges with regards to infrastructure, the need to conserve water, and climate change which may translate into lessons for other megacities facing similar problems.

3. Policy context – Megacities and water

A number of accounts suggest that global freshwater supplies are increasingly facing severe *stress*: a growing imbalance between available supplies within various regions on one hand, and demands on those supplies by multiple users on the other. Water stress is generally attributed to population growth, climate variability (including extreme drought), and inadequately maintained and/or deteriorating water supply and treatment infrastructure. Experts view stress as caused by demographic, climatological, and socio-economic factors intersecting in various ways (World Meteorological Organization, 1997; World Resources Institute, 1998; Alcamo, et. al., 2003; World Water Council, 2005).

While these three factors are compelling sources of stress, a more nuanced cause is rapid *urbanization*, exemplified by the phenomenal growth of so-called "megacities" composed of tens-of-millions of people. Megacities are a sprouting phenomenon in developing nations, especially, where cities and towns already comprise some 80% of the planet's urban populace. More than two-thirds of the world's urban residents live in cities in Africa, Asia, and Latin America. Moreover, since 1950, the urban population of these regions has grown five-fold, while in Africa and Asia alone, urban population is expected to double by 2030 (Satterthwaite, 2000; UNPF, 2007).

Large cities generally, and megacities in particular, contribute to water stress in two ways: 1) they are often located some distance from the water sources needed to maintain their growth; thus they must divert water from outlying rural areas which, in turn, often produce the food and fiber to support them; and, 2) soaring birthrates and in-migration (the latter often from these same outlying areas) place extra burdens upon water infrastructure, and generate severe health and hygiene problems. Both of these contributors underscore the complex ways demography, economics and climate factors interact.

Urban-related water stressors can be more precisely de-constructed as three-fold problems. First, large cities generate huge volumes of wastewater which are costly to treat and, if left untreated, can contaminate local wells and streams. Second, the *spatial* “footprint” caused by sprawling horizontal urban development and annexation imposes numerous water-related problems, including paving of city streets and commercial districts (contributing to pollutant runoff and diminished groundwater recharge), and consumption of water for parks and outdoor residential use (increasing evapo-transpiration and taxing local supplies).

Third, while greater concentration of people in cities may lower unit costs for many forms of water infrastructure (Satterthwaite, 2000) the need to expand water supply and treatment networks over vast distances increases the likelihood of distribution system leaks and other failures. All these problems have been observed in a number of Third World megacities, and underscore how urbanization exacerbates climate change impacts on scarce water supplies; imposes extraordinary pressures on surrounding regions; and, outraces infrastructural capacity (UN, 2009: 32; Adekalu, et. al., 2002; Downs, Mazari-Hiriart, Dominguez-Mora, & Suffet, 2000; Gandy, 2008; Tortajada and Casteian, 2003; Yusuf, 2007; and Zérah, 2008).

3.1 Hydrology and Geography as prologue – A Los Angeles and New York overview

So, what can the experiences of Los Angeles and New York teach us about water stress and large cities? Conventional wisdom might suggest that being located in highly-developed societies both are far better in managing water supply and quality than their counterparts in less-developed nations. In reality, however, their longer-standing experience as large urban conurbations makes them instructive cases for other megacities. This is so for three reasons.

First, early in their histories, both cities faced many of the same challenges to public health and wastewater management that their Third World counterparts face today. These challenges included confronting the role foul and unhealthful water plays in the spread of infectious disease (a particular problem for New York City which, in 1832, suffered a severe cholera epidemic attributed to contaminated drinking water, Koeppel, 2000, 2001; American Museum of Natural History, 2011). Another includes the need to take decisive, yet adaptable, action to upgrade public works in order to provide residents with abundant water, and determining whether satisfying the need for safe, secure, and dependable supplies was best left to the “efficiencies” provided by private sector investment, or better suited to management by governmental entities. Los Angeles and New York confronted this latter challenge early in their histories, as we will see (Glaeser, 2011: 99; Mulholland, 2002). To a large extent both challenges drove these cities to divert water from outlying regions.

Second, in diverting water from outlying hinterlands, Los Angeles and New York generated well-documented, but vastly different, environmental and social impacts upon these adjacent regions. In the case of Los Angeles, diversion of water imposed reductions of both in-stream flow and groundwater in Owens Valley. These reductions, in turn, degraded local fisheries and wildlife habitat (McQuilkin, 2011), while acquisition of adjacent lands overlying aquifers deprived Owens Valley communities of the ability to pursue real estate development for commercial and residential use (VanderBrug, 2009).

For its part, by acquiring much of the open space surrounding its reservoirs in the Catskill and Croton watersheds, a positive economic outcome generated by New York City was retention of low-density residential development that preserved the region’s rural character

(Westchester County Department of Planning, 2009). Later, sewage plant outfalls and non-point pollution around these same reservoirs released contaminants into the city's water supply which generated further, less popular land acquisition measures to avert pollution through eminent domain and condemnation suits - a strategy that continued through the early 1990s (New York State Department of Environmental Conservation, 2010a, 2010b).

Finally, although these cities have very different hydrological features, New York and Los Angeles share *two* remarkably similar water problems. First, both cities have experienced an outracing of available supply as a result of locally-generated demands. Second, while the former is located in a wet and humid region, while the other is dry and semi-arid, both cities have needed to look outside their political boundaries for additional supply. They have also employed similar strategies to acquire water and land rights to ensure control over the watersheds from whence their water comes. By their wide range of conditions, we might suggest that these cities bound the impacts faced by most of the world's large urban centers.

That both cities share these problems in common underscores an important point about water stress: the traditional distinction between arid and semiarid regions on the one hand and more humid areas on the other, as a means of maintaining that arid regions' water problems mostly revolved around inadequate water quantity while humid areas' problems are water quality related, is not a valid claim. Water scarcity can occur in any *urbanized* region if demands cannot be attenuated (Feldman, 2009).

Los Angeles is located in a flat, triangular-shaped semi-arid basin bounded on its north and east by mountains and on the west by the Pacific. Its Mediterranean climate experiences some 39.54 cm (15.58") of average annual precipitation, all in the form of rain, which is collected by two major streams that rise in the San Gabriel portion of the Transverse Range dividing Southern from central California - the Los Angeles and San Gabriel Rivers. The Los Angeles River was the city's major source of water for nearly a century, providing drinking water and serving as the irrigation source for local vineyards and orange groves - both through an elaborate system of ditches and channels called *zanjas* (Gumprecht, 2001: 3; Los Angeles Department of Water and Power, 2010b).

New York City, by contrast is located on the Atlantic Coastal Plain in a slender portion of land bounded by the outfall of the Hudson and East Rivers, and referred to as the Atlantic slope drainage. The humid continental climate, fed by the Gulf of Mexico and Atlantic weather systems, produces some 127 cm (50") of precipitation per year, some 63.5 - 76.2 cm (25 - 30") of which falls as snow. In its initial period of settlement, local water supplies were provided through ponds, streams, and springs located on the island of Manhattan (American Museum of Natural History, 2011; New York State Department of Environmental Conservation, 2010b). These hydrological differences help explain how both cities initially managed water supply, while their phenomenal demographic growth helps us understand the remarkably similar path both took in seeking hegemony over regional supplies. Table 1 depicts major features of the water supply systems of New York and Los Angeles.

4. Comparing policy history – The evolution of regional dominion

While Los Angeles and New York developed along different trajectories, especially early on (i.e., New York grew at a faster rate much earlier), in regards to water supply they followed two strikingly comparable patterns of development. First, both sought to fully exploit

locally-available resources through collective effort. Second, when these sources proved insufficient to support further growth, they acquired more distant sources. Acquisition of these sources was predicated on concerns with water security, safety, and plentifulness.

Water supply characteristic	Los Angeles	New York
Major supply sources	LA Aqueduct/E. Sierra = 18%* Metropolitan WD = 71% Groundwater = 10% Recycled wastewater = 1%	Croton Watershed = 10% Catskill watershed = 40% Delaware watershed = 50%
Distance from source to city	Owens Valley = 376 km (233 miles) Mono Lake = 544 km (338 miles)	Croton Reservoir = 201 km (125 miles)
Number of storage facilities	114 (reservoirs and tanks)	19 (reservoirs)
Water supplied/day	1998.7 million liters (528 million gallons approx.)	3792.9 million liters (1.2 billion gallons approx.)
Customers	9 million	4.1 million
Metered water rates ¹	\$2.92 - 5.19/hundred feet ³	\$3.17/hundred feet ³

*In recent years, the LA Aqueduct from Owens Valley has supplied upwards of 35% of the city’s water supply. However, mandated restoration of Mono and Owens Lakes has resulted in a reduction of supply of approximately half that annual delivery.

¹ New York charges a flat water rate while Los Angeles has a “tiered” or increasing block rate system wherein customers are charged a lower “base” if they stay within a designated conservation allotment. If they exceed that allotment (typically 79,287 liters or 2800 cubic feet/month), they are charged at the higher rate (Los Angeles Department of Water and Power (2009b).

Table 1. Water Supply Systems of Los Angeles and New York City

In the event, there is one major way their quest for regional dominion *differed*: Los Angeles sought external sources of supply mostly because its regional access to water was always precarious. After its first full century of settlement (c. 1880) the city suddenly aspired to grow, but found that its semi- arid region simply had few ground or surface water supplies available nearby. By contrast, New York was impelled toward the Croton Watershed in Westchester County, some 64.4 km (40 miles) to its north, by the poor quality and inadequate volume of its local supplies. A cholera epidemic in 1832, caused in part by degraded water quality and poor waste disposal, drove efforts to build a Croton Aqueduct. Declining well levels, which made fire fighting capacity inadequate, was also a factor (Koeppel, 2000: 6). Each city’s respective quest for regional dominion reveals these intricate patterns.

4.1 Los Angeles – Early water development

From its founding in 1781, and for nearly a century afterwards, the Los Angeles River was the city’s major water source. The first families who founded and settled the “pueblo” almost immediately set about constructing a brush “toma” or dam across the river, diverting water into a so-called “Zanja Madre,” or mother ditch, which fed homes and irrigation canals into fields that, at first, were closely adjacent to the plaza - the civic center of the early settlement (Los Angeles Department of Water and Power (2010b).

This cooperative effort to develop and manage local water supplies was animated by two principal, and somewhat contradictory, goals. First, harvesting of the river was necessary to accommodate a population sufficient to allow the young pueblo to serve, within its nexus in hispanic colonial culture, as a trading center for neighboring ranchos and missions (Hundley, 2001). In effect, the young pueblo was a “service” community for a regional economy. Second, the pueblo needed to secure rights to water from regional competitors in order to protect its modestly growing population and its own agricultural and commercial activities - including trade with local native American tribes.

What made these goals somewhat contradictory was the fact that within a few short years after its founding, interdependence with the Gabrielino community, which served as a labor source for the city’s own agricultural and commercial activities, threatened the authority of nearby missions and ranchos (Estrada, 2008). In effect, the Los Angeles River supported the small-scale agricultural and domestic needs of the pueblo, while the pueblo itself functioned as a commercial center for regional farming, ranching, and artisanal manufacturing.

In addition to developing an extensive system of locally-managed and maintained *zanjas*, to secure its local water rights, city officials sought and obtained ratification of a so-called “Pueblo” water right: an entitlement under traditional Spanish law to lay claim to all needed waters in the vicinity. This virtual ownership of water in the Los Angeles River was granted in perpetuity by King Carlos III of Spain in 1781 (Los Angeles Department of Water and Power, 2010b). However, various legal maneuvers were exercised during the 19th century - under Mexican and later U.S. rule - to ensure that this Pueblo water right was legally perfected. By the time the City of Los Angeles was incorporated in 1850 under the state’s first constitution, following California’s admission as the 35th state, the city of 1,600 was vested with all of the rights to the water of the river (Hundley, 2001).

Four years later (1854) the *zanjas* system became encapsulated into a city department which, within a few years, was leased to a private company and became the Los Angeles City Water Company. This company was purchased by the city in 1902 for some \$2 million in order to facilitate municipal control of the system, and to help facilitate the financial arrangement needed to build an aqueduct. Privatization of the water system of Los Angeles was largely a reaction to the high costs of maintaining and repairing the *zanjas* which, by the late 19th Century, had grown to encompass not merely ditches and channels but an arrangement of water wheels to lift the water to gravity flow irrigation systems, along with some 300 miles of water mains, reservoirs, infiltration galleries and pumping facilities.

4.2 New York – Early water development

While unofficially founded as a Dutch trading post in 1624, and centered for decades on Manhattan Island, early New York - like early Los Angeles - relied on domestic water supplies obtainable from sources in the immediate vicinity. Initially, these consisted of shallow, privately-owned wells. Under Dutch rule - a period of about forty years, sanitation and water quality were decidedly poor: accumulations of human and animal waste were common, contaminated runoff into holding ponds was frequent, and there was no concerted effort to regulate harmful activities impinging on locally-adjacent well-users (Koeppel, 2001). Thus, New York’s initial efforts to develop a water supply system were largely animated by three concerns: accommodating population growth, averting communicable disease, and achieving both objectives while saving money (Glaeser, 2011; 99).

Under English rule (1664 and after), improvements were only marginal. Foul, standing water was common, and outbreaks of epidemics stemming from poor water quality - including yellow fever and cholera - were not unknown (Koeppel, 2001). In 1677 the first general public-use well was dug near the fort at Bowling Green, while the first city reservoir was constructed on the east side of Broadway between Pearl and White Streets in 1776 - about the time the city's population grew to over 20,000 residents. Initially, water pumped from wells near the Collect Pond, east of the reservoir, was distributed through hollow logs laid along main thoroughfares in Manhattan (New York City, 2011).

As the city's population grew, pollution of wells became a serious problem, as did periodic supply shortages due to drought. These tribulations led to more concerted efforts to supplement local supplies through cisterns and springs in upper Manhattan (an area less developed at this time). Following the outbreak of a Yellow Fever epidemic in the last decade of the 18th Century (1798), New York (along with Philadelphia, one of the country's largest cities), sought to provide a safer, more secure, and disease free water supply.

In 1800 the Manhattan Company (forerunner of Chase Manhattan Bank) sank a well at Reade and Centre Streets, pumped water into a reservoir on Chambers Street and distributed it through wooden mains to a portion of the community. This venture became, in effect, the city's first quasi-public water utility and was a major enhancement to the earlier Collect Pond (Willensky and White, 1988: 18). In 1830, in an effort to enhance emergency supplies, the city built a tank for fire protection at 13th and Broadway which was replenished from a well. Water was distributed through 30.48 cm (12-inch) cast iron pipes.

As in Los Angeles, these advanced efforts to provide a safe and secure supply were largely privately funded and managed (Koeppel, 2000). Led, ironically, by two New York statesmen who soon became mortal enemies - Aaron Burr and Alexander Hamilton - the city's Common Council was persuaded to obtain state legislative endorsement of the Manhattan Company's charter. Burr and Hamilton had different motives in advocating the charter and the company: the former sought financial profit through transforming the "surplus" revenues of the firm to his own design, while the latter was swayed by the desire to unburden city residents of a tax-supported public system (Glaeser, 2011: 99).

In any case, the result - as in Los Angeles - was to acquire sufficient revenue to enlarge and expand the water supply infrastructure of the city. Moreover, in both cities the motive of water security eventually led them to expand greater *public* control in order to construct massive aqueduct systems: a feat begun by New York in the 1840s and by Los Angeles in the early 1900s.

4.3 Public works and urban triumphalism – The aqueduct age in both cities

After weighing various alternatives for additional water supply Los Angeles and New York expropriated distant sources. The contentious history of Los Angeles' efforts to acquire the Owens Valley, in contrast to those of New York in its Croton and Catskill watersheds, has been well documented (Walton, 1992; Davis, 1993; Mulholland, 2002). In a later section we will discuss why reactions differed. At this juncture, the important point is that neither city pursued much consultation with regional decision-makers in undertaking these efforts.

After exploring various options for increasing supply to keep up with growing demands, New York officials sought to impound water from the Croton River, in today's Westchester

County, and to build an aqueduct to carry water from what became known as the “Old” Croton Reservoir to the City. In contrast to Los Angeles, the urgency of an aqueduct was not as readily apparent to many local residents, and initial political support was far from unanimous. According to one writer, a major fire in 1835 which consumed a sizeable portion of what is now lower Manhattan, convinced many wavering citizens of the need for an aqueduct (Koeppel, 2001). Moreover, even after the aqueduct was completed – in 1842 – not all city water users chose to connect themselves to the system, preferring to rely upon less reliable, but still cheaper, local supplies from wells and cisterns (Koeppel, 2000).

New York city’s original aqueduct, known today as the *Old Croton Aqueduct*, had an initial capacity of about 90 million gallons per day and was placed into service in 1842. Distribution reservoirs were first located in Manhattan at 42nd Street (discontinued in 1890 – at the site where the present-day New York Public Library is located) and in Central Park, south of 86th Street (discontinued in 1925). Newer reservoirs were subsequently constructed to increase supply: Boyds Corner in 1873 and Middle Branch in 1878 (New York City, 2011).

In 1883, as the city’s continued growth and commercialization taxed this supply source, a commission was formed to build a *second* aqueduct from the Croton watershed together with additional storage reservoirs. This conduit, known as the *New Croton Aqueduct*, was built between 1885-1893 and first placed in service in 1890, while still under construction. One of the biggest land use issues was the need to acquire land and right-of-way for the New Croton Dam and Aqueduct System – an effort begun in 1880 when seven thousand acres were acquired to harness the Croton River’s three branches, while a twenty square mile area was needed by the city on which to build the New Croton Dam. Twenty-one dwellings and barns, one and a half dozen stores, churches, schools, grist mills, flour mills, saw mills, four towns, and over four hundred farms were condemned and taken over to build the dam – and some 1500 bodies were removed from six cemeteries and relocated along with their stones and fences. One local historical account states that “protests, lawsuits and some confusion preceded payment of claims” (Village of Croton, 2010).

At the same time, the present municipal system was consolidated from the various water systems in the communities now consisting of the Boroughs of Manhattan, the Bronx, Brooklyn, Queens and Staten Island. An important parallel with Los Angeles, here, is how water system consolidation became an important first step toward *municipal* annexation. For Los Angeles, completion of the first Owens Valley Aqueduct in 1913 leveraged the city’s ability to force smaller communities coveting water (e.g., Hollywood) to accede to annexation as a condition for becoming connected to the distribution system.

A third phase development occurred after the turn of the century. In 1905, a Board of Water Supply established by the New York State Legislature cooperated with the city in developing the Catskill region as an additional water source – with the former planning and constructing facilities to impound Esopus Creek, and to deliver the water to the city via the Ashokan Reservoir and Catskill Aqueduct. This project was completed in 1915. It was subsequently turned over to the City’s Department of Water Supply, Gas and Electricity for operation and maintenance. The remaining development of the Catskill System, involving the construction of the Schoharie Reservoir and Shandaken Tunnel, was completed in 1928.

A fourth and final effort to acquire water was the effort to allocate the Delaware River. In 1927 the Board of Water Supply submitted a plan to the state Board of Estimate and

Apportionment for the development of the upper portion of the Rondout watershed and tributaries of the Delaware within New York State. This project was approved in 1928. Work was subsequently delayed by an action brought by the State of New Jersey in the U.S. Supreme Court to enjoin the City and State of New York from using the waters of any Delaware River tributary (New York City, 2011). This case underscores the regional animosity brought about by the City's effort to seek water hegemony.

In May 1931 the Supreme Court upheld the City's right to augment its water supply from the Delaware's headwaters. However, a second Supreme Court ruling, in 1954, was required to adjudicate riparian allocation of the Delaware between New York, New Jersey, and Pennsylvania (Derthick, 1974: 48, 54). Construction of the Delaware System was begun in March 1937 and entered service in stages: the Delaware Aqueduct was completed in 1944, Rondout Reservoir in 1950, Neversink Reservoir in 1954, Pepacton Reservoir in 1955 and Cannonsville Reservoir in 1964. Figure 1 depicts the current New York water supply system.

Los Angeles took much longer, but followed a similar path in its efforts to build a major supply conduit from the Owens Valley. As the city's population rapidly grew after 1880, it became apparent that the Los Angeles River was simply was not large enough to support the city's transformation into a large metropolis. Its population doubled during the 1890s, from 50,000 to 100,000, and more than doubled again within five years (to over 250,000), all but depleting local groundwater. Moreover, the city's incorporated area doubled between 1890 and 1900 as many basin communities embraced annexation to ensure water supply.

Fred Eaton, one-time city engineer during the 1890s, mayor from 1899-1901, and superintendent of Los Angeles' municipal water system conceived of an Owens River aqueduct in the early 1900s (Davis, 1993: 5-9). Initial challenges proved to be fiscal, not logistical. The city - which had long sought to rationalize management and maintenance of the *zanjas* system - succeeded, under Eaton, in persuading voters to acquire public ownership of the vast, fragmented, and poorly maintained private network of water providers in 1902. Following consolidation of legal control over water in its immediate vicinity, the Owens Valley project was pursued.

After an unusually harsh drought in the summer of 1904, William Mulholland - a protégé of Eaton and now city engineer - asked his mentor to "show me this water supply" in the Owens Valley about which Eaton had often spoke. Following an intrepid journey both took through the region, which included a preliminary survey of an aqueduct route, events moved quickly. In September 1905, voters approved by a 10-1 margin a \$1.5 million project to acquire right-of-way, and to build an aqueduct that would stretch from north of Independence some 376 km (234 miles) southeast to the San Fernando Valley - a recently incorporated area of the city.

At precisely the moment political forces in Los Angeles maneuvered to acquire Owens Valley water rights, the newly-formed U.S. Reclamation Service drafted a plan to irrigate the Owens Valley by constructing one or more dams in the vicinity of Long Valley. As a federal agency mandated to promote irrigation, the Service was inclined to support the people of the valley against those of a large city seeking to augment its water supply. However, the Reclamation Service's southwestern regional chief, Joseph P. Lippincott served (secretly) as a paid consultant to Los Angeles - abetting the city's plans, since Lippincott advocated for the city's interests in Washington, DC, not those of the Owens Valley. Lippincott also helped

ensure that, while valley lands would be set aside for public purpose, no land rights would be secured: an action that abetted Eaton’s efforts to set about buying up options on lands for aqueduct construction (Kahrl, 1982).

Within two years, two other efforts were completed in the city’s favor: a successful campaign to obtain Congressional approval of the City’s application to build the aqueduct



Fig. 1. New York City’s Water Supply System

was effectuated in June 1906; while in 1907, Los Angeles voters approved a second bond measure authorizing \$23 million for aqueduct construction. Construction began in 1908 and the project was completed in November 1913.

Like New York City, the Owens Valley was one phase in the city's water supply expansion. By the early 1920s, the Board of Public Service commissioners (the overseers of the Los Angeles Department of Water and Power or LADWP), became aware that the city would exceed the Owens Valley's supply by 1940 (thus, a second aqueduct was built in the Owens Valley all the way to Mono Lake - a project approved by voters in 1930 and completed in 1940).

A third phase was symbolized by the efforts of Mulholland to acquire water from the Colorado River. A four-year series of surveys began in 1923 to find an alignment that would bring the water of the Colorado River to Los Angeles. In 1925 the Department of Water and Power (LADWP) was established, and the voters of Los Angeles approved a \$2 million bond issue to perform the engineering for the Colorado River Aqueduct. While the six-cooperating states of the basin sought a means to allocate the Colorado's flow - an effort that began with the 1922 Colorado River Compact and required Congressional passage of the Boulder Canyon Dam Act in 1928 - Los Angeles proactively sought to move events forward.

Needing allies in Washington, and help from neighboring Southern California cities who also coveted this water, in 1928 the city and LADWP got the state legislature to create the Metropolitan Water District of Southern California or MWD (Fogelman, 1993: 101-3; Erie, 2006). In 1931, voters approved a \$220 million bond issue for construction, and work began on the ten-year 300 mile long project which now supplies 60% of Los Angeles, Orange, Ventura, San Bernardino, Riverside, and San Diego Counties' water. In the 1970s the regional cooperative also began importing water from Northern California via the State Water Project and the California Aqueduct. Figure 2 depicts Los Angeles' water system.

4.4 Post-aqueduct policies – Collaboration with external regions

Subsequent to completion of their respective aqueduct systems, both cities began to face a series of water-related environmental quality challenges which, unlike the efforts to initially acquire water, required unprecedented levels of regional collaboration to resolve. In Los Angeles' case, this collaboration emerged after a series of litigious actions resulting from adverse ecological and tribal-equity issues. In New York, they came about through harsh economic realities brought to the fore by a severe federal regulatory challenge.

As far back as 1913, the virtual draining of Owens Lake as a result of the opening of the first Los Angeles Aqueduct exposed the alkali lake bed to winds that lofted toxic dust clouds containing selenium, cadmium, arsenic and other elements throughout the region. Airborne particulates were often suspended for days during excessively dry periods - and have long posed a health hazard to local residents. They have even posed risks to communities further to the South. In the 1970s, the siphoning off of additional flows following completion of a second and larger aqueduct worsened the problem - igniting further protest.

These environmental impacts to Owens Lake - and to other, smaller watersheds within the Owens Basin (e.g., Lee Vining, Walker, and Parker Creeks) - dovetailed with concerns

regarding water management in Los Angeles itself, beginning in the 1970s. Continuing drought and unrelenting population growth compelled the city to embrace a more adaptive approach to water management reliant on conservation, drought management, and a balance between augmenting supplies while providing incentives to lower demands: a method termed *integrated resource management*. This approach came to rely on non-structural, incentive-based, and education-driven methods to reduce water use and has been facilitated in part by concerns over climate change as well as the stresses and strains felt throughout its water importing regions (Los Angeles Department of Water and Power, 2010a).



Fig. 2. City of Los Angeles’ Water Supply System

These issues came to a head in the 1990s through public protest, litigation, and federal intervention. In 1994, a settlement was reached between Los Angeles, Inyo and Mono Counties, and the U.S. EPA, and was enforced - in part - through a series of massive fines levied upon the LADWP. The settlement forced the agency to restore 62 miles of the lower Owens River, to “re-water” portions of Owens Lake and to allow the return of flows through Owens Gorge, and to restock bluegill, largemouth bass, fingerling trout, and other aquatic species.

Over time, native fauna are expected to return in significant numbers. In exchange, LADWP will receive 18,503 fewer cubic meters (15,000 fewer acre-feet) of Owens Valley water each

year - reducing Los Angeles' reliance on the Owens Valley from some 35% of its total imported supply to approximately 18-20% (Linder, 2006; Hundley, 2001). As important as these changes in policy outcome may prove to be, of at least equal if not greater significance is the change in decision-making process by which they are being implemented. A Collaborative Aqueduct Modernization and Management Plan, or CAMMP, led by LADWP, the California Department of Fish and Game, and two environmental groups - California Trout and the Mono Lake Committee - has been undertaken to determine the means by which aqueduct operations can best be modified to facilitate changes in streamflow that can satisfy environmental restoration needs on the one hand, while continuing to provide water to Los Angeles. Thus far, extensive data gathering, analysis, and drafting of prescriptions have been conducted, and the effort has entailed far more cooperation among protagonists than in the past (McQuilkin, 2011).

While these environmental restoration activities involve consultation among intervenor groups, elected decisionmakers, and regulators, another collaborative effort has been conducted, off-and-on, regarding Native American water rights in the Owens Valley. Several Paiute Indian tribes lost their land and water rights in the region following white settlement in the mid-19th Century - and well-before the aqueduct was built. A partial restoration of water rights occurred in 1908 following a pivotal Supreme Court case - *Winters vs. U.S.* - which "explicitly affirmed water rights on Indian Reservations" by, in effect, setting aside correlative water rights on these reserved lands (Burton, 1991).

An Owens Valley Indian Water Commission - comprised of representatives of the Bishop, Big Pine, and Lone Pine Paiute tribes - are negotiating with LADWP to ensure they receive the water they are entitled to. While a final settlement has yet to be reached, when completed it will set relations regarding water use between Los Angeles and its surrounding region on another new footing (Owens Valley Indian Water Commission, 2009).

One of the notable benefits of New York's acquisition of much of the Catskill and Croton watersheds during the 19th Century was the opportunity to, in effect, ensure a virtually pristine source-water strategy. The storage reservoirs built by the city are surrounded by hardwood and evergreen forests that naturally filter water and retard erosion, thus averting sedimentation that would otherwise reduce drinking water quality. This asset also saves New York City billions of dollars in water treatment costs, according to the World Bank; has averted water-borne diseases; and, facilitates New York's distinction as the nation's largest city *without* a drinking water treatment plant (American Planning Association, 2011).

In the 1970s, water quality in these watersheds began to deteriorate as a result of contamination from sewage outfalls, leaky residential septic systems, agricultural runoff, and land cleared for residential development. The most significant issues that arose were: 1) sediment problems or turbidity within the Catskill Watershed, which can transport pathogens and interfere with the effectiveness of water filtration and disinfection; and, 2) excess nutrients, particularly phosphorus. The former can generate algae blooms that cause serious odor, taste and color issues, while excess phosphorus can cause eutrophic water conditions and increase carbon. Moreover, this water, mixed with chlorine, can result in the formation of "disinfection byproducts" suspected of being carcinogenic (New York State Department of Environment and Conservation, 2010b).

After years of study, environmental protection officials in New York City – and state officials representing the Department of Environmental Conservation – concluded that there were two feasible options to forestall threats of federal intervention, by EPA, to institute more strenuous remedial measures. The first was to build an artificial filtration plant, the city's first, at an estimated cost of between \$8-10 billion, with an annual operating expense in the vicinity of some \$360 million. The second option was to restore the Catskill/Croton watersheds through a combination of land purchases, compensation of existing private property owners for growth restrictions (e.g., conservation easements), and subsidies for septic system and other improvements. The city chose this much less-expensive option (at a total cost of approximately \$200 million) – paid for through the sale of municipal bonds (New York State Department of Environment and Conservation, 2010b).

The second option – now known as the *New York City Watershed Protection Plan*, has been effective in complying with federal drinking water standards and delaying the need for a filtration plant. It is based on explicit, legally binding agreements – a Filtration Avoidance Determination (FAD) agreement, and a Memorandum of Agreement (MOA), concluded in January 1997 between several federal, state, New York county and city agencies, as well as various educational and non-profit organizations and watershed coalitions to provide regulatory oversight, perform environmental monitoring, protect water quality, educate the public, communicate about issues pertaining to pollution and watershed stewardship, and provide funding and other assistance to watershed communities (Westchester County Department of Planning, 2009: 2-26).

This partnership acknowledges the common interest of both public and private entities – in the city and within the two watersheds – in abating pollution through working together, especially given the limited power of any single entity to abate non-point pollution. Unlike the Los Angeles case, where collaboration on environmental quality issues initially emanated from an adversarial clash of interests, this partnership came about more amicably, while its composition has been similarly diverse. Members include New York City agencies, upstate communities in the twin watersheds, the U.S. EPA and other federal agencies, the New York State Department of Environmental Conservation (DEC) other state agencies, and various environmental groups.

One explanation for this comparatively amicable partnership is political realism: most watershed communities would have been adversely affected had New York City been forced to build a drinking water filtration system. This is so for two reasons: 1) the plant would have been paid for by all water users (and, in all likelihood, by regional taxpayers); and, 2) the state – if not the City itself as eminent domain tenant – would have been forced to impose more onerous land-use controls over the watershed if a partnership had not been formed. In effect, the indirect threat of having to pay for a water filtration plant was exactly the incentive needed to collaborate. Moreover, the choice of a multi-party partnership best suited the goals of all protagonists. It offered a viable, effective solution at manageable cost and through largely voluntary action (Croton Watershed Clean Water Coalition, 2009). However, given continued growth in rural areas throughout the region, and continued problems with turbidity, it has been necessary to revisit this plan.

In 2004, the city began construction of a \$2 billion underground filtration plan in Van Cortlandt Park, Bronx designed to filter water from the Croton system, which is scheduled

to be completed in 2012. It has also continued to acquire sensitive lands in the Catskills/Delaware watersheds to further buffer their reservoirs from contamination, and thus, to remain in compliance with the state/EPA approved FAD agreement (New York City Department of Environmental Protection, 2010).

In sum, for both Los Angeles and New York City, local collaboration was abetted to some degree by federal and state government action. For the former, EPA intervention forced Los Angeles to rectify the condition of Owens Lake (and thus, indirectly, also improve the condition of other valley watersheds affected by adverse flows). Ironically, violation of the Clean Air Act (not the Clean Water Act) forced the city to work with state agencies, local valley officials and intervenor groups. For New York City, it was the *threat* of EPA (and state regulatory) intervention under the Safe Drinking Water Act (the Croton and Catskills are, after all, potable water sources) which compelled the city and its neighbors to collaborate to avert further sewage and non-point runoff contamination of the region's reservoirs.

5. Conclusion

Two fundamental questions are prompted by our discussion of Los Angeles' and New York City's diversion of water from their surrounding regions. The first is: why the absence of overt political conflict in the latter case as compared with the former? The second (as earlier noted) is: what can other megacities learn from these cities' experiences?

Taking the first of these questions – the attenuation of conflict in New York, and its intensity in Los Angeles, it is important to parse the question somewhat. An often assumed difference in the two cases is socio-economic: the Croton and Catskill watersheds are closer to New York City than the Owens Valley is to Los Angeles, and far better integrated into the former's economy. In the present-era, for example, evidence of the strong integration of the Croton Watershed's economy with that of New York City's five boroughs is offered by commuter traffic patterns – some 17,000 Croton Watershed workers commute from New York City daily – nearly 40% of the region's workforce, while some 18,000 workers living in the watershed commute to the city daily (about 35% of the workforce – see Westchester County Department of Planning, 2009: 2-27, 8).

However, this explanation is a bit trickier than might at first appear. New York and Los Angeles share profound socio-economic contrasts with their importing watersheds, which remain highly rural in character. While this is obvious with regards to the Owens Valley – a rural region initially dependent on farming and ranching before Los Angeles diverted its water – it is just as true for the Croton and Catskill watersheds. When initially settled, the upper Croton watershed, for example, was a remote and economically self-reliant region. Its residents developed separate and distinct ways of life initially dependent on dairy and crop farming (Westchester County Department of Planning, 2009: 2-26). Only in the late 19th Century, after completion of the aqueduct system, did the region's economy become more closely integrated with that of New York City.

A better explanation for the seeming absence of inter-regional conflict in the Croton and Catskill watersheds is the fact that New York's efforts to develop the water resources of these basins were, by comparison with those of Los Angeles in the Owens Valley, far more transparent and politically above-board. There is no evidence that the former sought to buy

up watershed lands in secret, or to secure both surface and groundwater rights exclusively for its own use (and with federal government help). By comparison, the well-documented resistance to Los Angeles' activities in the Owens Valley, evidenced in part by the militancy of opposition, including acts of sabotage against the aqueduct during the 1920s, and tacit complicity in these acts displayed by many valley residents, dramatize the deep resentments generated by Los Angeles' actions. Many Owens Valley residents believed they had become a virtual colony of Los Angeles (Walton, 1992: chapter 5).

Their animosity was strengthened by what they believed was national-level collusion in the city's actions. President Theodore Roosevelt personally interceded in the Owens Valley case, persuaded that the future growth of Los Angeles was more important than the interests of Valley settlers. He not only ordered the eastward extension of the Sierra National Forest to discourage additional homesteading, thus ensuring protection of the aqueduct's right-of-way, but he further stated that the interests of Los Angeles exemplified ". . . the greatest benefit of the greatest number and for the best building up of this section of the country" (Los Angeles Department of Water and Power, 2010b).

Given all this, one must remain cautious about putting too fine a point on these differences. Opposition to New York City's efforts in the Croton Watershed, while infrequently reported, nevertheless existed. As early as 1837, some Westchester County residents lamented the implications of a Croton Aqueduct on their welfare. As one writer stated: "If the rivers of Westchester County are to be taken from it, how is it to rise in arts, manufacturing, and farming" (Quoted in Koeppe, 2001: 8)? Clearly, some residents acknowledged the long-term economic implications of diverting water.

There are two other reasons to avoid drawing too radical a contrast between New York and Los Angeles with regards to inter-basin conflicts. First, both cities have experienced intense *interstate* water conflicts, in both cases entailing Supreme Court litigation. And eventual water apportionment. Conflict between California and Arizona, spurred mostly by Los Angeles' utilization of the Colorado River as a major source of water after 1940, led to the important case of *Arizona v. California* (1964) by which the court reduced the amount of Colorado River water available to California, and further ruled that lower basin states (e.g., Arizona) were entitled to reasonable uses of tributary flows (U.S. Department of the Interior, 2008). Similarly, conflict between New York, Delaware and Pennsylvania led to two U.S. Supreme Court decisions allocating water among protagonists. Initially, the court upheld New York City's right, as an upstream riparian, to use a portion of the Delaware watershed. In a later case, the Court acknowledged the rights of all three states to an equitable apportionment of the Delaware River (Derthick, 1974). Environmental concerns under the Endangered Species Act have likewise prompted federal courts to reduce water deliveries from the Sacramento-San Joaquin Delta in recent years (Erie, 2006).

A second reason for caution is that both cities have experienced intense political conflict over the respective roles of private, market-driven water development efforts on the one hand and advocates for public control on the other. As noted in section 4, while both cities' preoccupation with water security led them to seek expanded public control of their local water systems to permit construction of massive aqueduct systems, originally, things began quite differently. In their early civic histories, both Los Angeles and New York viewed private water provision as the most desirable way to achieve water security. In fact, private

provision was the norm throughout much of the 19th century. Incorporated in 1799, New York's Manhattan Company was inefficient and scandal-ridden. Yet, until 1834, it conspired with water cart owners to block the New York legislature's creation of a board of water commissioners, which ultimately bought out the company and built the Old Croton Aqueduct (Erie, 2006: 174).

Recall that Los Angeles, in 1902, acquired its private water company in part to amass the finances to build an Owens Valley Aqueduct. Even after acquiring its water company, however, Los Angeles never succeeded in eliminating the sway of private capital over water-supply. As is widely known, a syndicate of land investors sought to enrich themselves through the Los Angeles Aqueduct project by purchasing lands in the San Fernando Valley. Contrary to widespread belief, William Mulholland – the project's principal engineer – did not share this syndicate's avaricious motives. He sought to free the city from dependence upon erratic water sources in order to permit orderly growth. While he only conveyed knowledge of plans to build an Owens Valley Aqueduct to the Board of Water Commissioners and a few local officials, he did so simply to avert a stampede of speculators into the valley that would cause land prices to skyrocket (Mulholland, 2002).

5.1 Lessons for other megacities

So, what can other megacities learn from the experiences of New York and Los Angeles in regards to collaboration on regional issues and impacts of water development? The basic answer to this question brings us back to where we started this chapter – the challenge of water stress. As we have seen, Los Angeles and New York historically experienced stress, took various actions to address it which impacted their hinterlands, and continue to reckon with it through efforts to conserve water, improve infrastructure, and plan for climate change. While neither city has “solved” the problem of stress, their efforts to manage it harbor lessons for other megacities.

Since the 1970s, Los Angeles' conservation efforts have principally revolved around metering, conservation pricing, low-flow water appliance mandates, and efforts to compensate low-income groups for the costs of installing the latter. Water use has been considerably reduced – average water demands in period 2004 – 2010 are comparable to those of 1980, even though some 1.1 million additional people now live in Los Angeles (Los Angeles Department of Water and Power, 2010a: 8).

In 1988, New York City began metering to induce conservation and to ensure that larger volume water users pay their fair share. By the 1990s, water use declined some 28 percent as compared to 1979 (Shultz, 2007). Like Los Angeles, New York has also invested nearly \$400 million in a 6.0 liter (1.6-gallon) per-flush toilet rebate program, which reduced water demand and wastewater flow by 342.96 million liters (90.6 million gallons) per day, a seven-percent reduction. One effect of this rebate program, aside from saving some \$600 million, is delaying by about 20 years the need for water supply and wastewater-treatment expansion (U.S. EPA, 2010).

From the standpoint of regional collaboration, these experiences hold important lessons for other megacities in one important respect: conservation efforts lessen impacts on outlying

communities - including the same communities from whence water supply originates. For Los Angeles, the more water that is conserved, the easier it becomes to reduce reliance upon both Owens Valley imports and those from other regions. For New York, similarly, the less water used, the less likely it is that stored water supplies will be depleted - thereby stretching available water and making less urgent the completion of various infrastructure improvements to deliver water to the city. Both cities are pursuing additional "active" conservation measures - with Los Angeles emphasizing stormwater capture and wastewater reuse and New York focusing on drought management and distribution system leak detection (Los Angeles Department of Water and Power, 2010a; New York City Department of Environmental Protection, 1998). While New York will continue to rely on incremental improvements to achieve conservation goals - more metering and the like - it, too, is likely to experience the same economic pressures as Los Angeles. It is likely that other megacities will look to both cities for assessments of these innovations' effectiveness.

As for infrastructure, issues related to stress may be far more problematical. Both cities suffer from aging and deteriorating water distribution systems. New York City is rebuilding its aqueduct system - and is currently engaged in construction of "Tunnel n. 3", an upgrade of the Croton aqueduct system, which loses millions of gallons annually. New components are also being added to its Delaware Aqueduct - all at a cost of some \$2 billion. Los Angeles is rebuilding - piece-by-piece - its oldest distribution network components. However, the city faces a unique megacity challenge - continuing to deliver water in the event a major seismic event ruptures the Colorado and/or State Water Project Aqueducts. This is a major preoccupation for the Metropolitan Water District (MWD) which is the primary importing water agency for the region. While Los Angeles aspires to reduce reliance on MWD, during dry years it cannot do so. Moreover, it has made numerous investments in MWD projects under the assumption that it will continue to be a beneficiary of its supply (Los Angeles Department of Water and Power, 2010a).

Finally, as regards climate change, both cities are devoting enormous efforts in embracing climate issues in water resource planning. In New York City's case, sea-level rise threatens water infrastructure, especially for water treatment (Beller-Simms, et. al., 2008: 104-5). For Los Angeles, climate change threatens the robustness of already precarious imports - the aforementioned Metropolitan Water District, for example is already concerned that climate change will complicate its ability to engage in water trading schemes with rural, agricultural water users in the future (Erie, 2006).

In conclusion, it is not far-fetched to suggest that the massive water diversion projects Los Angeles and New York have pursued have had a symbolic as well as practical significance. For Los Angeles, the Owens Valley Aqueduct, Colorado River and State Water Project Aqueducts, and Port of Los Angeles all became symbols of the city's rise to eminence, and its ability to surmount the difficulties of being located in an insular region not readily blessed by a natural port or source of abundant freshwater. Similarly, for New York City, the Croton Aqueduct - the city's oldest imported water project - became part of a tradition of "grand civic projects" that, in the 19th Century, included the Erie Canal, Brooklyn Bridge, and IRT subway - all of which made the city the greatest metropolis in North America (Hood, 1993: 92). A final lesson here is that all these projects were not just civic activities, but publically-funded ones financed through bond markets, reminding us that neither the

private nor public sectors alone can solve urban water problems - an important reminder in a political climate increasingly ambivalent about “privatizing” water supply.

6. Nomenclature – Key terms

CAMMP	Collaborative Aqueduct Modernization and Management Plan
DEC	Department of Environmental Conservation (New York State)
FAD	Filtration Avoidance Determination Agreement
IRT	Interborough Rapid Transit (New York City’s original subway)
LADWP	Los Angeles Department of Water and Power
MOU	Memorandum of Understanding
MWD	Metropolitan Water District (of Southern California)
US EPA or EPA	United States Environmental Protection Agency

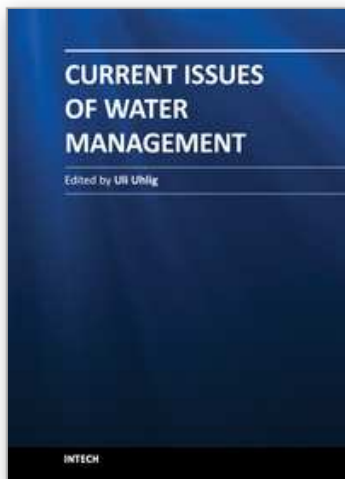
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There is an estimated 1.4 billion km³ of water in the world but only approximately three percent (39 million km³) of it is available as fresh water. Moreover, most of this fresh water is found as ice in the arctic regions, deep groundwater or atmospheric water. Since water is the source of life and essential for all life on the planet, the use of this resource is a highly important issue. "Water management" is the general term used to describe all the activities that manage the optimum use of the world's water resources. However, only a few percent of the fresh water available can be subjected to water management. It is still an enormous amount, but what's unique about water is that unlike other resources, it is irreplaceable. This book provides a general overview of various topics within water management from all over the world. The topics range from politics, current models for water resource management of rivers and reservoirs to issues related to agriculture. Water quality problems, the development of water demand and water pricing are also addressed. The collection of contributions from outstanding scientists and experts provides detailed information about different topics and gives a general overview of the current issues in water management. The book covers a wide range of current issues, reflecting on current problems and demonstrating the complexity of water management.

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