HYDRO-LOGICAL ARCHITECTURE

Brook Muller[1]
[1]University of Oregon, Portland, Oregon

ABSTRACT: Water serves as a medium through which to explore architectures of complexity and ecological responsiveness. I offer an encapsulation of the multiple water crises facing cities in the American West, in part a function of the reality that we dwell in what environmental historian Donald Worster, borrowing from Karl Wittfogel, labels a hydraulic society. Acknowledging the health, environmental and economic consequences of the ways we currently appropriate water resources, I advocate for the value of decentralized, site scale water systems in urban environments that integrate harvesting, storage, treatment, recycling and ecosystem recharge. In a time of the population growth and climate change, the 'big move' in a next generation of thinking about water and the built environment is counter-intuitively a focus on the urban site, the very location to put into meaningful relation pressing matters of supply with those of downstream effects.

Building from this larger contextual understanding, this paper offers the beginnings of a hydro-logical design approach, that is to say, a systems-oriented, water centric manner of conceptualizing and making architecture, one that involves:

- Tracing the journey of water through a site as a way to begin to internalize impacts that have historically been external to architectural design
- Identifying synergies amongst water system elements
- (Re)Defining the system as a coupling of architecture and environment
- Narrating the steps in the architecture-environment system

Two interrelated motivations guide this undertaking: (1) a growing realization of the exciting and important design implications that follow from foregrounding water concerns in architecture, and (2) an interest in the ways such a focus allows for the identification of important and often neglected systems interconnections, not the least of which are the many functional synergies to be derived between sustainable architectures and ecologically functional urban landscapes.

KEYWORDS: Water, architecture, hydro-logical, decentralized, passive

1.0 HYDRAULIC OR HYDRO-LOGIC[1]

A growing population, expanding cities, and climate change exacerbate longstanding water supply problems in the American West. Overall, and typically relying on relatively moist climate spells as a baseline for apportioning water, we have over-allocated our sources, the Colorado River being the most celebrated example. In addition, aging water supply infrastructures are out of sync with changing hydrological regimes. Snowpack in the mountains, a critically important natural storage reservoir, is now much reduced and causing summer shortages (simply filling up dams with the rains of winter and spring to meet summer demand would lead to reduced flood storage capacity; water managers must proceed cautiously).

Borrowing from and recasting Karl Wittfogel's controversially framed argument, environmental historian Donald Worster describes the American West as a hydraulic society.[2] Like others in arid environments throughout history, it is one in which impoundment, irrigation and related water infrastructures have allowed for both spectacular economic growth and a decidedly technocratic management structure necessary to the system's construction and maintenance. According to Worster hydraulic society "is a techno-economic order devised for the purpose of mastering a difficult environment" (Worster 1985, 6). That centralized water systems are conjoined with centralized energy infrastructures ("the water-energy nexus") compounds vulnerabilities and resource inefficiencies.[3] We need only look to the now famous California Energy Commission finding of 2005 that water related energy uses account for 19% of all electrical and 30% of non-power plant natural gas consumption in the State.[4] Or the fact that "in 2000 generation of electricity ranked first in total water withdrawals in the United States (fresh plus saline)," as incredibly large volumes are needed to provide cooling to dissipate rejected heat (Viessman et al. 2005, 85).

Worster is persuasive in articulating relationships between the manner of appropriation of natural resources and the prevailing characteristics of a culture. For Ingram and Malamud-Roam as with many other contemporary theorists, a defining trait of our hydraulic society is that of estrangement:

> Water is uniquely vulnerable to overuse. It falls freely from the sky, giving a false sense of abundance. Water policy in the West has made it a resource that is easy to seize and exploit by those with the power and will to do so. As yet there is little incentive to conserve water for the common good, despite scores of ingenious water conservation proposals. Society in the West lacks any sense of urgency concerning the growing scarcity of this life-sustaining resource. People in the region are oddly estranged from their natural relationship – living in human-created oases of concrete, manicured lawns, and air-conditioned homes. Few are aware of the origins of the water flowing out of their taps, which is probably due, in part, to the complexity of the region's modern, highly engineered hydrology (Ingraham and Malamud-Roam, 2013, 212).

The estrangement with respect to the origins of our waters has as its corollary insufficient awareness of downstream impacts. Few appreciate the severity of the health threats for those millions who live in cities in the US where a significant portion of drinking water comes from treated effluent of those living in communities upstream.[5] We also witness increasingly detrimental ecological consequences when "ultra urban pollutants" of non-point load sources combine with urban waters during increasingly severe storm events that punctuate prolonged periods of drought (see Salmon Safe, 2016). Motor oils, heavy metals and a suite of other toxics that collect on roadways and other urban surfaces during the dry summer months are conveyed in minutes to water bodies during the first fall rains with devastating impacts on salmonids and other forms of aquatic life.

These compounded impacts speak to the value of engaging in initiatives that explore different manners of dwelling in the (urban) watershed, of conceiving design as a means to overcome estrangement, of expanding the scope of concern while attending more carefully to the details of the systems we design, and of making buildings and neighborhoods better functioning elements of hydrological cycles. In the search for an environmentally responsive, hydro-logical antidote to the massive problems associated with hydraulic society, we need to embark on the kind of "intermediary projects" called for by philosopher Paul Ricoeur:

> Our expectations must be determined, hence finite and relatively modest, if they are able to give rise to responsible commitments. We have to keep our horizon of expectation from running away from us. We have to connect it to the present by a series of intermediary projects that we may act upon (Ricoeur 1988, 215)

Landscape architect Carl Steinetz contends that if we do not make sound decisions about land use and urban growth at the region scale, it matters little what an architect proposes for a site. Perhaps in this regard and with "responsible commitments" to our waters in mind, the appropriate metropolitan scale strategy would be to seek a greater diversity of assets, what water managers call a *portfolio approach*. San Francisco Public Utilities Commission for example, recognizing the vulnerability of relying on 85% of its supply from the Hetch-Hetchy Reservoir (with the increasingly undependable snowpack in the Sierras as its source), is searching for alternatives, encouraging use of potable water only where needed, and promoting strategies for conservation and greywater recycling. This is becoming the standard for urban areas in this and nearby regions and will continue to gain in emphasis as necessity dictates; as the authors of *Climate Change in the Pacific Northwest* contend: "With lower summer flows, it is projected that diversification and development of water supplies...and increasing drought preparedness would be required" (Dalton, Mote and Snover 2013, 49).

As a central component of a portfolio approach and as a corollary to hydraulic society, a hydro-logical commitment is predicated upon the conviction that as we modernize our water infrastructures, the soundest large scale investment - Steinetz' big move - is counter-intuitively a focus on the site and urban district. As engineer and author David Sedlak encourages, "to wean cities from centralized systems and all their associated problems, we might simply have to find a way to make decentralized water supply and treatment practical at higher population densities" (Sedlak 2014, 244). As he makes clear, this is not abandonment of existing infrastructures but a process of weaning or a transitioning to a localized and ecologically responsive set of approaches.

The site becomes the very locus for thinking holistically and for putting into meaningful relation pressing issues of supply and those of downstream effects, for engaging in micro-hydrological loops and nutrient flows that are responsive to those of larger magnitude. In essence we graft the two water 'petals' put forth in the Living Building Challenge:

> One hundred percent of occupants' water use must come from captured precipitation or closed-loop water systems that account for downstream ecosystem impacts and that are appropriately purified without the use of chemicals.
>
> One hundred percent of storm water and building water discharge must be managed on-site to feed the

project's internal water demands or released onto adjacent sites for management through acceptable natural time-scale surface flow, groundwater recharge, agricultural use or adjacent building needs.

To examine this grafting in greater detail is to explore a series of design operations that both frame and follow from a water centric orientation At a macro-level, this approach exemplifies a systems orientation: while It is critical to attend to sub-functions (collection, storage, filtration, recycling, wastewater treatment, other), what is most essential to operational effectiveness is the deriving of synergies amongst elements, honoring the capacity and creating the conditions for water to perform beneficial work in multiple ways, and being vigilant about water quality and its resourceful use throughout its journey.

2.0. GROUNDWORK FOR A HYDRO-LOGICAL APPROACH TO ARCHITECTURAL DESIGN

The following design strategies are intended to help shape a water-centric approach to urban architecture. This represents but one way of sequencing a hydro-logical design cycle, a narrative more suggestive than comprehensive as far as what design opportunities present themselves when we attend more carefully to our urban waters. In truth one can enter the process at any point, as one can productively float multiple options for sub-elements simultaneously, continuously moving up and down the system in its entirety in the search for positive feedbacks.

2.1 Tracing the journey of water through a site as a way to begin to internalize impacts that have historically been external to architectural design

To consider the journey of a droplet of water entering, moving through and off the landscape prior to urbanization is to tell a larger story of historic (baseline) ecological and hydrological conditions. In all likelihood, given the presence of vegetation and quite possibly more variegated terrain, the pre-urban 'coefficient of friction' of the landscape would have been significantly greater than today, with the water moving more slowly and becoming cooler and more oxygen rich along the way. These system attributes provide a basis for reworking the journey as a consequence of project development so as to recover functionality and achieve positive downstream effects.

While the hard surfaces of the city have proven most effective at channeling water and pollutants rapidly to urban water bodies, they also provide shade (and therefore can reduce losses due to evaporation) and can be configured to decelerate flows for the purposes of floodplain storage and numerous other uses. In other words, the morphological characteristics of the urban environment, what landscape architect and theorist Bart Johnson succinctly describes as in effect geological formations of rock outcrops, can be enlisted to perform ecologically beneficial work. In most instances this will mean manipulating building form in synchronization with the landscape so as to optimize the harvesting, use, recycling and treatment of water, in other words to instantiate micro-hydro loops that ultimately benefit the parent system in which a project is situated. The challenge and opportunity is to achieve this functionality in tight urban quarters and given competing demands for use of space. In this sense and in a most basic way, the design challenge becomes that of increasing surface area.

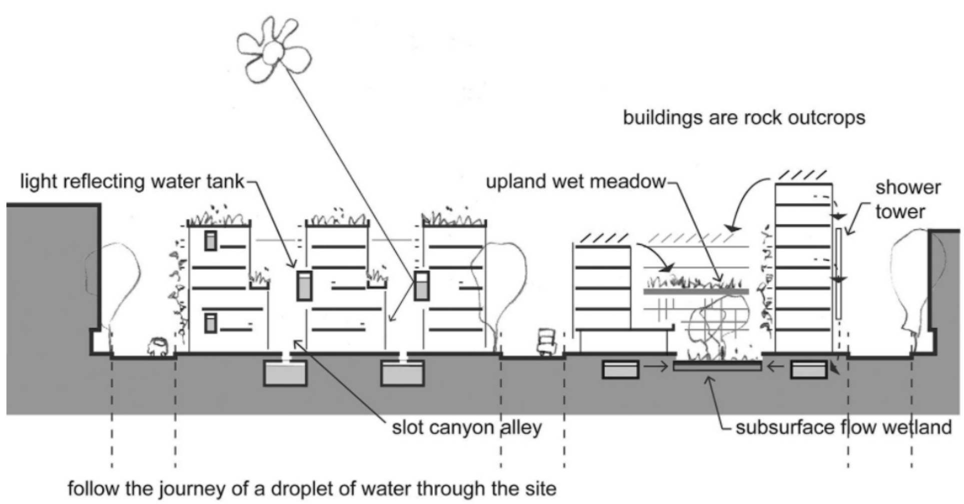

Figure 1: Manipulating the hard surfaces of the city to decelerate flows, put water to work, and cleanse it

2.2 Identifying synergies amongst water system elements

To rise to the Living Building Challenge is to commit to harvesting as much rainwater on site as possible to meet building occupant needs. Given that in much of the American West the majority of precipitation arrives in summer, and anticipating more prolonged drought events in an era of climate change, to follow through on this commitment in the design of any multi-level urban building is to incorporate significant capacity for storage. And as Brent Bucknum of the Oakland-based ecological infrastructure firm Hyphae Design Laboratory exclaims, “above 100,000 gallons, it gets expensive” (Personal correspondence, July 18, 2016). Justifying these costs requires identifying other potential uses for stored water; for example integration of preliminary filtration in a matrix of storage, or use of stored water as a fire suppression reserve or for the purposes of seismic dampening. Perhaps most promising for certain building types would be to utilize this water as thermal mass to reduce cooling loads.

Instead of the customary approach of delivering harvested water to underground cisterns and then pumping it to where it is needed, Cook and Fox architects, in their One Bryant park skyscraper project in New York, organize storage elements on different levels throughout the building. This localized and largely passive method of storage and distribution leads in essence to the formation of vertically deployed water ‘precincts.’ And yet instead of burying these storage elements in the building’s interior, as is the case with One Bryant Park, they could be configured in more overt ways to shape space and to help establish architectural identity. For example, tanks in an atrium space could be clad with light reflective materials to help distribute daylight admitted through skylights to darker, recessed spaces below. And perhaps the building’s hydro-logic can positively inform a building’s social logic: water precincts gather neighbors inhabiting a suite of dwelling units around a common and precious resource. Where water collects, people collect.

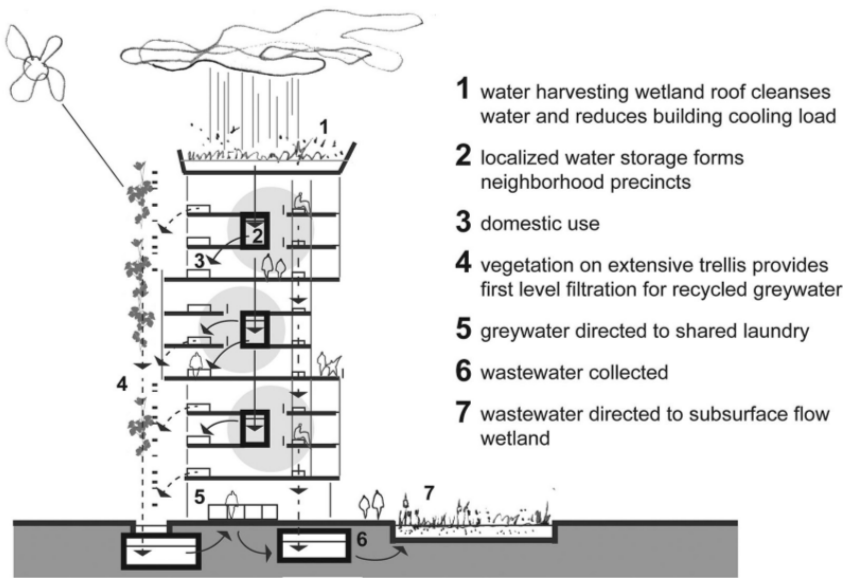

Figure 2: Storage elements and other water system elements shape space and impact architectural identity

Pushing out to a project’s perimeter, it warrants considering synergies derived through the introduction of ecological envelopes, matrices of vegetation and water features operating in tandem with facades, roofs and other building elements and systems to deliver myriad benefits. Mecanoo Architects’ competition entry for the Kaohsuing Public Library in Taiwan, for example, a cube-like building in a subtropical garden landscape, uses planters and vegetative screens on each level along the building’s perimeter in association with chilled beams and other elements in the building’s interior to create a range of comfort-providing microclimatic gradients and to offer visual delight while reducing energy loads. For Hyphae Design Laboratory, a common strategy is to utilize recycled water to irrigate living roofs that provide habitat and visual amenity while reducing cooling loads and decelerating stormwater flows. With Mick Pearce’s Council House 2 project in Melbourne of 2004-2006, water is drawn to the tops of ‘shower towers’ on the building’s south façade. This water then falls and cools by evaporation; it is then used to pre-cool water from chilled ceiling panels, resulting in a significant reduction in overall energy consumption.

Given the water and energy inputs and maintenance regimes required to keep them alive and healthy, Brent Bucknum of Hyphae describes living walls, modish as they are, as “ICU’s” (intensive care units). Hyphae focuses on an alternative ecological envelope strategy that utilizes extensive trellises to support vegetation that is watered at grade and that assists with cooling, pretreating air and serving in other capacities (Personal correspondence, July 18, 2016). And yet perhaps living walls are warranted if enlisted in a synergistic manner, whether as part of a greywater filtration and recycling system as is the case with Bertschi Living Science Wing in Seattle (the greywater is also used by the plants), or in lieu of cooling towers, a strategy now being investigated by Alexander Felson of the Urban Ecology and Design Laboratory at Yale University.

This handful of examples begin to suggest how an emphasis on resourceful and passive use of water has ripple effects that touch other aspects of buildings, both along its surfaces and in the depths. And this syncretic design force continues outward, shaping the landscape along its course and intensifying relationships between buildings and the sites in which they are located.

2.3 (Re)Defining the system as a coupling of architecture and environment
While there are numerous aspects of this coupling, the aforementioned ecological envelopes offering one example, recent incorporations of environmentally responsive wastewater systems on urban sites are particularly significant for the architectural/landscape architectural impacts they bring about.[6] While there are a range of options for on-site treatment, with choice of system dependent on building type, project scale and site conditions, Kieran Timberlake (architects) and Andropogon Associates' (landscape architects) Sidwell Friends School in Washington, D.C offers and illustrative, integrated example. With Sidwell 100% of wastewater is treated "through a terraced, subsurface-flow constructed wetland designed into the site landscape" that students and faculty monitor (Cascadia Green Building Council 2011, 99). This becomes a didactic device and a central site feature that works in tandem with the channeling of harvested rainwater through wetlands, downfalls for aeration, and into a biology pond where it is infiltrated to recharge groundwater. Rainwater makes its way from building to landscape; some of this returns to the building for use in the wastewater system; the wastewater returns to the landscape in a co-dependent, multi-loop flow.

Another manner of coupling involves conceiving processes of building construction as processes of ecological regeneration. Portland-based urban ecologist Mark Wilson gives us some insight as to how we might align sought after ecological attributes with desired characteristics of a project from a human-centric perspective. Wilson visits building sites near riparian corridors where historic wetlands have been largely obliterated (and where the city has encouraged their reintroduction), observing locations of staging areas, patterns of movement of construction equipment, and the reshaping of terrain. He conducts percolation tests where soils have been compacted and identifies locations where proper subsurface conditions for constructed wetlands have been established.[7]

Using this example of 'accidental regeneration,' what Wilson describes as "opportunistic ecologies," we might proceed with a greater level of intentionality and identify ecological and hydrological goals as part of the problem definition statement itself, goals that will depend in great measure on where a particular project sits in the urban watershed. In the case of low lying development sites and goals of wetland complex restoration, a building could release recycled and treated water at critical times to ensure the hydroperiods (water levels) necessary for aquatic species to complete their life cycles. In an era of climate change, prolonged drought, and greater meteorological unpredictability, architectures become in effect 'hydrological batteries' that help enable the perpetuation of critical ecosystem services and biological processes.

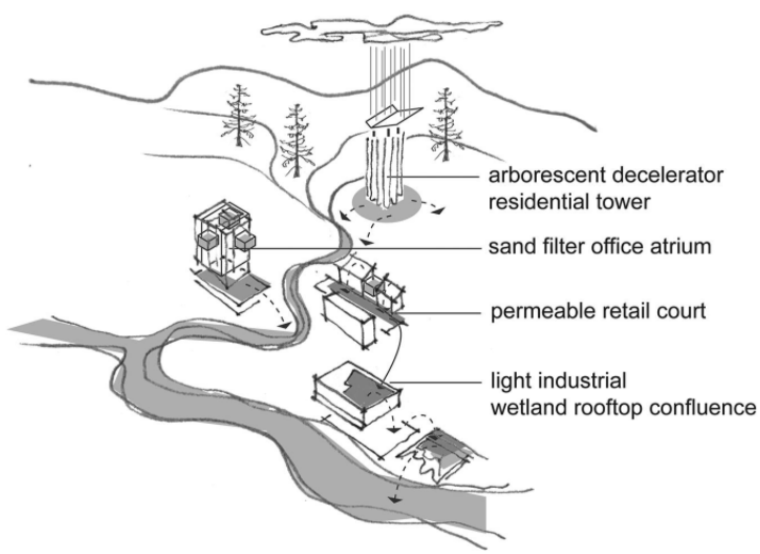

Figure 3: A project acquires particularity by virtue of where it sits in the urban watershed

2.4 Narrating the steps in the architecture-environment system
What the above suggests is a different way of designing and thinking in systems than architects ordinarily pursue. Following a journey of water, viewing the built environment as conduit and decelerator, seeking synergies and couplings

also require the effective representation and narration of systems. An early step in the design process may be to build up a perspective from the sky looking obliquely down on the site in question and describing graphically and in proportion sources, flows and points of recharge, as for example Hyphae Design Laboratory's "Sankey" operational depiction of inputs and outputs and relative volumes for the Waterman Gardens multi-family residential complex in San Bernardino, CA. Next and focusing in on the site, a water schematic in section or section perspective would depict the basics of systems elements and their interactions (see Figure 2). Coupled with this would be a bulleted sequence of steps in the hydrologic design cycle.

In the design of a parking garage adjacent to a constructed wetland as part of a university level design studio investigation, students Lore Burbano, Andrea Detweiler and Nicki Ghiseli devised a particularly novel sequence that contended aggressively with a highly problematic building type from the standpoint of environmental quality:

1 Owner drops off car
2 Car is given a shower (is washed)
3 Mechanical lift hoists car to parking space
4 Polluted water is directed to facade to grow algae
5 Algae cleans water
6 Excess water is sent to adjacent constructed wetlands
7 Algae is used to produce biofuels

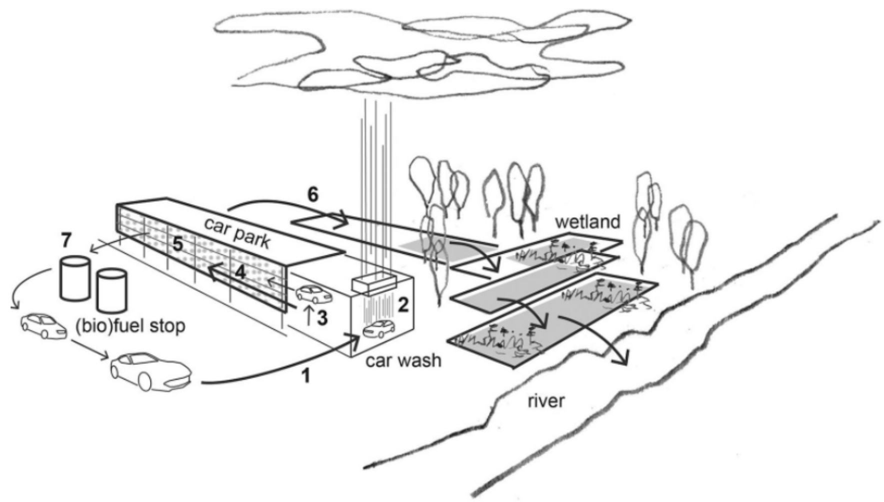

Figure 4: "A motorcycle is part of the hydrological cycle" parking garage design water system sequence by Lore Burbano, Andrea Detweiler and Nicki Ghiseli. The constructed wetlands are configured as part of the proposed project development (winter 2014)

As this proposal demonstrates, the basics of project organization follow not only from manipulation of space but thoughtful devising of processes as they would play out over time. While beyond the ability to examine in detail in this essay, the water emphasis, building-environment coupling and attention to temporality that this project and the "opportunistic ecologies" approach represent also speak to the value of new and highly integrated interdisciplinary partnerships at the intersection of buildings, ecologies and economies.

CONCLUSION: ANCHORING

> Detail anchors perception in a context of vastness (MacFarlane 2014, 212).

Herbert and Grau Ludwig Dreiseitl's reflection that "we are constantly discovering that water is our best teacher" inspires the ruminations in this essay (Dreiseitl and Dreiseitl 2001, 42). To draw from our urban water in driving a design process is to seek syncretic relationships between ecologies, interiors and envelopes. In this way and much like low energy, passive approaches to heating, cooling, lighting and ventilating of buildings, a water-centric commitment offers a means of arriving at a place-based architecture: while any one project necessarily has multiple functions to perform, its hydro-logic adjusts in relation to its location within the urban watershed. Such built interventions in aggregate and in a time of reduced snowpack form surrogate mountain ranges that collect water during the rainy season and make it available throughout the year.

To draw on our urban waters is also to begin to overcome the estrangement touched on earlier. Rick Basatch says of the current water situation in the State of Oregon, "if a measure of caring is the degree to which society organizes its thinking and allocates resources to the future, then on this score there is no contest: in Oregon, roads trump water any day" (Bastasch 2006, 281). This degree of neglect and unpreparedness in light of climate change and population growth plays itself out in many states and municipalities in the American West. A culminating argument of this essay is that to concentrate on localized, site-based water systems is to heighten our concern over our common dwelling place and to galvanize attention to the larger water predicament contemporary society finds itself in. As Robert MacFarlane has said, "if we attend more closely to something then we are less likely to act selfishly toward it" (MacFarlane 2014, 211).

What is at stake is not only different manners of attending to and thinking in systems, but altogether different notions of temporality, progress and purposefulness than what obtains in hydraulic society. Paul Ricoeur encourages that "when confronted with the adage that the future is open and contingent in every respect but that the past is unequivocally closed and necessary, we have to make our expectations more determinate and our experience less so" (Ricoeur 1988, 216). More determinate expectations mean working toward a future in which the material, experience-able and environmentally responsive – vs. the buried, invisible and damaging – characterize our infrastructures and architectures. Less determinate experience means viewing the past as fluid, diverse and laden with constructive possibilities; while we face unprecedented urban challenges, simple and robust, pre-modern and passive approaches to water infrastructures are well worth revisiting as a means of addressing them.

An ecologically oriented emphasis on water in the built environment, what amounts to in effect a hybridization of water infrastructure and architecture, leads designers to circulate across scales, erode distinctions amongst systems, and dissolve boundaries between buildings and landscapes, ecologies and cites. Such sustained attention can bring about a sense of satisfaction and enchantment, "a pleasure at moving with the world and being swept along in its rhythms rather than sweeping it along with us" (MacFarlane 1985, 6 2014). Through this effort and at the same time we reconnect people in the present to the larger systems on which they depend, our successes become a legacy of care.

Drawings by author

REFERENCES

Basatch, R. 2006. *The Oregon Water Handbook: A Guide to Water Management, Revised Edition.* Corvallis, OR: Oregon State University Press. (originally published 1998).

Cascadia Green Building Council. March 2011. *Toward Net Zero Water: Best Management Practices for Decentralized Sourcing and Treatment* (primary authors: Joel Sisolak, Kate Spataro).

Chen, C., MacLeod, J., and Neimanis, A. 2013. "Introduction" in *Thinking with Water*. Chen, MacLeod, and Neimanis, eds. Montreal and Kingston: McGill-Queen's University Press, 3-22.

Dalton, M., Mote, P., and Snover, A. 2013. *Climate Change in the Pacific Northwest: Implications for Our Landscapes, Waters, and Communities.* Washington, D.C.: Island Press.

Dreiseitl, H., and Dreiseitl G.L. 2001. *Waterscapes: Planning, Building and Designing with Water*. New York: Princeton Architectural Press

Ingram, L., and Malamud-Roam, F. 2013. *The West Without Water: What Past Floods, Droughts, and Other Climatic Clues Tell Us About Tomorrow.* Berkeley, CA: University of California Press.

MacFarlane, R. 2015. *Landmarks*. London: Penguin.

Ricoeur, P. 1988. *Time and Narrative Volume* 3. Translated by Katherine Blamey and David Pellauer. Chicago: The University of Chicago Press.

Salmon Safe. 2016. *Model Stormwater Management Guidelines for Ultra-Urban Development.*

Sedlak, D. 2014. Water 4.0: *The Past, Present, and Future of the World's Most Vital Resource.* New Haven, CT: Yale University Press.

Viessman Jr., W., Hammer, M., Perez, E., and Chadik, P. 2015. *Water Supply and Pollution Control, 8th Edition*. Noida, India: Pearson India Education. (originally published 2013).

Wittfogel, K. 1957. Oriental Despotism: A *Comparative Study of Total Power*. New Haven, CT: Yale University Press.

Worster, D. 1985. *Rivers of Empire: Water, Aridity, and the Growth of the American West.* Oxford, UK: Oxford University Press.

ENDNOTES

1 Water 4.0 is the title of David Sedlak's book of 2014

2 Worster 1985 borrows this term from Wittfogel 1957. Wittfogel controversially suggested that oriental societies were hydraulic and as a consequence despotic; Worster argues persuasively that the American West is a hydraulic society par excellence

3 We might triangulate as many do and add food to the energy-water nexus

4 We also ought to attend to another dimension of this nexus: while hexavalent chromium, a chemical linked to cancer, is used in a number of industrial processes, the greatest source of contamination is the electric power industry

5 Of particular concern are those "contaminants of emerging concern," pharmaceuticals and personal care products for example, that are not regulated through the National Pollution Discharge Elimination System, the regulatory structure set up with the passage of the Clean Water Act in 1972

6 That said, there are emerging systems involving 'contained treatment' and localized resource recovery that when commercialized will render the term wastewater meaningless, as water will no longer be the means of conveyance, and where human waste will be processed into a nutrient rich precipitate

7 This paragraph is based on personal correspondence