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Toward Integrative Stormwater Design in Urban Spaces

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***Abstract*—**The design requirements for successful human accommodation in urban spaces are well known; and the range of facilities available for meeting urban water quality and quantity requirements is also well established. Their competing requirements must be reconciled in order for urban spaces to be successful for both. This paper outlines the separate human and water imperatives and their interactions in urban spaces. Stormwater management facilities' relative potential contributions to urban spaces are contrasted, and design choices for achieving those potentials are described. This study uses human success of urban space as the evaluative criterion of stormwater amenity: human values call on stormwater facilities to contribute to successful human spaces. Placing water's contribution under the overall idea of successful urban space is an evolution from previous subjective evaluations. The information is based on photographs and notes from approximately 1,000 stormwater facilities and urban sites collected during the last 35 years in North America and overseas, and the author's experience on multi-disciplinary design teams. This conceptual study combines the disciplinary roles of engineering, landscape architecture, and sociology in effecting successful urban design.

***Keywords*—**Stormwater, SUDS, Urban design, Values, Urban space.

I. Introduction

IN today's cities, both human accommodation and stormwater management are imperative. Echols and Pennypacker [1], the SUDS (Sustainable Urban Drainage Systems) program in the UK [2], and Stahre's [3] approach in Sweden, advocate treating human amenity as one with the water quantity and quality values of environmental protection, by using 'rainwater to create amenities that enhance a site's attractiveness or value'. However the different requirements potentially compete for the design of urban places, and must be reconciled in order for a place to be successful on the whole. This paper outlines the separate human and water values and their relationships in urban spaces, and presents a framework for resolution of the conflict through integral design of stormwater facilities and anthropocentric spaces. The information is based on photographs and notes from approximately 1,000 stormwater facilities and urban sites collected during the last 35 years in North America and overseas, and the author's experience on multi-disciplinary design teams.

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II. Human and Water Values

A city is built for and defined by a population that is large, dense, and diverse [4]. The interactions among diverse people produce the social systems that evolve there. One type of system is the economy, in which people exchange all kinds of work and property. Diverse, dynamic exchanges build mutual cooperation, knowledge, competence, and innovation; the system as a whole supports employment, opportunity, wealth, and resilience [5], [6]. Another type of system is community, which is any group of people tied by commonalities such as family, work, living place, religion, or military experience. Through communities people build identity, purpose, and values. Communities are diverse, dynamic, and overlapping; they interact with each other and with interests of wealth and power, and compete with each other for individuals' loyalty. Communities are the drivers of a lot of what happens in societies, including deciding what to do in the economy, because communities are where values come from.

In building contemporary cities, the traditional infrastructural imperatives of drainage and sanitation are now supplemented with mandates for protection of water quantity and quality, and the environmental resources that depend on them. Facilities built to meet these expectations are diverse and versatile. Authoritative guides to their application [7], [8] have made comprehensive reviews of the facility types, which can be combined and generalized as: permeable pavements; green roofs; water harvesting; rain gardens (bioretention); swales, channels, downspouts, and culverts; ponds, basins, and wetlands; storm-sewer inserts (filters, traps, inlets, vaults, wells, separators); and surface filters, screens, traps and racks.

The roles of anthropocentric and water systems vary in urban space. Fig. 1 distinguishes three urban spatial types, each of which represents specific potential types of stormwater flows and features, and human structures, activities, and values. The figure shows them arranged in a downstream flow direction. The source area is where stormwater flows originate; it is defined by its fundamentally anthropocentric purpose. The perimeter area is defined by its stormwater purpose; it is where specialized stormwater facilities buffer the source area's discharges or help to carry them away. The downstream area is where excess flows end up.

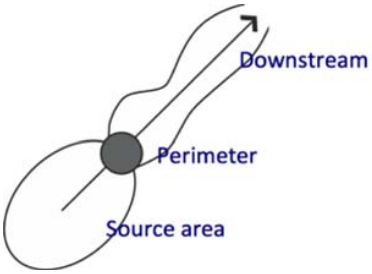

Fig. 1 Types of urban spaces representing different human and water features and values, aligned along the stormwater flow route

An example is shown in Fig. 2, on the site of a large contemporary development in the semi-arid southwestern area of the United States. The corridors are the downstream areas; these are floodways that receive urban discharges, either directly or through a perimeter area. Dots and circles show the locations of urban source areas: each dot represents a multi-use village center; the circle around it represents residential areas of varying densities.

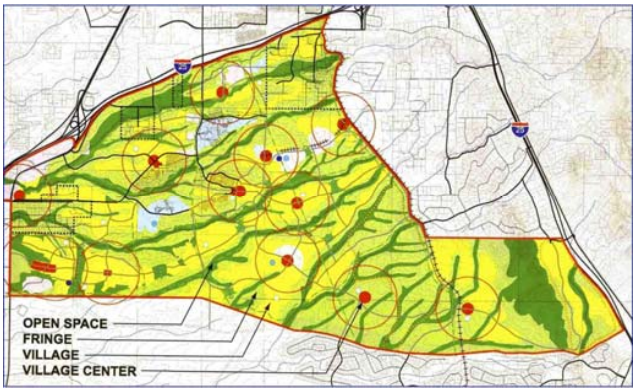

Fig. 2 Floodway open spaces and urban development locations at Rancho Viejo, Santa Fe, New Mexico (adapted from [9])

Fig. 3 shows detailed connections among those spaces. The source areas include shops and residences and their immediate landscapes; some stormwater management features are within these areas such as water harvesting. The perimeter area includes the swale alongside the road and a detention pond which buffers downstream flows. The downstream area is the wash where excess flows eventually end up.

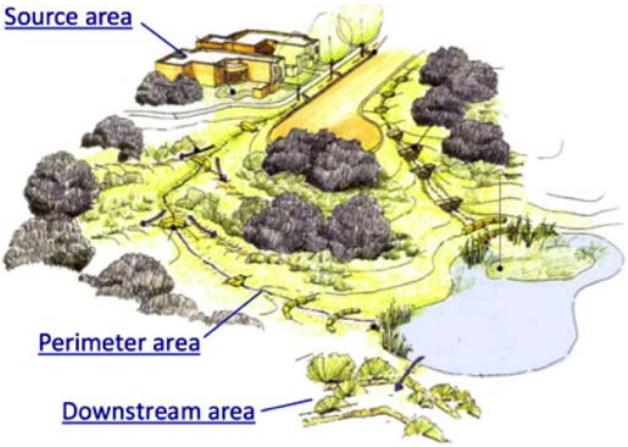

Fig. 3 Source, perimeter, and downstream areas at Rancho Viejo, Santa Fe, New Mexico (adapted from [9])

III. Interactions of Values in Specific Places

Human and water features and values converge and interact in individual urban places.

The measure of success of an urban space is safe, active human use [5], [6], [10], [11]. Active use indicates attraction of residents, visitors, and immigrants. It is associated with employment, wealth, and economic growth; community identity; and personal safety and well-being. To evaluate a particular space one can count the people in it, or survey nearby people about their feelings about it, or, at a larger geographic scale, relate a district's demographics, immigration, and property values.

Urban design provisions that encourage active use are well known from the findings of researchers such as Gehl [10] and Whyte [11]. They include diverse uses, linkages to streets and buildings, comfortable microclimate, and seating with views of interesting activities, flowers, water, trees, or scenery. In the perception of the communities that share a place, place identity evolves with a place's history and environment [12].

Rain water is known to be capable of contributing to the success of urban places by bringing interesting motion, color, variation in time, and associations with the rest of nature such as earth, rocks, and living things. These perceptions and associations are known to contribute to emotional, mental, and physical health; they reduce stress, improve relaxation, accelerate healing, and encourage walking, productivity and well-being, where they are perceptibly controlled, safe, and neatly maintained [13].

Design can articulate water's processes and associations. In architecture, 'articulation' means to make a latent process, function, or spatial transition more 'readable' with distinctive materials, configurations, and detailing, so people can interact with it through their perceptions [14].

Types of design provisions to articulate water and its associations were suggested by Echols and Pennypacker [1] and Dreiseitl and Grau [15]. Since actual rainwater flow is only occasional, most of the provisions apply to the permanent channels and pools that convey water, and the permanent

forms, materials, vegetation, and structures which are associated with water, its movement, and the rest of nature. They can be combined with general provisions for successful urban space from Gehl [10] and Whyte [11] as follows: visibly continuous flow route through channels and pools; different flow levels along the route, signifying interesting activity such as plunges and riffles, and the sounds of splashes and falls; articulation of flow direction changes; perceptible safety with separation from people and limitation of depth, velocity, and fall height; seating and walkways oriented to facilitate viewing of water and its associated channels, falls, vegetation, stones, and other materials; and continuity of materials and forms with surrounding architecture, with interesting variations and repetitions.

IV. Integrative Design Choices

Fig. 4 compares potential contributions to place of different types of stormwater management facilities. The figure's vertical axis is the perceptual contribution to place through degree of human contact, readability, and association with nature. Most facilities occupy a range on the vertical scale, indicating the importance of specific design choices for achieving or not achieving contribution to place in specific applications. Along the horizontal axis the facilities are arranged in order of priority for spatial use, from fully human on the left to fully water on the right. The overall horizontal sequence is the stormwater flow sequence, from source area, through the perimeter, to downstream. The following sub-sections outline specific design choices for each type of facility.

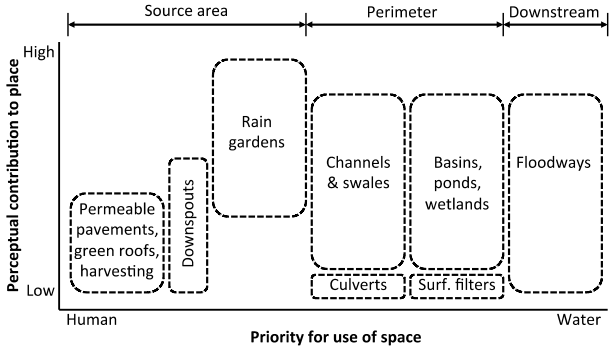

Fig. 4 Stormwater facilities' relative spatial occupation and perceptual contribution to place

A. Facilities in Source Area

At the chart's far left, green roofs, water harvesting, and permeable pavements put the source area's buildings and pavements to dual use. Different green roofs contrast in their degree of visibility to people, and their attractiveness as gardens. Permeable pavements' readability varies with the distinctiveness of their materials, colors, and patterns, and whether they are set apart from other pavements with dividing bands. Water harvesting depends entirely on perceptible and interesting cisterns and flow routes.

Also on the left are downspouts and scuppers which convey roof water down. Although they are small details in urban design and are conventionally mundane, some have been made into intriguing artworks, including 'rain chains', planted channels, and twisted and articulated sculptures.

Rain gardens rise the highest on Fig. 4's vertical axis. Rain gardens use a layer of permeable soil to combine water restoration with plant growth; they are sometimes called bioretention. In this paper the name 'rain garden' is preferred because it implies the multiple roles of collection of rainwater, support of living plants, and arrangement for human accommodation. Rain gardens tend to be built into small pockets of space amid the source area's streets and sidewalks, like those in Fig. 5. In these locations spatial organization is rigorous: the rain gardens' outlines are fixed by the geometry of street curbs and walkway edges. Their spatial constraints seldom permit their connecting flow routes to be visible. But many have been built with architectural edges, visible inlets for street runoff, and very distinctive vegetation; they are readable and attractive features in close contact with people.

Rain gardens decline in contribution to place where their design subdues their perceptibility. For example at the Buckman Heights apartments in Portland, Oregon, old-fashioned hedges and shrubby plantings were used to hide bioretention stormwater flows so the small outdoor space would seem safe for young families with children [16]. One could question whether the place would be more diverse, interesting, and successful even for young families if the bringing in of runoff were somehow articulated, and whether there could be a way to articulate it without seeming to endanger young children.

Fig. 5 Rain garden in Portland, Oregon

B. Facilities in Perimeter Area

In the perimeter area are channels and swales, draining water away from source areas while in some cases giving treatment and infiltration. Open, grassy, but unarticulated swales are common in American low-density residential developments. Their drainage routes' continuity is readily apparent, but their ambiguous edges, indistinctive vegetation,

and homogeneity limit their readability and interest.

More demonstrative swales were given to the Village Homes residential community in Davis, California [17], [18]. Swales and public footpaths occupy narrow open-space corridors between groups of homes; people are in routine contact with them. The residents in each group of homes installed and maintain diverse plantings and surfaces in the swales and open spaces.

It is difficult for most swales to rise as high as rain gardens in contribution to place because of their peripheral location. A swale that is unusually integrated with the source area is at Springhill Housing in Stroud, UK (Fig. 6). The planted stormwater-treatment 'rills' are tightly located between the residences and public paths; seating faces from them into the public space. The rills frame the houses, reinforce the distinction between private and public, and contribute to the interesting character of the walkway.

Culverts are alternatives to swales for their conveyance function. Since they are buried and hidden, they contribute nothing to place. With them in that low status are their various inlets, filters, and inserts. Culverted streams have been 'daylighted' to bring their flows into interaction with the people and ecology of the surface [19]. For example at Strawberry Creek Park in Berkeley, California, the culvert under a former railroad yard was daylighted as the place was converted into a neighborhood park, bringing ecological health, perceptibility, and recreation.

Fig. 6 Planted 'rill' at Springhill Housing, Stroud, UK (c/o Robert Bray)

Also in the perimeter are stormwater basins, ponds, and wetlands. Many detention and treatment basins in the US have been designed only to satisfy technical requirements: located in low corners of sites, excavated into pits, and often isolated with fences, giving them low positions in Fig. 4. Ponds and wetlands higher on Fig. 4's vertical scale are laid out for perception by people. One at the Orange County Convention Center, Florida is located adjacent to the building's main entranceway, where it is highly visible to convention goers (Fig. 7). It is articulated with native plants, an architectural weir, and aeration fountains.

Fig. 7 Stormwater basin at Orange County Civic and Convention, Center, Kissimmee, Florida

Another demonstrative pond is at University Center, Charlotte, North Carolina (Fig. 8). It is located at the center of a commercial area, where it is lined with a wide walkway connecting large commercial buildings, and articulated with aeration fountains, trees, and furnishings. The most successful shops in this development are on the other side of the buildings, where they are supported by direct parking access. The highly structured pond space serves as a well equipped and moderately successful urban park.

Fig. 8 University Center, Charlotte, North Carolina

Surface filters are alternatives to ponds and wetlands in their treatment functions. They are very difficult to make into attractive spaces; they tend to be isolated from occupied places. Fig. 4 gives them as low a place as culverts.

C. Facilities Downstream

At the far right of Fig. 4 are downstream floodways. Many floodways near built-up districts are confined structural channels such as that of the Los Angeles River, allowing little

contribution to place. In recent years proposals have been made to reclaim confined channels to give them more ecological diversity and public visibility.

Other floodways have been set aside in parks. Philadelphia's Wissahickon Creek is surrounded by the wooded Fairmont Park. In Scottsdale and Tempe, Arizona, the Indian Bend Wash floodway is developed with golf courses and ball fields. Many cities are reclaiming formerly industrial riversides with waterfront parks.

An unusually active and successful articulation of a floodway's human values is in San Antonio, Texas. In the 1930s it was decided that an arm of the San Antonio River would not be culverted to make land for a new street, and instead would be developed for human use and comfort. The river corridor is now a very successful commercial area. Its narrowness has allowed pedestrian architecture to connect from side to side of the river and up to surface streets; its central location has brought numerous mutually reinforcing commercial and hotel developments.

V. Conclusion

Different types of stormwater facilities have different locations in and around urban spaces, and different potentials for human interaction. Selection and design have the ability to articulate water and its associations so it contributes to place. This reconciliation of human and water values in urban spaces allows urban spaces to be more successful on the whole.

Placing water's contribution under the overall idea of successful urban space is an evolution from the stormwater amenity evaluation presented by Echols and Pennypacker [1]. They evaluated amenity subjectively in terms of 'mainstream Western aesthetics', with positive projects pointed out by professional design awards and notice by design practitioners. In contrast, this paper uses success of urban space as the evaluative criterion, with positive projects pointed out by spaces that are, or have provision to be, safely and actively used. Cities are defined by their people, and the success of an urban place is its safe, active use. Human values call on stormwater facilities to contribute to successful human spaces. Amenity – the attractiveness and value of a place – is embedded in urban design. Rainwater's amenity is only part of the Whyte-Gehl program for successful urban space. In this role water is a place resource like others that are familiar in urban design: artworks, movement of people through a space, heritage landmarks, and natural things such as trees and flowers. Putting amenity in the context of city values gives a basis for properly integrated design.

Integral design seeks to raise stormwater management on Fig. 4's vertical axis by choosing types of facilities with high potential, and making design choices that give them articulation and readability. The ability to implement such choices depends on the constraints of their specific locations including closeness of people and availability of pockets of space. Integral design is characterized by tight spatial organization, close human contact, and evident placement under human care. Integral design makes a place as a whole more complex, multi-functional, and interesting. With integrated drainage, specialized stormwater and human-oriented facilities become less important; in their places are dual-function, dual-value facilities and spaces which demand multi-disciplinary application.

References

[1] S. Echols, and E. Pennypacker, From Stormwater Management to Artful Rainwater Design, *Landscape Journal* vol. 27, no. 2, pp 268-290, 2008.
[2] CIRIA, *Sustainable Urban Drainage Systems: Best Practice Manual*, Report C523, London: Construction Industry Research and Information Association, 2001.
[3] P. Stahre, *Blue-Green Fingerprints in the City of Malmo, Sweden*, Malmo: VA SYD, 2008.
[4] J. J. Macionis and V. N. Parillo, *Cities and Urban Life*, 4th edition, Upper Saddle River: Pearson Prentice Hall, 2007.
[5] E. Glaeser, Edward, *Triumph of the City*, New York: Penguin, 2011.
[6] J. Jacobs, *The Death and Life of Great American Cities*, New York: Random House, 1961.
[7] T. N. Debo and A. J. Reese, *Municipal Stormwater Management*, 2nd ed., Boca Raton: CRC Press, 2003.
[8] Water Environment Federation, *Design of Urban Stormwater Controls*, WEF Manual of Practice No. 23 and ASCE/EWRI Manuals and Reports on Engineering Practice No. 87, New York: McGraw-Hill, 2012.
[9] Design Workshop, *Toward Legacy*, Denver: Design Workshop, 2007.
[10] J. Gehl, *Cities for People*, Washington: Island Press, 2010
[11] W. H. Whyte, *City: Rediscovering the Center*, New York: Doubleday, 1988.
[12] R. Florida, *Who's Your City?*, New York: Basic Books, 2008.
[13] R. H. Matsuoka and R. Kaplan, People Needs in the Urban Landscape, *Landscape and Urban Planning* vol. 84, pp. 7-19, 2008.
[14] P. von Meiss, *Elements of Architecture: From Form to Place*, New York: Van Nostrand Reinhold, 1990.
[15] H. Dreiseitl and D. Grau, *New Waterscapes: Planning, Building and Designing with Water*, Basel: Birkhauser, 2005.
[16] T. Liptan and R. K. Murase, Water Gardens as Stormwater Infrastructure (Portland, Oregon), in *Handbook of Water Sensitive Planning and Design*, R. L. France editor, Boca Raton: CRC Press, 2002.
[17] M. Corbett, *A Better Place to Live*, Emmaus: Rodale Press, 1981.
[18] R. L. Thayer Jr. and T. Westbrook, Open Drainage Systems for Residential Communities, in *Water, Proceedings of the 1989 Conference of Council of Educators in Landscape Architecture*, Washington: Landscape Architecture Foundation, 1990, pp. 152-160.
[19] R. Pinkham, *Daylighting: New Life for Buried Streams*, Old Snowmass: Rocky Mountain Institute, 2000.

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