Elastic Boundaries

WILLIAM H. SHERMAN
University of Virgina

CASE STUDY: THE INEVITABLE FLOW OF WATER

As one of the many issues to be represented in the design process, the flow of water is critical due to the number of ways and scales in which it affects design. From the detailing of a material joint to the building siting and planting strategies, the design of a building is inseparable from an intention with regard to water flows. Since water is also the lifeblood of entire ecosystems at both local and regional scales, the effect of design decisions is cumulative and potentially destructive. Without attention to the behavior of water on a site, the design decisions may turn the water flow into a toxic current, transform natural cycles into catastrophic events and contribute to a gradual degradation of the ecosystem downstream. These issues become particularly pressing in the construction of the contemporary city, both because of the scale of land area being developed in short periods of time and because the inherent low density may allow alternatives to the strategies currently in place. This research is not predicated on the architectural ideal of nineteenth century metropolitan urbanism, but may be applicable to the urban fragments of edge cities, the sub-urbs and ex-urbs of contemporary development and most appropriately, the quasi-institutional scale and nature of corporate land strategies.

A renewed concern for hydrology as a design issue was argued by Ian McHarg in Design *with Nature,* and developed in the 1960's in such projects as The Woodlands, Texas by McHarg, Wallace, Roberts and Todd. It is interesting that such a project has had so little impact within the discipline of architecture, in large part because it has no form that architects can readily recognize. This is perhaps deliberate, given McHarg's dismissal of the products of Western culture, the discipline of architecture and culturally-rooted patterns of urban form. But just as the Woodlands could have benefited from a formal self-consciousness that architecture might provide, architecture could benefit from an environmental self-consciousness pioneered by McHarg. Hydrologically intelligent design has been pursued around the edges of architectural culture ever since and will remain on the fringes of architecture as long as it remains formless. Currently, the "analysis worlds" of architecture and environmental design are separated by a visual gulf. Neither can literally see the concerns of the other. This research represents the beginning of an attempt to bridge this gulf by developing a common visual tool.

THE TELOS OF TOOLS

Every tool reveals an ideological bias as well as a philosophical understanding of the world. The tools used to develop the industrial and metropolitan cities were predicated on an ideal condition of stability. The Enlightenment notion of a balance of nature served the aspirations of the networked city well. It provided the philosophical foundation for the professionalization of engineering in the eighteenth and nineteenth centuries, which in turn designed the artificial balance of the modem infrastructure. In practice, this leads to design as a form of control, in which, for water, the presumed certainty of a pipe is favored over the unpredictability of nature. The effect is to relocate the "problem" to a facility where it may be controlled. The resultant accumulation of previously decentralized phenomena, when combined with the acceleration of flow and the reduction of natural filtration, create a negative economy of scale. Just as toxicity is a function of dosage, the difference between a beneficial rain and a cataclysmic event is a question of concentration. The intention of engineered infrastructures to ensure stability in effect increases the potential for catastrophe. A strong but brittle structure, it is unable to stretch.

As recurrent uncontrollable events bear out, the premise of a balanced state is increasingly untenable. As the sciences explore the implications of this insight with new techniques for modeling the world, the entire culture of urban production, architecture included, clings to ideals of stability, bound by the demands of contemporary programs and the inherent fragility of the networked city. The assumption underlying this research is that nature is fundamentally unstable and that the challenge of design is not to achieve stability but to take advantage of the inherent dynamism.

THE PARAMETERS OF HYDROLOGY

This research investigates and represents the parameters which influence hydrologic structure of a site. In order to understand the downstream impact of design decisions, one must consider a range of factors, including absorption, impedance, detention, evaporation, and evapotranspiration. Each affects the ability of the site to respond elastically to the varying volumes of water which may fall on or flow through it. Every site manipulation, building material and plant specification alters these parameters. No site is a "pure" natural condition; the hydrologic cycle is a composite of constantly changing natural and constructed elements. The parameters, then, are inclusive and do not presume an ideal state of nature. They instead record the degree to which construction changes the hydrologic elasticity of a site as found, including both the built and natural preconditions. Thus roads, buildings, storm sewers and imported vegetation have already altered the boundaries of hydrologically linked terrain, and must be factored into any strategy. The partial restoration of a natural condition, in effect based on the unfulfillable desire for complete restoration, may do more harm than good. The reality of the context would have to be idealized; a stable natural state would have to be assumed. The challenge is to graphically represent a degree of difference, much as an economist studies the marginal shifts in figures rather than focusing on the absolute size of a number.

A critical factor in hydrology which serves as an initial example is the ability of a site to absorb water. A low absorption rate implies a higher volume of runoff, with natural and infrastructural consequences, both in terms of volume and toxicity of the water. The variables which affect absorption include the permeability of the soil or surface and the rate of flow, a function of the slope of the land as well as the impedance provided by vegetation or constructed obstacles. Both permeability and rate of flow imply a relationship between volume and time, the fundamental variables of natural dynamic cycles.

The typical consequence of building is the division of the land into permeable and impermeable areas. If the permeable surfaces are not reconstructed to compensate for the increased impermeable area, there is a net increase in the magnitude of the unabsorbed runoff. Given the scale of contemporary construction both with respect to building footprints and paved areas, vast areas of impermeable surfaces demand like-scaled infrastructures. One can imagine the existing condition as a duality, not unlike a figure/ground diagram, constructing a pattern of permeable and impermeable surfaces, with an unseen infrastructure (or the degradation of pre-existing conditions) to compensate for what is unrepresented. In visual terms, the graphic intention of the tools is to convert the diagram from a black and white duality to a gray scale in which the conditions of impermeability would be readily apparent. Existing absorptive site conditions would take on a visible form; inelastic conditions would be equally apparent. The groundwork is then laid for modifying the design to increase the overall elasticity, designing the form of that which is to be built with an understanding of the structure of that which exists.

THE UNIVERSITY OF VIRGINIA AND THE NORTH SLOPE OF CARR'S HILL

The case study under consideration is the grounds of the University of Virginia with a focus on the north slope of Carr's Hill, the site of the School of Architecture (figure 1). This research is being executed in a collaboration initiated by Kathy Poole, Assistant Professor of Landscape Architecture and with Shaw Yu, Assistant Professor of Civil Engineering.

Carr's Hill is part of a ridge on which Thomas Jefferson designed the original Academical Village. The north slope lay beyond the scope of the University's interest until the twentieth century. Over the long history of the site, the construction of roads, storm sewers and increasingly large-scaled buildings has modified the hydrology beyond natural recognition. It is now entirely dependent on a patchwork of engineered solutions. There is clear evidence of being a contributor to downstream site degradation as one small component of the nested watersheds leading to the Rivanna

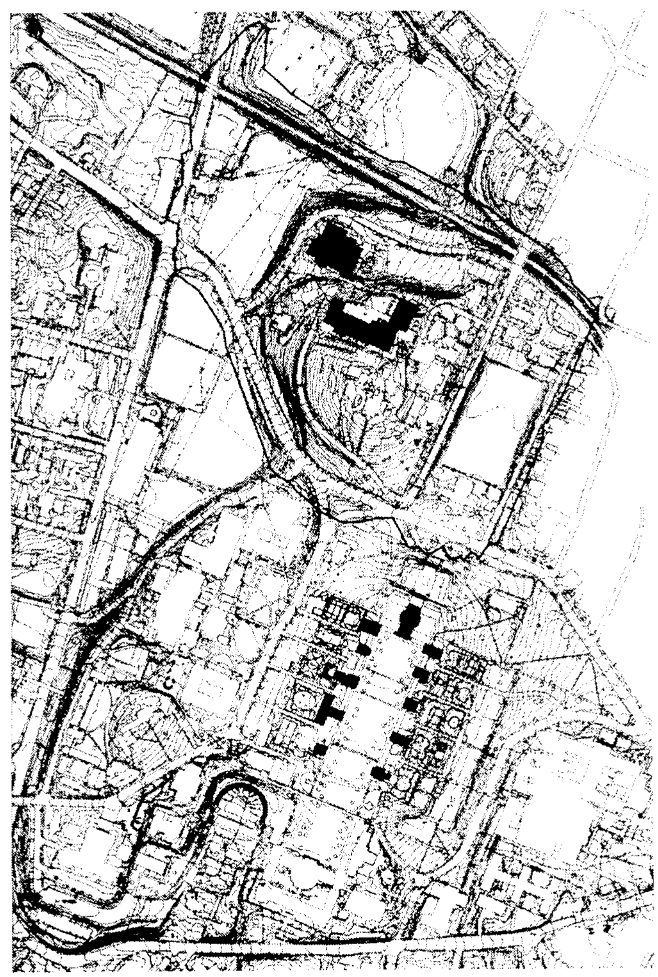

Fig. 1. The Academical Village and Carr's Hill, University of Virginia Grounds

River and ultimately the Chesapeake Bay. Though small in scale, the issues it faces are typical of contemporary construction.

The hydrological intelligence of Jefferson's original Academical Village, accommodating storm water on the surface with a reliance on reservoirs now filled and watersheds now piped, could be seen as an extension of the Jeffersonian philosophy of minimizing infrastructure through the decentralized assumption of individual responsibility. Here the concept of the elastic site may be mapped not only in hydrologic terms, but in social, political and spatial terms as well. The conception of the Academical Village as an urban model was overwhelmed by industrialized urbanization in the nineteenth century. Its current usefulness as a formal model is diminished by its remoteness from the scale of contemporary building programs, supporting services and cultural expectations, but the lessons of decentralization and individual responsibility, if not the form, are transferable.

Unfortunately, the area under study was not as well conceived. As is typical in contemporary construction, the site includes large impermeable roof plates and paved areas, minimal landscape development (primarily in service of building access), evidence of erosion and toxic runoff, and the complete reliance on an engineered infrastructure with significant off-site ramifications. Our intent is to visualize in a comprehensive way the existing conditions, allowing the effect of site modifications through new construction to register in the reconception of the site. Rather than make a design proposal, however, the first goal is to see the site as it exists.

There are several components of the analysis within this study. One attempts to qualitatively show the formal structures which impact the hydrologic cycle. Another attempts to quantify changes in hydrologic elasticity by redefining the planning units of the University in terms of hydrologically determined precincts. **A** third component investigates the technology of both building and landscape strategies that expand the elastic range of the site. A fourth maps the landscape to reveal connections to regional ecological structures. This paper focuses on the first component, using the newly developed visual tools to identify a possible alternate relationship between the architecture and the land.

In order to map the structure of absorption on the site, twenty four increments of absorption were assigned values on a gray scale from total impermeability (white) to absolute permeability (black). It shows the range from conditions which absorb slowly (if at all) and release quickly to those which absorb quickly and release slowly. The variables include slope, soil type, vegetation, aspect (orientation to the sun), and building materials.

In the preliminary example which serves to illustrate the potential of the tool, a series of computer-generated maps record a number of these parameters. The slope diagram (figure 2), generated from a three-dimensional computer model shows a gray scale corresponding to the degree of slope. Building footprints are added to the slope layer, resulting in a drawing similar to a reverse figure/ground, but including topographic information within a similar graphic convention. The addition of roads, walks and parking lots (figure 3) allows the description of the site in hydrologic terms. The conventional boundaries, walls, property divi-

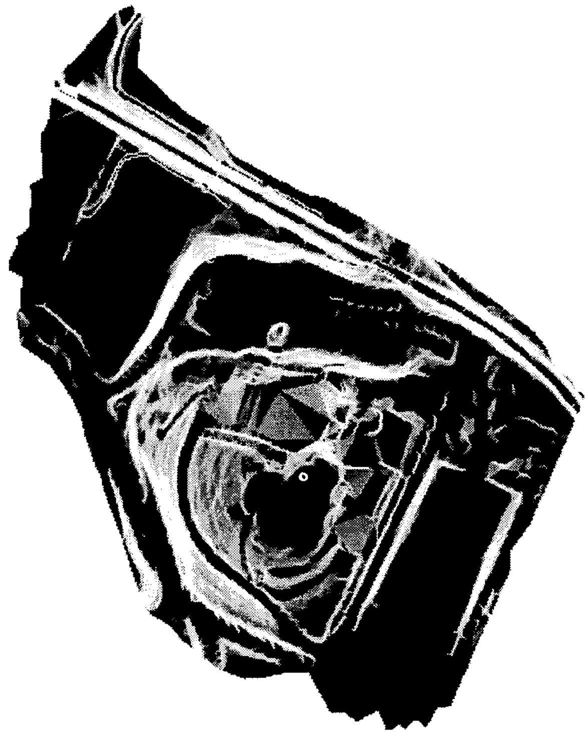

Fig. 2. Absorption Study: Slope

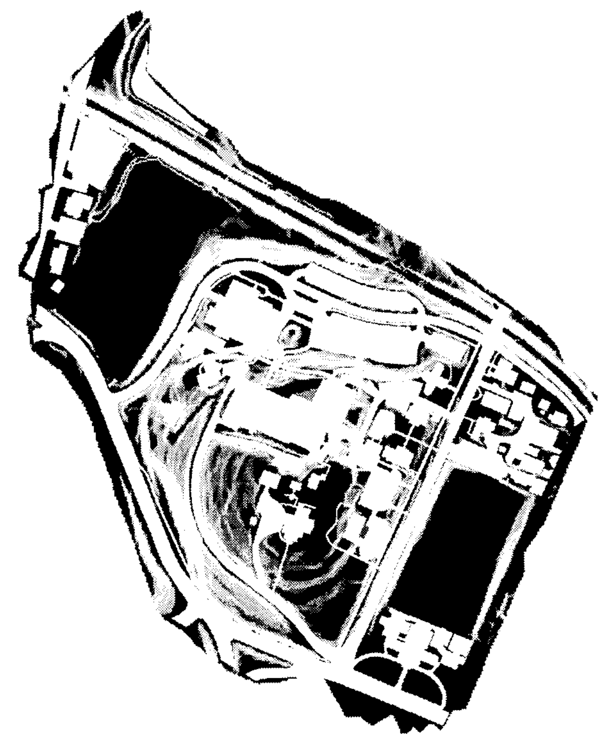

Fig. 3. Absorption Study: Slope, Buildings, Roads, Walks and Parking Lots

sions and building mass are subordinated to the properties of the surface.

In a map thus generated from existing conditions, the impermeable surfaces of roofs, roads and parking areas are clearly visible, approaching the contrasts of a reverse figure/ground diagram. But the structure of areas of absorption is also apparent within the gray scale. With this information graphically presented, the diagram suggests possibilities for increasing the site elasticity in such a way that it expands the coherence of absorptive structures already in place. This is important, because it allows the establishment of priorities for effective redesign and also takes into account that there is a correspondence between hydrologically elastic conditions and the potential for an ecologically healthy structuring of the site.

As a simple example of the possibilities of the diagram, the second version (figure 4) has assumed the substitution of absorptive technologies in paved and roofed areas. The immediate impression of a lessened contrast and tonal shift from white to gray (away from impermeability) is a visual indicator of both heightened elasticity and the possibility of visualizing new absorptive structures. The original figure/ground contrast which drew rigid boundaries between the built and the "natural" has given way to a more ambiguous condition in which the boundary itself becomes elastic. This is the heart of the concept: the boundaries would be redefined as fields of hydrologic affinities rather than programmatic function. Areas which can absorb and hold water cross over

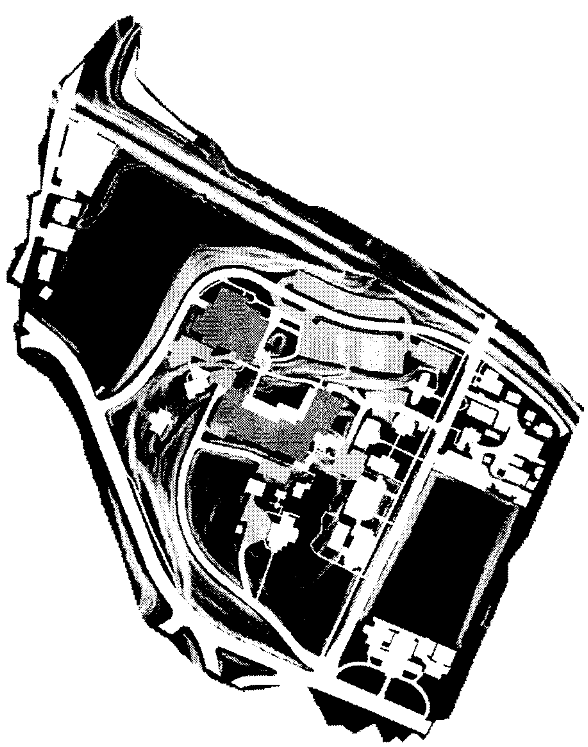

Fig. 4. Absorption Study (Potential): Slope, Buildings, Roads, Walks and Parking Lots, with gray scale indicating altered absorption rates

the boundaries of use and enclosure. In section and plan, there is an opportunity for spaces which behave as sponges, which support diverse plant life, which extend the revealed ecological structures. The diagram is a vehicle for conceiving of construction in concert with, rather than in contrast to, the dynamic existing conditions.

As these techniques prove useful at the site scale, they are equally instructive at the scale of the university grounds, city or county jurisdictions. The concept of the elastic boundary is transferable across scales, and provides a way of seeing the gaps in a larger ecological structure or of evaluating local concerns in increasingly larger contexts.

This research represents an attempt to develop the tools to visualize dynamic forces in terms that allow them to be credible catalysts for design proposals, whether at the urban scale or at the scale of the individual building. It is based on the idea that verbal and quantitative descriptions of a condition are insufficient without a means to translate intentions into form. If architecture is to establish a new relationship to the dynamic forces of nature, the use of readily accessible tools to describe the salient variables must be part of the architect's process.

STABILITY IN A DYNAMIC LANDSCAPE

While the act of construction is often described by architects in philosophical, social or political terms, on a physical level it is the stabilization of a fundamentally dynamic natural condition to provide a stable setting for the activities characteristic of a culture. The dynamic vicissitudes range from the time scale of the geological, to the growth of vegetation, the decay of building materials, the fluctuation of climatic conditions — temperature, humidity and wind velocity — and the flow of water, both above and below the ground. To occupy the land is to alter it, for better or worse. The history of architecture is a record of the development of the technologies of stability without regard to consequences. This is either because the scale of effect was so marginal that stabilization was a process without apparent impact or, as density increased, a highly engineered infrastructure was developed to deal (or not deal) with the results. In industrialized cultures, as well as in dense or continuous occupations of the land, profound natural consequences are unavoidable, and in many senses magnified by the reliance on the engineered infrastructure.

The modem infrastructure, a nineteenth-century development in response to the density of the industrial city, has attained an autonomous status as an assumed precondition for development. This assumption may not be valid in the contemporary city, characterized by a lower density of development. In addition, technological advances allow alternatives to the centralized infrastructure, often a possibility but usually an unexplored opportunity in the post-industrial city. With cities now being developed in large parcels by corporate landholders who are creating this infrastructure, the regional result is a patchwork of potentially unnecessary engineering solutions, conceived without a coherent understanding of the incremental effects. This lack of coherence may even be the case within the terrain of a single institution such as a university.

VISUALIZING THE POTENTIAL OF THE CONTEMPORARY CITY

A philosophical shift would invert the modern reliance on engineered infrastructures by considering them the solutions of last resort rather than the precondition of construction. This relocates the burden of collective responsibility from a largely invisible, though costly, common infrastructure to each individual participant in the construction of the city. The proposed tools allow an overlay of the implicit boundaries of the city -- property lines, building envelopes, the edges of paving, etc. -- with the gray zones of the elastic mapping. One may then identify the places where a more elastic boundary is possible, reducing the need for infrastructural solutions resulting from the construction of unforgiving edges. Infrastructure would then be reconceived to include design strategies at the source, avoiding the typical infrastructural concentration of consequences.

The opportunity for the architect is to seize upon this possibility and program the inevitable open spaces which result and develop the spatial potential implied by elastic edges and walls. In the end, hydrology is but one dynamic factor among many, from the scale of geologic forces to the movement and temperature of air. As with the resolution of structural forces, which can either be accomplished by appropriate geometries or selection of material, there is a resultant spatial impact which offers an extraordinary opportunity for building and urban form. For architects, there is an obligation to fulfill an essential role in imagining the form of the contemporary city in such a way that it sustains the natural cycles, rather than expanding the swath of destruction. The intention here is to turn the process of physical decentralization of the city into a constructive rather than destructive process with respect to nature. The graphic tools allow the qualities which make a condition successful or problematic to be more readily understood: a visual means of evaluating the fit between the building and the land.

The challenge is immense, however, because major factor in the construction of the contemporary city is in direct opposition to the dynamic properties of nature. The development of land is according to the abstract and arbitrary boundaries of land ownership and the laws protecting property rights. By acknowledging this fact, rather than dreaming of the end of capitalism, as theorists are wont to do, the architect can turn this obstacle into a defining issue of professional responsibility. Such a clearly defined contribution by this profession to the construction of the contemporary city is sorely lacking. If the tools of the architect remain autonomously formal with respect to architecture, the architect's present irrelevance in the production of the city will only accelerated to the status of urban decorator. If the architect serves only the client's private interest, there is no other professional directly engaged in production with the institutional credibility to represent the public interest. If, however, the architect's responsibility is to public values including the understanding of site ecologies, values which are not inherent in the institutions of contemporary urban construction, then the discipline needs to develop new ways of representing those values. As a culture, we only value what we can see.