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Infradependency:

Sanitation Standards and the Shaping of Cities

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Infradependency:

Sanitation Standards and the Shaping of Cities

We can discover a difficulty in rightly judging the works of a city in the fact that innovations or changes are frequently resisted by those in charge either from a force of habit adhering to old customs or from the inconvenience of altering existing laws.

Rudolph Hering 1881 (in *Report of the Results of an Examination Made in 1880 of Sewerage Works in Europe*)

The Power of Standards

Cities are shaped by standards and codes that virtually dictate all aspects of urban form. Simple standards for subdividing land, grading, laying streets and utilities, configuring rights -of-way and street widths, may seem harmless, but because they have been copied and adopted from one place to another across lands they have an enormous impact on the way our cities look, feel, and work. Today's standards represent the sum of decades of rules designed to promote particular practices. Because so much has been built according to these dictates the accumulated rules now have the force of universal acceptance. Treated as if they have some kind of biological significance, standards have become the definers and promoters of places, the genetic code of urban development.

Many institutions and practices converge to give established standards their reach and power. Methodical administration of public works, the centralized supervision over land development, and the rise of the various engineering and urban planning professions have established design standards as absolutes. Local governments have often automatically adopted and legitimized such standards to shield themselves from lawsuits and from responsibility in decision making. Financial institutions and lenders have also been hesitant to support a proposal outside the mainstream, particularly when it does not conform to established design practices. With the crafting of exact rules and standards, regulatory bodies can predictably shape development, even though the actual results may be less desirable than a variable approach.

Obviously, standards can assure a level of quality in performance as do many plans and construction standards designed to protect our health and safety. The problem arises when standards intended for health and safety overstep their bounds and lose grounding in the objective measures of their benefit or break the connection with the original rationale for their existence. This disconnect has overtaken many standards and regulations today because they have failed to be responsive to their negative impacts on the environment. The net effect is one of a dynamic planning enterprise frustrated by its inability to carry through innovation in the form of alternative development proposals that violate existing standards yet may be of great service in creating desirable communities.

Inherent Problems

Three important trends can be seen as crucial in forming our collective understanding about the impacts of standards and codes on urban development and the need for change:

- the global dispersion of uniform formulas and standards,
- deficient urban patterns appearing in the forms of sprawl,
- insufficient responses by regulatory agencies despite numerous calls for reforms.

With the high rates of growth and the expansion of the metropolitan fringe, concern over the adverse impacts of development continues to mount. Debate over the nature and type of growth has taken central stage in both the professional and political arena. Whatever position the various debaters have taken, almost all agree that the current forms of land-use regulations and their related codes are archaic and inadequate. At base the trouble lies in the poor connection between land-use regulation systems and physical design. The rational for regulating development based on the separation of uses as devised by the standard zoning enabling act, does not address physical design beyond rudimentary dimensional requirements.[i]

The American model, adopted and applied in many places around the globe focuses on individual cases and parcels, and neglects to address broader contextual issues. This type of model forces idiosyncratic rules, which it seeks to make uniform by the application of generic dimensional standards such as lot configurations and building set-backs.

Calls for regulatory reforms have been as numerous as the various overlay zoning layers and ordinances. Dominating the discussions, and the calls for change, has been the critique of standards associated with housing affordability. Numerous federal commissions, state committees, and private studies indicate that the typical regulatory envelope discourages efficiency, is costly, and increases housing costs. As recently as 2003 a study by the Pioneer Institute for Public Policy Research and the Rappaport Institute for Greater Boston concludes that in Massachusetts "Excessive regulation by agencies and boards at both the state and local level has gotten to the point of frustrating the development of housing in Massachusetts. Both level of government need to prune back the sprawling regulations and improve coordination among the different regulatory player" (Euchner 2003, 42). Another statement by the US Advisory Commission on Regulatory Barriers to Affordable Housing declares that: "The cost of housing is being driven up by in increasingly expensive and time-consuming permit approval process, by exclusionary zoning, and by well intentioned laws aimed at protecting the environment and other features of modern-day life." (in Luger, and Temki, 2000, xiii)[ii]

Challenges to regulatory barriers have not escaped the international arena. Of particular interest is the attempt in reforming standards associated with international lending institution, such as the World Bank, and creating reforms in practices such as slum upgrading. Reformers such as Gakenheimer and Brando (1987), Dowall (1992), Rivera, (1996), Angel (2000), and Yahya et al. (2001), have repeatedly challenged existing practices where countries strive for standards that were a part of their colonial legacy, or for standards that are imported at face value from the industrialized nations.

These authors conclude that the key to solving the problem of urban shelters lies in the relaxation of existing standards and regulations. They show that in many instances existing standards often impair livelihood by not allowing the incorporation of alternative building materials such as building with soil or not allowing for incremental construction. According to a recent study, less than half of the urban population in developing countries can afford to build according to the prevailing standards (Yahya et al. 2001,1).

Attempts to reshape development standards are also thwarted by engineering standards and procedures. The impacts can be seen in the administration of street layouts and widths, as well as in grading and drainage practices. One of the most troublesome stages in the site development process involves the clearing of vegetative cover and mechanical grading. The use and attributes of the heavy equipment, and the desire to cut costs by executing massive grading, often result in complete alteration of the landscape and degraded environmental conditions. (Figure 2) Local governments have generally recognized the consequences of such practices and many have adopted standards of practice for this development phase. These typically include restrictions on clearing steep slopes, requirements to install sediment controls, and requirements to revegetate exposed soils or protect existing trees. Yet as shown by Corish (1995) these regulations are not only poorly implemented and enforced, they are seldom revisited, revised or amended.

Codes and standards associated with subdivision development have also resulted in urban form characterized by excessive impervious surfaces and piped drainage systems. A joint study by the American Rivers, the Natural Resources Defense Council, and Smart Growth America shows that this type of development increases runoff while decreasing the supply of portable water. Wide streets, excessive parking requirements and increased pavements around setbacks contribute to loss of potential infiltration.[iii] Subdivisions sewerage collection system standards are also so entrenched and widely accepted that alternative planning, sizing and location of the systems is seldom considered. As early as 1967, the Urban Land Institute warned that "the basic parameters for sanitary sewer design were set at the turn of the century and, for the most part, have remained unquestioned since that time. Sewerage collection systems today are designed almost by rote, picking values off charts and conforming to standards which were in existence before the present generation of engineers were born."[iv] In the book *Land Use and the Pipe* Richard Tabors further suggests that planners in particular feel inadequate in challenging proposals put forward to them because of perceived lack of expertise, and a general attitude of not being able to address engineering criteria and parameters.[v] The lack of public interest and knowledge in the manner or methods of sewerage has both perpetuated old methods and served well officials and their technicians. This view is acknowledged by the International City Managers Association: "One hears often of local situations in which the people reject the financing of a new city hall or a new central plaza in favor of an expenditure for improved sewage system. It is rather fortunate in this connection that the people ask only for results, for this gives a freedom of action to the administrator and the technician."[vi]

Indeed, in the next 20 years, American communities will spend over $1 trillion to upgrade and build new wastewater infrastructure. While U.S. Federal assistance programs will provide 15 percent of the funding for metropolitan area wastewater treatment projects, it is the local communities who must provide the major share of funding for these projects.[vii]

Such spending are not confined only to the U.S. In 2003 the World Bank granted loans for water, sanitation and flood prevention projects in excess of $1.3 billion, compared with $546 million in the previous fiscal year.[viii] While infrastructure shortfall can be attributed to various factors, such as aging pipes and inadequate treatment facilities, the questions to be asked are: Will the upgraded systems be any better? Will they be more appropriate to a changing world where groundwater shortage looms, fresh water resources decline, and sustainability is vital? Or will the upgraded systems rely on entrenched practices and technologies that are outdated and inappropriate, rather than seeking new alternatives?

For over a century engineers have chosen sewer removal and treatment solutions from a small range of wasteful technologies. All are based on water as the carrying agent for the waste and dependent on thousands of treatment and collection facilities and millions of miles of pipes and conduits. Poet Wendell Berry vividly describes this illogical situation as follows: "If I urinated and defecated into a pitcher of drinking water and then proceeded to quench my thirst from the pitcher, I would undoubtedly be considered crazy. If I invented an expensive technology to put my urine and feces into my drinking water, and then invented another expensive (and undependable) technology to make the same water fit to drink, I might be thought even crazier. It is not inconceivable that some psychiatrist would ask me knowingly why I wanted to mess up my drinking water in the first place."[ix]

Consider, for example, that in households not yet utilizing water-efficient fixtures, toilets use the largest fraction of family's consumption --20 gallons per person per day.[x] This figure means that one person contaminates about 7,300 gallons of fresh water to move a mere 165 gallons of body waste each year. It also means that we destroy a valuable resource for fertilizer by mixing it together with water, and making it just about useless.

Even more troubling are indications that such practices are being adopted and encouraged in countries which have long, sustainable traditions in recycling human waste. China, for example, has a long tradition of ecologically sound wastewater recycling in multi-level biological systems based on aquaculture. Yet, during the current development process, and with the encouragement of international experts who are advocating state of the art solutions, these practices have been stigmatized as old fashioned. Villages and towns are encouraged to abandon them. Instead of the former methods, over 2,000 medium to large treatment plants based on typical waste removal technology will be constructed in the near future. [xi]

Do these systems represent the best solution available? Or are these engineering practices, and the planning apparatus that support them, operating within an outdated technological paradigm? They seem to represent the anomaly of societies held captive to an existing technology in a world marked by voluntary decisions and pluralistic processes.

The paradigm of sewer infrastructure shows that dependencies on past decisions prevent the application of alternative technologies. Historical decisions about the methods and systems for sewerage collection have locked our current practice into a specific mode of operation. Such a situation means that ecologically appropriate alternatives are rarely advanced as options before decision-makers and therefore cannot gain wide acceptance.

The Sewer Infrastructure Paradigm

By means of a chain of past decisions we have established services of regiments for managing our settlements, our land and our water in ways that now prove to be an obstacle to our well being.

Economists and political scientists often attribute dependency of present actions on past decisions in explaining certain equilibria in technological development. Brian Arthur, for example, applied a Polya process, a mathematical example introduced by Polya and Eggenberger in1923, to demonstrate that random disturbances early in the history of selection, coupled with the self-reinforcing nature of these selections, shape subsequent outcomes.[xii] Termed "path-dependence," this theory suggests that current equilibria, such as the state of technological development, industry location, or a firm's organization, is a function of early random shocks in the decision process that led to the equilibrium.[xiii]

S.J Liebowitz and Stephen Margolis defined three distinct forms of processes that exhibit dependence on initial conditions. In the first form, initial actions create a path that cannot be left without a cost; however, the path proves to be optimal and the costs are being acknowledged. For example, a decision to use a particular type of an aircraft may have a controlling influence for decades on an airline's fleet, but the long-term effects of the decision are fully understood and taken into account by the initial decision-makers. In situations where the initial information is imperfect, decisions may not always appear to be efficient in retrospect. Under such second form situations, the deficiency of the chosen path is initially unknown but is later recognized when the initial decision leads to regrettable outcomes and costly changes. In third-degree path dependence, initial conditions lead to an outcome that is inefficient, even though feasible options for modifications and improvements exist.[xiv]

Path dependence theory has generated a lively debate in many circles. These include, among others, the discussions about the QWERTY keyboard layout, the use of VHS or Betamax video formats, and the utilization of Microsoft's Windows system in operating personal computers.

Arthur traces the decision of video formats and explains that dependency was created as a result of positive feedback in the video film rental market. Video rental stores stocked more film titles for the system with a larger user base, and new providers chose the system for which they could rent more videos.[xv]

Robin Cowan argues that political decisions have been the principle source of path dependence in the adoption of nuclear power techniques. He argues that the dominant "light-water" reactor design is inherently less efficient than potential alternatives, but it was rushed into use because the Cold-War political value of peaceful uses for nuclear technology overrode the value of finding the most cost-effective technique. Thereafter, engineering experience for the light-water technique continued to make it the rational choice for new reactors over less well developed alternative designs, despite the fact that equal development of the alternatives might have made them superior. The principle U.S. suppliers and sponsors of light-water reactors, Westinghouse and General Electric, offered early systems at prices below cost in order to gain experience and offer improved systems to later users at higher prices.[xvi]

The archetypal case of path dependence has been, of course, the configuration of the typewriter keyboard. Paul David, for example, argues that the standard "qwerty" keyboard arrangement was dramatically inferior to other arrangements offered at the time. Since qwerty was the prevailing standard and most people learned

on that equipment other layouts such as the "Ideal" keyboard (1880), and the Dvorak keyboard (1932), were never able to be introduced into the market place.[xvii]

Anthony Woodlief used path-dependence theory to show how city governments can get "locked into" suboptimal policies enacted at a time when their future consequences were unclear.[xviii] The history and choice of sewer technology is very much about path dependence and a "locked-in" situation. The adherence to a particular sewer system paradigm in the latter half of the 19th century constrained innovative research and the implementation of alternative solutions. Sharon Beder put forth a strong institutional argument that once a consensus is reached about a specific technology, and as this specific method is fully endorsed by a particular profession, it enables that group to consolidate their position and define themselves as the experts in that field. Other professionals are then likely to respect the boundaries of expertise set up by the particular technology further entrenching it in practice. As standards are set and regulations established to support a particular practice, others are restricted to the role of outsider, or as uninformed public "which is in no position to question the range of treatment methods available."[xix] Thus, the autonomy of the engineering community lay in its ability to dictate the range of technologies, which would be taken seriously. And while "outsiders" might demand a different solution from within the paradigm, they are not able to ensure that alternatives from outside the paradigm will seriously be considered.

Water-carriage systems, as advocated by sanitary reformers and government authorities, required an integrated system of underground pipes that was to be planned, engineered and coordinated with reference to a larger, citywide plan. Political boundaries could not fragment a sewerage scheme; rather local councils were forced to give authority to more centralized governmental bodies in the realm of waste disposal once water-carriage systems were adopted. Water-carriage, with its economies of scale, created the need for central administration, and thus was an important factor in facilitating governmental integration. Since water-carriage technology involved large-scale construction and required the centralization of methods of operation, it also brought sewer disposal within the engineering domain and was favored and quickly endorsed by many engineers.

The reform measures pushed by sanitary reformers in the 19th century were largely technological and the development of new technologies associated with water supply and the water-carriage of sewage offered the opportunity for a new professional group to form which claimed to have specialized knowledge in the field. Engineers were closely associated with large-scale public works, the construction of tunnels and the laying of pipes, and overseas engineers were carving out a profession for themselves in the area of sanitation.

Water-carriage systems and the use of centralized wastewater treatment plants had great appeal to policy makers and those in the engineering profession.[xx] As the laying of sewer pipes and the building of sewage treatment plants are costly endeavors, and since typical consultants' fees can be as high as 20% of the estimated construction cost, there was little incentive in finding and endorsing low-cost solutions.

The desire for consistency, particularly in building construction is understandable. As cities grew and experienced the consequences of disease, fire and structural collapse, they responded with ever more and complex laws. Early in the twentieth century the insurance industry, endeavoring to reduce their losses, developed a model code for states and local governments to enact into law. This

model, known as the *National Building Code,* was promulgated by the American Insurance Association to be a foundation on which a legislative body could create its own regulations. The model code gained widespread popularity since it allowed local governments to adopt technical requirements without the difficulties and expense of research and the production of individual local codes. It also guaranteed the compliance with insurance standards and the disengagement for personal liability.[xxi]

Building codes and standards, particularly those associated with fire safety, are reasonably enforced through a uniform model. However, the expansion of these organizations, and their universal codes, into other areas of urban development is questionable. In 1994 the International Code Council (ICC), was established as a non-profit organization dedicated to the development of a single set of national and international model construction codes, including standardized zoning. By the year 2000, ICC published an impressive array of codes containing an International Residential Code (IRC), an International Private Sewage Disposal Code (IPSDC), an International Property Maintenance Code (IPMC) an International Zoning Code (IZC) and even an International Urban-Wildland Interface Code (IUWIC). By 2003, 33 states in the U.S. and more than 509 local jurisdictions have adopted one form or another of these codes. Out of these, 32 jurisdictions have embraced the International Zoning Code.[xxii]

Model codes may provide an attractive blueprint for communities lacking financial resources to develop their own codes and standards, but they also pose a danger of becoming ubiquitous responses that override unique situations.

A Lesson from the Past

Although many ancient cities such as Babylon and Jerusalem had drainage channels to carry rain water and waste, it was the Romans who systematically planned and constructed underground sewers to drain uplands to the nearby network of low-lying streams. Roman sewers developed from open channels that drained most of the land prior to urbanization. The philosophy was to use the existing natural drainage channels to remove stormwater. The city then was built over the channels, and drains were provided from the surface to the underground streams. Yet with the growth of large cities, particularly Rome, sanitary conditions deteriorated. Residents constructed numerous altars and shrines dedicated to Febris, the Goddess of Fever, and Verminus, the God of Disease, hoping and praying for improvements.[xxiii]

While the prayers may have been answered by the Gods and Goddesses, they were also considered by the Roman engineers. By providing a general water supply and an elaborate drainage/sewer system, and by regulating burial grounds, Rome was gradually transformed into a less dangerous place. The Cloaca Maxima, for example, was an engineering marvel of the time. A 4.2 meter high and 3.2 meter wide vaulted, paved tunnel, it provided the main excess stormwater disposal system for the city, as well as a sewer collection system from the buildings along its route to the Tiber River.

In the centuries after the decline of the Roman Empire, urban sanitary engineering practically vanished. The urban environment was filthy and unhealthy. When underground channels were constructed, they were designed to carry stormwater rather than human and household wastes. The impure water supplies and accumulated waste of medieval cities fostered terrible epidemics which decimated much of Europe.

With the renewed interest in the study of science in the 14th and 15th centuries, attention again was paid to sanitary engineering. Still, surface and street drains, rather than sewers, were at the center of this development. Human waste was typically accumulated in cesspools or privies and as late as 1815 and English law forbade emptying waste into the street drainage system. With minimal application of available knowledge of hydraulics or topographical science, efforts to improve drainage or sewerage systems were often ineffective.[xxiv]

London typified the mid-nineteenth century experience of Europe. By the 1840s, London's population numbered over two million, living in several hundred thousand households. An awareness of the need for sewerage reform and development led to the first comprehensive study of the metropolis for the purpose of planning sewerage improvements. In 1847, the first official report on sewerage and drainage by the engineer John Phillips, contained the following description, which portrayed a typical situation of the time: "There are hundreds, I may say thousands, of houses in this metropolis which have no drainage whatever, and the greater part of them have stinking, overflowing cesspools, and there are also hundreds of streets, courts and alleys that have no sewers; and how the drainage and filth are cleaned away and how the miserable inhabitants live in such places it is hard to tell. In pursuance of my duties, I have visited very many places where filth was lying scattered about the rooms, vaults, cellars, areas, and yards, so thick and so deep that it was hardly possible to move for it. I have also seen in such places human beings living and sleeping in sunk rooms with filth from overflowing cesspools exuding through and running down the walls and over the floors... The effects of the effluvia, stench and poisonous gases constantly evolving from these foul accumulations were apparent in the haggard, wan and swarthy countenances and enfeebled limbs of the poor creatures whom I found residing over and amongst these dens of pollution and wretchedness."[xxv]

The conditions in London resembled those of most cities of two hundred years ago. By that time nearly every residence had a cesspool which collected and stored all house wastes beneath its first floor. With cesspools overflows, failure of proper drainage and the contamination of drinking water, epidemics and lingering illnesses became common. Fires and explosions due to methane build up in unventilated cesspools were just as frequent. Such conditions are vividly described in the following account from 1849, when workers entering to examine cesspools with oil lamps triggered sudden blasts: "Explosions occurred in two separate locations where the men had the skin peeled off their faces and their hair singed. In advancing toward Southampton, the deposit deepens to 2 feet 9 inches, leaving only 1 foot 11 inches of space in the sewer. At about 400 feet from the entrance, the first lamp went out and, 100 feet further on, the second lamp created an explosion and burnt the hair and face of the person holding it."[xxvi]

Facing these and other deteriorating urban conditions, some local authorities usually known as "Improvement" commissions sprang into existence. Through a series of Building Acts, these local authorities were endowed with limited powers to regulate the design, quality and location of buildings and the management of waste. London instituted such an Act in 1774, and Liverpool in 1825.[xxvii] However, constitutionally, financially and technically these commissions were ill equipped to cope with the immensity of the task, and their impact was hardly felt. State intervention was needed if change was to occur. Sanitary reformers of the time, particularly Edwin Chadwick, argued for the establishment and extension of both local and central government authority. Such views are also reflected in both the

1842 *Report on The Sanitary Conditions of The Labouring Population of Great Britain* and the 1844 *First Report of the Commissioners of the State of Large Towns and Population Districts*, which advocated a fundamental rethinking of the regulatory framework. A new centralized mechanism was seen as the key to controlling growth and ensuring long-term planning. One of the reports' ultimate outcomes was the Public Health Act of 1848, by which, for the first time the British Government charged itself with the responsibility of safeguarding the health and well being of its population through the establishment of the General Board of Health. The Act fell short of establishing a comprehensive nationally managed sewerage system, and left the design and planning with the local public health boards. It did, however, legislate that no new housing was to be built in an area within the health boards jurisdiction without suitable provision of sewer disposal. As stated in the General Board of Health Minutes: "The removal of all cesspools from amidst habitations is the first duty of local boards. As soon as a proper survey and system levels have been obtained, the first duty of a Local Board of Health will be the prosecution of measures requisite for the entire abolition of all cesspools, and the prevention of their further formation, by the complete drainage of every house in the towns."[xxviii]

Standardizing Sewer Systems

The General Board of Health was also engaged in an active debate about the nature and form of the appropriate technology of waste disposal. This debate came about because of a new technology introduced to the cities at that time. This new technology was that of piped-in potable water and the flushing toilet.

As piped-in water became available, households rapidly installed water fixtures. The introduction of large volumes of waste water into the cesspool system caused serious flooding, disposal and health problems. In Paris in 1832, 20,000 people died of cholera. In other parts of Europe the combination of piped water and open sewers consistently led to similar outbreaks. Facing this crisis the officials and experts argued over the following two options:

Retention of the dry or semi-dry conveyance method for human waste while disposing other grey water through the existing stormwater system

Combining human waste and gray water into one system to carry it toward natural water bodies.

Advocates for the dry or semi-dry system argued that such a system would retain the valuable nutrients and economic benefits associated with dry decomposing waste. The ability to use the waste as fertilizer was already a common practice in Europe as well as in many other parts of the world. The *Sydney Morning Herald*, for example warned its readers in Australia in 1851 that "We shall not always be able to rob the soil, and give it nothing in return."[xxix] The *New York Times* in an article under the heading "Utilization of Sewage," wrote "One of the greatest sources of waste in all American and most foreign cities, is the throwing away of the valuable fertilizing elements in the sewage. In China, that semi-barbaric, but exceedingly wise land, the inhabitants of cities are obliged by law and custom to return all fecal matter to the country, where it may be restored to the soil, from which it came in the shape of vegetable and animal food. . . The refructification of soils is getting to be an important question along the Atlantic States."[xxx]

Other experts, although acknowledging the economic benefits associated with recycling human waste, quickly (and retrospectively wrongly) argued that waste in water has as many benefits as when it is disposed of in the earth. In 1881, while giving a lecture on sanitation, the Boston engineer Edward Philbrick said: "The sewage of cities has often been used with success as a fertilizer for the soil. It has accordingly been argued by many that it must be a great waste for London, and on smaller scale for Boston, too, to throw their sewage into the sea. But experience has proved that the value of sewage as a manure is not so great as was once proposed, while the cost of applying it to the soil is often too great to be thus recouped. If thrown to the sea, the inhabitants of the particular district where this occurs may not profit by its value, but this is not lost to the world. It is soon decomposed by exposure and the elements of which it once consisted are stored in the air or water for the future use of either vegetable or animal life. The kelp is nourished and contributes to human wants, so do the various mollusks that fatten upon the mud in our bays."[xxxi]

In an article titled "Sewage Carried by Water," *Engineering Magazine* refers to studies done by Chadwick and remarks: "Mr. Chadwick, in his report on the Paris Exhibition on dwellings for the working classes, has drawn attention to a number of most important sanitary questions, of which the above is one of them, and at page 76 of this able report points out, that fresh sewage that has not undergone the process of decomposition is not only more valuable in its fructifying power in the proportion of one to three; but, instead of killing fish when it escapes fresh into the river, the fish come and feed on it."[xxxii]

Such arguments continued on both sides of the Atlantic. In a series of articles titled Modern Sewer Construction and Sewage Disposal, published in The *Sanitary Engineer and Construction Record*, the authors comment on Boston's 1875 Mayor's Commission on the Sanitation Conditions. In the article they write: "The most specious arguments against the scheme of disposal came from those who believed in the value of sewage as manure and advised its application to the land where such value could be availed of. It was called a sinful waste to consign so much organic matter to the ocean, and thereby ignore the advice of those celebrated modern chemists who had taught us its use as plant-food. Theoretically this sewage contained nitrogenous matter enough to render fertile hundreds of acres of waste and barren land in the neighborhood of the city that was now lying idle and producing nothing. But the commissioners, who had spent several months in the examination of the subject, had not overlooked this subject. We find in the appendix of their report a description of the methods adopted to dispose of the sewage in fifteen modern European towns, in many of which costly experiments had been tried with the view to utilize sewage on the land."[xxxiii]

There was no doubt in their mind that the only way to provide for efficient sewage system was by carrying it with water to the ocean. "In short," they conclude, "the disposal of sewage by irrigation, though often the cheapest and best way of getting rid of it for cities remote from the sea or large rivers, could not be looked upon as a possible source of profit anywhere."

Mansfield Merriman, in one of the first engineering sanitation textbooks to be published in the United States, *Elements of Sanitary Engineering*, fully endorses the water –carriage system and rejected any other methods as viable solutions for the American cities. "It was shown," Merriman writes in 1899, "that the pail method for the removal of excremental matter is an offensive and impractical one, and, as it is not used in the United States, it will be classed among the public systems. The cesspool plan is also shown to be an objectionable one for a large town or city, and, although it

is still extensively used in villages and country districts, it is to be regarded as a family method rather than a practicable and efficient public system and hence will receive no further consideration. There remains, then, only the systems of removal by means of public water supply, known as the water-carriage systems, which are an outgrowth of the plan followed in ancient Rome. Had these ancient methods been continued and developed throughout Europe the thousand years of filth, disease, and misery known as the dark ages might perhaps have been a thousand years of cleanliness, health, and happiness."[xxxiv]

Innovative Unconventional Carrying System

A most interesting and often overlooked element of the debate was the actual design of the removal system. At the core of the technology was the use of piping for transporting waste. While advocates of the water carriage system relied on ample water and water velocity to carry the waste, others pointed to alternative systems presently in use. These systems used vacuum, air, small pipes and very little water to carry waste. These particular technologies allowed for better utilization of the organic matter and the elimination of expelling harmful pollutant in existing water bodies. Advocates of these systems saw a potential for two separate methods for removing two types of waste: The removal of body waste by dryer conveyers and its composting in the earth, and the removal of gray water waste from baths and kitchens utilizing existing stormwater drainage.

Such systems originated in Holland, where many towns were below sea-level and therefore required sewer removal through pumping of some kind. The economical efficiency of these systems together with the ability to make use of the organic matter as fertilizer, helped extend these systems to other countries such as Belgium and France.

American sanitary reformer George E. Waring offers one the best accounts of this alternative system based on his visits to Amsterdam, Leyden, and Dortrecht, in the 1870s. Utilizing small diameter airtight pipes, and a mechanical vacuum system, each district of the city is connected by means of pipes and special holding chambers. Waring, describing the Liernur system, writes: "The initial principle of the system lies in the suction to a central public reservoir of the accumulation of famæl material deposited in receptacles at separate houses, these being connected with this reservoir by air-tight pipes. The reservoir being exhausted of its air, the accumulations are drawn toward it by pneumatic pressure. No matter how large may be the area occupied by the sewered houses, each district has its central reservoir, and these reservoirs are in turn and in like manner themselves discharged into a main vacuum chamber at any convenient point, being connected with this by a similar system of pneumatic pipes."[xxxv]

The vacuum system of Berlier, developed in France and used in some districts of Paris and Lyons, was based on the similar ideas. Unlike the Liernur's system, which applied vacuum at certain times of the day to remove waste to a central collection chamber, Berlier's system maintained partial vacuum continuously in the street pipes, pulling waste from small individual collection basins placed in the cellar of each house.

In England, a similar technique, the Shone Hydro-Pneumatic system was installed in a few towns and like the Dutch innovation competed as an alternative to the water-

based method.[xxxvi] Unlike the Liernur and the Berlier vacuum systems the Shone technique relied on compressed air to push waste. Although it had been applied in a few cities in England, and even used to remove sewage from the House of Parliament in 1886, its most interesting debut was at the World's Columbian Exposition which was held in Chicago in 1893. This was America's first international exhibition of the nation's vast technological and scientific strides made during the 19th century. It was the perfect showcase for the integration of innovative urban infrastructure with architectural beauty.

Located on a flat site next to the shore of Lake Michigan, and dubbed "The White City," the fair represented an unprecedented collaboration of artists, architects, engineers, sculptors, painters, and landscape architects who joined forces to create a single work -- an ideal model city. Since Chicago had earned a national reputation as "typhoid fever city" because typhoid, smallpox, and dysentery struck its population regularly, planners of the exposition site wanted to demonstrate an innovative system that did not pollute the lake with untreated water. Utilizing the Shone compressed air technique, they removed sewage through clay pipes into ejector stations and precipitation tanks. These tanks together with two water treatment plants were available for visitors to see as a sort of working exhibit that handled the sewer needs of the more than 6,500 lavatories and toilets, and the sufficient disposal of the sewage of 600,000 people per day.[xxxvii]

Despite favorable endorsements, calls for consideration, and the exhibit at the World's Fair, these alternative systems failed to gain wider acceptance in the United States and England. Waring, for example, wrote that "All that it is safe to say about the system now, in its relation to our own condition, is that it is, as regarded in the light of what we know about the water system and the dry-earth system, sufficiently promising to justify the most energetic investigation. So far as I know, its opponents have adduced nothing against it that may not be remedied by practicable mechanical improvements, and its advocates, who are many, speak of its advantages with a confidence that, often at least, has grown from favorable experience of its practical working."[xxxviii] Yet most engineers and public officials viewed these alternative systems unfavorably. They objected to the need to build separate mechanisms for disposing human waste and kitchen (gray) waters. Unlike available drainage systems that relied on existing pipes, velocity, and gravity to do the work, these alternative vacuum and compressed air systems were seen as complex and too technologically advanced for simple maintenance. Most importantly, sanitation engineers and public health officials at that time believed in the purifying nature of water. For them, the quick removal of waste away from the city was vital. Any system that advocated the

retention of waste and its utilization near human habitats was deemed dangerous and problematic. Such attitudes can be clearly seen in many of the reports issued by various sanitation committees of the time.

In 1880, for example, engineer Rudolph Hering, upon his return from a sewer study tour in Europe at the request of The National Board of Health, wrote: "The general opinion held at present is that sewage must, beyond all other consideration, be disposed of in a way which is least injurious to the community, and that a pecuniary profit can not be looked for in every case. . . When sewage can be safely discharged into a large river or the sea, this will generally be the most satisfactory and economical mode of disposing it."[xxxix] Florence Nightingale, the British pioneer of nursing and the reformer of hospital sanitation methods, also saw water as the solution for proper sanitation. In one of her statements endorsing this new technology she stated that "the true key to sanitary progress in cities is, water supply and sewerage. No city can be purified sufficiently by mere hand-labour in fetching and carrying. As civilisation has advanced, people have always enlisted natural forces or machinery to supplant hand-labour, as being much less costly and greatly more efficient."[xl]

Ultimately, the water-carriage technology triumphed over the other systems. Since removal was the paramount concern and not the treatment or utilization of the waste, the authorities and the engineers involved concentrated solely on the carrying system. Water-carriage, they believed, would remove waste from habitation as fast as possible. It was simple, automatic and did not require high maintenance. Such a system was attractive to the local authorities as it made waste disposal a more automatic procedure and relieved one from individual responsibility.[xli] These views were widely expressed by various reports. "The lower classes of people," said one of them, "cannot be allowed to have anything to do with their own sanitary arrangements: everything must be managed for them."[xlii]

Employing a technology which can remove waste as far from sight, and far from the mind of the public was the goal. As late as 1974 in an article published in *Scientific American* and titled "The Disposal of Waste in the Ocean" the author asserts that "Contrary to some widely held views, the ocean is the best place to put certain wastes."[xliii]

Toward Ecologically sustainable Standards

Outside the mainstream, innovators are working on various forms of ecological methods for the utilization and recycling of sewage. In 1996, for example, a system titled the Living Machine was installed in South Burlington, Vermont in order to determine the effectiveness of ecologically engineered wastewater systems. These independent and self-contained biological treatment systems consist of constructed wetlands, which filter and clean waste water. They require little piping, and their on-site location eliminates the need for an expensive carrying system and treatment facility.[xliv]

Under the auspices and support of the United States Environmental Protection Agency, 80,000 gallons of municipal sewage were diverted and treated by the Living Machine. Since the main purpose of this project was only to test the process, the EPA and the city of South Burlington would not allow the treated waste from the system to

be directly discharged into the waterways. Even though an analysis performed by the Environmental Protection Agency found that the end product of Living Machine met or exceeded the water quality standards of traditional systems, both the EPA and the City insisted that the water be cleaned again in the traditional treatment plant. [xlv]

Although the Living Machine experiment showed that it could match traditional wastewater systems, the initiative has not materialized beyond the experimentation phase. Once funding ended, neither the city, nor neighboring industries showed any interest in continuing its use. South Burlington stated that they could not afford to operate what were essentially two wastewater treatment plants; The Living Machine was not capable of handling all of the city's waste, and therefore the continued operation of the traditional treatment plant was still required. As a result, the Living Machine's wetlands now sit dry and The Living Machine Corporation, which ran the experiment, has been consolidated.

Alternative onsite wastewater treatment systems such as the Living Machine have a great potential in creating a paradigm shift in the treatment and carrying of wastewater. Even the EPA has realized that these systems can act as more than temporary solutions and can serve as low-cost, environmentally friendly alternatives to traditional systems. In a 1997 report to Congress, the EPA stated "Adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas."[xlvi] Yet most local regulations limit the introduction and use of such alternatives. It is difficult for prescriptive codes to specify the full range of technological options appropriate for a given site and anticipate the different sensitivities of the site's water and land resources. Most regulatory barriers to on-site wastewater treatment systems are derived from the perception that the decentralized nature of these systems prevents the necessary oversight to insure good water quality. Tight regulations make it difficult for developers to implement alternatives. Municipalities also find that funding opportunities play a large role in their decision whether or not to implement alternative systems. Many funding and planning grants are focused on the traditional systems, making them more economically beneficial for municipalities to build.

While government initiatives to regulatory reform may be slow to occur, industry forces such as developers, mortgage companies, and homeowners' insurance programs, may create a positive change. An interesting example has germinated in Washington State through an evaluation of accountability. This effort involves an attempt to upgrade the alternative onsite sewer industry through an insurance program that gives every practitioner a stake in the success of each system by assuring the owner that the alternative system will perform as designed.

Such accountability by the industry allows the designer, the manufacturer, the installer, the operator, and foremost the public official regulator to operate without the fear of liability. In fact, the National Onsite Wastewater Recycling Association (NOWRA), which advocates this approach, is ready to negotiate the accountability agreements with insurers to monitor successes, and coverage rates for practitioners based upon performance. [xlvii]

By letting the industry take responsibility through insurers, the onus on the regulator would shift from enforcement to monitoring to code modifications. With sets of local operation data, and a shift from national to regional testing performance,

performance standards, suitable to each locale would evolve. These standards would be designed to address specific site and watershed goals.

The development of such performance standards, together with innovative accountability approaches, would provide the tools for communities who are willing to build alternative systems. Ultimately, such approaches may need the backing of various government agencies, as local officials are often reluctant to approve the use of new technologies locally when no endorsement is given by higher authorities.[xlviii]

Changes in sewer system designs seem to come about only when circumstances force alternatives on standard procedures. Christine Rosen, in her work on the fires that devastated Baltimore and Boston, shows that infrastructure system designs were the last to adapt to imperatives of economic forces and social reforms, and their modernization was typically related to their failure or underperformance.[xlix]

David Wojick, in the "Structure of Technological Revolutions," argues that anomalies occur in technological paradigms when standard procedures repeatedly fail to eliminate known ills or when knowledge shows up the importance of factors which have previously been incorrectly evaluated.[l] Yet in many instances, those contesting existing practices may be outside the paradigm community and their views are often disputed. The governmental regulatory authorities are unlikely to force changes because they are well aware of the costs that would be involved in changing the system. For these new developments to be incorporated into standard planning practice, a change in the engineering and urban planning paradigm needs to be made, in particular in the current emphasis on "good enough" solutions based on slide rule answers from often obsolete formulas. Both public officials and engineers must realize that the science of sewer design is capable of change. The fruit of alternative research must be accepted and converted into practice supported by flexible guidelines.

Conclusion

If the only tool you have is a hammer, you tend to see every problem as a nail.
Abraham Maslow

There are a number of principles and practices that promise to carry these beginnings forward. A change list might go as follows:

Adopt a ranking system instead of rigid standards
Emerging attitudes and technologies geared toward sensitive environmental design must inform the coding process. A future oriented checklist, one that can provide

benchmarks for project evaluation, can be utilized to rank proposed projects according to their suitability in accordance with a set of locally derived criteria.

An interesting example of such system is the recently developed Leadership in Energy and Environmental Design (LEED) Green Building Rating System (United States Green Building Council, 2002). LEED is a voluntary, consensus-based, market driven building rating system, which evaluates environmental performance, and provides a norm for what constitutes a "green building". The ranking system not only accommodates existing and known energy and environmental principles but also looks at emerging concepts. This is partly due to its unique integration of all segments of the building industry, and its openness to public scrutiny. Since it is a ranking system, different levels of green building certification are awarded based on the total credits earned, thus often resulting in a higher development standard through incentives rather than compliance.

Adopt a 'user affordability' approach in setting standards for projects in developing countries

In the international sphere setting standards at levels the local population can afford is essential. One of the key problems in many of these settings follows from the habits of engineers who often pursue "modern" performance. Their strong belief in modernity, and their robust design solutions, often chosen form fears of later poor maintenance --cause them to reject minimum adequacy as an objective. These professionals often resist variations in service quality by locality, and foreclose designs based on greater affordability. Recognizing the differentiating ability of consumers to pay for necessary goods like sewerage, water and housing can begin a process for improvement and will result in a wider facilitation and acceptance of minimal standards.

Leading educational and lending institutions need to advocate the mixing of suitable modern technology with less expensive local materials and traditions. A move in this direction can be seen in the recent cooperation between the Cities Alliance, the World Bank, and the Massachusetts Institute of Technology to form a resource showcasing and evaluating the experiences gained from upgrading projects in poor urban communities. [li]

Establish best practice clearing-houses

In a climate of increased bureaucracy and complexity, decision making and legislative changes are slow to occur. However, actual examples are the best catalysts. Best practices provide an immediate way to compare experiences and to evaluate projects based on actual performance. They are often the most effective tools to persuade skeptical decision-makers and the public.

Government agencies as well as international organizations are realizing the importance of such vehicles in creating change. Essential to these clearing houses is the ability to spread and exchange information over the internet, disregarding political, economical and cultural boundaries. Such interactive databases allow for the exposure of current and emerging trends and promote networking and incite policy development based on what works. The United Nations-Habitat for example,

maintains a clearinghouse of best practices for human settlements.[lii] This searchable database contains over 1,600 examples from more than 140 countries that demonstrate ways to provide improved shelters, and how to protect the environment while supporting economic development. It is unfortunate that this powerful tool is currently available only to subscribers and not free for all potential users.

Unlike the subscribers-only UN database, the US Department of Housing and Urban Development Regulatory Barriers Clearinghouse (established in December 2002) is a free forum to share ideas and solutions for overcoming state and local regulatory barriers to affordable housing.[liii] Its services include an electronic newsletter that highlights successful barrier removal strategies and policies, and a searchable database that offers possible solutions based on actual experiences.

Such clearing-houses should also provide for a follow-up or post-occupancy analysis of best practices. Too often projects that are showcased are in their initial stages and indictors of success are not measured or accounted for through time. In an era of media and marketing, the ability to showcase achievements and alternative practices may prove to be the most important tool for change. Planners, and planning organizations, in particular, must devote more time in the effort to disseminate their experiences and successes and make it readily available in tangible form.

Allow for experimentation and provide legal backing

To evolve we must allow for experimentation and discretion. Alexis de Tocqueville observed on his 1830s tour of the United that "the great privilege enjoyed by the Americans is not only to be more enlightened than other nations but also to have the chance to make mistakes that can be retrieved" (Tocqueville 1966, 255).

Taking chances, allowing experimentation, and letting experts and regulators use their judgment are practices that must find their way back to infrastructure processes. The hope rests with the upcoming generation of new planners, (and hopefully engineers) tuned and responsive to the natural environment, and competent in the intersection between socioeconomic issues and spatial design.

[i] It is interesting to note that historically the American Standard Zoning Enabling Act (1922) failed to sufficiently emulate its German source. For example, the German practice allowed commercial uses in residential zones although subjected them to performance standards such as objectionable odors. Such uses were prohibited in American zoning in order to foster the ease of administrative procedure by the enabling authority (Liebman, 1991, 9). The German technique for regulating physical form was based on density limitation, these were converted and rigidified in the American system to minimum lot sizes and setback requirements.

[ii] Other studies such as those by Field and Rivkin (1975), Seidel (1978), Rosen and Katz (1981), Fischel (1990), Martin (1998), Luger, and Temki (2000) show a direct correlation between regulations and higher housing prices.

[iii] In Dallas, for example, potential amounts of water not returned to the ground annually range from 6.2 billion to 14.4 billion gallons, while in Atlanta the amounts can reach 132.8 billion gallons or enough water to supply the average daily household needs of 1.5 million to 3.6 million people per year (American Rivers 2002).

[iv] Newville, J. *New Engineering Concepts in Community Development*. Washington, D.C.: Urban Land Institute. 1967, 27Newville 1967, 27

[v] Tabors, R. et al, *Land Use and the Pipe* 1976 Lexington, MA: DC Heath & Co.

[vi] International City Managers Association. 1941. *Local Planning Administration*, Municipal Management Series. Chicago: ICMA. , 146

[vii] United States General Accounting Office. 2001. *U.S. Infrastructure Funding Trends and Federal Agencies' Investment Estimates.* Washington DC: General Accounting Office.

[viii] World Bank 2003 Annual Report. See: http://www.worldbank.org/annualreport/2003/ (March 2004)

[ix] In Van der Ryn, S. *The Toilet Papers: Designs to Recycle Human Waste and Water: Dry Toilets, Greywater Systems and Urban Sewage.* North Atlantic Books1995, 1

[x] American Water Works Association. *Residential End Uses of Water* 1999 Denver, CO AWWA, 1999

[xi] Niemczynowicz, J. Water Management and Urban Development: A Call for Realistic Alternatives for the Future. Impact of Science on Society 1992, UNESOC 166: 131-147

[xii] To understand the Polya process, Arthur suggested an example of an urn with infinite space containing one red ball and one white ball. If one were to randomly select one ball, there is a 50% probability that one would select either a red or a white ball. If one then proceeded to sample with replacement but with each replacement, added another ball of the same color as the ball replaced, one would be sampling with double replacement. Therefore, if one had selected a red ball in the first round and after replacement, two red balls and one white ball were in the urn, the corresponding probabilities of selection are 66.6% and 33.3%. "Polya-Eggenberger model is derived by drawing balls of two different colors from an urn. As the balls are drawn, they are not only replaced, but new balls of the same color are added. In this way, numerous

drawings of balls of one color greatly increases the probability of that color being drawn.

[xiii] Arthur, W. B. 1989. Competing Technologies, Increasing Returns, and Lock-In by Historical Events, *Economic Journal* 97, 642-65.
Arthur, W. B. 1990 Positive Feedbacks in the Economy. *Scientific American* 262, Feb, 92-99

[xiv] Liebowitz, S. J. and Stephen E. Margolis. 1995. Path Dependence, Lock-In and History. *Journal of Law, Economics and Organization*. April.

[xv] Arthur, W. B. *Increasing Returns and Path-Dependence in the Economy*, University of Michigan Press, Ann Arbor, Mich., 1994.

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[xix] In Beder, S. 1997. Technological Paradigms: The Case of Sewerage Engineering, *Technology Studies*, 4,2, pp. 168.

[xx] Tarr, J. and Dupuy, G. eds. 1988. *Technology and the Rise of the Networked City in Europe and America, Philadelphia*. Temple University Press.
Beder, S. 1998. *The New Engineer: Management and Professional responsibility in a Changing World*. South Yarra, Australia: MacMillan Education Press.

[xxi] Although legislative bodies are not obligated to adopt a model code and may develop their own, studies conducted by the federal government have indicated that 97 percent of all United States cities with a building code have adopted the National Building Code. Three organizations: the Building Officials and Code Administrators (BOCA) International, Inc., International Conference of Building Officials (ICBO) and Southern Building Code Congress International, Inc. (SBCCI) have also been created to administer the code enforcement.

[xxii] (ICC 2003), Ward 2001, 48)

[xxiii] Ancient Hygiene *The Sanitary Engineer and Construction Record.* January 1887, 179-180.

[xxiv] See Metcalf, L. and Eddy, H. *American Sewerage Practice*, 1914 New York, McGraw-Hill,1-2, 10-14 and *Wastewater engineering : Collection and Pumping of Wastewater*. New York: McGraw-Hill, 1981, 2-3.

[xxv] Metcalf, L. and Eddy, H. *American Sewerage Practice*, 1914 New York, McGraw-Hill, 4.

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[xxix] Cited in Beder, S. (1990). Early Environmentalists and the Battle Against Sewers in Sydney. *Journal of the Royal Australian Historical Society*, 76,1. 27-44. p.30

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[xxxi] Philbrick, E. Lecture I: Introductory, *American Sanitary Engineering* New York: The Sanitary Engineer, 1881, pp. 1-15, 10-11.

[xxxii] *Engineering Magazine* Volume 1 1869 Oct. p. 882

[xxxiii] Philbrick E. Modern Sewer Construction and Sewage Disposal *The Sanitary Engineer and Construction Record.* March, 1887, 345 -346.

[xxxiv] Merriman, M. *Elements of sanitary engineering*, New York, NY, 1899 149-150)

[xxxv] Waring, E. G. Liernur's Pneumatic System of Sewerage. *The Atlantic Monthly*. Vol. 37, No. 222, April 1876,, 482

[xxxvi] The Shone Hydro-Pneumatic System of Sewerage. *Manufacturer and Builder.* May, 1887, 104-5).

[xxxvii] Merriman, M. *Elements of sanitary engineering*, New York, NY, 1899, 173

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[xliv] Wynn, J. Innovative and Alternative to On-Site Treatment of Residential Wastewater, Produced for United States Housing and Urban Development Grant RH-00-OH-I-0335, September 30, 2003 pg. 21

[xlv] U.S. Environmental Protection Agency, Office of Water, Wastewater Technology Fact Sheet: The Living Machine, October 2002

[xlvi] Dix, S., and Nelson, V. The Onsite Revolution : New Technology, Better Solutions *Water Engineering& Management*, October 1998, Vol. 145, Issue 10, 20

[xlvii] See Kreissl J. and P. Chase, Proposed National Onsite Standards: A Broad Assessment of Their Relative Benefits to Industry in *Small Flow Quarterly*. Vl.3 No 1 Winter 2002 28-33

[xlviii] The value of the creation of performance based standards as a vehicle to implement new concepts has also acknowledge by government agencies such as EPA See for example the 2001 publication *Onsite Waste -water Treatment Systems Manual*, EPA.

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[li] For the Upgrading Urban Communities: A Resource for Practitioners web site see: http://web.mit.edu/urbanupgrading/

[lii] See: http://www.bestpractices.org

[liii] See: http://www.regbarriers.org

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