Recapturing the Heart of the City: ***Evaluating Integrated Water Resource Management in Urban Areas***

A Comparative Analysis between Three Cities: Portland, London and Sao Paulo

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Abstract

This thesis discusses a new integrated framework for the management of water resources in three cities: Portland, London and Sao Paulo. Water resource management in urban areas is extremely important due to its vitality as a resource to the health of humans and the fate of cities. Cities that cannot overcome pollution related challenges or that cannot efficiently and sustainably manage their freshwater resources will face many public health and water scarcity issues. Specifically, this thesis discusses how, why and on what scale the integrated water resource management framework has been implemented in each city. This will add to the current literature on integrated water resource management. Through a comparative analysis of Portland and London, this paper suggests that currently, an integrated approach to water resource management at a sub-basin scale is the most effective framework for motivating a participatory method for improving a river's water quality, functionality and socio-economic value in urban areas. Furthermore, this analysis is extended to the third case study of Sao Paulo, in order to discuss if an integrated approach could or has been successful in the world's rising megacities.

Introduction

Fresh water is arguably one of Earth's most vital and indispensible natural resources because it is essential to human survival and is self- renewable. Earth's hydrologic cycle is responsible for constantly replenishing its various forms of natural waterways with fresh water. As a resource, water has been exploited for human use since the beginning of human history. Major cities developed in proximity to major waterways because they could be used for consumption, trade, industrial development, and agricultural expansion. Cities that could effectively and innovatively manage, protect and use their water resources became more prosperous and experienced rapid population growth. However, the economic benefits that resulted from major water innovations such as hydroelectric dams and population growth were accompanied with negative consequences. Population and industrial growth greatly increased the demand for water resources, which led to issues of over-use and pollution. Therefore, throughout history, the only cities that were able to adapt and over-come both naturally occurring and anthropogenic water challenges such as flooding and water pollution, were able to flourish.

The interaction between urban societies and fresh-water resources has become increasingly important as the amount of people living in cities continues to increase with population growth. The UN estimates that the world's urban population will grow to nearly 5 billion by 2025, which is a staggering increase when compared to the 1975 total urban population of only 190 million (Varis 2006). Currently it is estimated that almost 1.1 billion people worldwide lack access to a sufficient supply of potable water, while nearly 2 billion still live without basic sanitation infrastructure (Agyenim 2011). These statistics are attributable to rapid population growth and water quality degradation. Many cities, such as Sao Paulo, are unable to build sanitation and drinking water infrastructure fast enough to keep up with population growth (Barraque et al. 2008). This creates an issue of relative-water scarcity because potable water is only scarce due to the degraded state of the drinking water sources, not because there is not enough quantity of water to meet demand (Barraque et al. 2008). It is important to note that in some regions water scarcity issues are caused by seasonal trends of low rainfall or by major droughts that can drastically decrease the amount of available water.

Water challenges such as pollution, scarcity and competition for water resources are further exacerbated in urban areas when the water resource management plans are ineffective. The first water management plans focused on developing infrastructure that could bring potable

water to the public's homes and transport sewage waste out of the city and away from drinking water sources. Infrastructure based water management was implemented in response to the public health issues that ensued in many cities due to drinking water contaminated from the human and solid waste that was simply discharged into the river systems of many cities. Perhaps the most well known case is of London, where a large and innovative city-wide sewage system was developed in 1864 after tens of thousands of people died from water-borne diseases such as cholera due to the polluted Thames River (Johnson 2006). Solving pollution related water quality issues and water management problems is not as easy task and is one that involves a range of policies and integrated management programs that do not consider sanitation infrastructure as the only solution. The development of infrastructure is just one activity that is included in the definition of water management. Other water management actions include implementing incentives for its efficient use, managing the allocations of the resource, and enforcing water quality standards (Lenton and Muller 2009).

Furthermore, there are many actors that play vital roles in creating effective water pollution control and clean-up policies. The state and city governments and environmental agencies play a large role, but the participation of the general public in policy-making decisions has recently been acknowledged as an important part of effective water resource management. Traditional approaches to water resource management were based on the idea that water management should be centralized and sector-based. Moreover, each sector that was involved in water management acted individually rather than collectively (Lenton and Muller 2009). As more and more users demanded water resources, it became increasingly difficult to manage water resources without communication and coordination between each sector (Agyenim 2011). Politically, traditional approaches to water management were planned, implemented and enforced by federal and state governments and state based municipalities. The public and local planning or environmental groups had little to no role in any type of the water management process (Lenton and Muller 2009). During the 1990's a new framework called Integrated Water Resource Management (IWRM) developed. This approach focuses on increasing the coordination between different water sectors and users and integrating social and economic development with water resource protection (Mitchell 2005). The main principles of IWRM are based off the main ideas of sustainable development, where a resource is utilized to meet human

demand in a way that promotes environmental protection and ensures that the resource will be available for future generations (Agyenim 2011). In 2000, the Global Water Partnership defined IWRM as:

> …a process which promotes the coordinated development and management of water, land, and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Brichieri-Colombi 2009, 13).

Furthermore, the IWRM framework establishes the river basin as the appropriate scale for water management. A river basin is defined as the geographic area drained by the river, including all of the various pathways that water reaches the river (Brichieri-Colombi 2009). IWRM is now a widely favored framework to water management that many cities throughout the world are using to guide their water management plans and policies. Although many case-studies prove that it is an effective approach, there are plenty of studies that criticize IWRM because it is too idealistic and much too complex to implement on a river basin scale especially because some river basins are situated throughout many different states or countries (Brichieri-Colombi 2009).

Overall, this study discusses IWRM in the context of three case-studies: London, Portland and Sao Paulo. It discusses how, why and on what scale IWRM has been implemented in each city. This will add to the current literature on IWRM. Through a comparative analysis of Portland and London, this paper suggests that currently, an integrated approach to water resource management at a sub-basin scale is the most effective framework for motivating a participatory method for improving a river's water quality, functionality and socio-economic value in urban areas. Furthermore, this analysis is extended to the third case study of Sao Paulo, in order to discuss if an integrated approach could or has been successful in the world's rising megacities.

Methodology

This thesis compares three cities (London, Portland and Sao Paulo) that differ in geographical situation, population size (scale) and historical significance. Extensive scholarly literature was used to construct the historical and background components of this paper. Developing a historical background and context for each city is important because it shows that

as political, economic and social changes occur over time, the cities water needs and issues also change. It is interesting to compare how each city responded to these changes and what types of resource management have been the most successful throughout different periods in history. Although each city has a different story to tell, there are clear patterns in the types of pressures and actors that motivated the clean up of each respective river.

In order to compare each cities current use of IWRM, I chose two state or municipal water management plans outline the main goals and the intended implementation process for in each city. For my analysis of Portland, I focus on *The River Plan*, which is a plan adopted in 2008 and the *Portland Watershed Management Plan* that was adopted in 2005. For London, I focus on the *Thames River Basin District plans* that are part of the River Basin Management Plan in the UK and on the *London Rivers Action Plan*, both of which were adopted in 2009. In my analysis of Sao Paulo, I focus on the project appraisal document for *Programa Mananciais*, which is an IWRM plan that is largely funded and over-seen by the World Bank. In my comparative analysis I compare the scale of implementation, the main goals, implementation strategies, and the levels of participation in the planning process by different actors. I compiled my findings into a comparative table that summarizes the main similarities and differences between each cities respective plan. It is also important to note that although this thesis is based on a comparative analysis between case studies, my analysis is not case limited because it can be extended to offer implications for other cities that are currently dealing with river pollution and management problems. Therefore my discussion of Sao Paulo and its current pollution issues and management plans is included in the last section of my thesis. This is because Sao Paulo is one of the world's largest mega cities and is representative of the recent global phenomenon of rapid urban growth throughout the developing world. Still, just like London and Portland, Sao Paulo and other megacities are attempting to implement new water management plans that incorporate the IWRM framework, especially as pollution and water scarcity problems become larger issues. In my analysis of Sao Paulo, I focus on the project appraisal document for *Programa Mananciais*, which is an IWRM plan that is largely funded and over-seen by the World Bank. My comparative analysis and evaluation of the IWRM plans that are in place in the Thames and Willamette River basins, reveals some of the successes and short-comings of IWRM. I use these findings as a point of departure to discuss how effective IWRM could be in megacities.

Background

The Nature of Water Pollution in Urban Areas

Water pollution poses a public health threat because many of the pollutants commonly found in a polluted body of water are directly related to infectious or water-borne diseases (Newson 1994). Diseases such as cholera, diarrhea, typhoid and malaria are all water-borne diseases that are common among humans in areas where water quality is poor and polluted (Newson 1994). In addition, many aquatic species that reside in river ecosystems are highly sensitive to toxic pollutants and to chemical or physical changes in their environment. Common problems associated with polluted water include death of fish populations and macro-invertebrates and chemical water issues such as eutrophication (Newson 1994). The health of both the river ecosystems and of the public is compromised by poor water quality. Therefore environmental health is a main pressure that drives environmental reform and river clean-up policies.

Evaluating water quality is a complex task because it involves sampling and measuring certain chemical, physical and biological quantities specific to the body of water and then comparing them to the established quality standards (Gleeson1972). Water quality standards are set in order to ensure that the body of water is safe and healthy for use by all users, focusing primarily on humans and aquatic species. In order for water quality to be evaluated precisely monitoring systems and stations must be operating throughout the river because the quality of water in one area of the river is likely to be very different from other locations.

Environmental agencies define water quality standards depending on how it will be used. Therefore the water quality standards for a body of water that supplies drinking water are likely to be quite different then the standards for a river whose water is mostly used for commercial or industrial purposes. Most water quality monitoring stations measure a variety of chemical and physical properties of water including the pH, the dissolved oxygen level (DO), water temperature, turbidity, stream flow and nutrient levels. Many of these variables are dependent on

each other; for example if water temperature is high, then this will decrease the amount of DO in the water (Gleeson1972). Furthermore, all of these properties of water can be dangerous to aquatic life if they reach levels above the established standards. Many fish species such as salmon are particularly sensitive to changes in water temperature, DO and nutrient levels. Point and non-point source pollution as well as land-use transformations of riparian zones or transformations of the river itself (ie. Dams, channels) are all processes that can greatly affect the water quality of a river. In addition, population growth, urbanization and lack of infrastructure are major causes of water pollution in metropolitan areas worldwide. Cities as large as Sao Paulo, which has a current population of over 18 million, London in comparison is home to about 8 million people while Portland is the smallest city of about 580,000 people.

Integrated Water Resource Management Framework

The Integrated Water Resource Management framework (IWRM) emerged in 1992 at the UN Conference for the Environment and Development in Rio de Janiero (Agyenim 2011). At this conference IWRM was articulated under Article 21 of the Earth Summit as an approach that seeks to address the key water development challenges by balancing economic efficiency, social equity and environmental sustainability (Lenton and Muller 2009). IWRM also emerged in response to traditional water management approaches that were unsuccessful due to the lack of co-ordination between sectors. Similarly, in the 1980's a comprehensive framework for river basin management developed. Although the comprehensive approach is similar to IWRM, it had many weaknesses that the IWRM attempted to correct (Mitchell 2005). For example, Mitchell (2005) argued that the comprehensive approach was unsuccessful because it created a large number of general recommendations and were hard to implement since the parties responsible for planning were not involved in the implementation process. Since 1992, IWRM has become a widely acknowledged and used approach to water management in river basins and cities internationally. It is recognized by international organizations such as the World Water Council, the Global Water Partnership, the World Bank and the International Water Association

(Agyenim 2011). An integrated approach to water management requires public participation, decentralization and communication between all state, municipal, and civil society actors (Keck 2002). In most cases this approach to water resource management focuses the scale of management on the watershed or river basin level. Water management policies should encourage communication with neighboring water basin governments or basin committees because the water quality of one basin can often affect neighboring basins due to cross-basin tributaries or from surface or ground water (Barraque et al., 2008).

Integrated water management should also combine technology and land-use based solutions (Barraque et al. 2008). Regulation must take both quantity and quality into consideration, especially since in many cases water users are also water polluters and because water cannot be used if its quality is poor. Whereas centralized or traditional water management policies often focused on supply side solutions, integrated water management emphasized the demand side and therefore policies must make sure that all stakeholders who demand water are taken into consideration. Although integrated water management is considered to be a holistic approach and does not imply that everything must be managed and connected all together, "a situation which would rapidly become unworkable" (Lenton and Muller 2009) Lenton et al. (2009) outlines four parameters that make water management policies successful, including: the use of sound infrastructure in order to protect surface and groundwater, setting appropriate goals for water use, protection and conservation, implementing transparent processes of decision making that includes the participation of stakeholders and making use of the management and technological tools already available in order to make strong management plans.

The integrated water management approach is also systems based because it recognizes the inherent connection between human and environmental systems. This means that policies are created with an understanding of the natural systems that are involved. Good water management should attempt to further economic growth, reduce social inequality issues such as poverty by increasing potable water access and promote sustainable environmental practices (Lenton and Muller 2009).

IWRM is not a framework that is supported in totality. Currently there is a large selection of literature that deeply analyzes IWRM and focuses on its many flaw and failures. Biswas (2005) and Brichieri-Colombi (2009) both strongly criticize IWRM for not having a clear, established, implementable definition. Biswas (2005) states:

> First, there is no clear understanding of what exactly integrated water resources management means…the absence of any usable and implementable definition has only compounded the vagueness of the concept and has reduced its implementation potential to a minimum (251).

Agyenim (2011) argues that the definition of IWRM differs depending on the main water management objectives in the basin that it is being implemented in. Furthermore, the term "integrated" in the various definitions of IWRM has many different meanings. Lenton and Muller (2009) discuss how in some definitions, integration meant bridging the sectors of the economy with the water sector, while other definitions focused on coordinating between different levels of government in the decision-making process. In addition, Lenton and Muller (2009) suggest that IWRM should not attempt to broadly formulate connections between all of the possible actors in a river basin area and they acknowledge that some degree of focus is necessary for any type of management plan to be feasible.

Biswas (2005) strongly argues that a uniform IWRM strategy cannot effectively or realistically be implemented in every river basin in the same manor, he asks, "Can a single paradigm of integrated water resource management be equally valid for an economic giant like the United States, technological powerhouse like Japan, and for countries with diverse conditions as Brazil, Bhutan, or Burkino Fasso?" (255). Additionally, Brichieri-Colombi (2009) argues that IWRM is only implementable if a strong framework of laws, policies, and concepts of equity are already in existence and that these conditions are likely to be in place in all international river basins.

Historical Context

History of the Thames River and Urban Growth in London

Stretching a total of 215 miles, the Thames is the longest river in England (Ackroyd, 2007). The Roman's strategically situated London at the head of the Thames River estuary, because the river provided a main waterway for commerce both with inner England and with

greater Europe and beyond. Historians and archeologists trace the beginning of London's urban development back to 54 BC (Sheppard, 1998). The city was not officially known as London until after the Roman invasion of England in AD 43 (Sheppard, 1998). A period of steady growth brought the population of London up to almost 100,000 in 1300, but this period was quickly followed by a period of decline due to the bubonic plague in 1348 (Sheppard, 1998). The plague caused about 18,000 deaths in less than two years in London (Sheppard, 1998). However, by the late 1500's, London's population recovered because migration and foreign trade both increased (Sheppard, 105). During the late Middle Ages the first pollution problems in the Thames River emerged. The first sewers found in London date back to the period of Roman occupation. These sewers were simply wooden pipes located underneath buildings the emptied directly into the Thames (Ackroyd, 2007). Public laboratories were located directly above the river on main bridges or in tidal areas where the excrement could be easily washed away by the tides of the Thames (Ackroyd, 2007). The amount of effluent in the Thames drastically increased throughout the 17th, 18th and 19th centuries as London's population increased sevenfold from 75,000 people in 1550 to about 575,000 people (Sheppard, 1998). Therefore by the year 1700, London was the largest metropolis in Western Europe (Sheppard, 1998).

In the mid 1700s the first privatized drinking water pipes were built throughout London. By the mid-1800's about ten major firms controlled these pipes, that now brought water to people all over the city. However, the water supplied to households by these pipes was directly pumped from the tidal zone of the Thames River, and thus it was extremely unsanitary (Johnson, 2006). London's water companies made many technological changes such as the installation of steam pumps and better pipe systems that allowed them to pump water to all districts of London (Inwood, 1998). Still, no effort was made by any of London's water companies to build filtering or purifying systems until the mid 19th century (Inwood, 1998). Since the public used the majority of the water that was pumped from the Thames river as drinking and bathing water, water-borne diseases were common . Disease partially explains why 40% of deaths were among children under the age of two years old between the years 1700-1750 (Inwood, 1998). Water-borne diseases that were rampant in London included typhoid, dysentery, and infantile diarrhea (Inwood, 1998).

During this time period, London's population grew substantially, partially due to the government reforms and enclosure movements that changed and disrupted the traditional system of rural life in England causing a huge migration of people moving from the countryside to the city (Johnson, 2006). These migrations were also largely fueled by the Industrial Revolution that inspired economic expansion through industry and innovation in London (Solomon, 2010). Innovations such as the steam engine, canals and better ships for transportation and commerce were all developed in the late 18th century and proved to be essential for the success of the industrial revolution (Solomon, 2010). Steam power powered factories, water pumps, trains, riverboats and other equipment. As steam power allowed factories to produce more, faster, the need for laborers grew, explaining why in 1854 London's population reached about two and a half million people (Johnson, 2006). As London's population continued to grow, so did the amount of human solid waste. It is not surprising that London's growing population and budding industrial sector resulted in the Great Stink of 1858. Centuries of disposing human waste in cesspools, in heaps on the sidewalks and in inadequate sewage pipes, all of which eventually ended up in the Thames, finally reached a level that could no longer be ignored. A toxic mixture of river water and effluent slowly backed up under London's streets with each high tide, creating an awful stench. As described by the Chancellor, Benjamin Disraeli, the Thames was, "a Stygian pool reeking with ineffable and unbearable horror" and was reported to have sewage as thick as 6 inches along its banks (Ackroyd, 2007).

London's unsanitary river water conditions created a huge public health concern because drinking water was still primarily pumped directly from the Thames. Major health concerns such as the emergence of Cholera in London and its direct connection to the dirty Thames water, finally launched a sanitary awakening and which led to the Sanitary Revolution throughout London (Johnson, 2006). However, no significant changes were made in London's sewage system until four outbreaks of Cholera swept through London, killing over 30,000 people in London alone (Sheppard, 1998). This is partly because the relationship between Cholera and polluted drinking water was not accepted until the late 19th century after studies were conducted tracing the location of the epidemic and the source of drinking water, which in all cases was the Thames River (Johnson, 2006). Cholera is a waterborne bacterium that attacks the bodies' digestive system and causes dehydration, fever and diarrhea that quickly kills the victim and is easily spread to others via poor water and excrement (Johnson, 2006).

Finally in the 1860's, London's Metropolitan Board of Works started constructing a proper sewage system that was carefully designed by engineer Joseph Bazalgette to be built under the city and parallel to the Thames River (Solomon, 2010). This sewage system re-routed the sewage waste out of the city and downriver. By 1866 the only Cholera outbreaks occurred in areas of London that were not connected to the sewage system and therefore still consumed some contaminated water (Solomon, 2010). The Sanitary Revolution and the water borne disease epidemics also prompted drinking water companies to build filtration and purifying systems using chemical, light and ozonization systems (Solomon, 2010). Another genius element that Bazalgette worked into his sewage system design, was the construction of three river embankments that had many other practical uses, such as housing an underground railway, gas and electric lines as well as providing above-ground public space next to the river (Solomon, 2010). These embankments act today as major esplanades and parks that are heavily used and important to the city. Overall, Bazalgette's complicated sewage system was a huge engineering and public health feat, and was a major turning point in London's history, as it proved that a massive public works project could actually address and resolve a major city-wide environmental health crisis (Johnson, 2006.

History of Urban Growth in Portland and the Causes of Pollution in the Willamette River

The Willamette River stretches 187 miles in total through the Willamette Valley emptying into the Columbia River about 99 miles from the Pacific Ocean (Gleeson, 1972). Due to its position within a fertile river valley, and its navigability, many major cities developed and prospered along the river. Cities such as Portland, Salem and Eugene were strategically located along the river, allowing for the development of commerce and major industries that would prove to be economically essential to the state of Oregon (Gleeson, 1972). Furthermore, due to the Willamette River, a major proportion of the total population of Oregon has resided in the Willamette Valley since the beginning of the 19th century (Gleeson, 1972). This paper will primarily focus on the Lower portion of the Willamette River Basin because this section includes the metropolitan area of Portland. Portland will be the main focus of the discussion of pollution in Willamette River because it is the largest city in Oregon (current population is about 585,000 people) and has an interesting history of water pollution due to heavy industrial, commercial and human use surrounding the river. The combined affects of population growth, rapid industrial

expansion along the Willamette River and lack of environmental concern and regulations in the Portland area, obviously resulted in deteriorating river water quality that was first addressed by the city in the beginning of the 20th century (Robbins 2004).

Starting in the 1920's Portland's newspaper, *The Oregonian*, repetitively referred to the Willamette River as an "open sewer" because of the industrial and human solid waste that was dumped into the river due to the lack of sewage systems (Robbins 2004). A water quality test conducted by the Oregon State Board of Health in the early 1920's determined that the lower Willamette was mostly polluted as a result of industries that were dumping their waste directly into the river (Gleeson 1972). By 1927 the city conducted more extensive water quality tests that reveled a depletion of the dissolved oxygen content, which engaged more groups and agencies such as the newly formed "Anti-Pollution League" and The City Club in studying the poor condition of the Willamette River (Gleeson 1972). The City Club was outraged by the Willamette's "intolerable" condition and therefore pushed for anti-stream pollution legislation (Gleeson 1972). Efforts to create viable policies to clean up the Willamette River continued throughout the early 1930's, although effective legislation was hard to establish because of deficient funds from the State and because many of the laws were not sufficiently enforced (Gleeson 1972). By 1935 there were 17 statutes related to pollution control as determined by the Oregon State Board of Health, however, the statutes were not supported by the public and in general, they accomplished little (Gleeson 1972). One of the most promising initiative measures passed in Oregon in 1938, established the Oregon State Sanitary Authority, an agency that eventually led to the development of proper domestic and industrial waste removal and treatment procedures through sewage systems (Gleeson 1972). However, World War Two stunted the development of pollution abatement in Oregon and encouraged the growth of industry and the need for jobs throughout the state, adding to the pollution problem (Robbins 2004). As the war ended in 1945, Governor Earl Snell pushed the Sanitary Authority to conduct in-depth water quality and fish life surveys of the lower Willamette River and once again the results determined that the state of the Willamette had not changed since the first studies were conducted in 1929 (Gleeson 1972). Furthermore, the results concluded that all fish species living in the Willamette were seriously affected by the polluted state of the river, especially the salmon species that are extremely intolerant to low oxygen levels (Robbins 2004). The survey results stated:

> Pollution in Oregon's great river, along with other detrimental activities, has depleted a world-famous commercial and game fish fauna. The Willamette River and many of its tributaries are a story of lost miles of fishing waters and of lost important spawning grounds for Chinook salmon (Gleeson 1972, 65).

In addition, another outcome of the Sanitary Authority's survey was the recognition that sewage and industrial waste could no-longer be diluted by the flow of the Willamette River because in general, periods of high waste loads were often discharged during seasonal periods of low stream flow, causing high concentration of pollutants and low oxygen levels (Robbins 2004). Following this realization, the city finally approved a multi-million dollar project to build sewage and waste treatment plants throughout the city. This project would not only improve the water quality of the Willamette, but it also provided many post-war jobs that were in high demand (Robbins 2004). By 1960 the Sanitary Authority required that all waste-industrial and domestic-be treated in secondary treatment facilities before it was returned to the Willamette River (Robbins 2004). Although sewage treatment facilities were widely used throughout the Portland area, the state of the Willamette River was still dismal.

In 1962 local media and the new state senator and later governor of Portland, Tom McCall, produced a documentary that highlighted the poor water quality in the Willamette River. McCall's documentary, *Pollution in Paradise,* targeted industries that dumped pollutants into the river and hoped to instill the urgency of the problem to the public and to the Sanitary Authority (Robbins 2004). McCall argued that in order for Portland to have a healthy economy, it needed to be "livable" or provide a good quality of life and have a clean environment (Robbins 2004). Shortly after McCall's documentary was released to the public, the Sanitary Authority strengthened its anti-pollution laws by requiring all industries to purchase waste-permits in order to discharge any waste into the river. These programs allowed the authority to enforce how much waste each industry discharged into the Willamette (Robbins 2004). In 1969 the newly formed Oregon Department of Environmental Quality established water quality standards that were meticulously outlined in a series of statutes (Gleeson 1972). In order to assure compliance to these standards the bill stated that:

> to check compliance with standards, continuous monitoring of the river is a requirement. The Department of Environmental Quality has established designated stream surveillance stations at approximately 30 locations on the main stem of the Willamette from Springfield to the Columbia Slough…(and)…the

> Department of Environmental Quality is empowered to issue Water Discharge Permits… (Gleeson 1972, 55).

The main industries in the Portland area that were closely monitored were the pulp and paper mills that consistently disobeyed waste discharge standards and were criticized by the Sanitary Authority and McCall for dumping "gallons of bubbling pulp wastes directly into the river" (Robbins 2004). In addition, two chemical plants located on the westside of Portland were cited for dumping their waste directly into Doane Lake. The contents of this lake were eventually pumped into the Willamette River or migrated to the river after leeching into the groundwater (Robbins 2004).

Improved enforcement methods and water quality standards, allowed the Willamette River to finally see improvements in water quality throughout the 1980's. The initiative to clean up the Willamette that resulted from McCall's documentary and the DEQ water quality standards was viewed nationally as a major success. In 1972 the the National Geographic declared the Willamette River as a "river restored" and the EPA used the Willamette River improvement efforts as a model of for the Clean Water Act (Otto 2002).

Still, the Willamette River faces pollution concerns today from many of the same sources that originally affected the river. In 2002, the Oregon DEQ stated that 994 water bodies in Oregon, including most of the Lower and Middle sections of the Willamette River, were considered "water quality impaired" (Otto 2002). The 6-mile stretch of the Willamette River that runs through the Portland Harbor was federally declared a Super Fund Site as of 2000 because of high levels of toxic contaminants (PCBs, mercury, dioxin) found in the river sediments (Otto 2002). Water quality standards and technological methods of keeping waste out of the river prove to be only part of the solution. Portland adopted other strategies to stabilize the water quality of the Lower Willamette River such as implementing a Willamette River Plan that includes using greenways and integrating local environmental groups and public stewardship.

Comparing the Historical Patterns of Pollution and Control in Portland and London

In general, the Thames and Willamette Rivers, have similar stories of pollution, where both stories begin with the build-up of human effluent in the river due to lack of infrastructure and population growth. Depositing human waste into the river was a common practice in both

cities and did not pose any serious issues until the cities population grew. In both London and Portland population growth corresponded with the Industrial Revolution because people migrated to the cities in order to work in the factories and industries. A larger population meant that more waste was released into the river and that the demand for water as a resource grew. Widespread public use of polluted water, especially in London, quickly created major public health problems. The population of Portland also experienced water borne disease problems related to high levels of sewage in river water but they were nowhere as brutal as the cholera epidemics that raged through London throughout the 1800s.

One of the main differences between London and Portland is the main source that supplied drinking water to each city. Throughout the 1800's drinking water companies in London pumped their water directly out of the Thames River and into peoples homes. Therefore much of London's population was, "ingesting small particles of human waste" because their drinking water was laced with sewage (Johnson 2006). Not only was most of London's population drinking their own sewage, but they were also drinking water full of lethal bacteria such as cholera. Portland on the other hand did not use water from the Willamette River as drinking water because the city is situated near the Bull Run Watershed that has been used as the main supply of drinking water in Portland since the late 19th century (Portland Water Bureau 2012). The Bull Run Watershed is located 26 miles outside of the city of Portland and it has been protected under the law since 1892 (Portland Water Bureau 2012). Therefore, since a majority of Portland's citizens received water from the protected and pristine Bull Run Watershed, rather than from the polluted Willamette, Portland never experienced lethal waterborne disease episodes like London did.

Although London experienced the most lethal bouts of disease associated with poor water quality, health concerns were major pressures that drove the creation of water quality standards and technological advancements in sanitation infrastructure in all three cities. Once cholera was accepted as a waterborne pathogen, efforts to clean up the Thames River quickly increased due to the urgency of the problem. The first solution to water pollution issues was the use of civil engineering to construct sewage collection systems and treatment facilities. Clearly, London was the first cities to develop an effective citywide sewage system. Balazagette designed and built London's system in the 1860's, whereas in Portland a concrete pipe sewage system was not built

until 1933. London's sewage system was one of the first ones to be built in a major city in Europe and therefore many cities modeled their own systems after it (Johnson 2006).

Integrated Water Resource Management Plans in Portland

The River Renaissance Plan

After the federal government announced that the Portland Harbor was a superfund site in 2000, and after the DEQ declared that parts of the Willamette River had "impaired water quality" in 2002, the Portland Bureau of Planning and city officials drafted the Willamette River Renaissance Plan. This plan integrated many other river related initiatives such as the Willamette River Greenway plan, Portland's Clean River's Plan and the Endangered Species Act (Otto 2002). By creating one plan that encompasses the goals and strategies outlined in other initiatives, the River Renaissance Plan attempts to unify these into one framework as to limit conflicting or duplicative policies. The renaissance plan outlines many short-term and long-term goals that according to Portland's Mayor, Vera Katz, would "make the river Portland's front yard" (Otto, 2002). The main goals of the plan, as articulated in *The River Renaissance Vision*, were broadly defined as:

1. To Ensure a Clean and Healthy River
2. To enhance a prosperous working harbor
3. To Create vibrant waterfront districts and neighborhoods
4. To embrace the river as Portland's front yard
5. To promote partnerships, leadership and education (The River Plan, 2006)

These broadly defined themes were long-term, overall goals that the Bureau of Planning admittedly acknowledged as unrealistic. The Plan states, "each vision theme cannot realistically be fulfilled on every stretch of our rivers, not in every part of each watershed, but River Renaissance thinking means striving to address all five themes" (The River Concept 2006). The broad goals represent the values behind the plan and are goals that would only be able to be achieved in the long term. Another key aspect of the River Renaissance plan that is also a key element in any integrated water management policy is public participation. The renaissance plan strives to make the river more accessible and integrated into the daily lives of Portland citizens

(Otto 2002). The plan states that it will focus its attention on expanding and improving the existing esplanades and create more river-water access locations to encourage recreation.

The River Plan

By 2006, the River Renaissance Plan was incorporated into a new overarching, integrated initiative, called the Willamette River Plan that focuses on the revitalization of the North, Central and South reaches of the river over the next twenty years. The North reach is the first area of the river to receive detailed planning and restoration. The North Reach is an important area both industrially and ecologically because it is where the Willamette River meets the Columbia. Therefore the one of the main objectives of the river plan is to regulate and protect industrial land in the North Reach that is essential to the regions economy (Proposed River Plan/North Reach 2008).

The North Reach River Planning Process includes involvement of many different stakeholders, community members and federal, state and local level government. The plan appoints a River Plan Committee that is led by a commissioner from the Portland Bureau of Planning and made up of community member volunteers. Below is a concept map outlining the levels of leadership and the different actors involved in the planning process of the *River Plan* (Proposed River Plan/North Reach 2008).

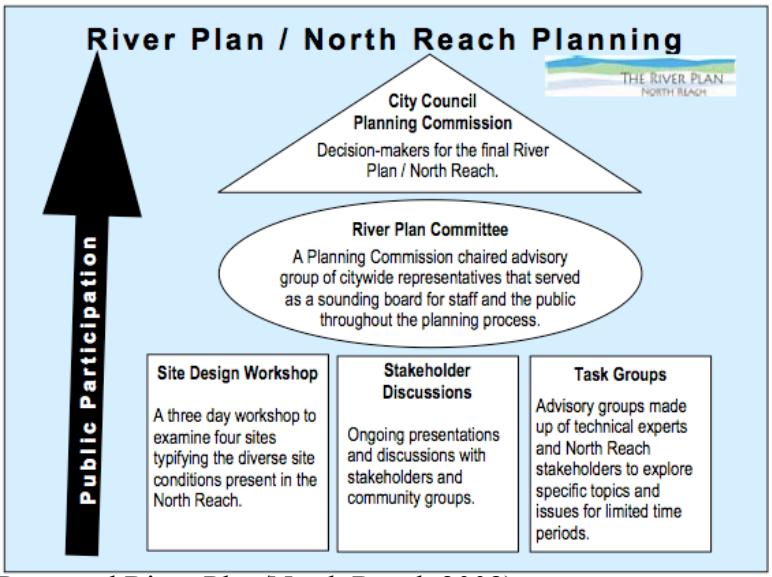

Fig.1. (Proposed River Plan/North Reach 2008)

This diagram illustrates how the Willamette River Plan planning process does take an integrated approach because it involves participation by all of the different stakeholders, communities and city government officials that live, work, or simply just care about the river. Even though this plan is a localized approach to water management because it only applies to the Willamette River, its success is partly because of strong water quality and resource management policies at the state and national level. At the national level, the strict water quality guidelines and standards outlined by the EPA in the Clean Water Act make it easier for the localized policies such as the *River Plan* to actually accomplish their goals, especially those related to water quality. There are water quality standards that are already outlined by the Clean Water Act, and thus one of the overall goals of the *River Plan* is creating strategies that work towards meeting these standards. In the *River Plan*, they focus on restoring riparian areas and work with industries and community members to develop more sustainable and less-polluting practices. Without the CWA, enforcing water quality standards at a localized basin or watershed level might be more difficult.

Portland's Watershed Management Plan

In 2005 the city of Portland and the Bureau of Environmental Services presented the *Actions for Watershed Health* plan which lays out a comprehensive, strategic and integrated approach to improving watershed health in Portland (Actions for Watershed Health 2005). This plan focuses on, "integrating the activities of multiple City bureaus, and maximizing limited resources by looking for solutions that meet multiple interests" (Actions for Watershed Health 2005). This plan focuses on the five watersheds that are included in the Portland area, which are the Columbia Slough, Willamette River, Johnson Creek, Tryon Creek, and Fanno Creek. Under the Portland Watershed Management Plan, all activities that affect watershed conditions such as transportation and redevelopment are considered collectively rather than as separate issues. One of the main goals of the plan is to restore and maintain watershed health, which is defined as:

> A healthy watershed has hydrologic, habitat, and water quality conditions suitable to protect human health, maintain viable ecological functions and processes, and support self-sustaining populations of native fish and wildlife species whose natural ranges include the Portland Area (Actions for Watershed Health 2005, 39).

Besides promoting watershed health, the watershed action plan aspires to improve livability, sustainability, human health and education in the Portland area. The strategies for putting these goals into action include mapping out target areas in each watershed that need to be addressed in the next five years. It also outlines different ways in which community members, city bureaus, environmental services and local leaders can be involved in implementing different sections of the collaborative plan. For example there are many community stewardship opportunities in each watershed that the public can get involved in. These include invasive species removal projects and positions in non- profit planning and development groups. Meanwhile the Environmental Services can focus on projects such as limiting the amount of combined sewage overflow that reaches the Willamette during storms.

Integrated Water Resource Management in London

The Thames River Basin District Management Plans

In 2009 the Environmental Agency in the UK published a series of river management plans that are focused on managing the Thames River Basin District. The *Water for life and livelihoods* and *River Basin Planning: Working Together* are two of the management plans that outline essentially the same approaches and goals to the river management of the Thames River Basin. Both of these plans were published in accordance with the EU's Water Framework Directive (WFD). The WFD establishes new guidelines and methods for protecting and improving rivers, lakes, groundwater, and coastal waters throughout the EU (River basin planning: working together 2009). The WFD is based on the IWRM framework and therefore it focuses on creating management plans on the river basin level through the creation of river basin districts. The WFD develops short-term plans that are supposed to be feasibly implemented over six year periods. Thus the goals outlined in these first two plans for the Thames River Basin District are supposed to be implemented and hopefully produce results by 2015 (Water for life and livelihoods 2009). The Thames River Basin District (TRBD) is particularly important because it is home to 13 million people, even though the city of London only houses about 8 million people. Therefore the TRBD is the most populated river district in the UK. The TRBD is also particularly important because the Thames River provides over two thirds of London's drinking water while groundwater from the basin provides about 40 percent of the public water supplies in London (Water for life and livelihoods 2009). Therefore it is essential to maintain its

quantity and quality. The *Water for life an livelihoods plan* discusses the current state of the Thames River's water quality and then provides methods for improving the water quality of the Thames by 2015. First this plan broadly outlines the major water quality concerns over the entire basin but then focuses on 17 river catchments throughout the district. The plan very briefly outlines the major water quality issues at each catchment and then provides three to five key actions to improve the state of each catchment.

The steps for implementing this plan include developing extensive water quality monitoring throughout the Thames River Basin District that will be primarily carried out by the Environmental Agency by the end of 2012. Local groups or volunteers in each catchment will also carry out water quality monitoring. The *River basin planning: working together* plan discusses the public's role in river basin planning in the TRBD. By involving local people and groups in the process of water quality monitoring in their local area, these plans hope to inspire further public participation in the decision-making process.

The London Rivers Action Plan

The most recent and localized water management plan that is used to regulate and restore the Thames River and its basin, is the *London Rivers Action Plan (LRAP)*. This plan was developed in 2009 to increase the rate of river restoration both on the Thames River and for its many tributaries that also suffer from poor water quality due to heavy urbanization and land-use changes (London Rivers Action Plan 2009). The LRAP focuses on long-term goals to ensure that the river can be used as a resource and for enjoyment by future generations. Particularly the LRAP is concerned about flooding and climate change related to the Thames River (London River Action Plan 2009). The LRAP is focused on urban regeneration by restoring riparian habitat and developing greenspace along the Thames River and in other areas in London. This plan mostly focuses on restoring riparian lands and floodplains at specific sites located throughout the Thames River basin. Unlike Portland's *River Plan* the LRAP does not outline the different sectors that were involved in developing the plan and it also does not outline which groups, committees will be involved in carrying out the site-specific projects. The LRAP offers mostly guidance and background information about how riparian restoration, flood control, and urban regeneration will benefit both the environment and the public.

Evaluating the IWRM framework in Portland and London

This section looks in depth at each of the water management plans that were discussed above in Portland and London. The goal of this section to evaluate and compare each plan based on different criteria that is essential to the definition of IWRM. All of the plans that are discussed above incorporate some of the themes and goals of the IWRM framework. Yet all of the plans seem to move away from some of the main elements incorporated in the IWRM definitions such as the river basin scale. In the UK the river basin scale is used to manage the Thames River, but in Portland the management plans are all based on a much more localized scale, focusing on the watersheds and sub-basins or areas of the Willamette that are located within the metropolitan area.

Each plan will be evaluated in detail by comparing their key goals and objectives, the scale at which they are implemented, their incorporation of land-based and water quality monitoring programs, and levels of participation that each plan promotes. The table below summarizes the key findings of management plans in Portland and London that are discussed further in this section.

	Portland	**London**
Integration of prior policies/ plans/programs	Comprehensive plan (1980), Willamette Greenway Plan (1987), River Renaissance Plan (2001),River Concept (2006)	Water Framework Directive (EU), Integrated Pollution and Prevention Control (1996)
Main goals outlined in plan(s)	1.Increase public access to riverfront and public participation 2.Ensure Portland harbor's long-term vitality by integrating water quality management and promotion of industry 3. Integrate cities responses to regional, state and federal laws 4.Make sure Cities activities are consistent with watershed health goals	1.Expand scope of water protection to all waters, surface water and groundwater 2.Enhance public and stakeholder involvement in decision-making process and implementation of policies 3.Focus on developing long-term solutions
Scale	River Plan: implemented on North, South, Central reaches of river in Portland (all located in lower Willamette Sub-basin)	The WFD sets goals to be implemente the river basin district level; Water for life and livelihoods Implements goals in entire Basin, but also specifies goals in the 17catchments that make

Scale	River Plan: implemented on North, South, Central reaches of river in Portland (all located in lower Willamette Sub-basin)	The WFD sets goals to be implemente the river basin district level; Water for life and livelihoods Implements goals in entire Basin, but also specifies goals in the 17catchments that make up the TRBD
Land-based /land-use projects, as part of water management	Incorporates Willamette Greenway Plan: make river more assessable Riparian zone restoration	Primary focus on riparian zone restora as part of protecting River water quality and Ecosystem Does not focus on implementing gre Greenways or other land-based programs
Participation of different levels in Planning Process	EPA, Oregon DEQ Portland Bureau of Environmental Services,	EU, Environmental Agency of UK River Basin Districts, Thames River Basin District Liaison

Fig.2. This table was created by Isabel Kuniholm.

Key Objectives and Goals

One interesting similarity between London and Portland's plan is that they both aspire to restore their river in order to "recapture the heart of the city"(Otto 2002). The history of both cities shows that as pollution and industrialization increased, the river was transformed from a natural, aesthetically pleasing part of the city, to a dirty, smelly wasteland that became a burden to the cities environment. Therefore urban regeneration and river restoration plans in both London and Portland hope to almost re-instill a sense of naturalness to the river, and by doing this they hope to re-connect the public to the river.

The key objectives of the *River Plan* are congruent with the main goals of the *River Renaissance Plan* and the *Portland Watershed Management Plan* because the *River Plan* is an integration of those plans. The objectives of this plan are interdisciplinary, in that they focus on enhancing all of the different functions and values that the river brings to the city. This includes

promoting the Willamette as a "working harbor" and encouraging industrial development through more flexible and predictable regulations (Portland River Plan 2006). Other key objectives include promoting the river as an important corridor for outdoor recreation through the construction of greenways along the riverbanks and nature reserves. Improving public access to the river is also important for promoting public awareness about the state of the Willamette River. A third main objective of the *River Plan* is to protect the aquatic ecosystems by maintaining the water quality of the Willamette River. This requires extensive monitoring, better enforcement of industrial pollutants and combined sewage overflow.

The water management plans in London are motivated by similar objectives, although they are mostly focused on protecting and improving the water quality of the Thames River and its tributaries that are included in the basin district. Like the *River Plan* the *Water for life and livelihoods* plan combines the efforts of other sectors and existing plans to, "ensure our combined efforts achieve the improvement needed in the Thames River Basin District" (Water for life and livelihoods 2009). The main objectives are the same as the ones found in the Water Framework Directive. The goals include:

- Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters
- Aim to achieve at least good status of all water bodies by 2015. Where this is not possible and subject to the criteria set out in the Directive, aim to achieve good status by 2021 or 2027;
- Meet the requirements of Water Framework Directive Protected Areas
- promote sustainable use of water as a natural resource
- progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment;
- contribute to mitigating the effects of floods and droughts (Water for life and livelihoods 2009).

Each country in the EU is required to meet these goals through the development of basin specific plans such as the *Water for life and livelihoods plan*. Unlike the water management plans in Portland, the goals guiding water management in the Thames River Basin are primarily focused on implementing water monitoring programs and promoting clean and sustainable use of water as a natural resource. The objectives of the *Portland River Plan* are equally focused on improving social, economic and environmental aspects as they relate to the Willamette River.

Scale

Integrated water resource management is based on the river basin scale. However, the plans that are currently in place in London and Portland are all implemented at a smaller sub-basin, watershed or catchment scale. Although the EU's *Water Framework Directive* plan divides water management into river basin districts in each country, the *Water for life and livelihoods* plan reduces its goals and specific plans to 17 catchments within the Thames River Basin District. The plan describes the main issues regarding water quality in each catchment and then offers a few key actions that should occur in the future. These action plans are not discussed in detail. For example, in the London catchment 57 percent of the water bodies located within it are considered to have poor water quality (Water for life and livelihoods 2009) The key actions for this catchment include, "The Environmental Agency will undertake pollution prevention projects on Pymmes Brook, Brimsdown Ditch and the River Wandle" and "the Environmental Agency and Natural England will work together to continue to develop and implement the London Rivers Action Plan to improve ecology through habitat creation and enhancement" (Water for life and livelihoods 2009). These two actions state the main actor that will oversee or implement the action for that catchment and in general the main actor is the Environmental Agency. Overall the implementation processes for these actions are not described in detail.

In comparison, Portland's *River Plan* is focused on the areas of the Willamette River that are included in the metropolitan area of Portland. The plan is divided into three sections that each focus on a different part or reach of the Willamette River as it flows through the Portland Area. *The River Plan* does not offer any goals or objectives for the Willamette Basin as a whole. Yet, most of the goals of the plan were made in order to meet city, state and national standards and laws, and therefore it can be inferred that other plans for the Willamette River that have been made outside of Portland most likely have similar objectives. Compared to the *Water for life and livelihoods plan*, each reach of the Willamette that the plan focuses on is discussed in great detail and the exact implementation plans are laid out in much more detail then the key actions in the *Water for life and livelihoods* plan. By focusing on a localized scale, the *River Plan* is able to clearly define the key objectives for each reach and is able to formulate a cohesive action plan that is feasible. Federal and state laws and plans such as the Clean Water Act, the Comprehensive Plan for Portland, and statewide water quality standards as determined by the

ODEQ, are incorporated into the planning process of the *River Plan* because ultimately the plan must be compatible with these laws.

Use of Land-Based Programs and Water Quality Monitoring

The first version of the Willamette Greenway plan was enacted in Portland in 1987. Currently, the greenway plan is no incorporated in the River Plan and has been modified to fit the current needs of the city. Greenways are multi-objective and are used along rivers to address the needs of wildlife, flood damage reduction, water quality, education, recreation and urban aesthetics (Searns 1995). Many greenways include trail systems, bike paths, riparian restoration and wildlife zones, and green spaces for recreation and provide access points up and down the river cooridor. They can be considered as a land-based infrastructure that in some ways can benefit the river's water quality and public value of the river as an important aspect of the city (Searns 1995). In Portland, the Tom McCall waterfront park that was built in place of the highway Harbor Drive in the 60's, is one of the first examples of a greenway park. Since the development of the plan, the eastside esplanade and the spring water corridor have been built. Both of these offer area right along the river for people to recreate and to simply just connect to the river. They also offer public spaces that can be used by school groups or environmental groups to educate people about the water quality and riparian habitats of the Willamette. The River Plan hopes to expand the greenway system in Portland in the future. IWRM framework endorses greenways because they serve many different purposes and increase pubic involvement with the river. Neither of London's river management plans discuss the use of greenways, but they do focus on the need to restore and protect riparian zones.

Water quality monitoring and protection is another huge part of the IWRM framework, because it stresses the need to monitor the water quality of the entire river basin, not just the river, as hydrological, the water quality of the tributaries will effect the state of the main water body. Based on the historical discussion of the Willamette River and the Thames River above, it is obvious that both rivers suffered from high amounts of sewage and industrial waste discharges until the city installed proper waste management infrastructure and established effective management plans. Although technological advancements in waste management such as secondary and tertiary sewage treatment facilities were successful in decreasing the discharge of

pollutants into both the Willamette and the Thames, recent water quality assessments show that neither river has fully recovered to a "clean" or "restored" state of being. These assessments do show that the water quality improved after monitoring programs were initiated, but they also prove that both rivers' have much room for improvement especially in the major metropolitan areas of Portland and London.

The most recent water quality assessments of the Thames River used benthic monitoring to assess the overall health of the river. Benthic monitoring measures any change in macroinvertebrate communities that may be a result of water quality stressors such as toxic pollutants or substrate alteration (Singh and Davidson 2011). This particular report used the Pollution Tolerance Index and the Family Biotic Index to evaluate the biological health of the Thames River. Under the Pollution Tolerance Index, each macroinvertebrate that is collected is sorted into one of three groups based on its known tolerance to pollutants (Singh and Davidson 2011). To determine the PTI total for the river, Singh and Davidson multiplied the number of different invertebrates in each group by its respective index number (1, 2 or 3) and then added all three groups totals together (Singh and Davidson 2011). Stream water quality is considered to be good when the PTI number is greater than 40 and considered to be poor when the PTI number falls below 20 (Singh and Davidson 2011). This study sampled macroinvertebrates as well as the stream temp, pH and DO level at 17 sites throughout the Thames River. Davidson and Singh found that most of the sites warranted a fair PTI rating and one site received a poor PTI rating. The results also showed PTI improvement in a few sites when compared to data collected in 2010 (Singh and Davidson 2011).

Another recent water quality assessment published in 2009 discusses the phosphorous levels in the Thames River, "Phosphorous levels in the Thames River are unfavorable in that they exceed the surface water quality objective by a factor of 2.3 in 2009 entering London, and by a factor of 3.5 at Byron"(Standish 2009). High prosperous levels are congruent with algae blooms. This study states that about 18% of the phosphorous found in the Thames is discharged from the cities pollution control plants of PCPs (Standish 2009). The Ministry of Environment Certificate of Approval requires that the phosphorous levels in sewage be reduced to at least 0.75mg/L (milligrams/Liter) in London. Standish's study found that the phosphorous level in

effluent from London's PCPs averaged .55 mg/L (Standish 2009).

Standish's study also addressed the bacteriological quality of the Thames River by looking at the total coliform and E.Coli levels (Standish 2009). According to this study, the city of London is required to sanitize all effluent that flows through the PCPs especially during the spring and summer months when flows are generally low and water temperatures are high enough to support bacterial growth (Standish 2009). Disinfection of effluent is essential especially because the Thames has consistently failed to meet the total coliform standards that are determined by the Ministry of the Environment (Standish 2009). Currently London is dealing with problems such as combined sewage overflows during periods of high precipitation, when the PCPs reach capacity the excess sewage flows into the Thames without being treated.

Similar to the Thames River, the Willamette River is thoroughly monitored and its water quality is assessed based on many of the same water quality components that are measured in the Thames River. The Oregon Water Quality Index (OWQI) measures pH, temperature, dissolved oxygen, phosphorus and nitrate levels, total solids and bacteria (based on presence of E.Coli) (Mrazik 2007). The OWQI interprets water quality at each of its monitoring sites and then uses the data to assign a score to each site based on a range of 10 (very poor water quality) to 100 (excellent water quality) (Mrazik 2007).

Based on the data for the Lower Willamette River provided in this report, four out of the fourteen sites located in the Lower Willamette River Basin received rankings of "very poor", three sites were ranked as "poor" and three sites were ranked as "excellent" (Mrazik 2007). In comparison the upper and middle sections of the Willamette River received much higher OWQI rankings. For example more than half of the total sites in the Upper Willamette River (6/12) received excellent rankings and only one site was ranked as poor (Mrazik 2007).

Another DEQ water quality report, *The Willamette Basin Rivers and Streams Assessment* from 2009 also illustrates through graphs and tables that the Lower Willamette Basin suffers from the worst water quality. The Lower Willamette Basin is the most urbanized subbasin, where 51% of the land is classified as urban (Mulvey and Leferink 2009). In this study the DEQ also state that water temperature is the most severe water quality stressor in the Lower Willamette River, "warm water temperature is the
most extensive stressor we assessed impairing the ability of nearly 70% of the stream and river habitat to support salmon, trout, and other sensitive aquatic species" (Mulvey and Leferink

2009).

According to the Total Maximum Daily Load Standards, which are effluent limits assigned to rivers or streams that have exceeded the threshold limit (as determined under the Clean Water Act) of one or more water quality standards, state that stream temperatures are too high when they range from 73 – 79 degrees Fahrenheit (Mulvey and Leferink 2009).

Public and Stakeholder Participation in Planning and Implementation Process

Public participation is one of the key elements of integrated water management policies because it connects people to one of the most important elements of their city: the river. Greater public participation in management processes also raises awareness about current water quality issues and this in turn, encourages people to push for strong policies that will improve the state of the river and thus the state of their city.

Historical patterns show that after river pollution was initially stabilized due to infrastructure and water quality standards, the public's involvement with the river greatly decreased. One example of this is how most sewage infrastructure was built in public spaces, but was located under streets or enclosed in embankments. Barroque et.al. (2008) argues that by positioning infrastructure out of sight and since these infrastructure systems were able to quickly improve the polluted state of the river, people became less involved and detached from both the state of the river and from infrastructure development (Barroque et.al. 2008). Barroque et al. (2008), states, "people later became ignorant of the importance of systems: "out of sight, out of mind" …operators had no interaction with the public and with demand side problems: they just had to match the demand with more or less invisible infrastructure and that was it."

The plans in both London and Portland provide ways for the public to be involved in the planning process and the implementation process. For example as part of the planning process for the *River Plan* there is a River Plan Committee, which is a voluntary citizen advisory committee. A member of the Portland Planning Commission chairs the committee. The committee helped in the planning process and acted as a place for open discussion about the plan and other related issues (The River Plan 2008). The public was also encouraged to vote or voice their opinion at public hearings when the city was working on passing the program. In addition, the objective to improve access to the river will help re-connect people to the Willamette. The

greenway system and the esplanades that are located along the banks of the Willamette can be extended and improved to offer areas for recreation, natural riparian restoration and a corridor for transportation. The city hopes to re-instill the idea that the Willamette River is an icon of the city in the public, and providing more areas where people can enjoy the river will help to do this.

In London the Environmental Agency and the Water Framework Directive agree that water management must involve the participation by the public and other stakeholders, "it is important for everyone to play their part now and in the future. River basin management is an opportunity for this generation-for people and organizations to work together to improve the quality of every aspect of the water environment…" (Water for life and livelihoods 2009). One venue for public and stakeholder participation is through the Thames River Basin District Liaison Panel, which is a group that has been involved in the management of the planning process. The panel includes representatives from local businesses, industries, planning authorities, environmental organizations, regional and local government and local citizens (water fore life and livelihoods 2009). The panel will also be required to help promote broader stakeholder involvement and to help coordinate and increase communication between all stakeholders and levels of government. The *River basin planning: working together* initiative in the Thames River Basin focuses on raising public awareness of the environmental concerns throughout the basin and how they can get involved in the clean-up or mitigation process. The plan discusses how they will create forums where the stakeholders and the public can provide feedback about the water management plans in the TRBD.

Can an Integrated Approach to Water Resource Management be Successful in Sao Paulo?

History of Water Pollution in the Tiete River and Modernization of Sao Paulo

The Tiete River is the largest river (about 1,1100 km) in the Brazilian state of Sao Paulo in southeastern Brazil. The metropolitan area of Sao Paulo and about 99.5% of population of Sao Paulo reside in the Alto-Tiete sub-basin (Johnsson, 2005). Although the state of Sao Paulo in Brazil only contains about 10% of the countries fresh water resources, it is home to about 73% of Brazil's total population (Johnsson, 2005). In comparison, the Amazon River Basin contains more than 75% of Brazil's fresh water resources but only houses 4% of Brazil's population. Furthermore, Sao Paulo is one of the main areas of industrial production in the country,

accounting for 20% of Brazil's total industrial production (Johnsson, et.al., 2005). Currently the metropolitan region of Sao Paulo has a population of nearly 19 million people. Based on these statistics it is clear that one of the primary issues relating to water in the Alto-Tiete River Basin is the struggle over water resources between the public, hydropower plants, and industrial users (Johnsson, et.al, 2005). The first dams and reservoirs were built on the Tiete River in the early 20th century. The two main reservoirs-Guarapiranga and Billings-were both supplied with a large volume of water from the Tiete and neighboring Pinheiro Rivers and historically, most of the water stored in both reservoirs was allocated to the hydroelectric dams such as the Henry Borden hydropower plant, until the 1970's (Johnsson, et.al, 2005). By the 1970's the need for water throughout the city of Sao Paulo increased due to population growth. To meet drinking water demand, some of the water in the Billing's reservoir had to be directed to the city of Sao Paulo rather than just to the hydropower plants (Barraque et al. 2008). Throughout the 20th century, the main goal of the state government was to increase rapid economic growth by giving more power to the energy sector (Keck, 2002). Therefore the government continuously prioritized giving the hydropower companies more water than the city of Sao Paulo because they were more concerned about economic interests than about sanitation or health concerns related to drinking water (Keck, 2002).

Water resource management in Sao Paulo before 1991 was disjointed and ineffective because there was little communication between the two main environmental agencies (DAEE and CETESB) (Johnsson, 2005). The DAEE, or Departamento de Agua e Energia Eletrica, is a centralized state department that primarily issues water use permits in Brazil. Companhia de Tecnologia de Saneamento Ambiental (CETESB), (Environmental Technology and Improvement Company) was established in 1970 and became the first agency to monitor the water quality in the Tiete River and the Billings Reservoir (Keck, 2002). Although CETESB created many beneficial pollution control policies at the state level, it failed to regulate water and sanitation companies because it focused primarily on regulating industrial polluters (Johnsson et.al, 2005).

Water quality issues ensued after the mandate in 1970 for much of the water in the Billings Reservoir to be used to supply drinking water for the city and suburbs of Sao Paulo (Keck, 2002). Since the early 20th century, a majority of the waste from Sao Paulo was deposited

into the Tiete River as it flowed through the metropolitan area. The Billing's Reservoir, thus became a pollution trap, as all of the waste that was discharged into the Tiete River through Sao Paulo accumulated in the Billings Reservoir, causing it to be severely polluted (Johnsson et.al. 2005). In response to the polluted state of the Billings Reservoir, the 1970's marked the beginning of water pollution control policies and programs throughout the state of Sao Paulo (Keck 2002).

Policies for Basic Sanitation in Sao Paulo

Sao Paulo's first attempt at implementing a sanitation management program was a program called Solucao Integrada (Integrated Solution) that proposed to use a tunnel to remove all of the sewage out of the city and then treat it in a series of pools (Keck, 2002). Although this plan was popular among the public and the environmental groups because it promised to keep waste from entering the Tiete River and Billing's reservoir, political and economic unrest throughout the late 70's and 80's made it difficult for programs such as Solucao Integrada to be implemented. A more serious sanitation program called PLANSA-the National Plan of Basic Sanitation- was implemented in 1971. This program was based off the idea of "basic sanitation", which was defined as "giving priority to evidently essential systems, such as water and sewerage, but excluding drainage and solid residue collection, and delaying sewage treatment" (Barraque et al., 2008). This program favored centralization at the state level and this reduced the role of the local government in developing sewage and water infrastructure. However, the centralized structure of PLANSA had negative consequences because the plan invested more in providing services to wealthy areas and did not take local plans of development and population growth into account when designing infrastructure networks (Barraque et al., 2008).

The failure of the PLANSA program to develop proper infrastructure networks to the city of Sao Paulo is one reason why the Tiete River and both the Billings and the Guarapiranga reservoirs remained severely polluted throughout the 1980's and early 1990's. As a result, local environmental agencies advocated for the development of a new water and sanitation management framework in Sao Paulo during the late 1980's and 1990's. Policies such as the Sao Paulo Water Law of 1991 focused on an integrated approach to water resource management (Johonsson, 2005). Under this law a basin committee that included representatives from the state government, municipalities and civil society controlled the Tiete River Basin (Johnsson, 2005).

Projecto Tiete (Project Tiete) was one of the first programs formulated after the 1991 water law in Sao Paulo. A radio program publically broadcast throughout Brazil in 1990 compared the state of the Tiete River to that of the Thames in London a century before (Economist 2011). This program was just one media technique used to spread awareness about the terrible state of the Tiete and to stimulate the public to take action. The media also publicized the state of the Tiete by drawing attention to a lonely alligator "Teimoso" who was seen sunning on the banks of the Tiete River (Keck 2002). Teimoso acted as a flagship species in a campaign to clean up the Tiete River; as the public fell in love with the little alligator, they in turn learned about the state of the river, and worried about his ability to survive in such a polluted environment (Keck 2002). Environmental groups such as SOS-Rio Tiete (Save the Tiete River) also helped promote the project among the public (Keck 2002). Unlike previous programs such as PLANSA, Project Tiete received international funding from the Inter-American Development Bank that has allowed the project to outlast hyperinflation and changes in political leadership (Economist 2011). The two main Brazilian companies involved in this project are the Companhia de Saneamento Basico de São Paulo (SABESP) and CETSEB. SABESP is a utility company in Sao Paulo that is responsible for building sewage systems and treatments facilities throughout the city of Sao Paulo (SABESP 2010). The company divided their efforts in Project Tiete into three stages. During the first phase, from 1992-1998, SABESP built three new treatment plants throughout Sao Paulo and connected about 250,000 households to a sewage system (SABESP 2010). SABESP estimated that these new treatment plants increased the rate of treated sewage in Sao Paulo from 26% to 62% (2010). Phase two of the project began in 2002 and was completed by 2008. During this phase SABESP focused on cleaning up the area surrounding Billings Reservoir and the Pinherios River (a neighboring river that also drains into Billings Reservoir). The goal of this phase was to stabilize the pollution in the Billings Reservoir so that it could be used to supply drinking water to Sao Paulo (SABESP 2010).

Project Tiete is a successful program because it has proper funding from the Inter-American Development Bank and because it was implemented in feasible stages. Although one goal of the program is to promote public awareness about pollution issues and to encourage participation by stakeholders and the public, Project Tiete is not considered an integrated approach to water management. Other water laws such as the State Headwaters Law (1997) and the 2007 laws that defined new operating rules for sanitation services outlined a more integrated

approach than Project Tiete. The laws that were passed by congress in 2007 defined a new regulatory framework that, "creates participatory management bodies at municipal level, encourages new territorial scales of service management, and gives municipalities more control over services" (Barraque et al. 2008). This new framework also created river basin committees that were intended to mobilize local leaders and citizens in the management and decision making processes (Keck, 2002). Also these committees were a further attempt at making water resource management decentralized throughout the state of Sao Paulo.

IWRM in Sao Paulo, Programa Mananciais

Currently a new approach at integrated water management called Programa Mananciais in Sao Paulo is being implemented. This program is funded through an Adaptable Lending Program with the Intra-American Development Bank and the World Bank. The programs main objectives focus on maintaining water quality of potable and non-potable water resources, to improve the quality of life for poor communities who reside in the urban river basin areas, and to improve the management and coordination between different water management, pollution and basic service sectors (World Bank, 2012). Therefore this program seeks to integrate many different programs and plans that are already in place throughout Sao Paulo, such as Project Tiete into one program. This will ensure that all programs are properly funded and are coordinated rather than fragmented. Furthermore each initiative of the Mananciais Plan targets a specific environmental, social or urban development problem in the city of Sao Paulo or focused on the headwater reservoir catchment areas (World Bank, 2012). Although the World Bank will oversee the plan, the state of Sao Paulo, municipal governments and other stakeholders such as SABESP and river committees all support the program (World bank, 2012). Much of the program is specially focused on improving the quality of life in squatter settlements by bringing local urban upgrading interventions with metropolitan initiatives in water, waste and sanitation management (World Bank, 2012).

Program Mananciais will support the third phase of Project Tiete. This phase will allow SABESP to provide 1.5 million people in the metropolitan area with sewage collection and will expand major treatment facilities so that they can treat a larger amount of waste (SABESP 2010). SABESP estimates that by 2015 (or at the end of the project's third stage), the percentage of the population whose sewage is collected will increase to 87% and that the amount of sewage that is

treated will increase from 70% to 85% (SABESP 2010). Translating this from percentage to number of people, 16 million people (87% of the current population of 18 million) will be connected to a sewage system in 2015 while about 2 million people (23%) will still be living without proper sanitation infrastructure.

Public and stakeholder participation is another objective of Program Mananciais. Through the urban upgrading programs, community participation especially by local leaders and families will be essential. Similarly public actors, stakeholders and NGO's will be necessary to avoid the reoccurrence of environmental degradation in areas that are being protected or restored near the river (World Bank 2012). Environmental awareness and education will be an important pre-cursor to gaining public participation.

IWRM and Implications for Sao Paulo

The state of Sao Paulo began to take steps towards the adoption of a new approach to water management in the early 1990's. Therefore the idea of IWRM is not a new concept to Brazil. Still, it is unclear if an integrated approach to water resource management is the most realistic and effective approach for the state of Sao Paulo. Programa Mananciais appears to be a promising program because it is well-funded and focuses on integrating water resource management with land-use policies through the integration of several individual projects. Since Programa Mananciais is still being implemented throughout Sao Paulo, it will be many years before the successes and failures of the program become apparent. However, based on the first attempts at implementing an integrated approach during the 1990's , it is clear that there may be many obstacles that must be overcome in order for an integrated approach to be realistic and beneficial to the metropolitan area of Sao Paulo.

First, the river basin committees that were created throughout the Alto-Tiete River Basin in 1994, were less effective than they were intended to be, " The Alto-Tiete committee is a social force, but has yet to become a forum of decision-making about the problems of and solutions for the basin" (Johnsson 2005). The basin committee had a few initial successes such as sponsoring a two-year public hearing and debate about the Headwaters Protection Law that was eventually implemented in 2007 (Keck 2002). In this case the basin committee acted as an arena where the public and other groups could voice their opinions about controversial water related issues.

Johnsson (2005) and Keck (2002) agree that the basin committee were largely unsuccessful because their ability to be a central part of the decision making process was still dependent on the political will of the state government and on institutions such as SABESP. Therefore although the basin committee were technically part of the process of decentralization, and were supposedly given regulatory power, the committee struggled to act independently from state institutions. This illustrates how hard it is to overcome centralized systems of decision-making and control and that the process of decentralization is only achievable in the long-term. On the other hand, Johnsson (2005) and Keck (2002) suggest that decentralization within the basin from the main committee to sub-committees has been more effective. Local sub-committees are more dynamic and can respond to specific issues related to their specific sub-region. This is more effective because it is easier to organize and coordinate multiple sectors at a lower sub-basin level (Johnsson, 2005).

A second obstacle that may make IWRM hard to implement in Sao Paulo is the enormity of the socio-economic and environmental problems related to squatter settlements. Programa Mananciais highlights the need to confront this issue through the integration of land-use, urban upgrading and water policies. This is a loaded problem because the people who live in these informal settlements are direct users and polluters of the Tiete River. They often live in unhealthy conditions because they are not provided basic sanitation or potable water infrastructure and therefore they have no choice but to pollute the very water that is essential to their existence. The problem is further complicated by water quality policies that often call for the restoration of riparian and flood-plain areas, which are the very places that most informal settlements in the Tiete River Basin are located. According to a recent article in *The Economist*, many of the squatter settlements in Sao Paulo are located on the banks of the Tiete River and sometimes must be removed by the government in order for clean-up projects to be carried out (2011). The removal and re-settlement of millions of people who live in squatter settlements is an extremely difficult and resisted response to informal settlements. Furthermore, simply removing squatter settlements from the banks of the Tiete River will not fix the overall problems that are causing these settlements to exist, such as social inequality and lack of available low income housing. Although the integrated approach as outlined in Programa Mananciais has the potential to be effective, it also has the potential to fail because the actor-networks that result due

to a holistic approach may become too complex and simply end up complicating the potential solutions.

Overall Conclusions

Clearly many of the land-based solutions that have been implemented in Portland and London, such as urban greenways, riparian zone restoration, natural waste and storm water filtration systems are completely unrealistic options for the city of Sao Paulo, especially due to informal settlements and the urban density of the Sao Paulo Metro area. Still the World Bank's current integrated plan is an interesting approach and very different from the plans being used in London and Portland. The plans in London and Portland are relatively similar, yet out of all the plans that were looked at in this thesis, Portland's River Plan seems to be the most implementable and successful example of integrated water management approach to water management. This is because the plan outlines its main objectives and plans of action in a detailed manner that is not apparent in any of the Thames River Basin District plans. Also, since the River Plan is very localized and focused on the sub-basin scale, it is easy to implement and to enforce. It also does a good job encouraging public involvement with the river through the greenway plan and the River Basin Committee.

Still when you compare the IWRM plans in all three cities there are some key similarities. Primarily, the main similarity is that based on literature about the plans and on the plans themselves, it is obvious that implementing water management on the basin scale is hard and unrealistic. Therefore in Portland, the plans are all targeted on the watershed and sub-basin level, while in Sao Paulo, the River Basin Committees had no power until they were further decentralized into sub-basin committees that acted on a more local level. Once this occurred, then they had a bit more power in the decision making process. London is the one city that most strongly attempted to implement a plan on the basin level. This is because the Water Framework Directive has only established objective and plans for each country of the EU to implement at the basin district level. If you take a step back and focus on some of the geographic, demographic and hydrological features of each city, it is also clear that each city benefits from the integrated water management approach in a slightly different way. Also these characteristics might explain why each cities plan is slightly different even though they are based on the same framework. For example, the Thames River Basin is about half the size of the Willamette River Basin, and

therefore this may explain why it is more realistic for the UK to attempt to implement a plan at the basin level. Furthermore, the objectives of the plans in the Thames River Basin District had less of a variety and were primarily focused on water quality and ecosystem health. Therefore the plan also involves less actors than Sao Paulo's and Portland's plan and thus it may be feasible to implement the IWRM approach on the basin scale. Also each cities geographic location is different and therefore this partially determines the different types of water issues that each city deals with. For example, Portland is geographically located near pristine watersheds that can provide enough drinking water for the city and therefore the polluted state of the Willamette has never created any major water scarcity or public health concerns. Meanwhile, 2/3 of all of London's drinking water still comes from the Thames River and in Sao Paulo a majority of the water comes from one of two reservoirs that are extremely polluted due to the way the city has urbanized. Also demographically, Portland has the smallest population, and therefore the networks involved in an integrated approach to water management are not as complex as the ones in Sao Paulo and even London. Sao Paulo is enormous and therefore the water quality issues are directly connected to major social problems such as squatter settlement and infrastructure issues of not being able to construct enough infrastructure to keep up with population growth. Thus, solving water quality issues becomes extremely complicated.

Going back to the historical comparisons between London and Portland shows that infrastructure is extremely important and was the most effective way to respond to the major water pollution crisis periods in both cities. Sao Paulo is currently still in that crisis period. Based on the cases of London and Portland, it could be suggested that many land-based, participatory and integrated approaches to water management that are working in London and Portland, may only be successful because they were implemented after most of the population had access to potable water and sewerage. Sao Paulo, therefore needs to continue expanding their infrastructure (which is currently being done by Projecto Tiete). It will be very interesting to see if Programa Manaciais is effective in Sao Paulo in the future.

Critiquing IWRM as a framework

Based on the analysis between Portland, London and Sao Paulo's plans, the main themes and objectives of the IWRM framework are beneficial and are included in all of the plans. The parameters that Lenton et al. (2009) outlines, including: the use of sound infrastructure in order

to protect surface and groundwater, setting appropriate goals for water use, protection and conservation, and implementing processes of decision making that include the participation of stakeholders, are all arguably important to include in any water management plan. In addition, incorporating social, economic and political realms into water management policies is also essential and clearly articulated in Portland's River Plan and in Sao Paulo's Programa Manaciais. However, IWRM as a whole is a bit idealistic, as clearly basin wide planning is not the most realistic, depending on the size of the basin. Many scholars have discussed how absurd a basin management plan for river basins such as the Amazon or Nile Rivers, especially since they cross many different international boundaries. Overall, the results of this thesis suggest that IWRM must be looked at realistically and not just applied without taking into account the current political, social, geographical and economic conditions of the city at the time of implementation.

Further Research and Limitations of this Thesis

The comparative analysis and the evaluation of the IWRM plans in this thesis were limited due to time and due the fact that I could not conduct extensive analysis in each city. Further research could create a methodology where the effectiveness of each IWRM plan is quantified. Also, this topic proved to be extremely large, and in the future, it would be interesting to simply study each of these case examples in more depth. Interviews with major stakeholders and policy makers in each city would also have been helpful.

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