1. Water Sources in Shanghai

This section examines the quantity and quality or water from each source, as well as the general topographic and geographic information of Shanghai.

1.1. Introduction

Shanghai is a coastal city in China situated on central China's eastern shores at 30.42'-31.48'N. It lies on the southeastern frontier of the Changjiang (Yangtze) Delta and therefore contains many rivers, canals, drains and lakes. Most of Shanghai sits on early strand plains, which are primarily constructed by waves and tidal currents from currents washed down the Changjiang. Relief is low at about 3 to 5 meters above sea level. The ground is mainly composed of coarse silts and sandy mud. Cultivation of this region has resulted in soil losses that lead to an acceleration of the coastline's advance to about 37.5 meters per year. Shanghai is also very flat as a result of its formation process.

Shanghai lies in a subtropical climate zone and is thus characterized by mild annual temperatures, high humidity, and distinct seasons (Zhang and Wang, 1998). Shanghai's mean annual temperature is 15.5C. The warmest month is August (mean temp 32.5C) and the coldest month is January (mean temp 7.8C). Shanghai's climate is strongly affected by economic activity, which increases heat, air pollution and smog (Zhang and Wang, 1998), monsoon circulation, flatness (which allows cold air from the north and moist warm air from the south to meet and mix above Shanghai unimpeded) and coastal currents. Relative humidity is highest in June, July and August (approx. 83%) and lowest in January and December (approx. 77%).

1.2. Characteristics of Water Sources in Shanghai

This section looks at the characteristics and quantities of the three main freshwater sources in Shanghai: groundwater, surface water and freshwater.

Groundwater

The water table along Shanghai's coast is shallow at about 80 to 120 cm below the surface. Groundwater is abundant and widely distributed. Dense surface water network also means that the average distance to discharge points is short. Groundwater in Shanghai is recharged through rainfall, infiltration from surface water, irrigation, recharge and tidal water. It is lost through evaporation, human use, and discharge into surface water (Zhou and He, 1998). Shanghai's groundwater may be drawn primarily from six sources: a shallow phreatic layer, and five confined aquifers.

- <u>Phreatic Layer</u>: This layer occurs close to the surface, usually within 5 meters. Its closeness to the surface means that it is easy to access but also that it has been polluted by infiltration of wastewater. The poor quality of this layer means that it is rarely tapped into.
- <u>First Aquifer</u>: This is the first layer of groundwater beneath the phreatic layer. It typically lies 25-45 meters below the surface. However, water from this layer is not exploited because it is not abundant and poor in quality: this layer is made of fine, sandy particles.
- <u>Second Aquifer</u>: This layer is 50-70 meters below the surface, contains marine facies deposits, widely distributed, and slightly saline or semi-saline (except in the northeast, where the water is fresh). The abundance of water in this layer has lead to its rapid exploitation in the past, which has lead to subsidence since recharge is slow. From 1921 to 1965, the mean subsidence level in the city was 1.76 meters – at one place, the ground had subsided 2.63 meters (Zhou and He, 1998)! As a result of subsidence, extraction of water from this layer "is more limited." (Zhou and He, 1998)
- <u>Third Aquifer</u>: This aquifer is 100-120 meters below the surface. While the third aquifer covers an extensive area and large volume, it is never exploited because the water is saline.

- Fourth Aquifer: Currently, the most exploited layer of groundwater is the fourth layer. This aquifer is 160-240 meters below the surface. The water here is abundant and of high quality.
- Fifth Aquifer: This layer is the lowest layer of groundwater. It is 250-270 meters below the surface and therefore not exploitable due to the heavy costs associated with extraction from that depth.

Shanghai's geology Department has estimated that while there are 4.45 billion cubic meters of groundwater beneath Shanghai. Only 0.57 billion cubic meters (13%) are exploitable because of economic and geological limitations (Zhou and He, 1998).

Surface Water

Shanghai, as a result of its humid climate and low relief, is abundantly supplied with water resources. The average annual available surface water resources are 59.35 billion cubic meters. Shanghai's location along China's largest river, the Changjiang, and it's "maze of waterways that never freezes" (Zhou and He, 1998) ensure a large supply of surface water. Several of these sources are of greatest importance (see Figure 1.1). These are:

Huangpu River: This is the lowest branch that feeds into the Chiangjiang and the main river running through the county of Shanghai. The Shanghaiese affectionately call it the "mother river" (Zhou and He, 1998) because it serves the multiple purposes of water supply, waste disposal and transportation (Zhou and He, 1998).

The Huangpu is 112 kms long, with a depth of 5-15 meters, and a width of 300-500 meters (800 m at the estuary). It is born from the convergence of Xietang and Yuanxiejiang creeks from Tai Lake, and the Damaogang Creek from Zhejiang Province at Mishidu in Songjiang County. The Huangpu then winds through six counties (Qingpu, Songjiang, Fengxian, Shanghai, Chuansha, Baoshan) and is joined by the over 200 branches, the largest of which are the Dianpu River and Suzhou River. The Huangpu then proceeds through downtown Shanghai and finally drains into the Changjiang at the estuary of Wusong mouth. The 39 kilometer section of the Huangpu that runs through Shanghai's downtown serves to geographically divide the city up (with the new Pudong are to the east of the Huangpu and Shanghai's central area to the west of it).

Figure 1.1: Shanghai's river system (Zhou and He, 1998).

The Huangpu River is a tidal river with an average annual tidal range of 2.27 meters. The average annual net discharge at Mishidu is 308 cubic meters per second.

Suzhou River
Suzhou River is the largest branch of the Huangpu River. It stems from East Tai Lake and runs eastward for 125 kms from Guajingkou in Jiangsu Province to the Huangpu River in Shanghai, passing through Suzhou and the counties of Quingpu and Jianding. It is a narrow, shallow tidal river with an average width of 40-60m (130m at the estuary). The average discharge rate is 10-25 cubic meters per second. Although the Suzhou River is heavily polluted by industrial wastewater and sewage, it is an important waterway in Shanghai as it runs for 17 kms through Shanghai's downtown.

Changjiang River: Water from tidal surges in the Changjiang River are an important water source for Shanghai. Tides from the East China Sea surge into the Changjiang estuary twice daily raising the river stage. When the surge of the Changjiang is higher than that of the Huangpu River, a mixture of fresh water (from the Changjiang) and seawater (from the East China Sea) enters the Huangpu and flows upstream to Dianshan Lake. The salinity of the water depends on whether it is a dry (more saline) or wet (less saline) season because in wet seasons, more water flows in from the Changjiang and in the dry season, more water flows in from the sea. This tidal surge makes up 47.47 billion cubic meters of tidewater, or 80% of the area's surface water resources. "These tidal waters make up for a deficiency of fresh water in Shanghai and are of vital importance to the area." (Zhou and He, 1998)

Tai Lake
By far the most important lake to Shanghai is Tai Lake, situated about 80 kilometers away from the city. This lake, with a catchment of 370,000 square km channels 70-80% of its water, or about 10 billion cubic meters, through the Huangpu into the Changjiang (Zhou and He, 1998). The volume of water in Tai Lake varies greater from year to year and thus its significance in providing water to Shanghai also varies. On average, however, Tai Lake provides 16.9% of surface water resources in Shanghai (Zhou and He, 1998).

Other Lakes, Rivers, Creeks and Streams
There are many other surface water sources in Shanghai, such as Dianshan Lake, Xoetang Creek, Yuanxiejiang Creek, Damaogang Creek, creeks from other provinces , as well as a network of small brooks and streams. Most of these water sources eventually empty into the Huangpu River. Additionally, there are also newly constructed human-made canals in Shanghai: Dianpu, Chuanyang and Dazhi.

Rainfall
Shanghai is considered a rainy city. Some of the characteristics of Shanghai's rainfall are as follows:

Abundance: Rainfall in Shanghai is abundant with 129 rainy days annually (Zhou and He, 1998). Average annual rainfall is about 1,143.5 mm, placing Shanghai about equal to Vancouver in terms of precipitation (see Figure 1.2 for a comparison with some other world cities).

Seasonal Variability: The monthly rainfall in Shanghai varies greatly from month to month. Fifty percent of rainfall typically occurs between June and September during what are known as 'plum rains,' 'typhoon season,' or flood period (see Table

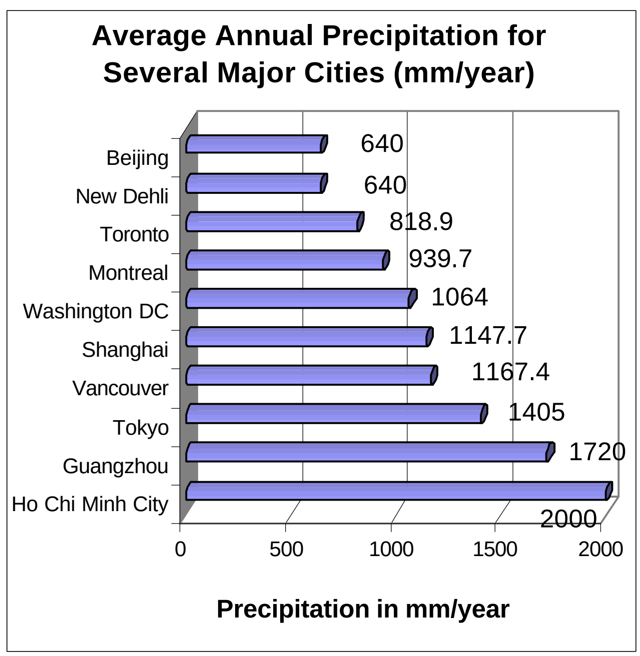

Figure 1.2: Average annual precipitation for ten large cities.

1.1). During this heavy rain period, average rainfall reaches 590 mm! As well, on an average of three days per year, Shanghai experiences torrential rains, during which more than 50 mm of rain fall in a single day (Zhang and Wang, 1998).

Geographic Variability: The spatial distribution of rainfall in Shanghai county is uneven with urban areas receiving a greater annual rainfall than the surrounding areas. Within the urban region, the amount of rain decreases from south to north.

Month	Average Monthly Rainfall (mm/yr)	Ave. Number of Rainy Days
January	47.9	9.6
February	61.0	10.4
March	48.2	12.5
April	94.8	13.5
May	104	13
June	176	13.9
July	143	11.2
August	136	10.8
September	136	11.0
October	69.2	8.9
November	53.1	8.5
December	38.9	7.9
Annual	1143.5	131.8

Table 1.1: Average monthly rainfall and number of rainy days in Shanghai (Zhang and Wang, 1998).

1.3. Quality of Water Sources

Surface Water Quality

In Shanghai, surface water quality is measured by the "Shanghai Classification Standards for Surface Water Environmental Quality" (see Table 1.2). According to this classification system, clean water is Classes 1-3, and polluted water is labeled Classes 4-6.

	Class 1 (clean)	Class 2 (fairly clean)	Class 3 (general)	Class 4 (polluted)	Class 5 (heavily polluted)	Class 6 (seriously polluted)
Dissolved Oxygen	>8	>6	>4	>3	>1	<1
Permanganate Index	<2	<4	<6	<20	<50	>50
BOD5	<1	<3	<5	<15	<30	>30
Volatile Phenols	<0.001	<0.005	<0.01	<0.1	<0.5	>0.5
Cyanide	<0.01	<0.05	<0.1	<0.5	<2	>2
NH3-N	<0.3	<0.5	<1.0	<2.0	<4.0	>4.0
Arsenic	<0.01	<0.04	<0.08	<0.3	<1	>1
Mercury	<0.0001	<0.0005	<0.001	<0.01	<0.05	>0.05
Chromium	<0.01	<0.02	<0.05	<0.2	<1.0	>1.0
Cadmium	<0.001	<0.005	<0.01			
Lead	<0.01	<0.05	<0.1			
Copper	<0.005	<0.01	<00.03			
Petroleum	<0.05	<0.3	<0.5	<1.0	<3.0	>3.0

Table 1.2: Shanghai classification standards for surface water environmental quality (mg/liter) (Wu and Shi, 1998)

Most of the surface water in and around Shanghai is of a poor quality. The main section of the Huangpu River that travels through the city proper is undoubtedly the most polluted section designated class 3 to 5, depending on the location of the measuring devices[1]. In general, water quality declines in the Huangpu as it enters the Shanghai city proper.

The upper reaches of the Huangpu Riiver, while in general of a higher quality than the main section of the river, are also highly polluted. Dianshan Lake, Taipu River are in Class 3, while Yuanxiejiang is Class 4 and Damaogang is Class 5 (Wu and Shi, 1998). Tai Lake is increasingly polluted by enterprises owned by nearby villages and townships. Pollutants from these sources threaten those that use Tai Lake as raw water supply, but also the whole of Huangpu River (Wu and Shi, 1998).

[1] For example, five of the water quality variables at the Linjiang Section were over the standard of Class 3, and six of the variables at Yangpu Section were over standard Class 4 (SEB, 1996).

Most of the tributaries of the Huangpu river are even more highly polluted. Aside from some parts of the Dianpu River, all tributaries (such as Suzhou and Yunzhaoban River) are of Class 5 or 6 quality (SEB, 1996)! The quality of Suzhou Creek is especially poor, particularly where it joins the Huangpu: "it is highly toxic and has minimal oxygen available, with bubbles of gases along its entire course." (Ward and Liang, 1995)

Water in the Chiangjiang Estuary (from Xuliujing to the mouth of the river) is the best of the city's surface water (class 1-2) (Wu and Shi, 1998)

Information to be gathered: A useful tool would be a colour-coded map showing the water quality classes of ALL lakes, rivers, streams and creeks in and affecting Shanghai.

Groundwater Quality

We have already noted that the phreatic, first and third aquifer are unsuitable for extraction due to poor quality. As well, the fifth aquifer is uneconomic to tap. This leaves the second and fourth aquifers which both contain abundant high quality water. However, this pristine water may have been degraded in the 1980s. In reaction to rapid subsidence at 3 mm a year, the government pumped surface water into the aquifers. This action contaminated the aquifers with polluted surface waters and once contaminated aquifers are extremely difficult to clean (Ward and Liang, 1995).

Information to be gathered: Data showing the water quality of various aquifers would be very useful.

Rain Water Quality

Shanghai is plagued by problems resulting from high ambient concentrations of sulphur dioxide in the air. High SO_2 and suspended particulate levels stem from Shanghai's reliance on coal-burning. SO_2 in Shanghai creates a chronic smog known as the Yellow Dragon and rain that is so acidic that it burns holes through nylon shirts (AIT, 1999).

Information to be gathered: Data on the pH levels of rain is important data to collect and assess. Also, since the levels of ambient pollutants vary by geographic location, it may be necessary to measure rainwater quality at various areas of the city.

1.4. Current Water Supply Infrastructure

Intake Infrastructure

The Huangpu River is Shanghai's main water source with water from the Changjiang and groundwater supplementing.

Of these sources, groundwater accounts for the smallest percentage of water use: less than 1% of Shanghai's total annual water consumption (Zhou and He, 1998). Most of this water is used by industry (the industry to residential ratio of groundwater usage is 19:1) and mainly during the summer (in winter, groundwater is not extracted so as to allow for recharge). However, in 1996, over 1,200 groundwells were dug in Shanghai to provide high quality drinking water (Xinhua, 1996). The level of water supply through ground wells, although not known at the time of this report, is likely to be negligible.

In 1987, Shanghai has 12 waterworks plants, 11 of which were along the Huangpu River (one plant was at Taopu which was inland and treated water for industrial purposes only) (Ward and Liang, 1995). Currently, there are over 30 waterworks plants in Shanghai, 11 of which are in the urban district along the Huangpu (Zhou and He, 1998).

While the quantity of water supplied to the urban areas of Shanghai has increased, the distance between Shanghai and the water source has also increased. Rapid deterioration of the Huangpu's water quality in the 1980s has pushed new waterworks infrastructure to draw on water from sources and areas of higher water quality. Before the 1980s, most of the city's water supply was drawn from the middle and lower reaches of the Huangpu, close to and in the city downtown area. But from 1985, water intake plants were built in the upper reaches of the Huangpu.

Intake was first shifted to the upstream Linjiang waterworks plant (completed in 1987), but by the 1990s, it was clear that water quality at Linjiang was also deteriorating rapidly. Phenol concentrations were recorded to be high, affecting water taste and smell. Other chemicals, such as chlorinated organic hydrocarbons were also prevalent, leading to potential health problems (WB, 1994). In 1994, work began on a World Bank funded project to draw water from Da Qiao, 40 km upstream from Linjiang. This involved the construction of a water intake station with a capacity of about 5.4 million cubic meters of water per day, pumping stations, multiple-barrel low-pressure supply main, surge protection, telemetry and controls and selected improvements to existing treatment facilitates and distribution networks (WB, 1994). The upstream Minhang water stations were also improved and extended.

In 1996 a project was completed to provide 20% of Shanghai's water from the Changjiang River. Currently, two pumping stations, the Chenhang Reservoir and 40 kilometers of 2.7m diameter pipelines deliver 1.1 million cubic meters of water daily from the Chiangjiang to Shanghai users (SS, 1996; Xinhua, 1995). The Changjiang supplies residents of Baoshan, Hongkou, Zhabei, Yangpu, Putuo and Pudong with clean water (Class 1 or 2) (SS, 1996). These areas were formerly drawing purely on water from the polluted Huangpu.

Information to be gathered: What is the capacity and use-rate of each existing water works treatment and pumping station?

Distribution Infrastructure

100% of Shanghai residents have access to drinking water in or very near their homes. However, some pipes and distribution infrastructure are known to be old and dilapidated. In fact, according to the vice-manager of the Shanghai Running Water Company, Wu Jinming, old pipes and water tanks act as a source of pollution (SS, 1994). Many of these water pipes are rusty and some are over a century old (SS, 1994).

Information to be gathered: What is the leakage rate of old pipes? A map of the age of all of the city's piping network is useful in determining where oldest pipes lie. How much water is lost due to poor distribution networks?

2. Water Needs in Shanghai

This section examines current and future real and perceived water needs in Shanghai.

2.1. Current Actual Needs

Water Quantity (Demand and Supply)

Demand

Currently, water consumption by the city of Shanghai is approximately 10 billion cubic meters per year. Water consumption however, exhibits two characteristics: year to year variation based on weather and rainfall, and a general increasing trend due to population growth and industrialization.

In Shanghai, water is used by three sectors: agriculture, industry and household (see Figure 2.1). The primary use is in agriculture, which in 1990 used 5.52 billion cubic meters, or 51.5%. Agricultural use of water, however, depends strongly on weather. In wet years, less water is required for irrigation than in dry years (see Table 2.1). Industry is the second major water user with a fairly constant usage rate of about 3.7-4.0 billion cubic meters annually. Finally, households require about 1.3 billion cubic meters of water per year (1990). The ratio of industrial to agriculture to domestic use is 3:6:1. Figure 2.2 demonstrates the ratio of water use by sector. As you can see the domestic sector accounts for only a small wedge of total water volume.

Since the end of the 1970s, water consumption has been increasing by 4.5% annually "largely due to continued industrial expansion."(Zhou and He, 1998). Figure 2.3 shows the general rising trend of water usage in all sectors from 1977 to 1990. For example, the total annual volume of water used increased from

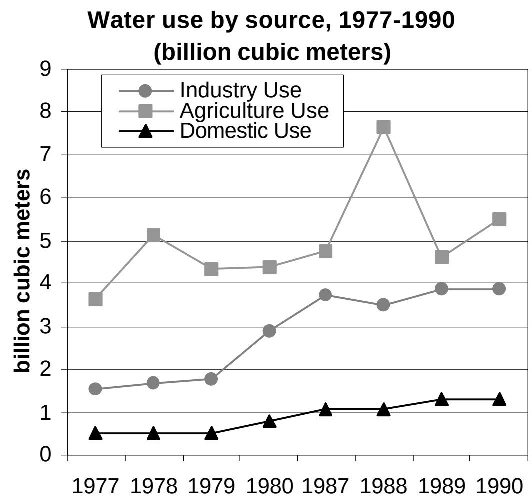

Figure 2.1: Water use by source. As you can see, domestic use is relatively stable from year to year, with a long-term upward trend. Agricultural use, on the other hand, fluctuated greatly from year to year, although it appears to also be on a slightly upward trend.(from data in Zhou and He, 1998)

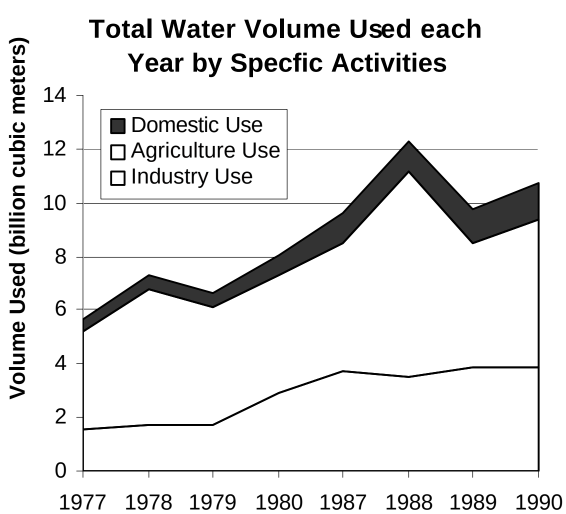

Figure 2.2: Total water volume used by sector. This chart shows clearly the ratio of water use by sector (from Zhou and He, 1998).

Year	Weather	Total Volume Used (billion cubic meters)	Industry (%)	Agriculture (%)	Domestic (%)
1977	Wet	5.700	27.2	64.1	8.7
1978	Slightly dry	7.339	23.0	69.8	7.2
1979	Very dry	6.646	26.4	65.5	8.1
1980	Moderately dry	8.053	35.8	54.6	9.6
1987	Moderately wet	9.591	38.9	49.7	11.4
1988	Dry	12.270	28.7	62.5	8.8
1989	Wet	9.768	39.7	47.1	13.2
1990	Slightly Wet	10.720	36.3	51.5	12.2
Average %			32.0	58.1	9.9

Table 2.1: This table shows the ratio of use by sector as well as the level of use in years of various precipitation levels (Zhou and He, 1998)

5.7 billion cubic meters to 10.7 billion cubic meters. "Clearly consumption in 1990 was almost twice that of 1977." (Zhou and He, 1998)

Supply

Total volume of water available in Shanghai is about 60 billion cubic meters in a normal year, 54 billion cubic meters in a dry year and 63.2 billion cubic meters in a wet year marked by floods. In comparison to water consumption, even in the dry year of 1988, water availability exceeds significantly. In fact, consumption makes up only 19-22% of available water (Wu and Shi, 1998). It is important to remember, however, that current demand only looks at demand for water quantity, and not water quality. While the Shanghai area has at least 54 billion cubic meters of water available, the question is how much of this water is of a standard high enough to satisfy water quality demands?

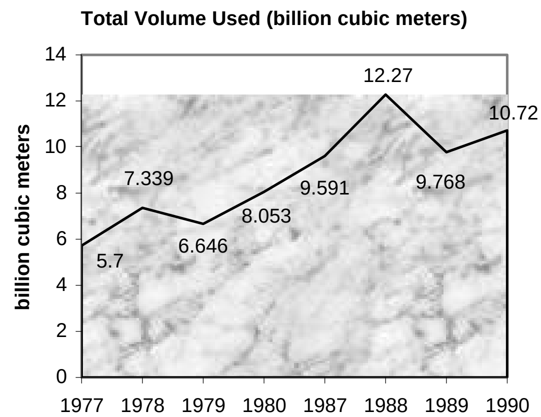

Figure 2.3: Total volume of water used 1977-1990 (Zhou and He, 1998).

Water Quality

<u>Demand</u>

It is short-sighted to say that water *must* be a pristine grade 1 in order to protect human health. In actuality, human bodies may be able to safely drink water of a lower quality. The Chinese government defines water of a grade 3 quality as the absolute lowest acceptable level of potable water. Industry can use grade 4 water, while irrigation can use grade 5. The question now is what levels of water quality are demanded by the various sectors and what is the high quality water deficit? Table 2.2 (derived from Table 2.1) gives us an indication of the quality of water needed by each industry.

Water Grade	Minimum Level of Water Needed (as based on 1990 use by sector, billion cubic meters)
Grade 5 (or better)	5.52
Grade 4 (or better)	3.89
Grade 3 (or better)	1.3

Table 2.2: Minimum water requirements by water quality level.

<u>Supply</u>

Information on supply levels of various water grades are not currently available. There is evidence that shortages of grade 3 or better water is common and that these shortages are causing health effects. For example, the cancer death rate in 1988 had risen 234% since 1963 (UPI, 1988). Scientists claim that part of the reason for this increase is "pollution from the city's 10,000 factories," (UPI, 1988) including pollution entering drinking water. The link between drinking water quality and cancer rates is so strong that "cancer and environment experts have urged Shanghai authorities to…develop waterworks that can divert water from the upper reaches of the Huangpu as a less polluted course of drinking water." (UPI, 1988)

Information to be gathered: More data on water availability of each quality must be collected.

2.2. Projected Actual Needs

Future water needs will be affected by weather and rainfall, population of people and industry, and level of wealth. As there is no general trend for rainfall levels[2]*, the focus of this section will be on trends in population growth and wealth.*

Population Increase

Shanghai's population has been increasing fairly rapidly since the mid-1980s (see Figure 2.4) and will continue to see positive growth albeit as a significantly reduced rate. While Shanghai's natural growth rate is negative (-1.38% in 1994 according to Gui, 1998), it continues to attract migrants from around the nation. "Growing numbers of contract workers are migrating from remote rural areas to fill jobs in Shanghai and increasing the demand for services," (WB, 1994) including a demand for water. Economic growth particularly in the secondary and tertiary sectors are expected to expand the labour force by 10.5% (WB, 1994). According to some estimates, the influx of migrants will bring Shanghai's legal resident population to 13.94 million by 2050 (Gui, 1998). Although population will increase, the success of government policies in creating negative natural birth rates, as well as controlling migration, means that population pressures will be minimal. What is of greater importance are wealth effects on water demand as per capita GDP increases.

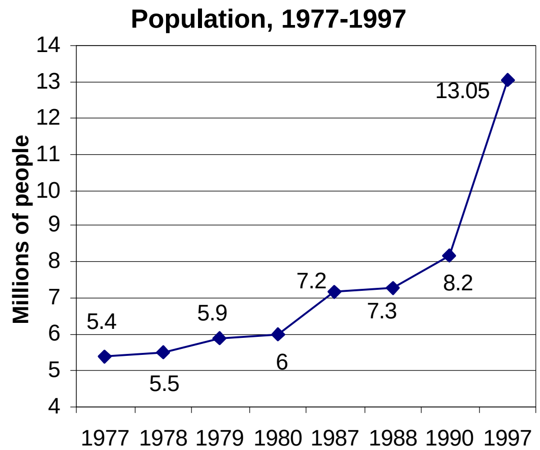

Figure 2.4: Population growth from 1977-1997 (please note that data from 1981-1986 and 1992-1996 are missing; AIT, 1999)

Wealth Increase

Per capita GDP has been rising steadily since the mid-1980s. Between 1996 to 1997, per capita GDP rose from US$2750 to US$3100, or just over 12%. Increased income results in increased ability to pay and willingness to pay for goods. This "wealth effect" also applies to water: as people become wealthier, they demand not only more water, but higher quality water. This is related to the issue of perception of need and increased standards, which will be discussed in section 2.3.

Industrialization

Currently, industry is the second largest consumer of water in Shanghai at about 3.89 billion cubic meters per year (36.3% of total water usage). This number is high compared to the nation as a whole, in which industry accounts for only 10% of total freshwater consumed (agriculture accounts for 82% and domestic uses 8% nationally; WB 1997). This reflects the fact that Shanghai is China's "leading industrial centre." (Yusuf and Wu, 1997) As such, the role of industry in the future demand (and supply, due to pollution) of water is crucial. There are several factors that influence the demand of water by industry:

<u>Number of industries</u>: Obviously, the sheer quantity of industries concentrated in one area will have an impact on the demand for water by the industrial sector.

Currently, there are over ten thousand industries in Shanghai (UPI, 1988), with the bulk of them concentrated in the inner ring of the city. 300 of these factories account for 60% of Shanghai's gross

[2] Some scientists are suggesting that global warming will affect water supply. However there is no known literature on the affects of global warming on Shanghai's water supply.

value of industrial output and profits (Yan and Feng, 1998). Shanghai industries have been "growing" (in terms of expanded production) at a rate of more than 10% per year (Yan and Feng, 1998). Generally, it is assumed that this trend will continue, particularly when supported by the designation of several areas of Shanghai as "open" economic zones.

<u>Location of industries</u>: The location of industries can affect water quality and supply.

As noted above, there is a strong concentration of industries in the inner ring. However, there are plans to move pillar industries out of this inner ring to make room for the tertiary sector and high tech industries. In 1994-1998, 455 enterprises were relocated out of this inner ring, and by 2010, only 1/3 of the present industries in this central area will remain as is. A third will be relocated and 1/3 will be converted into service industries (Yan and Feng, 1998). These industries are mainly being moved to suburban areas of Shanghai. The effect on water quality however is unclear. Further studies are needed to determine the impact of this relocation both on the water quality in the downtown core and in the suburban areas.

<u>Types of industries</u>: Different industries use different amounts of water. In general, heavy industries, such as iron and steel manufacturing or pulp and paper producing, use larger quantities of water than light industries. The tertiary, or services sector tends to use less water on average than light industries. Therefore, the industrial make-up of Shanghai will impact the level of water needed.

In the pre-Maoist era, Shanghai had a strong light industrial sector with textiles, paper, cigarettes, flour, leather, rubber, soap and matches as the "pillar" industries. However, Maoist determination to make Shanghai (and all Chinese cities) a place of production rather than consumption resulted in the increase of heavy industries. By 1978, light industry and heavy industry were about a 50-50% mix (Yan and Feng, 1998), where it has remained until the 1990s. Shanghai has six pillar industries which are a mix of heavy and light industry: automobile manufacture, communication equipment, electrical equipment, household appliances, petrochemicals and high quality chemicals, and the iron and steel industry. These pillars account for 45.1% of Shanghai's gross value of output.

Today, emphasis is placed on fostering three new pillar industries: integrated circuits and computers, biotechnology and new materials. There is an impetus to switch from labour-intensive textiles and other light industries to capital and technology intensive, high-tech industries (Yan and Feng, 1998). Shanghai's two high-tech parks, Zhangjiang and Caohejin, are an attempt to promote this high tech sector. Additionally, Shanghai hopes to become "an international economic, financial, and commercial centre" (Yan and Feng, 1998) by developing it's tertiary and service sectors.

Information to be gathered: The affect these industries have on water use needs to be examined by surveying the water needs of the various sectors.

<u>Industry Technology</u>: As the World Bank notes: "outdated production technologies also contribute to excessive water consumption. For example, coal-based ammonia manufacturing consumes 500-1000 tons of water per ton of ammonia, compared with 12 tons of water in the natural gas-based process. Chinese paper industries consume 400-500 tons of water to produce one ton of paper product, compared with 5-200 tons in OECD countries." (WB, 1997) The type of production technology and energy production technology therefore has implications on water demand. It is therefore important to examine trends towards importation of foreign, water-efficient technologies, and increasing use of alternative energy sources, such as nuclear power.

Agriculture

As table 2.1 demonstrates, water usage by the agricultural sector has declined relative to industrial and domestic uses. This reflects a general decline in the agricultural sector in Shanghai as the number of non-agricultural industries move into agricultural hinterlands (CERNET, 1999).

Information to be gathered: Some issues that need to be examined include:

- *<u>Level of agricultural production</u>: How much land is being used for agriucltural purposes. How quickly is this sector shrinking, if at all?*
- *<u>Type or agricultural production</u>: What are the trends in agriculture production? What is being produced in Shanghai and how much water do these different crops require?*
- *<u>Agricultural technology</u>: What is the level of technology current being applied, and how will change in technology affect water requirements?*

2.3. Perceived Needs

Perceived Water Deficit

There is little information on how much water people perceive that they require compared to how much they actually need.

Information to be gathered: Data on perceived versus actual needs is important in determining level of water wastage and overuse, and designing conservation/ education programs. The best way to attain this information is by first determining actual use requirements and then conducting surveys. One could also conduct observational studies to record the level of water wastage (such as running water taps, high-flow toilets). Another way of determining actual water quantity needs is to use surveys based on willingness to pay for water: ask people if water was set at a somewhat high price, how much water would they be willing to pay for.

Perceived High Quality Water Deficit

While actual water available exceeds water demands, it is important to keep in mind that current water usage levels do not reflect the need for higher quality of water.

Information to be gathered: In order to calculate the water deficit in terms of high quality water, several series of data need to be collected:

- *The level of demand/ use/ purchase of high quality water, such as bottled water or water filters. This can be calculated by looking at the "clean water industry's" yearly sales reports, customer base, forecasted growth potential etc. Currently, many Shanghai residents do purchase bottled or filtered water for drinking.*
- *The level of demand for high quality water by the industrial and agricultural industries. What class water is demanded and what is available? What is the deficit?*
- *Current availability of high quality water sources. As noted earlier, some natural sources include uncontaminated groundwater and water from the Chiangjiang.*
- *Number of complaints filed about water quality. In 1996, the Municipal Environmental Protection Bureau had received 2,529 letters, and 1,324 calls or visits from the public (about 3 times more than 1995; SEB, 1996). Of these, 64.8% were complaints about pollution and environmental sanitation. It is unknown how many complaints were made about water supply and quality in particular. Tracking trends in number of complaints filed provides good indicators of public dissatisfaction with water supply. The growing number of complaints, however, may be interpreted in several ways: (1) increasing pollution and environmental deterioration, (2) increased standards by the population (3) increased empowerment of the population to have their voice heard. Therefore, this method of determining perceived water deficits, should be used with caution.*

3. Water Management and Financing

This section examines the administrative, legal and financial structure of water management in Shanghai.

3.1. Ideology of Water Rights in China

Water rights in China have typically been ill-defined, at best, and schizophrenic, at worst. At one end, water supply is considered a state-owned sector, with the government obligated to supply water. On the other end, industries and individuals also have free access to this water and may extract it themselves if desired.

After winning power in 1949, the central government of China laid claim to public ownership of all rivers and water bodies in China (Ross, 1988). Socialist ideology is founded on the basic premise of equal provision of all items within the city: “irrespective of location, ethnicity, skills or income, all people shoud have access to the same standards or norms in housing, transport, education and medical care, and cultural and recreation facilitiles.” (Sit, 1995) Water is no exception to this rule and therefore “water resources are owned by the state, that is, owned by the whole people.” (Frederiksen et al, 1993). This edict has been enshrined in all of the PRC’s constitutions (Ross, 1988). Urban water supply has long been considered a basic government service (WB, 1997).

On the other hand, water is also treated as an unregulated free good. While the central government retains ownership of water, riparian parties (i.e. users whose property adjoins water bodies, such as municipalities) enjoy the right to make surface or groundwater withdrawals without limit. This has occurred because planners were ideologically inhibited from including water in their calculations because it was not regarded as a product of human labor in the Marxist sense but rather as a gift of nature (Ross, 1988). Self-extraction of water has therefore also been permitted. This has created a common property problem in which upstream users exploit water without regard for downstream users. One example is the city of Tianjin, which is located at the mouth of the Hai River. This city found itself over time with a progressively smaller share of water as upstream diversions decreased flow to Tianjin by 70% between 1960s and 1982 (Ross, 1988).

Due to their designation of water as a free good, “water planning” by Communist Chinese has historically been reactive, rather than proactive. When water appeared to satisfy the needs of favored economic sectors, especially heavy industry, there is no need to plan water consumption. Reactive water supply planning has emphasized satisfaction of the supply side of the equation without regard to the regulation of demand. Whenever demand rises, the bureaucratic response is to increase the supply (Ross, 1988). Indeed, there is a built-in incentive for water companies to accommodate demand because, under a fixed price structure, their bonus funds are predicated upon the volume of delivery rather than profits. This explains the propensity towards large supply oriented construction projects, like water diversion schemes such as the Middle Route Transfer Scheme.

The central government has been increasingly cognizant of “tragedy of commons” emanating from the notion of water as a free good and a lack of strategic water planning. It has created official bodies aimed at more regional, river basin based planning efforts, however, as the next section discusses, this has created a large and poorly coordinated bureaucracy (Tseng, 1997).

3.2. Governance Structure

National Agencies

Governance of water extraction in China is incredible complex. Water management is headed by the central government in a number of separate Ministries. The overarching ministry is the Ministry of Water Resources, however, as Box 3.1 demonstrates, various national agencies also have jurisdiction over water. Almost all of these ministries have corresponding bureaus at provincial, county, municipal and village levels. These water resource bureaus are relatively autonomous entities (WB, 1997). "Under the current decentralized system, the Central Government limits its role largely to guidance and interregional coordination, giving local governments great latitude to manage local affairs." (WB, 1994)

Currently, some venues of coordination between national agencies include the National Coordination Group on Water Resources (headed by the Minister of Water Resources) and the State Council.

In spite of these efforts, coordination between ministries is problematic. First, there is a lack of coordination between economic planning and water resource use. For example, the two coordinating commissions in charge of the economy, the State Planning and State Economic Commissions, do not exercise any influence over water resources (Ross, 1988). Second, parochial rivalries between agencies over funding and jurisdiction create a difficult environment for cooperation. Third, state planning offices cannot always prevail over provincial interests (Ross, 1988).

Box 3.1: National Agencies Related to Water (WB, 1997; Ross, 1988; WB, 1994)

Ministry of Water Resources and Conservancy: responsible for national water resources management (improvement and development of major rivers, planning water resources for urban water supplies, constructing basic rural irrigation facilities, implementing soil and water conservation programs, supplying rural hydropower, and building and managing medium-sized and large reservoirs for flood control, irrigation, water supply and rural hydropower). The ministry oversees seven river basin commissions that coordinate regional water resource management activities.

National Environmental Protection Agency: develops water pollution regulations to protect national water quality. These regulations are enforced primarily by local environmental protection bureaus.

Ministry of Construction (and its local counterparts): plan and construct municipal water systems, including sewage collection and treatment facilities. Any major investments in municipal water supply and wastewater treatment must have the approval of the Ministry of Construction.

Ministry of Electric Power (and its local counterparts): in charge of hydropower.

Ministry of Transportation: develops and manages inland rivers and coastal waters for navigation.

Ministry of Agriculture, Animal Husbandry, and Fisheries: manages fisheries.

Ministry of Geology and Minerals: explores and documents groundwater resources.

Ministry of Public Health: monitors drinking water quality and waterborne diseases.

National Coordination Group on Water Resources: unifies the management of water resources, enhances information exchange, and facilitates coordination among agencies. This group is headed by the minister of water resources and has members from all concerned ministries, as well as NEPA, State Planning Commission and Academy of Sciences.

River Basin Commissions

Many planners argue that the ideal water management scale is at the river basin level. In China, there are seven river basin commissions established to act as the "principle administrative, advisory and consulting agency within a river basin." (WB, 1997) However, these commissions focus mainly on flood-control, sedimentation and drought-control rather than river basin strategic planning. It also acts as a venue for resolving interprovincial water conflicts, and works to monitor water quality in coordination with other agencies (WB, 1997).

The relation between these commissions and national, provincial and local water agencies is unclear and needs further research. It appears however that this body is mainly advisory, rather than decision-making. Funding is also kept to a minimum in these commissions: many do not have enough funding to monitor water quality in smaller tributaries. Ross hypothesizes that regional institutions such as these commissions, are unlikely to have much clout because empowering them "requires a transfer of power from the central and local governments to the valley or basin authority and involves the sharing of power among neighboring territorial units, especially on an interprovincial basis." (Ross, 1988) Power relinquishing by any of these authorities is unlikely to occur voluntarily.

Shanghai (Provincial and Municipal) Agencies

As Shanghai is "one of three provincial-level municipal governments in China, the other two being Beijing and Tianjin," (WB, 1994) provincial and municipal administrative levels are collapsed into one. The highest governmental level in Shanghai is the Shanghai's People's Municipal Government (SPMG or SMG). The SMG is responsible for provincial duties such as planning, surveying, designing, constructing, operating and managing irrigation, drainage, flood control works and rural hydropower. It is also responsible for county and municipal tasks such as constructing and maintaining canals, related irrigation and flood control structures, medium-sized reservoirs (WB, 1997).

Figure 3.1 shows the structure of the Shanghai Municipal Government with a detailed examination of agencies that report directly to the Shanghai Construction Commission (SCC). The grey boxes are the most significant bureaus for water supply administration and implementation in Shanghai.

According to the World Bank, the most important water supply bureaus are those under the SEPB for ensuring water quality and those under the Public Utilities Bureau for ensuring water quantity and supply. These important bureaus are discussed at some length in Box 3.2.

There is much information missing and in need of collection (see end of this section for what needs to be gathered). However, in spite of a lack of information, some problems and issues are immediately apparent. First there is no agency designated to water demand management. This reflects the supply-focused tradition of Chinese bureaucratic government discussed in section 3.1. Secondly, there does not appear to be an agency responsible for coordination (however, the SCC may serve that purpose). Third, there is a clear separation between water resource management and pollution control (WB, 1997). These issues are closely tied as water pollution reduces water supply. Finally, these agencies appear to lack coordination with other provincial and national agencies. This may lead to inter-

Box 3.2: The main water-related agencies under the Shanghai Municipal Government.

Shanghai Environmental Protection Bureau (SEPB): This bureau is responsible for enforcing environmental guidelines in Shanghai. It is placed in charge of large water supply projects (for example, the Upper Huangpu diversion project was placed under the administration of the SEPB). The Shanghai Environmental Protection Office is staffed and organized by the SEPB, and is responsible for the actual implementation of projects including supervision and monitoring of contracts, maintenance of project records and submissions of progress reports to financiers. The SEPB also oversees the SEMC, SAES and the Huangpu Research Department. The SEPB is a Shanghai-level office of the National Environmental Protection Agency (NEPA).

- **Shanghai Environmental Monitoring Center (SEMC)**: Established in 1981 as part of a national organization responsible for environmental monitoring in Shanghai. It's main functions are planning and environmental monitoring, collecting and analyzing data, providing technical and functional guidance to county monitoring stations, carrying out studies for environmental quality assessment technology, offering technical arbitration in pollution conflicts, and defining and revising environmental standards and regulations for Shanghai.
- **Shanghai Academy of Environmental Sciences**: Information unavailable. Likely this bureau conducts research into environmental sciences.
- **Huangpu Research Department:** Information unavailable. Likely this bureau monitors and conducts technical research and monitoring on the Huangpu River.

Shanghai Public Utilities Bureau: Responsible for overall water supply planning and issuance of licenses for water extraction by major users.

- **Shanghai Municipal Waterworks Company (SMWC)**: This state-owned enterprise, established in 1952, provides 4.7 million m^3 per day for about 8 million people (1991 figures). It reports to the Shanghai Public Utilities Bureau. The SMWC supplies water mainly to the five districts that make up the inner core of the Shanghai Municipal area and has necessary permits to abstract water from the Huangpu River. Sometimes sells water to nearby counties.
- **Shanghai Utility Companies**: There are a number of companies and departments reporting to the Public Utilities Bureau performs and administered by the SMWC. Some of these include the Shanghai Water Pipeline Construction Company (not a subsidiary of SMWC), the Shanghai Water Supply Equipment and Engineering Company (a subsidiary of SMWC) and the Shanghai Water Treatment Company which governs water intake treatment plants. These companies perform a variety of technical services related to water supply.

provincial conflicts, or sub-optimal solutions based on localized, rather than basin-wide, interest.

Information to be gathered: First, what is the role of the Shanghai Municipal Government and the Shanghai Construction Commission in water supply? Are there any agencies in the Planning or Science & Technology Commission that take part in water related planning? Also, what is the role of neighborhood, community or workgroups in water planning and implementation? Finally, much information is lacking on many of these agencies and should be collected.

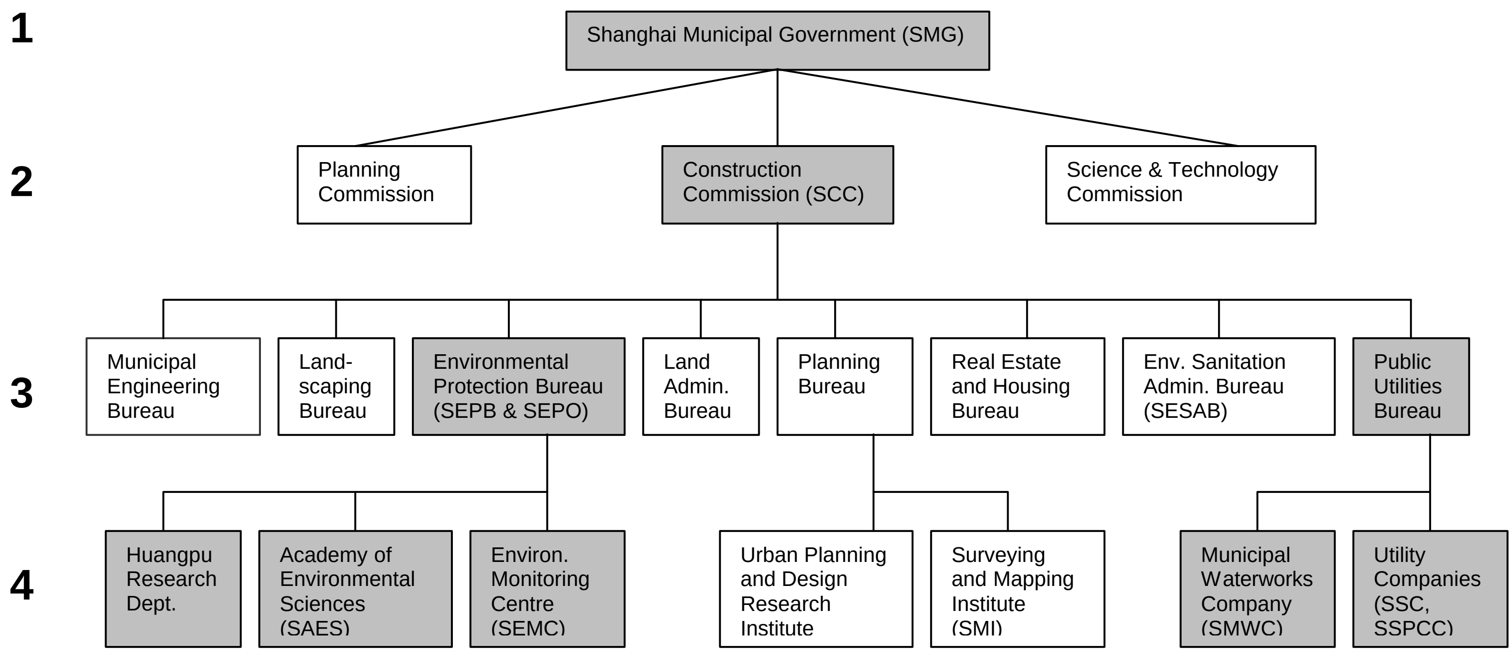

Figure 3.1: Partial diagram of the organization of the Shanghai Municipal Government with details on the Shanghai Construction Commission. The numbers on the left indicate the institutional responsibilities at various levels. Level 1 agencies are responsible for goal-setting, policy formulation and regulation. Level 2 agencies are responsible for multi-sectoral strategic planning. Level 3 agencies are responsible for sectoral strategic planning and programming. Level 4 agencies are responsible for operations and maintenance (WB, 1994).

3.3. Laws and Legislation

Beginning in the late 1980s, the National People's Congress began to pass a series of environmental legislation. The two that are most relevant to water supply are The Water Law (1988), and the Environmental Protection Law (1989). These laws provide the legislative underpinnings of Shanghai's various water management regulations and policies, such as Shanghai's Environmental Protection Code (1995), the city's first environmental law, and thus will be discussed in some detail.

Water Law of PRC: Established 1988 and revised ten years later, the purpose of this law, as stated in Article 1 is "to exploit, utilise and protect water resources rationally; prevent and control floods; and make full use of the comprehensive benefits of water resources in order to meet the requirements of the developing national economy and the needs of the people in daily life." (Xinhua, 1988a) The Water Law established several important tenets and regulations:

- **Domestic Priority**: Article 14 mandates that people in urban and rural areas are given primary consideration, above the needs of agriculture and industry in access to water resources.

- **State Control over Water Use**: Not only does this law establish the ownership of water resources by the State (Article 3 states that "Water resources are owned by the state, that is, by the whole people." (Xinhua, 1988a)), it also requires the state to be active in controlling water exploitation. First, Article 32 requires the state to "institute the system of licensing the direct tapping of water from under the ground, or from rivers and lakes. Licensing is not required for tapping small quantities of water for household use and for livestock drinking water. The licensing steps, scopes and measures shall be drawn up by the State Council." (Xinhua, 1988a) Article 34 mandates water resource fees as an economic device to control water use. It states "Water from a water supply unit must be paid for by the users according to relevant regulations. A water resource fee will be charged for water directly drawn from underground sources in cities. The provincial, autonomous regional, or municipal people's government will decide on water resource charges for water directly drawn from underground sources or rivers and lakes." (Xinhua, 1988a)
- **Comprehensive water resource planning**: Perhaps the most important feature of the Water Law is that it emphasizes the need for water resource planning, especially comprehensive planning that includes other jurisdictions and water uses. Some Articles that stress the need for comprehensive planning are:
  - Article 7: "The state shall use water in a planned and economical way. People's governments at all levels should strengthen their management in conserving water." (Xinhua, 1988a)
  - Article 11 "Unified plans shall be made for the exploitation and utilisation of water resources, and for the prevention and control of floods in various river basins and regions." (Xinhua, 1988a)
  - Article 16 "The state shall encourage the development and utilisation of water resources. Efforts shall be made to carry out planned, multi-purpose, and stage-by-stage development of rivers with abundant water resources." (Xinhua, 1988a)

  The role of the Water Administration Department under the State Council in ensuring comprehensive water resource planning is also stressed. The Water Administration Department is responsible for unified management of water resources including comprehensive plans for major river basins and groundwater extraction. It is also responsible for formulating unified licensing steps, scopes and measures, and regulations for levying water or water resource fees.
- **Water Conservation**: Article 7 states that "All units should adopt advanced technology to conserve water, to reduce water consumption and to increase the rate at which it is recycled." (Xinhua, 1988a) As well, Article 15 states that "areas with water shortages shall adopt water-conserving irrigation measures." (Xinhua, 1988a)
- **Pollution Prevention**: Article 6 notes the importance of water pollution. It states "All units should step up their work in preventing and treating water pollution, and protect and improve the quality of water. People's governments at all levels should strengthen their supervision and management of the prevention and treatment of water pollution in accordance with the law governing the prevention and treatment of water pollution." (Xinhua, 1988a)

Environmental Protection Law (EPL): Established in 1989, this law serves as the foundation for environmental and pollution regulation throughout the nation. Some of the most important regulatory instruments are discussed below.

- **Importance of monitoring, reviewing and publishing environmental data**: The EPL requires that "the departments with administrative responsibility for environmental protection of the State Council, each province, autonomous region and municipality directly subject to the central government should periodically publish reports on the environmental situation." The EPL mandates that all proposed construction projects either for new enterprises, or undertaken to rebuild and expand existing ones, must ensure environmental protection is considered during the design, construction and operation of new projects (Wu and Shi, 1998). In most cases, Environmental Assessments (EAs) are required in order to obtain approval to carry out any renovations or new construction.

- **Economic Incentives:** Some economic devices written into the EPL include the PPP (Polluter Pays Principle). These include administrative fines for discharges exceeding ambient air and water quality standards (the totaled RMB 12.72 million in 1987; EAER, 1988), effluent charges (fees for amounts in excess of permissible discharges totaled RMB 1.427 billion in 1987; EAER, 1988), financial penalties for excessive discharges, and fines for violations of rules. Additionally, environmental taxes were placed on polluting inputs, and tax incentives were created to benefit companies implementing pollution abatement schemes.
- **Command and Control Measures**: Command and control approaches include integrated environmental protection measures at project design construction and operation stages (the "three simultaneous actions" system), relocation of industry away from densely populated urban areas, requirements for low-polluting technologies in selected industries, and centralized treatment of wastes (EAER, 1988).
- **Criminal Sanctions**: Criminal prosecution of environmental offenders was also written into the EPL.

Information to be gathered: Details on Shanghai's Environmental Protection Code. While it can be assumed that this code is a localized application of many of the tenets in China's Water Law and EPL, nonetheless, information on how these national laws are translated and enforced is necessary.

3.4. Financing

There are two primary sources of water supply in Shanghai. First, many industries attain their water through self-extraction. Second, the Shanghai Municipal Waterworks Company (SMWC) provides the bulk of publicly supplied water in the city of Shanghai. As noted earlier, the SMWC supplies about 8 million people in the 5 districts that comprise of the inner core of Shanghai with 4.7 million m^3 of water daily. In the case of the former, water supply is self-financed and typically integrated into company operating budgets. The SMWC, on the other hand, is a public company financed by water tariffs and transfers from the Shanghai Municipal Government. The SMG is funded in large part by central government transfers and foreign loan/ development agencies. This section examines four main sources of funding: private enterprise financing, government transfers, international lending agencies, and water tariffs.

Private Enterprise Financing

In Shanghai, large enterprises are allowed to self-extract water from either ground or surface sources, with the appropriate licenses. Therefore, the actual provision of water supply in the city is shared by private firms and the Shanghai Municipal Government (and its corporations). Enterprise self-extraction of water, both for production and for employees, account for about half of the urban water supply in the early 1990s (WB, 1997). Companies that extract their own water, finance the extraction themselves.

Information to be gathered: The prevalence and volume of self-extracted water and the amount of money saved by the municipal government as a result of self-financed extraction.

Government Transfers

Government transfers and subsidies occur between several administrative levels. First, the Shanghai Municipal Government provides operating subsidies to the SMWC. In 1990, 41.93 million yuan was transferred from the SMG to the SMWC (WB, 1994). These transfers however have become increasingly less significant over time,

	1988	1989	1990	1991	1992
Total Revenue Collected	14.7	15.3	15.8	19.2	20.3
Transfers to Centre	10.5	10.5	10.9	11.1	10.9
Aggregate Local Revenue	4.2	4.8	4.9	8.1	9.4
Total Expenditure	6.5	7.3	7.6	10.1	11.2
Net Income (loss)	(2.3)	(2.5)	(2.7)	(2.0)	(1.8)
Transfers from Centre	2.3	2.5	2.7	2.0	1.8

Table 3.1: Summary of Past Municipal Finances (Y billion). (WB, 1994)

and as of 1994, the "SMG has indicated that no further operating or capital subsidies would be made to SMWC."(WB, 1994)

Second, the central government transfers money to the SMG. Central government between 1988-1992 transferred 2.26 billion yuan annually to the SMG. Table 3.1 shows a summary of Shanghai Municipal Government Finances from 1988 to 1992. As you can see, transfers from the Centre are equal to the net loss suffered by the municipality. These transfers also appear to be decreasing as of the 1990s. What is important to note is that there is a net transfer from the SMG to the Centre, rather than vice versa, as the SMG is obligated to transfer about 10.5 billion yuan per year to the central government.

Information to be gathered: The amount of subsidy between the SMG and other water-related bureaus is lacking. Other relevant information in need of collection includes the role of national ministries (such as the Ministry of Construction, Ministry of Water Resources and National Environmental Protection Agency) in providing funding to their provincial and municipal counter-parts.

International Lending Agencies

Several major water supply projects in Shanghai have received substantial funding from international donor agencies. For example, the Shanghai Environmental Project (SEP) which encompasses the creation of new water intake pumps at Da Qiao, is funded by the World Bank.

Some of these donors have made substantial contributions. For example, the World Bank has loaned $457 million to the Shanghai Environmental Project (SS, 1994a).

Shanghai's ability to attract foreign lending has certain implications for future projects. Foreign agencies prefer to lend to large projects, preferably related to infrastructure provision. This means that projects that are grand and visible are more likely to be proposed than modest, smaller initiatives. This reinforces the existing propensity towards supply-side solutions to water shortage, as supply infrastructure is more likely to be funded than demand management tactics, such as educational programs. Another implication is that these lenders are motivated by self-interest. Accepting foreign loans may bind Shanghai to giving out contracts to certain foreign companies. Some loans may come with certain ideological conditions. For example, World Bank loans generally are meant to support increased use of the market to provide goods such as water. As such, the World Bank strongly pushes the use of water tariffs, which will be discussed next.

Box 3.3: Lending Agencies and Associated Projects

World Bank	Shanghai Environmental Project (SEP)
UK's ODA	Two-year Design, Review and Advisory (DRA) consultancy to review the initial preparation work already undertaken by the SMG for the SEP (Burley, 1995)
Norwegian Govt.	Shanghai Second Sewerage Project (SSSP) (Burley, 1995) Hazardous Waste Management Study (WB, 1994)
Japanese Grant Facility	A project undertaken by NEPA to review the levy charging, collection and allocation systems (WB, 1994). Project preparation of the Solid Waste and Nightsoil Management component of SEP
AIDAB	Preparation of the Shanghai Environmental Master Plan
CIDA	Development of a Shanghai strategic planning information system and a water supply management system in the early 1990s
UNDP, Ford Foundation, World Bank	Workshop held in 1991 on integrated economic reform planning process for Shanghai

Information to be gathered: The actual monetary value of foreign-funded loans should be examined, as well as trends towards increasing or decreasing reliance on these loans.

Water Tariffs

Most of the funds supplied to the SMWC for water supply comes from water tariffs. Table 3.2 provides the accounting for the SMWC for the years 1990-1993. As you can see, revenues from water tariffs account for almost all of the company's operating budget. As noted earlier, as of 1994, the SMG is slowly phasing out subsidies to the SMWC, forcing it to rely even more heavily on water tariffs to recuperate operating and maintenance expenses.

Water tariffs are calculated on a sectoral basis with some sectors paying a heavier tariff than others. Table 3.3 shows the tariff rates in 1990, 1992 and 1993. Rates are divided by sector (domestic use vs. industrial use) and quality (regular water for industry or semi-treated industrial water). Note the gradual increase in tariff rate over time for all sectors. This tariff increase has resulted in an increase in SMWC's revenues from Y133 million in 1989 to Y357 million in 1992, a 2.7-fold increase over the period (WB, 1994).

Year	1990	1991	1992	1993
Operating Revenue	178	277	357	577
*Revenues from water tariffs	171.5	273.02	361.2	577.92
Water sold Mm^3	1,225	1,241	1,290	1,344
Average Tariff (Y/m^3)	0.14	0.22	0.28	0.43
Operating Expense	189	258	341	505
Net Income	9	15	16	66

Table 3.2: Budget of the SMWC from 1990 to 1993. Notice that revenues collected from water tariffs make up most of the company's operating budget. Also notice that over time, water tariffs have increased substantially, leading to large increases in revenues from water tariffs (WB, 1994).

* = calculated from water sold and average tariff.

In spite of progressively higher tariff rates, water tariffs in Shanghai are still low for both residential and industrial use. While data on the actual marginal cost of water supply is unavailable for Shanghai, we can assume that it is higher than the tariff charges by comparison to other Chinese cities. In Hubei Province, the marginal cost of new water projects is about 1.20 yuan per cubic meter. Also, the typical domestic water bill accounts for only 0.5% of per capita income (WB, 1994). "Consumer surveys have found that this amount is regarded as a trivial element of the household budget." (WB, 1994) One study suggests that tariffs can be raised to 1.8 yuan per cubic meter, because that is the amount urbanites in coastal cities are willing to pay for their water (WB, 1997). The World Bank suggests that increasing tariff rates in Shanghai is a method to both raise revenue and reduce water use. The Bank estimates that the price elasticity of domestic water demand varies from –0.3 and –0.6 (in other words, a 1% increase in price leads to a –0.3 to –0.6% decrease in water demand; WB, 1997). Industrial demand has an elasticity of -0.45 to –1.37 and agricultural demand is the most elastic at –0.37 to –1.50 (WB, 1997).

Type of Consumer	1990	1992	1993
Domestic	0.18	0.28	0.40
Standposts	0.13	0.28	0.30
Industry	0.26	0.36	0.51
Semi-treated Industrial Water	0.18	0.28	0.40
Average Tariff	0.14	0.28	0.43

Table 3.3: Water tariffs charged by the SMWC, 1990 to 1993 (Y/m^3) (WB, 1994)

In spite of these deficiencies, there is clearly room to build upon the existing tariff system in Shanghai. Currently, all private homes have meters which are inspected and repaired or replaced every 5 or 10 years (WB, 1994). Water bills are prepared by computer and hand-delivered to customers the day after the meter is read. Bills are payable at the SMWC or at 300 designated banks around the city. Accounts not paid within 9 days have a surcharge of 5% per day. Virtually all bills are paid within nine days of issuance, and 100% collection is attained within 2 months (WB, 1994). The SMWC also notes that the efficiency of these system means that only 10% of water is unaccounted for (WB, 1994). Compared to other Asian cities such as Beijing and Seoul with 28% and 42% of water unaccounted for, Shanghai's collection and monitoring system is very efficient (Lee, 1997). This system has proven to be effective at providing water-pricing management Shanghai and clearly future policies should build on this strength.

Box 3.4: History and Ideology of Water Pricing in China

Although water fees have been used in China since the early 1950s as the primary source of revenues for system maintenance and management, ideology has stood in the way of them being effective tools to manage water use and recuperate supply costs. In leftist periods, water usage fees were condemned for encouraging the people to become cunning protectors of their own interests with regard to their fair share of deliveries rather than willing defenders of the collective interest (Ross, 1988).

As a result, fees have been disregarded or collected on a flat-rate or area-served basis without regard to volume of water consumed. Water prices tend to be based on the allowable costs incurred to the distribution system rather than upon its scarcity. With residential fees, typically units, rather than individuals paid for water bills – this collective payment system deters individuals from conserving water.

Poor water pricing has been blamed for water wastage. It is estimated that only 25-40% of irrigation water was used effectively because area-based water pricing failed to encourage farmers to conserve water. For example, simple water-saving measures such as watering in the cool of the day were not adhered to (Ross, 1988). Industries also used inefficient technologies that were highly water consumptive. For example, paper, steel and other major industries in China consumed five to ten times as much water per unit output as their counterparts in developed countries (Ross, 1988) and industrial water reuse rates were less than 20% (Ross, 1988). Finally, domestic consumption was three times as great as under a progressive, metered tariffs system (Ross, 1988).

A drought and the beginning of the reform era in the 1980s instigated more efficient use of water.

4. Trends and Constraints

This section examines some important trends and constraints to consider when developing a water supply program in Shanghai, not previously covered in one of the early sections.

4.1. Drive for Economic Growth

An important constraint to consider in developing a water supply system, is the current economic obsession of this city. The desire to, in the words of President Jiang Zemin in 1992, "take the development and opening of Pudong in Shanghai as the dragon head, advance another step to open coastal cities on the banks of the Yangtze River and establish Shanghai as an international, economic, financial and trading centre as soon as possible" (Frolic, 1994) will certainly have implications for any sort of planning in Shanghai. This section discusses this impetus for growth.

In 1992, Deng Xiaoping toured China. During his stop in Shanghai, he regretted not opening Shanghai by making it a special economic zone in the early 1980s. This visit cemented what was already being discussed: making Shanghai into China's next growth pole. Shanghai would act as the catalyst and funnel for growth and opening along the entire Changjiang River Delta all the way to Chongqing in Sichuan over 6000 km inland. Shanghai was proclaimed the "dragon's head."

To reinforce this commitment, the Yangtze was designated the first of China's seven new economic regions (Frolic, 1994). The approval for the Three Gorges Project upstream in 1992 to provide an additional 12% power output for China (Frolic, 1994), and the creation of economic zones such as Waigaoqiao Free Trade Zone in Shanghai showed investors that the central government was serious about economic growth in Shanghai. One of the most important shows of central government support came in the creation of the new Pudong area in 1990. In 1992, "Li Peng announced that Pudong would be the focal point of China's reform for the next decade." (Frolic, 1994)

Initially, debate surrounded the functions of Pudong. Some people argued that Shanghai-Pudong "should have a much stronger business side than the old Shanghai, and which will be better placed for that reason to challenge Hong Kong" (Leeming, 1993) while others maintained that emphasis should be focused on upgrading Shanghai's existing manufacturing base for export. By the mid-1990s, it was clear that the Pudong area, with its gleaning skyscarpers and office towers would change Shanghai "from the country's largest comprehensive manufacturing city to an integrated, multi-function, key economic city." (Leeming, 1993) The central government paid almost 50 billion yuan for construction. In contrast, the Special Economic Zones of the south, received no funding from the centre. To investors, this was the reassurance they needed that Pudong was "open for business." As one Japanese banking official stated "Every city in China has a development zone, but the national government supports Pudong." (in Frolic, 1994)

As a result, "over 700 foreign firms signed agreements to establish operations in Pudong at the end of 1992, eager to reap tax holidays on the first two profit making years of the venture and a 50% reduction on the 15% tax rate during the next three years, provided industries are export-oriented." (Frolic, 1994) The number of new projects in 1992 totaled 2012, an increase of 451% over 1991 (Frolic, 1994). The contracted amount of direct foreign investment in 1992 was US$3.3 billion, 646% more than 1991 (Frolic, 1994). Shanghai is fast becoming a major financial and securities centre and a major trading port, with 30% of China's exports leaving from Chiangjiang Port (Frolic, 1994).

Implications for Water Supply

This impetus for growth has several implications for water supply infrastructure.

- <u>Replacement rather than repair</u>: The government's solution to the housing problems in Shanghai may be indicative of their approach towards infrastructure in general. Old houses in the Shanghai downtown area are being demolished, and residents relocated to suburban areas into new, Corbusier-style apartment blocks. Making Shanghai into a world city appears to be one reason for replacement rather than repair: in the Chinese mind, a global city must look modern and new. This issue will be discussed later. Replacement will therefore be a likely theme for water supply infrastructure. Old piping laid almost one hundred years ago will unlikely be reinvested on through upgrades, but completely torn out of the ground, and re-laid.

- Quick Change: Water supply must keep to the pace of economic growth in Shanghai, and thus improvements to water supply must be quick. The implication of this is that short-term immediate gains will outweigh long term gains that require more time to implement. If water shortage is a threat, the government is more prone to building a new water intake pump, rather than creating a comprehensive water conservation educational program. While the former solution immediately solves the impending water shortage problem. The educational program on the other hand, takes much longer to implement and it may be well over a decade before benefits are noticeable.
- Visible Change: In order to reassure foreign investors that the government is committed to economic growth, infrastructure must be constantly upgraded and improved. However, in order for these improvements to be recognized by the business community, they must be visible. This means that a large-scale water reservoir is preferred over a program to distribute free washers to encourage water savings at the household level. Leeming finds evidence to support this claim. He notes that "the Chinese communist party is prone to a preference for big-scale reconstruction schemes, rather than improved housekeeping." (Leeming, 1993) Both the desire for quick change and visible change prefer supply oriented approaches over demand management approaches, which tend to take longer to show effects and are generally less visible.

4.2. Drive for "Modernity"

Related to the drive for economic growth in Shanghai is the notion of "modernity." "According to Wen huibao, 'building Shanghai into a great internationalized metropolis is often called, restoring its awes-inspiring air.'"(Frolic, 1994) There are two strong reasons for the drive towards "modernity" and "modern" facilities and infrastructure. First, to attract foreign investors, "modern" infrastructure is necessary, and second, the Chinese sense of "face" finds traditional technologies unacceptable.

As discussed early, Pudong-Shanghai aims at economically developing its business services and tertiary sector, and in the process transforming Shanghai into China's Hong Kong. Inherent in this goal is the desire to attract "modern" services and businesses, such as large banks, multinational corporations, high tech industries etc. In order to attract "modern" businesses, Shanghai must have a "modern" image, equipped with amenities and services, such as luxury hotels and network connections to make the foreigner comfortable. Water supply must also keep with the modern image, and thus water supply technologies tend to copy western supply systems.

The Chinese concept of face, or *mainzi* is defined as "the kind of prestige that is emphasized in this country [the US]: a reputation achieved through getting on in life, through success and ostentation." (Harris-Bond, 1996) Face and status is a concept deeply ingrained in Confucian hierarchical traditions: "a set of social hierarchical order implies that one always stands in a definite relationship with the other, in a superior and inferior position in accordance with appropriate circumstances." (Chen, 1996) As the Chinese are more group-oriented than North Americans (Harris Bond, 1991), status is, in a group hierarchy, very important. Internationally, keeping face means building the world's tallest building, glass and steel towers and "modern" large-scale water supply facilities. Planners need to be sensitive towards this concept of face in suggesting water supply technologies. Modest, but seemingly "backward" technologies, such as rooftop rainwater harvesters, may cause the city to feel as if it is losing face because it appears as if it is unable to provide the same 'modern" facilities available in the west.

4.3. Ideological Shift towards Market Economics

Presently, China is experiencing an ideological shift from socialism to market economics and capitalist practices. While the government maintains that it adheres to the "bird in a cage metaphor" in which the bird of the market can fly free but only within the socialist cage (Frolic, 1994). However, the focus on economic growth in China at the risk of greater gaps between the rich and the poor, both within Shanghai and regionally, poor working conditions, and tax incentives for the wealthy seem to undermine any form of socialist ideology. Frolic considers China an "ideological vacuum." (Frolic, 1994)

The movement towards an increasing reliance on the market acts as both a constraint and as a positive trend for developing water supply systems.

- Decentralization means less regional cooperation: With a strong market-based economy, there is a reduced role for the central government and therefore increasing decentralization of power to provincial and municipal governments. This may erode the ability to comprehensively plan for water supply at a regional or national level.
- Reduced role of public sector: An increasing reliance on the market system may lead to reductions in government funds for infrastructure and education. This may affect the ability of government to provide these services in the future.
- Increase acceptance of full-cost recovery: Water pricing schemes are increasingly acceptable with the ideological shift towards market economics. As more goods and services lose their subsidies, it may become more acceptable to pay higher premiums for water. Economic incentives on water pollution are also increasingly acceptable.

4.4. Public Participation

The increased role of the public in policy making is a positive trend that will have impacts on the design of water supply systems.

While public consultation before decisions are made is still uncommon in China, the Chinese government does respond to public reaction and makes adjustments to assure a closer fit between the leadership's goals and popular sentiment (Ross, 1988). However, there are some instances of direct public participation. For example, in Wuhan, public protest over pollution in Pier 41 that had gone unattended by local officials, generated a positive response from Beijing (Ross, 1988). In Shanghai, letters and calls of complaint to the environmental protection bureau have increased substantially since the 1980s (see Table 4.1).

	Letters	Calls and Visits
1993	3252	957
1994	3362	1501
1995	702	172
1996	2529	1324

Table 4.1: Number of letters, calls and visits to the Shanghai Environmental Protection Bureau in 1993-1996 (SEB, 1993; 1994; SEB, 1995; SEB, 1996)

This increase in public involvement stems from the "reduction in the political risks associated with expressing one's views on such matters and because separation of political and economic institutions." (Ross, 1988) As well, government is beginning to encourage public participation as it considers the public a useful tool to monitor the effectiveness of policy. Article 8 of the Environmental Protection law affirms the right of citizens to act as pollution monitors (Ross, 1988).

The increase in public involvement means that Shanghai planners will be able to get more public input and information before creating water supply programs. Surveys, while still rare in China, may be a useful tool in the future to determine what are important water issues to Shanghai's citizens. As part of the Shanghai Environmental Project, staff from consultants Mott McDonald conducted household surveys to yield information on attitudes towards water tariffs (Burley, 1995). Public input is also useful in assessing public knowledge of issues. This is critical in developing educational programs, which, as we will discuss shortly, are another emerging trend.

Increased public participation also engenders greater success of programs. For example, a water conservation program with extensive public involvement in design will more likely be successful then one designed top-down by government officials. This is due to more accurate data collected from the outset, and an enhanced sense of "ownership" of the project's facilities, which "increases the facilities use, ensures better maintenance and provides more reliable operation." (Bhanjee, Hou, and Hunter, 1999)

4.5. Education

Another encouraging trend is the increased emphasis on environmental education in the city of Shanghai.

In 1984, the Shanghai Environmental Education Centre was established by the Shanghai Environmental Bureau "to promote environmental education, environmental protection, increase environmental consciousness, and mobilize public participation." (Wang, 1995) Since then, the SEEC has provided the general public with environmental protection education by publishing science articles and literary and artistic works in a weekly newspaper called the *Shanghai Environmental Press.* It also promotes special occasions, including the Planting Festival, Earth Day, and World Environment Day (Wang, 1995). Shanghai government bureaus have been quite creative in their environmental awareness campaigns. Box 4.1 gives some examples of the variety of educational medium used in Shanghai for educating the general public.

Box 4.1: Some educational programs in Shanghai (SEB, 1993; 1994; 1995; 1996).

Education Program	Purpose
Musical show on Chen Yi Plaza at the Bund (1995)	To provide publicity for the Shanghai Environmental Protection Regulation
Commentator's articles in the Jiefang Daily, Wenhui Daily, and Xinmin Evening (1995)	To make provide information about the Shanghai Environmental Protection Regulation
"One Globe, One Family" public debates by university students	To promote World Environment Day
Telefilms such as "the Green World " " No Horn within the Inner Ring Road "	To promote World Environment Day
Popular science film "Oxygen and Life"	Draw public attention to atmospheric pollution
Slogans such as "Take Care of Mother River, Protect Aquatic Environment, Let Us Safeguard the Future of Taihu Lake Basin Hand in Hand." (1996)	Draw attention to pollution in the Taihu Lake.
Public bike outing around Taihu Lake (1996)	Draw attention to pollution in the Taihu Lake

The Shanghai Primary and Middle School Environmental Education Coordination Committee, comprised of experts from the Shanghai EPB, organizes and implements environmental activities into the curriculum. (Wang, 1995) Primary and middle schools are increasingly embedding environmental awareness of issues into science curriculums. In the early 1990s, a series of activities were launched aimed at increasing environmental awareness among primary and secondary school students. Programs included "Go into Action to Create a Beautiful Future for Shanghai" which comprised of a series of stories, articles, lectures, picture-taking, drawing and thematic seminars about Shanghai's environment (SEB, 1994). Another major activity entitled "I Love the Huangpu River, the Mother River" was conducted to teach students about water quality protection. Some school have extracurricular environmental interest activities such as environmental inspection, social investigation and experiments (SEB, 1994).

This newfound focus on environmental education in Shanghai is promising to future water supply programs. Education is a vital part of any demand management program (such as educating the public about why and how to conserve water, or why water tariffs must be raised) and is useful for inciting public participation – which has advantages discussed in section 4.4.

5. Summary and Recommendations

This section summarizes the key goals and constraints in developing a water supply system in Shanghai. Several recommendations are made, following the summary, which tries to address these goals given the constraints.

5.1. Key Goals

From the baseline survey in sections 1-4, I have drawn out the some key points to consider.

Key Point 1: In Shanghai, the most pressing water issue is not water quantity, but quantity of high quality (class 3+) water.

- This is because Shanghai is a water-rich area, and consumption only makes up 19-22% of available water. (2.1)
- The quality of most of this water however is low as groundwater aquifers have been contaminated, most of the Huangpu is below potable water quality, the Huangpu's tributaries are toxic in most areas and rainwater is heavily acidic. (1.3)
- Water demand is expected to rise in the industrial and domestic sectors. Both of these sectors require higher quality water than the current heaviest user – agriculture. Thus water quality will have to improve to accommodate these growing sectors. (2.1, 2.2)
- As wealth increases, domestic users will demand not only more water, but water of a higher quality. Recent complaints about the smell of tap water (WB, 1994) and the increase use of bottled and filtered water indicate that water quality is perceived to be deficient. (2.2)
- The movement away from heavy and light industry to tertiary sectors may mean less demand for lower quality water (class 4) and increased demand for higher quality water. However, more data is required before this assumption can be made. (2.2)
- Rising cancer rates in Shanghai may signify a need to improve water quality. (2.1)

Key Point 2: The primary water source will likely continue to be surface water.

- Groundwater pumping in the past has caused ground subsidence. (1.2)
- Force recharge of groundwater has caused aquifers to be contaminated. (1.3)
- Rainwater is unlikely to be pure given the high concentration of industry and motor vehicles in Shanghai. (1.3)
- Primary surface water sources are the Huangpu, it's tributaries, and the Changjiang.

Key Point 3: There are three possible interventions to increase quantity of high quality water. These are presented in Box 5.1 with some sub-alternatives:

Box 5.1: Alternatives to solving Shanghai's main water problem

1. Improve water quality at the source
   a. Sewage treatment plants
   b. Control discharge of pollutants through various means
      i. relocate polluting factories
      ii. economic incentives to abate prohibition of polluting
   c. Better treatment of water at intake
   d. Distribution method that does not cause quality deterioration (i.e. replace/ upgrade leaky pipes)
2. Reduce the level of consumption of high quality water
   a. greywater recycling systems
   b. prevent wastage (demand management)
      i. price water by quantity and quality, or by sector
      ii. education
   c. limit the number of consumers
      i. population control
      ii. migration control
3. Move intake point to area of higher quality water

Key Point 4: There are several other goals that Shanghai is striving for and those goals act as constraints when choosing an intervention. Figures 5.1, 5.2 and 5.3 summarize these goals in hierarchies. These goals are divided into environmental, social and economic to reinforce the notion that water supply is not purely a technical matter. These goals are ordered so that the most fundamental goals are at the top, and the most technical goals (or interventions) are at the bottom. Another way to grasp these hierarchies is by thinking that the goals at the base of the arrow serve to achieve the higher goals at the end of the arrows. [Note: these hierarchies only show those goals which are somehow related to water supply; some goals have been based on assumptions. For example, while not explicitly stated, I can assume that sustainable extraction of water, or in other words, long term availability of water is a goal]

Key Point 5: There are additional constraints that influence the choice of intervention. Some of these are as follows:

- Government regulations and norms in China typically require water to be provided by the SMWC, unless granted permission otherwise (for example, large companies may draw their own water). (3.1)
- Government bureaucracy is such that separate bureaus with poor interagency cooperation control water supply and pollution. This suggests that in choosing an intervention, we must think narrowing and choose on behalf of one agency (in our case, since we are dealing with water supply, we will be making recommendations to the SMWC) (3.2)
- Poor regional of river basin coordination means efforts will likely be isolated to the city of Shanghai. This restricts the ability to perform some interventions, such as relocating factories away from Shanghai. (3.2)
- Government transfers are increasingly scarce. Large projects may be financed by users (through fees), International lending agencies, or both. (3.4)
- Government prefers large-scale, visible and quickly implemented water supply systems

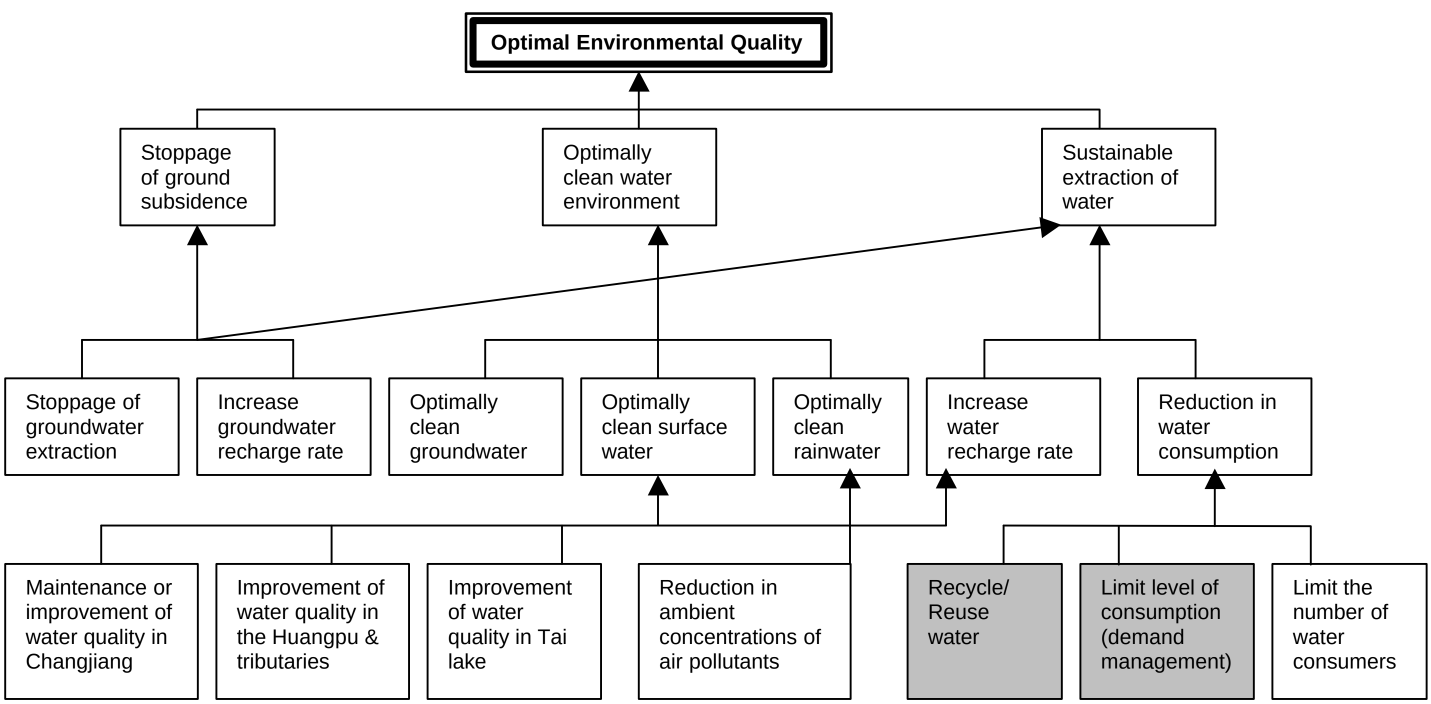

Figure 5.2: Hierarchy of economic-related goals and interventions.

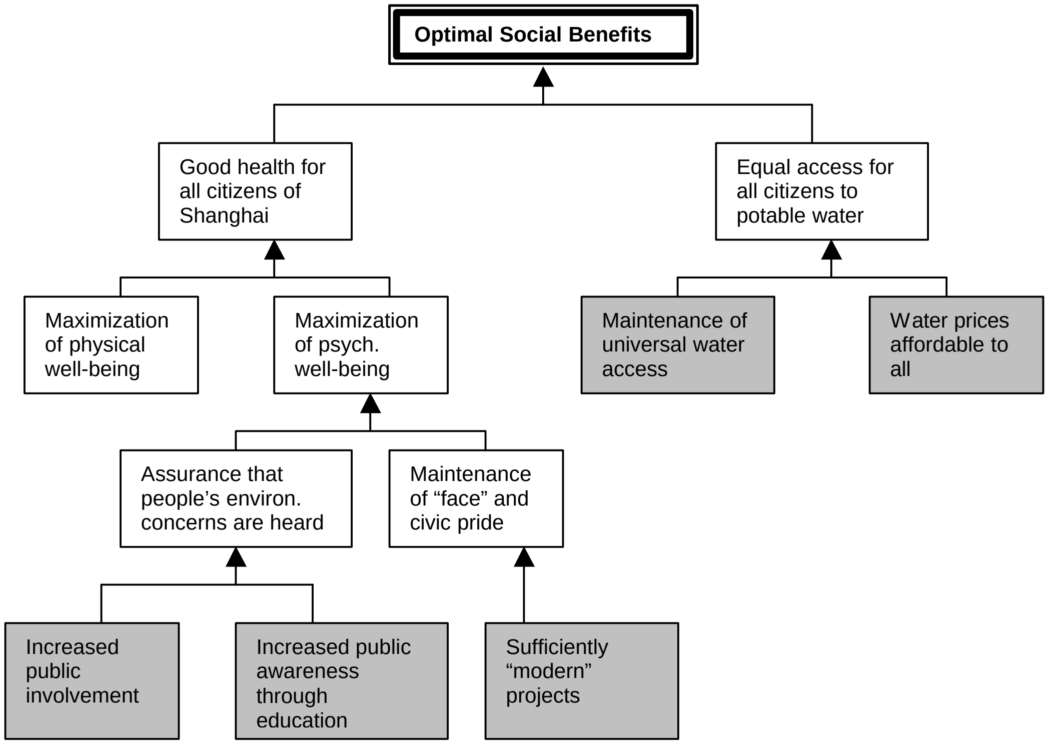

Figure 5.3: Hierarchy of social-related goals and interventions.

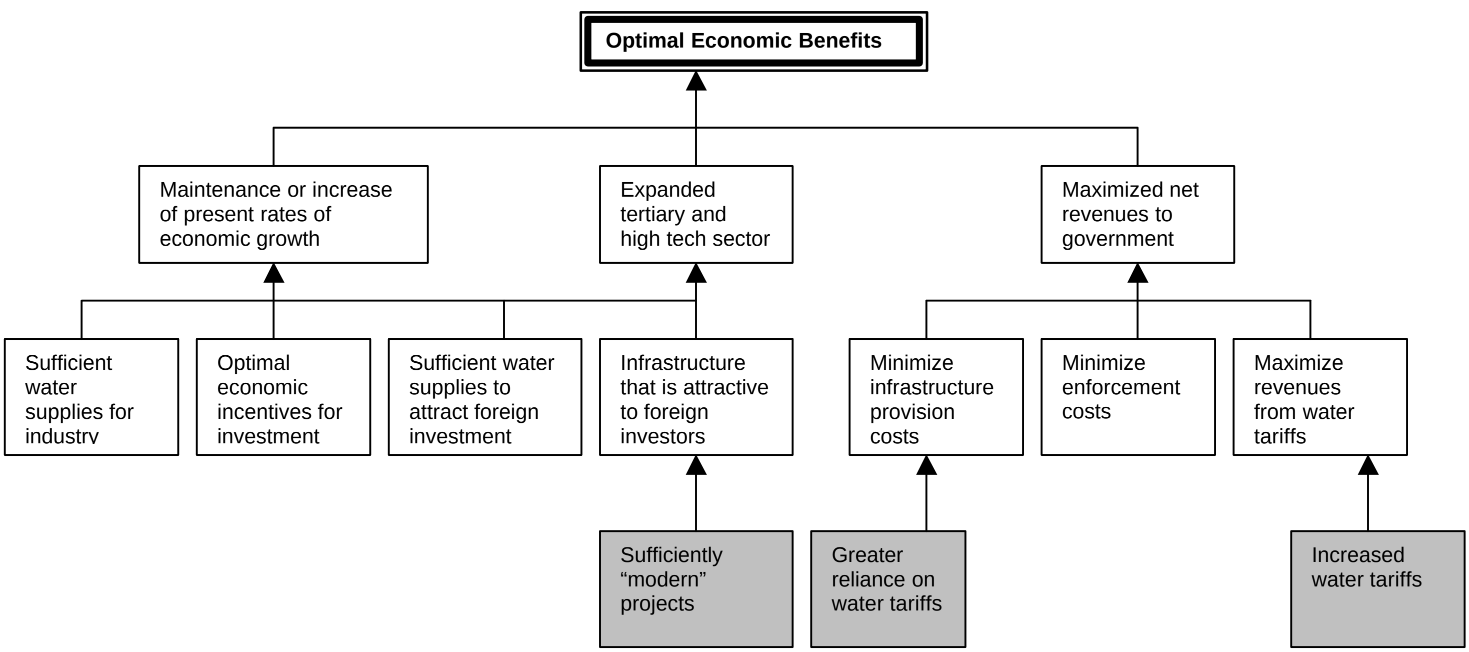

Figure 5.4: Hierarchy of economic-related goals and interventions.

5.2. Key Recommendations

These recommendations are aimed at the existing water providers, the Shanghai Municipal Waterworks Company. As such, alternatives not directly related to water supply are unlikely to have success when proposed by the SWMC.

My recommendations focus on reducing consumption of high quality water. These are option #1 in Box 5.1 and the shaded gray boxes in Figures 5.1, 5.2, 5.3.

Greywater Recycling Systems

The SMWC could feasibly implement a program to provide at a subsidized price technologies for greywater recycling around in the home.

"Greywater lies in between potable water and black water (which is water from the toilets, kitchen sink, garbage disposal and dishwasher or any other water source with a high concentrations of organic waste). Greywater is derived from domestic household sources such as the bath or shower, the washing machine, and the bathroom sink." (Bhanjee, Hou, Hunter, 1999) Shanghai citizens are increasingly using dishwashers and washing machines as wealth rises. This greywater is currently being wasted, placing pressure on sewage treatment plants and adding to water pollution.

Here are some advantages of greywater recycling that make it a particularly suitable intervention for Shanghai:

- Recycling greywater for toilet flushing or plant watering can reduce the demand for potable water by about 50% (toilet flushing accounts for about 50% of household water consumption; Duttle, 1990).
- Recycling greywater reduces the pressure on already insufficient sewage treatment plants.
- Greywater recycling systems are "modern" technologies which can be quite sophisticated. They are currently popular in North American cities. Many of the greywater technologies are high-tech because they recycle water from machines such as washing machines and are therefore unmistakable for traditional technologies.
- A program to provide domestic greywater recycling devices may create a niche for Shanghainese firms to produce high-tech greywater recyclers. This supports Shanghai's other goal of economic growth in the high tech sector.
- Greywater recycling promotes sustainable water usage.

<u>Water Tariffs</u>

There is clearly room to build upon the existing water tariff system. Current billing, metering and collection systems are effective and thus improvements are largely a matter of changing prices and/or pricing structure.

Some goals that relate to water pricing are:

- Prices must be low enough to provide equal access to everyone for basic water usage.
- Prices must not be so high as to deter businesses from investing in Shanghai.
- Water tariffs are soon to be the sole source of funding for the SMWC, therefore revenues from water pricing must increase.
- Keep enforcement costs as low as possible.

Some recommendations for revising water prices are as follows:

- Water should be priced according to volume purchased
- Water should be priced according to water quality
- Water should be priced according to marginal cost of providing that water (including environmental or social costs involved). Marginal cost pricing means that water prices will invariably increase with increased consumption because cost of water provision increases as water becomes increasingly scarce.

- Cross-subsidies are one way to ensure that all users, no matter how poor, have equal access to basic water needs. One system of implementation is to calculate the amount of basic water needed to sustain a person. This should be a low estimate that assumes hand washing of dishes and clothes. This first block of water should be free or underpriced (keeping it at 0.40 yuan per cubic meter seems appropriate and accessible to all citizens). The next block of water (from level a→ b) is priced according to marginal cost, while high water consumers (from b→ ∞) are charged marginal cost plus an additional penalty for over-consuming. This penalty will work to offset subsidies to the first block.

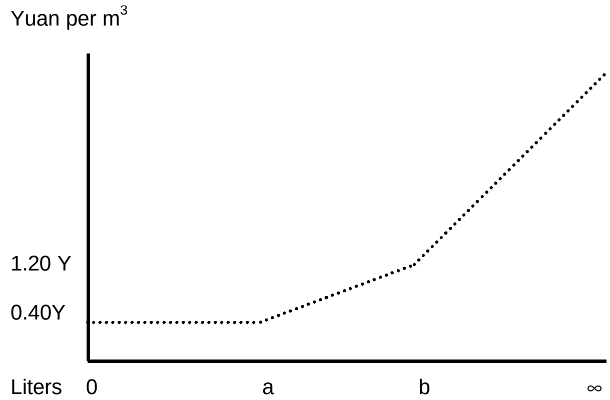

Figure 5.5: One proposed option for water tariff pricing.

- Industrial water tariffs should encourage the use of low quality water where production permits. Currently, tariffs reflect this idea as semi-treated industrial water is less expensive than regular water (0.40 yuan/m^3 to 0.51 yuan/m^3)
- Current water tariffs should be raised to reflect (at the very minimum) cost of provision for industry and for domestic use above basic needs. The current low rates are too low to provide incentives to conserve water.
- Tariffs for agriculture should also rise to encourage water-saving practices (this is less of an issue as the agricultural base around Shanghai shrinks. Also Shanghai may want to keep local agriculture profitable as a means to deter excessive rural migration.)
- Any tariffs increase scheme should be carried out with education and options for water conservation simultaneously. An education program teaching the general public why water prices are currently too low and must be raised are needed. These programs may have the effect of reducing enforcement costs later, as more people understand the need to increase prices and may therefore be more accepting of price increases. Programs to help consumers reduce their water use such as subsidized greywater recycling kits, washers or low flow showerheads, as well as general education on good water conservation habits will help to ease the transition to higher water prices and reduce water wastage.

Implementing reforms to the water pricing system will

- increase revenues for the SMWC
- increase fairness in that wealthy citizens who make heavy use of water supply for washing machines and lawn watering, will be taxes progressively
- ensure basic water needs are affordable by all
- reduce water consumption
- increase water conservation measures and provide incentives for people to install water conservation devices and implement water-saving practices
- increase Shanghai's likelihood of attaining World Bank loans, as one of tenets of the World Bank is to encourage appropriate water tariffs

<u>Education</u>

The other major demand management tool is increased education. This is a current trend in Shanghai which should be built upon and encouraged.

The following are some recommendations for a water-related education program. As you'll notice, many of these recommendations are already in place in Shanghai.

- Create an education plan that attempts to comprehensive educate Shanghai's citizens about the water issues in that city.
- Use various forms of media to educate. Make use of some of the most popular TV shows, radio shows and newspapers to ensure large viewer ship. For example, the United State EPA puts environmental messages in video game machines in arcades. Some suggestions are provided in Box 5.2.
- Educate the public on both the general and the specific. For example, some programs should introduce people to the hydrologic cycle, while others should discuss the specific problems of the Huangpu River. Still others should give step-by-step instructions of guides as to how to reduce water consumption.
- Make efforts to involve the business community. Companies that are make efforts to conserve water with new technologies should be recognized and may act as sponsors.
- Environmental education should be a consistent part of the school curriculum. Perhaps different grades should explore a different environmental issue facing Shanghai.
- Education should accompany any policy changes or programs to ensure greater effectiveness.

Box 5.2: Suggestions for education (Bhanjee, Hou, Hunter, 1999)
- Lectures by experts
- Public debates
- Film shows/ slide shows/ puppet shows
- Exhibitions
- Posters/ cartoons/ essays/ quizzes
- Nature training camps, tours
- Lectures during regular meetings and gatherings
- Public circulation of booklets, folders, magazines, journals, periodicals, coloring books, fact sheets
- Workshops and training sessions
- Lectures/ information/ tips delivered by TV or radio
- Visitor centres/ museums
- Fairs
- Information hotline
- Open houses
- Theme song/ mascot/ slogans
- Dance/ Drama

Omitted Options

Some options from Box 5.1 are not recommended. As well, the hierarchies are not complete because some obvious options are omitted. My rational for omitted these options are briefly explained below.

- **1. Improve water quality at the source**: While I feel many of these sub-options are not only feasible but very necessary in Shanghai to improve high quality water supply, they are omitted because of bureaucratic constraints. Since these recommendations are aimed at the SMWC, and as option #1 deals with water pollution rather than supply, it is outside of the jurisdiction of the SWMC, regardless of the fact that cleaner water means more water available for use. Also, the limited scope of this paper also restricts the focus to water supply, rather than expanding into issues of pollution and sanitation. This is clearly a shortcoming of both this paper, and Shanghai's bureaucratic structure.
- **2c. Limit the number of consumers**: Again bureaucratic division of labour prohibits the SMWC to implement measures to control population growth and migration. Relocation of factories is also not within the jurisdiction of the SMWC.
- **3. Move water intake**: This option is not discussed for several reasons. First, building new intake pumps does not satisfy the criteria of maximizing net revenues for the government. In a time of reduced subsidies from the SMG and the national government, building large-scale infrastructure is not economically feasible. Second, it is not a sustainable solution. Without options 1 and 2 (from Box 5.1) carried out in conjunction, water from the new source will eventually be polluted or depleted. This option is therefore only a short-term immediate solution. Finally, this option is the one currently chosen by the city of Shanghai under the Shanghai Environmental Project (see Box 5.3 for more information). It's advantages are that it is visible and quickly constructed – thus satisfying Shanghai's need to show investors that it is serious about improving infrastructure. In the long term, however, it does not satisfy Articles 7 and 15 of the Water Law which encourage water conservation. Also, both the Water law and the Environmental Protection Law advocate prevention first, then treatment only after than has failed. Moving water intake is clearly an "end of tail-pipe" solution.