WATER RETICULATION MODEL FOR TAMAN MAJU, PARIT RAJA

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This thesis is presented as to fulfill part of the requirement for the award of the Master of Civil Engineering

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MAY, 2011

Especially dedicated to

My Mother and Father

Words cannot express everything you have done for me ...

thank you

For all of the love and support from my

brothers, sisters, uncles, aunts, friends and all those who

have been a great

help in the completion of this thesis

My love for you all remains forever…

ACKNOWLEDGEMENTS

First and foremost, thanks to the Almighty Allah, the creator, the cherisher, the most wise, the all knowing, the lord of the world, the master of the universe and the sustainer of life under whose protection and guidance I was able to fulfill this task. Certainly Allah's assistance has been the most important not only for the successful completion of this thesis but for my entire life as a whole and the hereafter.

Full appreciation to my mother and my family, which can be hardly expressed in words.

I would like to extend my sincere thanks and appreciation to my supervisor, Dr. Tan Lai Wai for invaluable encouragement and guidance during the preparation of this thesis.

Lastly, a million thank you to all persons and individuals who have been involved towards the completion of this project whether directly or indirectly.

ABSTRAK

Satu model numerikal telah dihasilkan untuk menilai kuantiti kehilangan turus tenaga dalam jaringan pengagihan air di Taman Maju, Parit Raja, Johor. Sebuah pengiraan numerikal mempunyai kelebihan berbanding sebuah pengiraan manual apabila menganalisa sebuah jaringan pengagihan yang kompleks. Bahasa pengaturcaraan yang digunakan dalam kajian ini ialah Microsoft Visual Basic 6.0. Kaedah Hardy-Cross dipilih untuk mengira jumlah kehilangan turus tenaga yang berlaku dalam jaringan pengagihan air gelung Taman Maju. Jenis paip yang digunapakai dalam jaringan pengagihan air Taman Maju ialah jenis *unplasticised polyvinyl chloride* (uPVC) dengan pemalar kekasaran k = 0.0015 mm. Oleh kerana Taman Maju meliputi perumahan teres, permintaan air ialah 1360 liter/unit/hari. Tiga gelung rangkaian telah dipertimbangkan, iaitu gelung A, B dan C untuk sistem retikulasi Taman Maju. Kadar alir akhir dalam setiap paip telah diperolehi. Model ini berguna untuk mengurangkan tempoh masa yang digunakan dalam pengiraan kadar alir yang telah didapati berada dalam keperluan rekabentuk. Jika perbandingan dibuat di antara pengiraan manual, akan terdapat sedikit perbezaan. Hasil akhir adalah berbeza kerana bilangan tempat perpuluhan yang ditetapkan dalam pengiraan manual dan model adalah berbeza.

ABSTRACT

A numerical model is developed to quantify energy head losses occurred in the water distribution network of Taman Maju, Parit Raja, Johor. A numerical computation has the advantage over a manual computation when analyzing a complex distribution network. The programming language used in this study is the Microsoft Visual Basic 6.0. Hardy-Cross method is selected to calculate the total energy head loss incurred in the looped water distribution network of Taman Maju. The type of pipe used in the water distribution network of Taman Maju is the unplasticised polyvinyl chloride (uPVC) type with the roughness coefficient k = 0.0015 mm. Since Taman Maju consists of terrace houses, the water demand is 1360 litres/unit/day. Three loop networks are considered, namely loop A, B and C for Taman Maju reticulation system. The final flow rate in each pipe has been obtained. This model is helpful in reducing the period of time to calculate the flow rate which is found to be within the piping system design requirement. If comparison is made between the manual calculation, it will definitely shows some difference. The final result will be different because the decimal places fixed are different in manual and model.

CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

a	acceleration of fluid flow
A	cross-sectional area of fluid flow
C	Hazen-Williams coefficient
D	diameter of pipe
δQ	correction for assumed flow rate
e	surface roughness of pipe
f	friction factor
F	inertial force
g	gravitational acceleration
h_f	frictional head loss
K	Hardy Cross coefficient or head loss coefficient
L	length of pipe
m	mass of fluid
υ	kinematic viscosity of fluid
Q	flow rate
Q_a	assumed flow rate
Q'	corrected flow rate
Re	Reynolds number
ρ	density of fluid
V	velocity of flow

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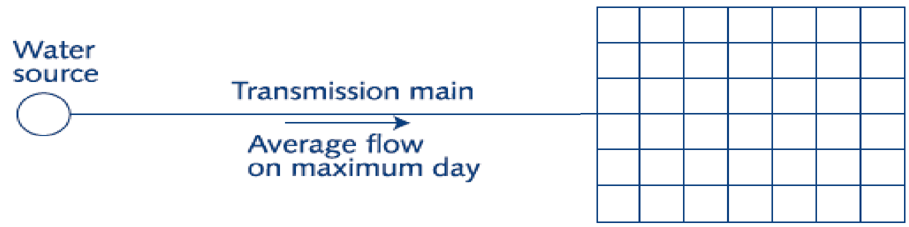
CHAPTER 1

INTRODUCTION

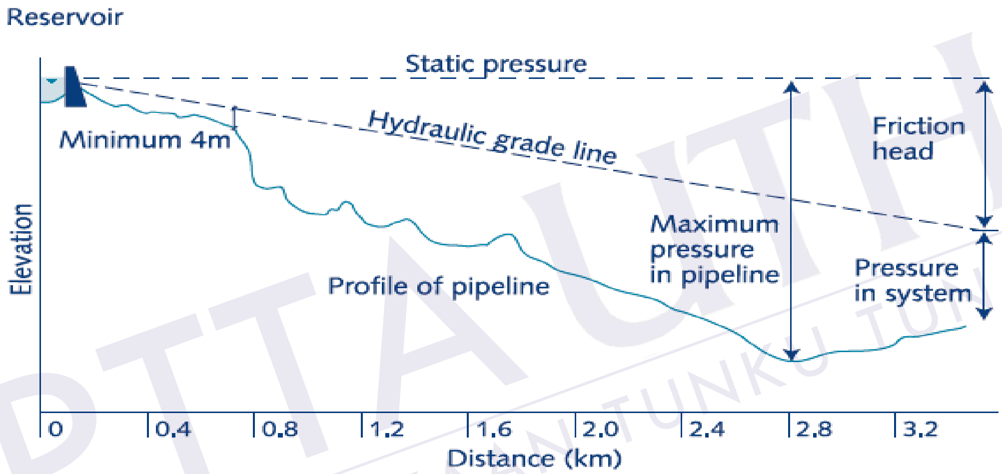
1.0 Research Background

Renewable sources of fresh water on the earth's surface are limited and irregularly distributed in space and time. There are about 1360 million km^3 of water on the surface of the earth. More than 97% of this volume comes from the oceans or seas. The remainder of about 37 million km^3 is fresh water (Eisenberg and Kauzmann, 1969). However, most of the fresh water on the earth is of little use because it is in the forms of ice-caps and glaciers. Approximately 8 million km^3 of the water is stored in relatively inaccessible groundwater and about 0.126 million km^3 are contained in lakes, reservoirs and streams (Franks, 1972). In recent years, the ever-increasing growth in the population of urban areas and the desire for security and a higher standard of living have attracted the attention on problems related to water economy. Such attention brought and will continue to bring about a surge in water-management work on a global scale. Thus, engineers, agriculturists, environmentalists, irrigation specialists, meteorologists, and hydrologists will have unparalleled opportunities to put their knowledge and skill to work for humanity.

Humans have contained water supply in one location by collecting it and creating a more reliable and constant supply despite its natural variation. Reservoirs are replenished by many sources including streamflow, groundwater, snow, and/or rainfall. They are diminished by multiple losses including consumption and friction losses. Water storage is designed to meet multiple objectives such as hydropower, irrigation, potable supplies, fishing and recreation, and to reduce the risk of floods and droughts (UNESCO, 2006).



(a) plan view



(b) cross sectional view

Figure 1.1: Head losses incurred in the distribution pipeline reduces the pressure in the System.

In hydraulic engineering practices, it is often necessary to estimate the head loss incurred by fluid as it flows through a pipeline and it is one of the most important problems in water distribution system. Friction loss refers to the difference in pressure needed to overcome the pressure drop during flow through pipe. Friction loss occurs as a result of dynamic movement caused by flow. Therefore, the pressure difference associated with this process is referred to as the dynamic differential pressure. Friction losses can only occur when flow actually takes place. Once a fluid begins to flow through a pipe it will therefore be necessary to overcome the extra difference in pressure caused by friction losses. This will have to be provided by the pump, in addition to it overcoming the stationary differential pressure. The pump's differential pressure will always be made up of the sum total of the stationary and dynamic differences in pressure.

Loss of head is incurred by fluid mixing which occurs at fittings such as bends or valves, and by frictional resistance at the pipe wall. Where there are numerous fittings and the pipe is short, the major part of the head loss will be due to the local mixing near the fittings. For a long pipeline, on the other hand, skin friction at the pipe wall will predominate.

Head losses are generally the result of two mechanisms, friction along the pipe walls and the turbulence due to changes in streamlines is through fittings and appurtenances. Head losses along the pipe wall are called friction losses or head losses due to friction, while losses due to turbulence within the bulk fluid are called minor losses (Ibrahim, 2005). Estimation of head losses due to friction in pipes is an important task in optimization studies and hydraulic analysis of pipelines and water distribution systems.

Using a distribution system model, we can have a better view of the flow in the water supply system and it is convenient to study for friction loss. Such numerical simulations save a lot of time and can be performed without actually doing the laboratory experiment.

1.2 Problem Statement

A water supply system is considered successful if it could supply water at the required quantity and quality with minor loss. In order to supply water to meet the demand, the water pressure has to adequate at all locations.

There is no network of pipes that is able to deliver water in fully accordance to the designed system. It is important for the engineers to maximize the delivery of adequate water supplies while reducing the head loss in the pipe network. Other than the loss due to water leakage or theft, head loss in water supply is also due to the friction loss in the piping system (Donald, Bruce and Theodore, 2000).

Complex network of pipes that has a lot of connections will increase head loss in the water distribution system. This factor has to be accounted for while analyzing the head loss in the flow. Manual method is not only time consuming, but may cause errors in analysis. Therefore, a pipe network model will be developed using the Microsoft Visual Basic to obtain an accurate and faster computations.

1.3 Objectives of Study

The objectives of this study are:

1. To develop a numerical model to calculate the head loss occurs in water distribution pipe system due to frictional resistance and other minor losses,
2. To determine the required head needed to supply water to Taman Maju, Parit Raja, Johor, and
3. To determine the total head losses involved in the water distribution system of Taman Maju, Parit Raja, Johor. This requires identification of the sources of head losses and its quantification.

1.4 Scopes of Work

The water distribution network system to be studied is of the residential area of Taman Maju, Parit Raja, Johor as shown in Figure 1.2. The pipe network layout and the characteristics such as the length, diameter, type of pipe as well as the number of consumers (or demand) are obtained from the Syarikat Air Johor Holdings (SAJH) Malaysia. The details are also available on the layout.

In this study, the head losses considered are due to friction, valve and pipe fittings. Hardy-Cross method is used to determine the total head loss in the pipe distribution network. The head loss due to friction is determined using Darcy-Weisbach equation along with the tabulated Moody chart. The advantage of Darcy-Weisbach method is that it can be used to calculate frictional losses for all types of fluids.

The programming language used in the study is the Microsoft Visual Basic 6.0. Microsoft Visual Basic 6.0 is chosen as the programming language as it is user-friendly and it is known for its graphical interface. The result of analysis can be projected on its form. Even the Microsoft Office programs utilize Visual Basic in their system development.

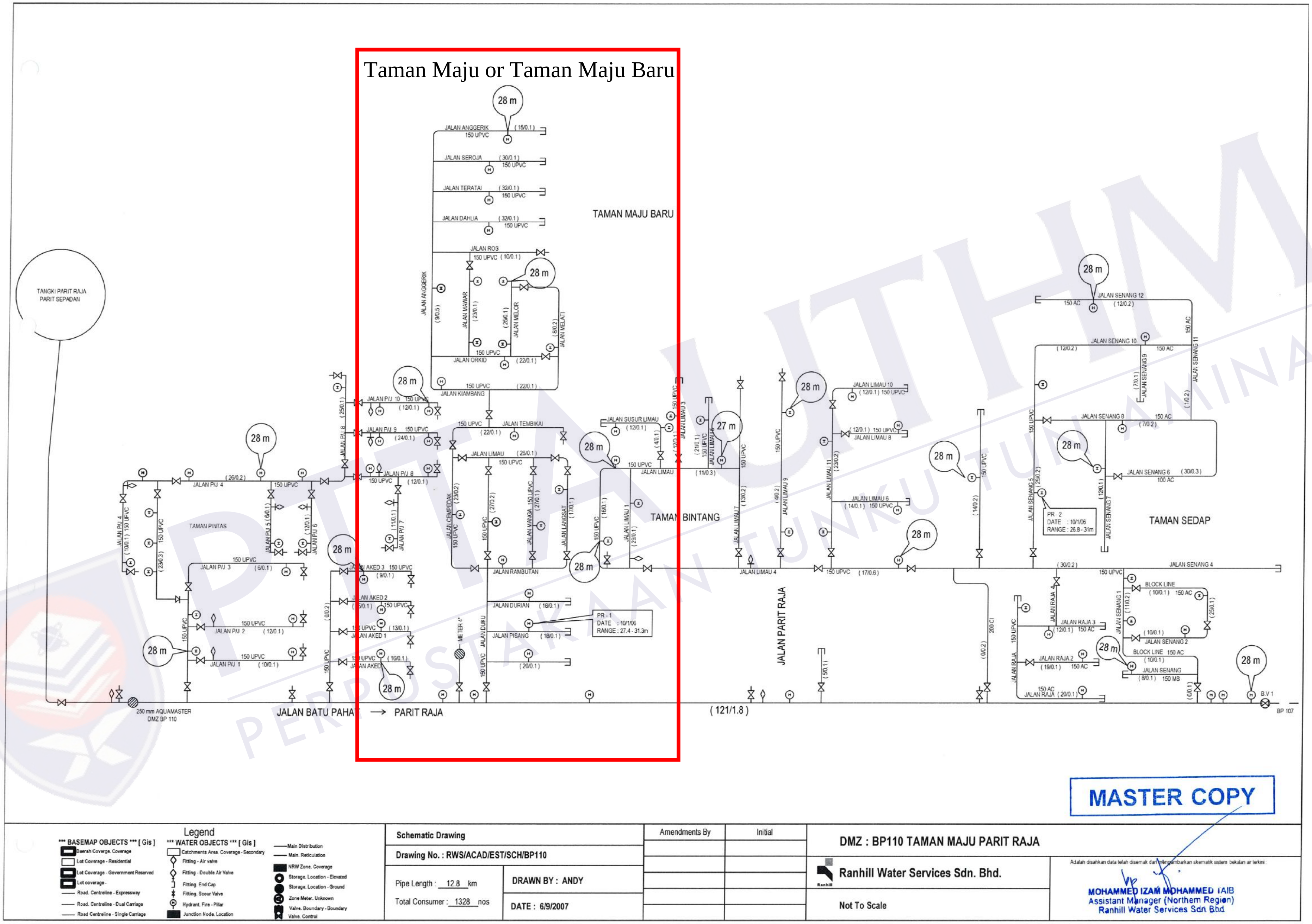


Figure 1.2: Layout of water reticulation system of Taman Maju, Parit Raja

CHAPTER 2

LITERATURE REVIEW

2.1 History of Water Supply and Distribution

The tap water in most of the world today is safe to drink and the source of water, for example river flow and groundwater are guarded against pollution. In the early 1900s, safe drinking water did not exist in the world and deadly waterborne disease such as cholera, typhoid fever, and dysentery were a constant threat. Table 2.1 shows the history of the development of water supply and its distribution since 1900.

Table 2.1. General timeline of water supply and its distribution (Constable and Somerville, 2011)

Year	Development
1900	**Sanitary and ship canal opens in Chicago** In Chicago, the main channel of the sanitary and ship canal opens, reversing the flow of the Chicago river. The 28-mile, 24-foot-wide drainage canal, built between Chicago and the town of Lockport, Illinois, is designed to bring in water from Lake Michigan to dilute sewage dumped into the river from houses, farms, stockyards, and other industries. Directed by Rudolph Hering, chief engineer of the Commission on Drainage and Water Supply, the project is the largest municipal earth-moving project of the time.

1913	**Los Angeles-Owens River Aqueduct** The Los Angeles-Owens River Aqueduct is completed, bringing water 238 miles from the Owens Valley of the Sierra Nevada Mountains into the Los Angeles basin. The project was proposed and designed by William Mulholland, an immigrant from Ireland who taught himself geology, hydraulics, and mathematics and worked his way up from a ditch tender on the Los Angeles River to become the superintendent of the Los Angeles Water Department. Mulholland devised a system to transport the water entirely by gravity flow and supervised 5000 construction workers over 5 years to deliver the aqueduct within original time and cost estimates.
1913	**Activated sludge process** In Birmingham, England, chemists experiment with the biosolids in sewage sludge by bubbling air through wastewater and then letting the mixture settle; once solids had settled out, the water was purified. Three years later, in 1916, this activated sludge process is put into operation in Worcester, England, and in 1923 construction begins on the world's first large-scale activated sludge plant, at Jones Island, on the shore of Lake Michigan.
1914	**Sewerage Practice, Volume I: Design of Sewers** Boston engineers Leonard Metcalf and Harrison P. Eddy publish American Sewerage Practice, Volume I: Design of Sewers, which declares that working for "the best interests of the public health" is the key professional obligation of sanitary engineers. The book becomes a standard reference in the field for decades.
1915	**New Catskill Aqueduct is completed** In December, the new Catskill Aqueduct is completed. The 92-mile long aqueduct joins the Old Croton Aqueduct system and brings mountain water from west of the Hudson River to the water distribution system of Manhattan. Flowing at a speed of 4 feet per second, it delivers 500 million gallons of water daily.

1919	**Formula for the chlorination of urban water** Civil engineer Abel Wolman and chemist Linn H. Enslow of the Maryland Department of Health in Baltimore develop a rigorous scientific formula for the chlorination of urban water supplies. In 1908 Jersey City Water Works, New Jersey, became the first facility to chlorinate, using sodium hypochlorite, but there was uncertainty as to the amount of chlorine to add and no regulation of standards. To determine the correct dose, Wolman and Enslow analyze the bacteria, acidity, and factors related to taste and purity. Wolman overcomes strong opposition to convince local governments that adding the correct amounts of otherwise poisonous chemicals to the water supply is beneficial – and crucial – to public health. By the 1930s chlorination and filtration of public water supplies eliminates waterborne diseases such as cholera, typhoid, hepatitis A, and dysentery. The formula is still used today by water treatment plants around the world.
1930	**Hardy Cross method** Hardy Cross, civil and structural engineer and educator, develops a method for the analysis and design of water flow in simple pipe distribution systems, ensuring consistent water pressure. Cross employs the same principles for the water system problem that he devised for the "Hardy Cross method" of structural analysis, a technique that enables engineers – without benefit of computers – to make the thousands of mathematical calculations necessary to distribute loads and moments in building complex structures such as multi-bent highway bridges and multistorey buildings.
1935	**Hoover Dam** In September, President Franklin D. Roosevelt speaks at the dedication of Hoover dam, which sits astride the Colorado river in Black Canyon, Nevada. Five years in construction, the dam ends destructive flooding in the lower canyon; provides water for irrigation and municipal water supplies for Nevada, Arizona, and California; and generates electricity for Las Vegas and most of Southern California.

1937	**Delaware Aqueduct System** Construction begins on the 115 mile long Delaware Aqueduct System. Water for the system is impounded in three upstate reservoir systems, including 19 reservoirs and three controlled lakes with a total storage capacity of approximately 580 billion gallons. The deep, gravity flow construction of the aqueduct allows water to flow from Roundout Reservoir in Sullivan County into New York City's water system at Hillview Reservoir in Westchester County, supplying more than half the city's water. Approximately 95 percent of the total water supply is delivered by gravity with about 5 percent pumped to maintain the desired pressure. As a result, operating costs are relatively insensitive to fluctuations in the cost of power.
1938-1957	**Colorado-Big Thompson Project** The Colorado-Big Thompson Project (C-BT), the first trans-mountain diversion of water in Colorado, is undertaken during a period of drought and economic depression. The C-BT brings water through the 13 mile Alva B. Adams Tunnel, under the Continental Divide, from a series of reservoirs on the Western Slope of the Rocky Mountains to the East Slope, delivering 230000 acre-feet of water annually to help irrigate more than 600000 acres of farmland in northeastern Colorado and to provide municipal water supplies and generate electricity for Colorado's Front Range.
1951	**First hard rock tunnel-boring machine built** Mining engineer James S. Robbins builds the first hard rock tunnel-boring machine (TBM). Robbins discovers that if a sharp-edged metal wheel is pressed on a rock surface with the correct amount of pressure, the rock shatters. If the wheel, or an array of wheels, continually rolls around on the rock and the pressure is constant, the machine digs deeper with each turn. The engineering industry is at first reluctant to switch from the commonly used drill-and-blast method because Robbins's machine has a $10 million price tag. Today, TBMs are used to excavate circular cross-section tunnels through a wide variety of geology, from soils to hard rock.

1955	**Ductile cast-iron pipe becomes the industry standard** Ductile cast-iron pipe, developed in 1948, is used in water distribution systems. It becomes the industry standard for metal due to its superior strength, durability, and reliability over cast iron. The pipe is used to transport potable water, sewage, and fuel, and is also used in fire-fighting systems.
1960s	**Kuwait begins using seawater desalination technology** Kuwait is the first state in the Middle East to begin using seawater desalination technology, providing the dual benefits of fresh water and electric power. Kuwait produces fresh water from seawater with the technology known as multistage flash (MSF) evaporation. The MSF process begins with heating saltwater, which occurs as a byproduct of producing steam for generating electricity, and ends with condensing potable water. Between the heater and condenser stages are multiple evaporator-heat exchanger subunits, with heat supplied from the power plant external heat source. During repeated distillation cycles cold seawater is used as a heat sink in the condenser.
1970s	**Aswan High Dam** The Aswan High Dam construction is completed, about 5 kilometers upstream from the original Aswan Dam (1902). Known as Saad el Aali in Arabic, it impounds the waters of the Nile to form Lake Nasser, the world's third largest reservoir, with a capacity of 5.97 trillion cubic feet. The project requires the relocation of thousands of people and floods some of Egypt's monuments and temples, which are later raised. But the new dam controls annual floods along the Nile, supplies water for municipalities and irrigation, and provides Egypt with more than 10 billion kilowatt-hours of electric power every year.
1980s	**Bardenpho process** James Barnard, a South African engineer, develops a wastewater treatment process that removes nitrates and phosphates from wastewater

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