# THE HISTORY AND DESCRIPTION OF

WATER SUPPLY, TREATMENT & DISTRIBUTION

# CITY OF BETHLEHEM, PENNSYLVANIA

 January, 2003

THE HISTORY OF THE BETHLEHEM

WATER SUPPLY SYSTEM

 In 1917, when Bethlehem officially became a City, the chief source of water supply was the Lehigh River and the wells at Illick’s Mill. In view of the fact that Bethlehem was expanding and growing at a rapid pace, it was evident that a more reliable and better supply of water, especially in quality and quantity, was the ultimate goal. As a result, our Council had the foresight in 1918 to instruct the City Engineer to make a comprehensive survey of the possible new sources of water supply so that the needs of the community could be fulfilled for future generations. The desire for the best possible source for a supply of water led to the selection of an area in the Pocono Mountains in Carbon County for the construction of the Wild Creek Reservoir.

 On July 26, 1938, City Council created the Bethlehem Municipal Water Authority, the first one to be established in the Commonwealth of Pennsylvania. After reviewing the report of the City Engineer on the Wild Creek waters, the evidence was presented to the State Water and Power Resources Board to obtain permission for the utilization of these waters by the Authority. Fortunately, the pattern for an expanding water supply system for the City of Bethlehem was approved by the Commonwealth of Pennsylvania.

 Construction of the Wild Creek Reservoir, the chemical treatment building, two one-mile rock tunnels, and twenty-one miles of 30” reinforced concrete water transmission mains was initiated on December 29, 1938. Work progressed at a rapid pace and in January, 1941, the total project was completed. The citizens of Bethlehem were most fortunate because their share of the expenditures was $2,500,000 with the Federal Government contributing $1,600,000; the total cost being $4,100,000.

 In 1938, the daily consumption of water in the City was 4 M.G.D. (million gallons daily). In 1944 the consumption rose to 17 M.G.D., in 1955 to 20 M.G.D. and in 1980 to 26 M.G.D. The rapid increase of water consumption, plus the demand for extending our water service, was a definite warning to us that our present supply was inadequate to cope with this situation. As a result, City Council and the Bethlehem Authority met on several occasions to institute proceedings to acquire an additional supply. After a comprehensive report and study was made of the Wild Creek drainage area, it was decided by both bodies to construct the Penn Forest Reservoir a short distance upstream from the Wild Creek Reservoir.

 On April 1, 1956 an 8 million-dollar bond issue was floated to pay for the cost of the new construction for the Penn Forest site, and to retire the indebtedness of the Wild Creek Reservoir. On April 2, 1956 the contractor commenced construction of the Penn Forest Dam and Reservoir. In September of 1958 the total project was completed. The Penn Forest Reservoir retains the water that was normally lost over the Wild Creek spillway. The total capacity of both reservoirs when filled is ten billion, three hundred million gallons of water or about a year’s supply at the present consumption rate.

 On December 22, 1964, additional bonds in the amount of 2.8 million dollars were issued to cover the cost of major improvements to the system and improved water service. The project consisted of a 42” steel transmission main paralleling the existing 30” Wild Creek transmission main for twenty-three thousand feet (stage II of the master plan). This project was completed in 1968 and increased our transmission capacity from 22 to 29 M.G.D. It also included the monies for the reforestation work at the Wild Creek watershed. Feeder mains were installed and the 5.0 million-gallon Southeast Low Service Reservoir was completed in 1965.

 One of the major projects in the Bureau of Water’s master plan was the metering of all water served, which was completed in 1964. Included in the bond issue were the funds to reimburse the City for the cost of the meters and installation.

 Water revenue bonds in the amount of 3.5 million dollars were issued in 1967 to finance the cost of construction of additional improvements. Included in this project were the Tunkhannock Creek addition to the Wild Creek water supply at a total cost of 3.4 million dollars. The City was fortunate in being able to secure a grant from the Federal Government in the amount of 1.5 million dollars to be applied to the Tunkhannock development. The Tunkhannock project was completed in 1968. This project allows for a 12 million G.P.D. average flow to be added to the Wild Creek water supply. However, because of the water quality, water is only taken from the Tunkhannock Creek during the winter months and spring runoff. The other items included in this project were the instrumentation telemetering and automation improvements, a 36” transmission main, feeder mains, a distribution reservoir and reforestation work at the Wild Creek watershed.

 The instrumentation and automation of the system was designed and installed in 1970.

 The parallel 36” transmission main under the Beltzville reservoir was constructed in 1968. A grant from the Corps of Engineers in the amount of $96,500 was received for this project.

 The reforestation program at the Wild Creek watershed was completed in 1968. This was an area of 2,300 acres, destroyed by a forest fire in 1963. The present program of watershed management is a continuing operation and it is funded by the Bureau of Water operating budget.

 The distribution system in the 45 square mile service area has also grown to where is serves approximately 109,000 people and has 476 miles of main line pipe. There is a network of small size pipes and about 35,100 service connections. In addition to servicing the City of Bethlehem, it serves two boroughs and all or parts of eight townships.

 On January 9, 1992 the Bethlehem Authority issued Water Revenue Bonds, Series of 1992 in the amount of $41,905,000 and Bond Anticipation Notes, Series of 1992 in the amount of $19,000,000. These bonds and notes were issued to pay for the first phase of a two phase water improvement project designed to upgrade and provide additional capacity to the water system. This included construction of a 42 M.G.D. water filtration plant, construction of 19,500 feet of a 48” steel treated water transmission main from the water filtration plant to the Howertown Control Station, a new Supervisory Control and Data Acquisition System (SCADA), a measuring weir across the Wild Creek, replacement of 27,300 residential water meters which were beyond their life expectancy for adequate accuracy and the purchase of additional lands in the Wild Creek watershed. Also, these bonds and notes allowed the repayment of a 1990 Bethlehem Authority $5,660,000 Bond Anticipation Note, refunding of all the outstanding 1956, 1965 and 1967 Bonds of the Authority and capitalizing a portion of the interest on the 1992 Bonds.

 On December 30, 1992 the Bethlehem Authority issued Water Revenue Bonds, Series A of 1992, in the amount $32,650,000. These bonds were issued to provide funds for the costs and expenses of the second phase of the Water Supply Project. This included construction of a 5.0 M.G. Southwest Low Service Reservoir to replace the 2.7 M.G. open reservoir behind St. Luke’s Hospital, construction of 23,800 feet of a 42” raw water transmission main from Wire Ridge to the Blue Mountain, replacement of 3,700 residential water meters and 1,000 commerical/industrial water meters and refunding of the $19,000,000 Bond Anticipation Notes, Series of 1992.

 On March 8, 1994 the Bethlehem Authority issued Water Revenue Refunding Bonds, Series of 1994, in the amount of $82,870,000. These bonds were issued to advance refund the 1992 Bonds and the 1992-A Bonds.

 Construction of the 42 M.G.D. Bethlehem Water Treatment Plant, a direct filtration plant, commenced on February 12, 1992 and was put into service on October 13, 1994. Construction of the 48” steel treated water transmission main commenced on November 30, 1992 and was put into service on July 15, 1994.

 Construction of the SCADA system commenced on October 26, 1992 and was put into full service in 1995. Construction of the 5.0 M.G. S.W. Low Service Reservoir commenced on March 15, 1993 and was put into service on July 15, 1994.

 Construction of the 42” steel raw water transmission main commenced on October 30, 1994 and was put into service in November, 1996.

 In 1996 the Bethlehem Authority issued Construction Notes – Series of 1996 in the amount of $10,000,000. By agreement dated July 1, 1997, the Emmaus General Authority agreed to loan $40,000,000 to the Bethlehem Authority. During 1998 a $20,000,000 principal payment was made to reduce the outstanding amount to $20,000,000. During 1998 PennVEST agreed to loan $20,000,000 to the Bethlehem Authority. In 1998 the Bethlehem Authority also issued Water Revenue Bonds, Series of 1998 in the amount of $25,142,165.35 and the Construction Note - Series of 1996 was paid off. This funding was required to pay for the new Roller Compacted Penn Forest Dam.

 Construction on the new Penn Forest Dam commenced in June, 1996, was substantially completed on November 17, 1998, approved by the PA DEP on December 7, 1998, began refilling in January 1999 and dedicated on June 21, 1999. This roller compacted concrete dam is the third largest dam by volume in the United States and the largest RCC dam by volume east of the Mississippi River. This new dam is buttressed on the downstream face by earth and rockfill excavated from the embankment of the original Penn Forest Dam. Savings of approximately $20 million was realized by choosing this design which utilized the existing spillway, diversion and intake structures from the old Penn Forest Dam.

 Various methods of refinancing the outstanding water system debt are constantly being evaluated and undertaken to reduce the total outstanding principal and interest due during the term of the debt.

 An upgrade of both the Water Treatment Plant and the Technical Division SCADA system commenced on July 13, 2001 and the Water treatment Plant upgrade was accepted by April 15, 2002 and the Technical Division upgrade was accepted by May 30, 2002.

 Prior to January, 1998 engineering projects were handled by the Department of Public Works, Bureau of Water Supply & Treatment. Subsequent to January, 1998 engineering projects were handled by the Department of Water & Sewer Resources, Bureau of Water Supply & Treatment. Currently, the City’s Department of Water & Sewer Resources is responsible for the maintaining of the water system while the Department of Public Work’s Bureau of Engineering is responsible for managing and/or executing engineering projects for the system.

CITY OF BETHLEHEM

WILD CREEK AND PENN FOREST RESERVOIRS

LOCATED IN THE POCONO MOUNTAINS

WILD CREEK RESERVOIR

Maximum Depth – 135 ft. Area of Watershed – 22 sq. mi.

Capacity – 3.9 billion gal. Top Length of Dam – 1,076 ft.

Length of Shoreline – 6 mi. Top Width of Dam – 30 ft.

Area of Water Surface – 304 acres. Maximum Bottom Width – 1000 ft.

Diameters of pipe lines – 36” and 30” Height above creek level – 155 ft.

Earth Fill in Dam - 1,300,000 Cubic Yards

Spillway elevation - 820 ft.

PENN FOREST RESERVOIR

Height of Dam – 180 ft. Area of Watershed – 16.5 sq. mi.

Maximum Water Depth – 125 ft. Top Length of Dam – 2,050 ft.

Capacity – 6.0 billion gal.

Length of Shoreline – 7 mi.

Area of Water Surface - 480 acres @ El. 1,000.6 ft.

Earth Fill volume – 1,900,000 Cubic Yards

RCC Volume – 370,000 Cubic Yards

Elevations

Penn Forest Dam Spillway – 1000.6 ft.

Wild Creek Dam Spillway – 820 ft.

Bethlehem Water Treatment Plant at Pennsville – 675 ft.

Broad and New Streets – 340 ft.

DESCRIPTION OF CITY OF BETHLEHEM

WATER SYSTEM AND OPERATION

 The water system of the City of Bethlehem services an area of 45 square miles that includes the City, two boroughs and all or parts of eight townships. The system has approximately 35,100 billing accounts servicing a population of approximately 109,000.

 The City of Bethlehem’s primary water supply is located on Wild Creek, 22 miles north of the City. Two series connected reservoirs, Penn Forest (6.0 billion gallons capacity) and Wild Creek (3.9 billion gallons capacity), provide the storage, and 30”, 36”, 42” and 48” transmission mains can carry up to 47.3 M.G.D. to the City’s distribution system.

 The City also has agreements with five adjacent water utilities for emergency interconnections. These are:

 Salisbury Township, 0.5 M.G.D.

 City of Allentown, 2 connections, total flow 2.5 M.G.D.

 Easton Suburban Water Authority, 1.0 M.G.D.

 Borough of Hellertown, 0.04 M.G.D.

 Northampton Borough Municipal Authority, 1.0 M.G.D.

## OPERATION

 Generally the system consists of two major zones. The first is the low level service zone at nominal hydraulic elevation 477 and the high level service zone at nominal hydraulic elevation 748. The source is a nominal hydraulic elevation of 820. Water is conveyed from the source through the transmission mains to the water filtration plant at Pennsville with an effluent HGL of El. 650 to the Howertown Control Station with an influent HGL of El. 645 in the Howertown South transmission main and an effluent HGL of El. 554 in the Howertown East transmission main. From this hydraulic elevation water is conveyed through interconnections from the transmission main predominantly into the low service zone through PRV’s, most of which are locked open and not in service. The remaining water in the El 554 zone is conveyed through the Howertown East or South transmission mains into the low level service storage facilities. Water is pumped from the low level service zone into the high level service zone from hydraulic elevation 457 to hydraulic elevation 748. This is done through two of the pump stations listed. From the southeast high zone a relatively small portion of demand is pumped up to the South Mountain zone at hydraulic elevation 1,025.

 A relatively small amount of water (0.75 M.G.D.) is transmitted from the southwest high and southeast high zones into the Saucon Valley area.

 There may be a small split between the southeast and the southwest low service area. This is suspected because the 5 M.G. Southeast Low Service Reservoir is at a higher elevation than the Southwest Low Service Reservoir.

## TREATMENT

 The treatment of the raw water is performed at the 42 M.G.D. Bethlehem Water Treatment Plant which is located in Lehigh Township. There area a number of chemicals added as described below:

Gaseous Chlorine:

 Purpose – Disinfection

Dosage – 8.3 lbs. per MG to provide a free pre-chlorine residual of 1.0 mg/L.

 10.8 lbs. per MG to provide a free post-chlorine residual of 1.30 mg/L.

Aluminum Sulfate:

 Purpose – Coagulation

 Dosage – 40 dry lbs. per MG to provide an alum concentration of 4.8 mg/L.

Hydrated Lime:

 Purpose – Increase the pH of the Wild Creek raw water to the desired coagulation

 pH range of 6.3 to 6.8.

 Dosage – 21 dry lbs. per MG to provide a hydrated lime concentration of 2.5

 mg/L.

Hydrofluosilicic Acid:

 Purpose – Provides fluoride which is known to reduce dental caries.

 Dosage – 39 wet lbs. per MG of 23% strength acid to provide a Fluoride content

 of 1.08 mg/L.

Zinc Orthophosphate:

 Purpose – Corrosion control.

 Dosage – 9.0 wet lbs. per MG to provide an inhibitor residual of 1.1 mg/L.

Caustic Soda:

Purpose – Increase the pH of the filtered water to the desired pH range of 7.5 to

 7.6.

Dosage – 60 wet lbs. per MG of 50% strength Caustic Soda to provide a Caustic

 Soda concentration of 7.0 mg/L.

Sludge Conditioner Polymer:

 Purpose – To optimize filter backwash residuals settling in the lagoons.

 Dosage – 0.4 wet lbs. per MG to provide a polymer concentration of 0.05 mg/L.

## TRANSMISSION

 Two transmission mains extend from the primary source to the Howertown control station near the outskirts of town. At this point, the transmission line splits into a 36-inch-diameter pipeline called Howertown East and a 30-inch-diameter pipeline called Howertown South. At the immediate upstream side of this junction the control station reduces pressure from the filtration plant effluent hydraulic grade line of El. 650 to El. 554 in the Howertown East transmission main..

 The Howertown South line continues to the Southwest Low Level Reservoir facility. Between the Howertown control station and the southwest facility are four connections with the main water system each of which have pressure reducing valves, most of which are locked open and not in service. The Howertown East line conveys water through a transmission line consisting of 36-inch-diameter, 34-inch-diameter, and 30-inch-diameter pipeline sections and conveys water to the 5.0 M.G. Southeast Low Service Reservoir. Between the Howertown Control Station and the southeast facility there are at least 5 connections with the system. Each of these have pressure reducing valves, most of which are locked open and not in service. The connections are listed below in the order of their distance from the Howertown control station:

1. Center Street and Macada Road
2. Washington Avenue and Linden Street
3. Pembroke Road and Stefko Boulevard
4. East North Street
5. Third and Marshall Streets

All of the pressure reducing valve stations have inlet and outlet pressure recorders located at the central monitoring and control room at City Hall.

## ARTERIALS

 Water is pumped from the Southwest Low Service Reservoir facility through the Southwest High Service pump station to the 2.0 M.G. Southwest High Service Reservoir.

 Water can be pumped through the Southeast High Service pump station to the 1.0 M.G. Southeast High Service Reservoir. The 1.0 M.G. Southeast High Service Reservoir and the 2.0 M.G. Southwest High Service Reservoir are connected with pipelines of about 16-inch-diameter.

 From the southwest high service zone water is conveyed to the Saucon Valley area. In this arterial is a pressure reducing valve station. From the southeast high service zone water is also conveyed to the Saucon Valley area.

 The low service zone comprises most of the system and is well interconnected with pipeline grid.

 The distribution system pipeline contains both ductile iron and cast iron pipe. Most of the system is about 30 to 50 years old and the largest expansion was shortly after World War II. Because of corrosion control treatment and good management, the Water Bureau has no real internal corrosion problems and regularly implements a flushing program to prevent build-up of sediments.

## STORAGE

 Total storage for the system is 30.5 million gallons.

Southwest Low Service Storage:

 This consists of a 12 million gallon Hypalon floating covered reservoir and a 5.0 million gallon reservoir.

 The water is conveyed from the Howertown South line directly into both the 12 million gallon reservoir and the 5.0 million gallon reservoir which have a maximum water surface elevation (MWS) of 477 feet.

Southwest High Service Reservoir:

 This covered reservoir holds a nominal 2 million gallons and its maximum water surface elevation is 748 feet.

Northeast Standpipe:

 This steel tank has a capacity of 5 million gallons and its maximum water surface elevation is 540 feet.

Southeast Low Service Reservoir:

 The capacity of this steel tank is 5 million gallons and its maximum water surface elevation is 498 ft. It is replenished by the Howertown East transmission main through an altitude control valve.

Southeast High Service Reservoir:

 The Southeast High Service tank has a capacity of 1 million gallons with MWS of 748 feet which is the same as the Southwest High Service Reservoir.

South Mountain Reservoir:

 This ½ million gallon reservoir has a MWS of 1,025. The primary purpose of the reservoir is to service the Lehigh University Mountain Top Campus and surrounding area.

## PUMP STATIONS

 There are three booster pump stations to convey water to the higher elevations not accessible via the gravity flow.

Southwest High:

 The purpose of this station is to pump out of the 5.0 M.G. Southwest Low Service Reservoir into the high level service zone.

Southeast High Service Pump Station:

 The southeast high service pump station pumps from the Howertown East transmission line upstream of the 5.0 Southeast Low Service Reservoir altitude valve. The pump station moves water from the nominal hydraulic elevation of 457 ft. into the high level service area with a hydraulic elevation of approximately 748 ft.

South Mountain Pump Station:

 This South Mountain station pumps from the high service zone into the South Mountain Reservoir which has a capacity of 0.5 MG.

## TELEMETRY AND SUPERVISORY CONTROL

 The critical points in the entire water system are monitored at the Central Control room at City Hall. Data are telemetered via radio and microwave link to provide indication of pressures, flows, and levels throughout the system for use by the operations staff.