REPORT ON WATER SUPPLY SYSTEM

For The

TOWN OF EXETER
NEW HAMPSHIRE

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TABLE OF CONTENTS

FIGURES

TABLES

I. INTRODUCTION

The purpose of this report is to provide, in detail, the results of our investigation of the Exeter water system and to make recommendations for the improvement and maintenance of the quality of water being delivered to the consumer and to provide for expansion of source and treatment to meet projected quantity needs of the Town through the year 2010.

The investigation took into consideration the following areas of concern:

a. An estimate of current and future population and water needs through the year 2010.

b. A review of water quality deficiencies in both treatment and delivery systems.

c. The availability of raw water including both quantity and quality as relates to treatment needs and system demands.

d. Review of the capacity of the plant as to both quantity and quality of finished water.

e. Review of distribution system as related to its ability to provide adequate flows at suitable pressures and the impact of the system on the quality of water being delivered.

f. Recommendations as to the best methods of providing water in sufficient quantity with consistently acceptable levels of quality together with an estimated cost of construction of the improved facilities.

II. Existing System

A. Sources

The Town of Exeter, New Hampshire can presently obtain its water supply from two surface water and four groundwater sources. The surface water sources consist of the Exeter River and the Dearborn Reservoir, with groundwater sources consisting of the Skinner Springs and the Stadium, Gilman and Lary Lane wells. All of the sources, with the exception of the Lary Lane well, can currently be treated at the Exeter Water Treatment Plant located at Dearborn Reservoir on Portsmouth Avenue. The three groundwater wells were at one time pumped directly into the water distribution system, however, due to poor quality and poor construction, they are no longer approved as untreated sources of supply by the United States Environmental Protection Agency (USEPA). A brief description of the sources follows:

Exeter River water is diverted to the plant through the River Pumping Station. This facility was constructed in 1972 and is located on the northeasterly bank of the Exeter River near its confluence with the Little River and adjacent to the Exeter Academy athletic fields. Water enters the pumping station's clearwell through three river intake lines. A 24-inch intake pipe is located at the center of the river at an approximate depth of 12 feet, and two 12-inch intake pipes are located on the river's bank at approximate depths of two feet and one foot. These more shallow intakes were installed to provide raw water with higher dissolved oxygen levels and therefore lower iron and manganese concentrations. The lower intake provides a cooler water supply, and one more stable relative to temperature changes.

A 60-horsepower motor drives a vertical turbine pump which can deliver up to 2.4 million gallons per day (MGD). This water is treated at the station with potassium permanganate to oxidize iron and manganese. The treated water has an approximate detention time of 35 minutes within the

12-inch raw water main between the river and the water treatment plant.

The second surface water supply is the Dearborn Reservoir. This reservoir is located adjacent to the treatment plant and has a capacity of approximately 60 million gallons. Due to its elevation relative to the plant, raw water flows by gravity through the 16-inch inlet pipes (one at a depth of 12 feet and the other at a depth of 17 feet below the overflow) into the intake structure and thence through a 24-inch water line to the water treatment plant. This reservoir was constructed by impounding a brook and springs around the turn of the century.

The Skinner Springs are a group of wells located near the Town line in the Town of Stratham about 3800 feet east of the water treatment plant. There are six 30-inch wells, two 42-inch wells, and a 30 foot diameter collector well. Water flows by gravity from the wells through a 10-inch pipe to the treatment plant. Plant personnel estimate that approximately 100,000 gallons per day can be obtained from this source.

Three groundwater wells are located in the southern section of Exeter along the banks of the Exeter River. The Gilman and Stadium wells can be pumped directly to the River Pumping Station discharge line and thence to the plant or reservoir. These wells have not been in operation for a number of years.

The Stadium well is located approximately 100 feet southeast of the River Pumping Station. A 25-horsepower motor drives a deep well turbine pump. This station was constructed in 1963 and has a capacity of approximately 800,000 gallons per day. A subaqueous water main beneath the Exeter River connects this station with the Gilman well.

The Gilman well was constructed in 1950. A 20-horsepower electric motor drives a deep well turbine pump. This facility has a capacity of 250,000 gallons per day.

The Lary Lane well was constructed in 1958, approximately 2,000 feet south of the Gilman well. This well is presently connected to the water distribution system only. The 40-horsepower electric motor pump has a capacity of about 800,000 gallons per day. A Cummings, four-cylinder auxiliary diesel engine and Johnson right angle gear drive can be used to operate the deep well turbine pump during a power failure.

B. Water Treatment Plant

The original Exeter Water Works Company was incorporated in 1885, and began serving the Town in 1886. The original pressure filters were replaced in 1906 by rapid sand filters. In 1924, some improvements were made to the plant, including construction of the water tank. The Town of Exeter purchased the water company in 1950. During 1972 through 1974, the existing water treatment plant was renovated and expanded.

The existing plant uses the traditional process of coagulation, flocculation, clarification, and filtration to treat the raw water furnished from the above sources.

Plant chemicals are applied at a rapid mix basin. Aluminum Sulfate (Alum) and Sodium Aluminate are added at this point for coagulation; caustic soda can be added to adjust pH to optimize the coagulation process; potassium permanganate can be added to oxidize the iron and manganese in water from Dearborn Reservoir, and powdered, activated carbon is added to the water to remove taste and odors with some reduction in the color of the water. The mixed water then enters the flocculation basins where it is gently agitated by walking beam paddles to assist in the formation of floc particles. The water then flows to clarification basins where upflow, tube settlers assist in the removal of the flocculation particles. Accumulated sludge slides down the inclined tubes and settles out in the clarification basin where it is removed by sludge collectors and sludge pump.

Settled water is chlorinated and then piped to mixed media filters. These filters are constructed in three layers - one of gravel, one of sand quartzite, and the third of anthricite. Chlorine is added prior to filtration in order to control bacterial growth in the filter media. The filtered water enters the clearwell where chlorine is added for disinfection and caustic soda is added to reduce corrosion in the distribution system. Finished water from the clearwell is pumped into the distribution system by two, 2-million gallon per day, high service vertical turbine pumps.

The mixed media filters are cleaned through back washing. In this process, water is forced through the media in a direction opposite to normal flow. The backwash water, together with sludge removed from the sedimentation basins, is pumped to lagoons adjacent to the plant. The heavier sludge settles out of the liquid and the supernatant can be reintroduced at the plant inlet to conserve water and to aid in the coagulation/clarification process.

C. Water Distribution System

Water, treated and chlorinated at the existing water treatment facility, is pumped into the distribution system to meet the Town's daily water demands. Exeter water distribution system consists of approximately 22.5 miles of 4 to 12-inch cast iron and asbestos cement water mains, two one million gallon water tanks, and one booster pump station. Constructed beginning in the late 1800's to serve the downtown area, the system has been expanded to serve outlying areas as shown on Figure No. 1.

III. Growth Trends & Future Water Use

A. Planning Area Description

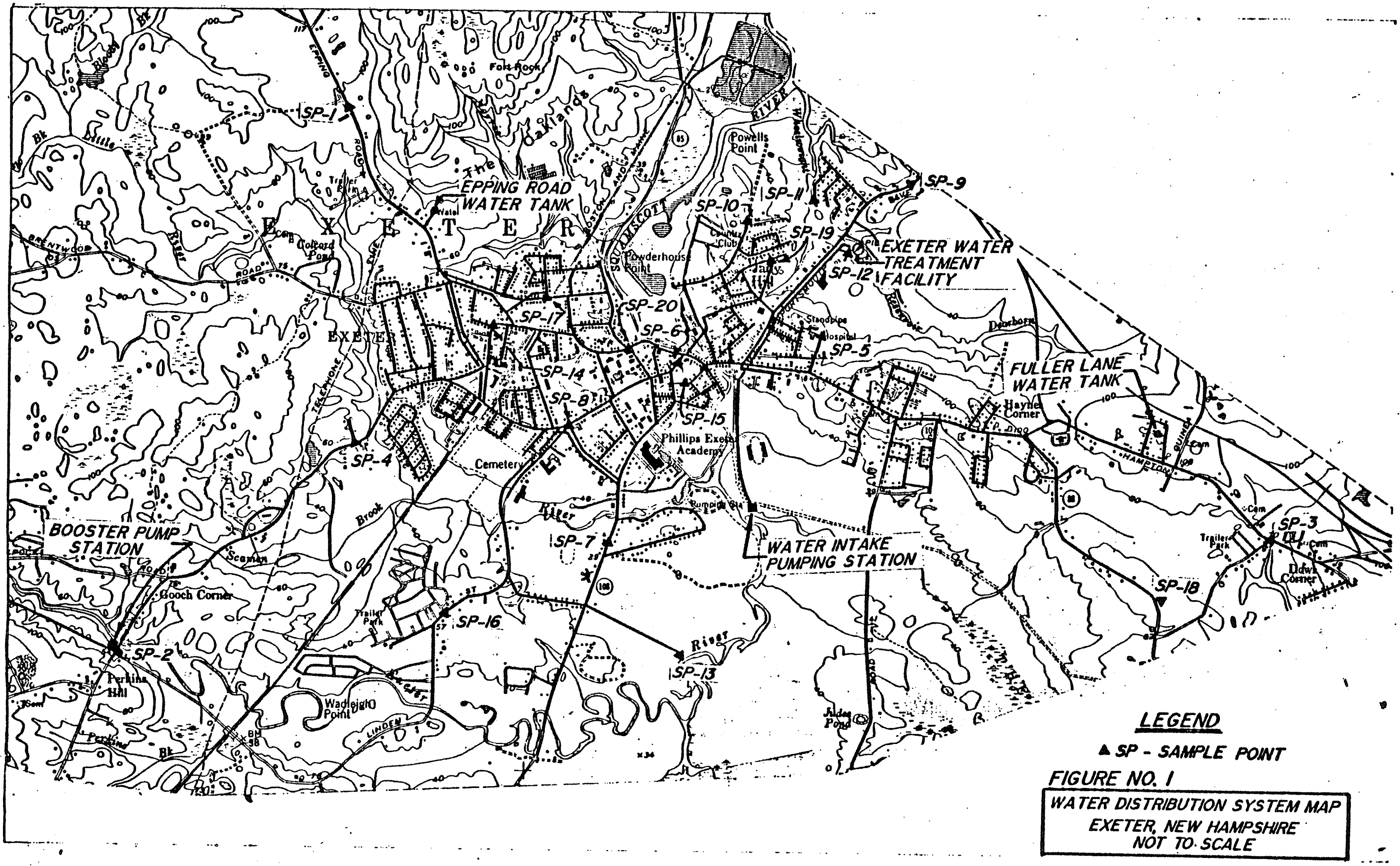


FIGURE NO. 1

WATER DISTRIBUTION SYSTEM MAP
EXETER, NEW HAMPSHIRE
NOT TO SCALE

The Town of Exeter is located approximately twelve miles southwest of Portsmouth, NH. The Town has an area of 19.5 square miles of which about 20% is developed. Routes 95, 101, 88, 108, and 111 are the principal highways serving the Exeter area, making it easily accessible from Portsmouth and surrounding areas.

B. Demographics and Land Use Data

The 1980 U.S. Census population for Exeter was 11,024. Having a land area of 19.5 square miles, Exeter has a density of 4.4 persons per developed acre. The Town's Master Plan, prepared in 1985, presents a thorough discussion of existing and future growth.

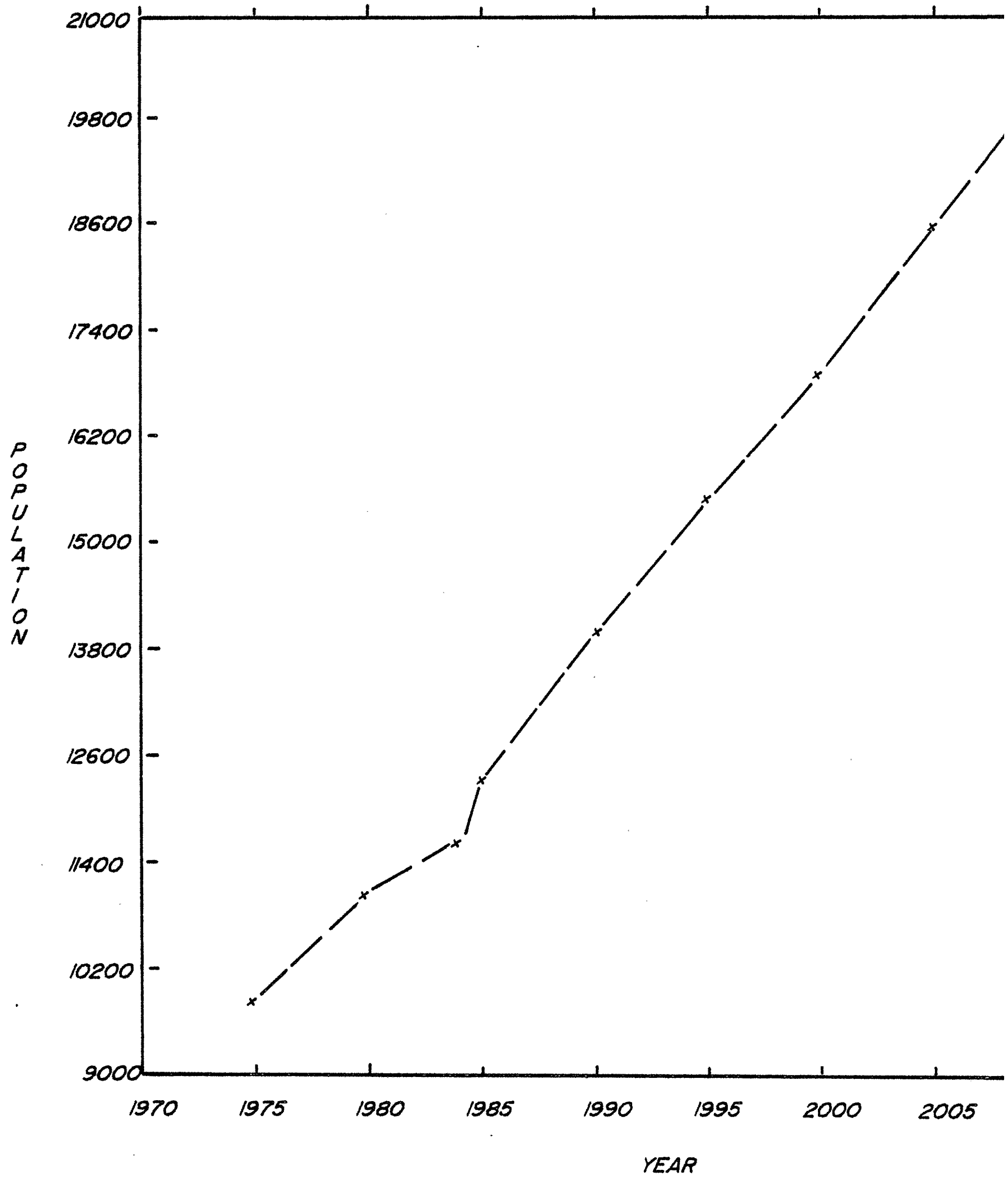
1. Residential - "Housing growth outside of the downtown area has been considerable over the past three decades. The early part of this period saw mostly single family home construction, but since 1970, a growing number of multi-family units have been built. There is every indication that pressure for residential growth will continue unabated for the foreseeable future. It should be expected that the

remaining vacant land in all areas of the Town will come under development pressure. Even in the absence of sewer and water, the area north of Route 101 can expect to be developed over the coming decades".* The New Hampshire Office of State Planning predicts that the population in 2010 will be 20,260. Figure No. 2 shows the continuing rate of growth predicted by NHDSP for Exeter.

2. Commercial - Existing commercial development is located primarily in the downtown area and along Portsmouth Avenue, with additional development along Epping and Hampton Roads. "The current commercial zones are logically placed and reflect where businesses are located. The amount of commercial land still available for development is quite limited".*

3. Industrial - "The industrial zoned land stretches along Epping Road and Route 101, west of the intersection with Epping Road, as well as along the railroad.

With the industrial park now filled, and adjacent industrially zoned land quite



POPULATION PROJECTION *
EXETER, NEW HAMPSHIRE

* POPULATION PROJECTION BASED UPON DATA FURNISHED BY N.H. OFFICE OF STATE PLANNING.

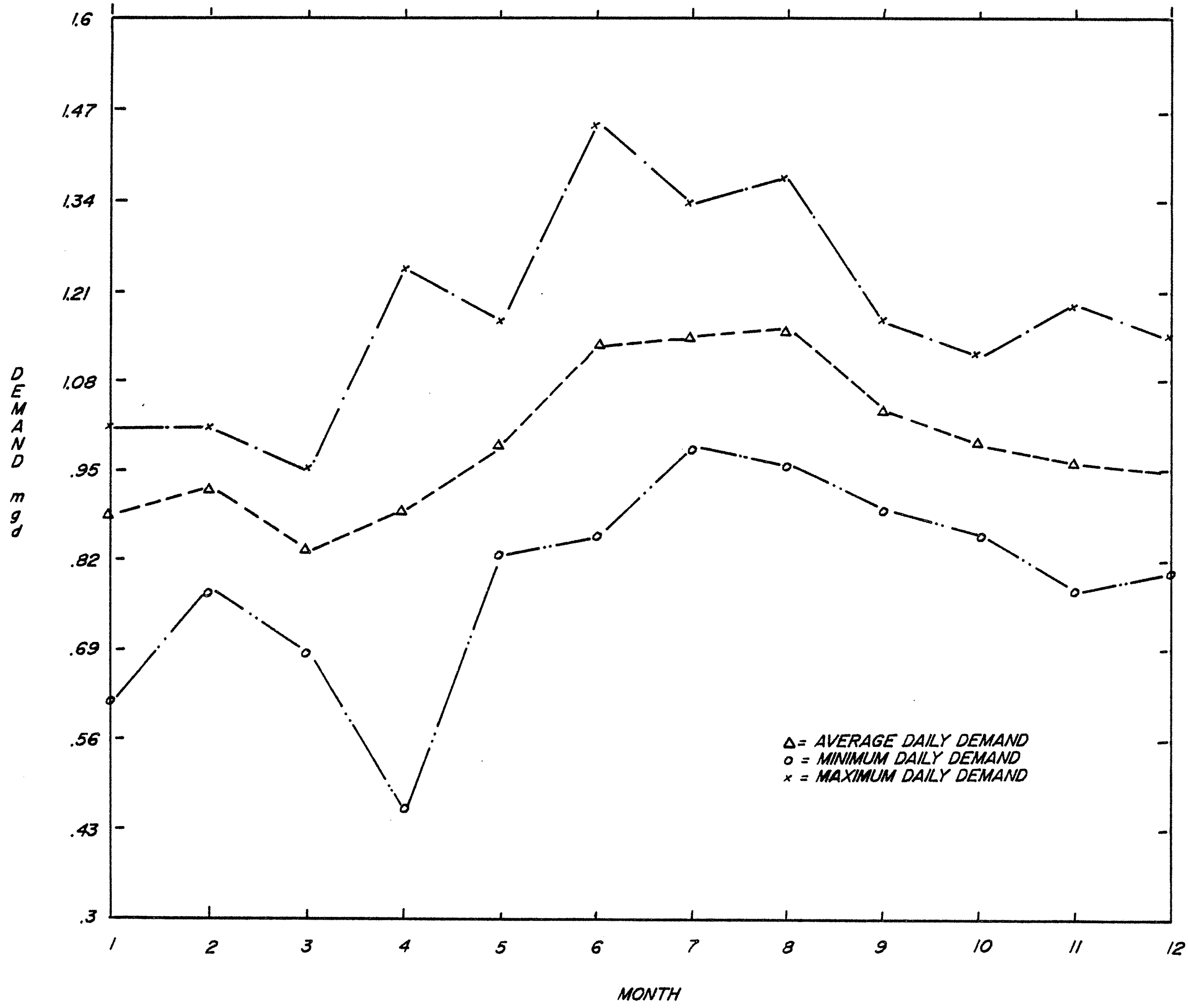
FIGURE NO. 2

wet, the Town should look toward efforts to utilize the strip of industrial land to the south of Route 101".*

*Exeter Master Plan, 1985.

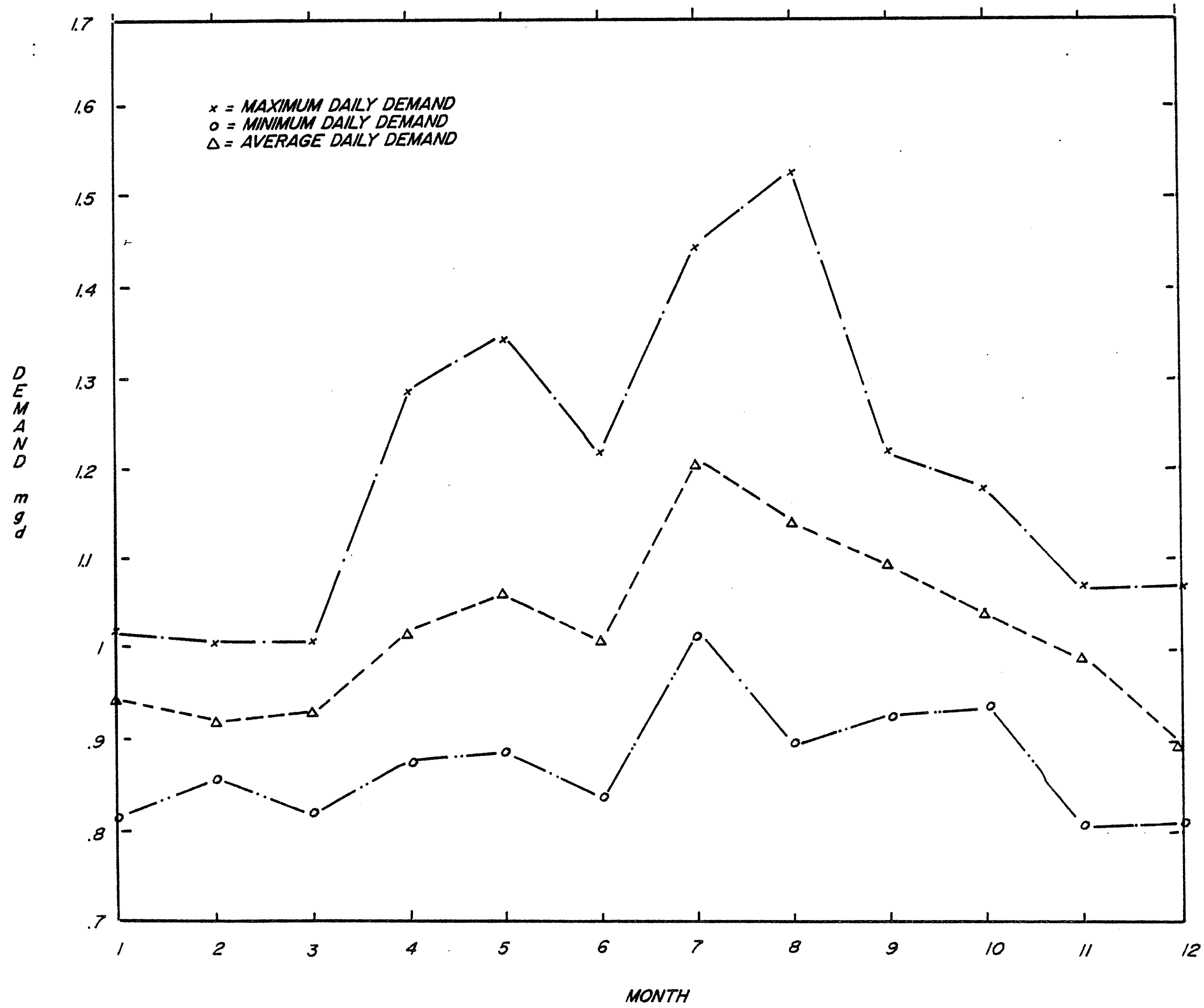
C. Existing and Future Water Demand

As shown on Figures No. 3 and 4, the average daily water demand in 1984 was 991,000 gallons per day and in 1985, was 1,022,000 gallons per day. The peak demand for both years was approximately 1,500,000 gallons per day. Table No. 1 shows both the average and maximum daily demands for 1980 through 1985. The figures show a decrease in the water demand in 1981, when Clemson Fabrics closed, however, demand has steadily increased since that time. Table No. 2, based upon anticipated development, shows projected water demand for the year 2010 to be approximately 2.2 MGD with peak flows approximately 3.4 MGD. Corresponding population areas are shown on Figure No. 5. In order for the Town of Exeter to meet these peak demands and to allow for emergency conditions and normal maintenance and



1984 WATER DEMAND
EXETER, NEW HAMPSHIRE

FIGURE NO. 3



1985 WATER DEMAND
EXETER, NEW HAMPSHIRE

FIGURE NO. 4

TABLE NO. 1

WATER SYSTEM DEMANDS

1980 - 1985

Year	Average Daily Gallons of Water Pumped	Maximum Gallons Pumped Per Day
1980	1,114,712	1,466,400
1981	989,817	1,441,000
1982	913,373	1,514,000
1983	906,634	1,494,200
1985	990,525	1,460,000
1985	1,022,187	1,525,510

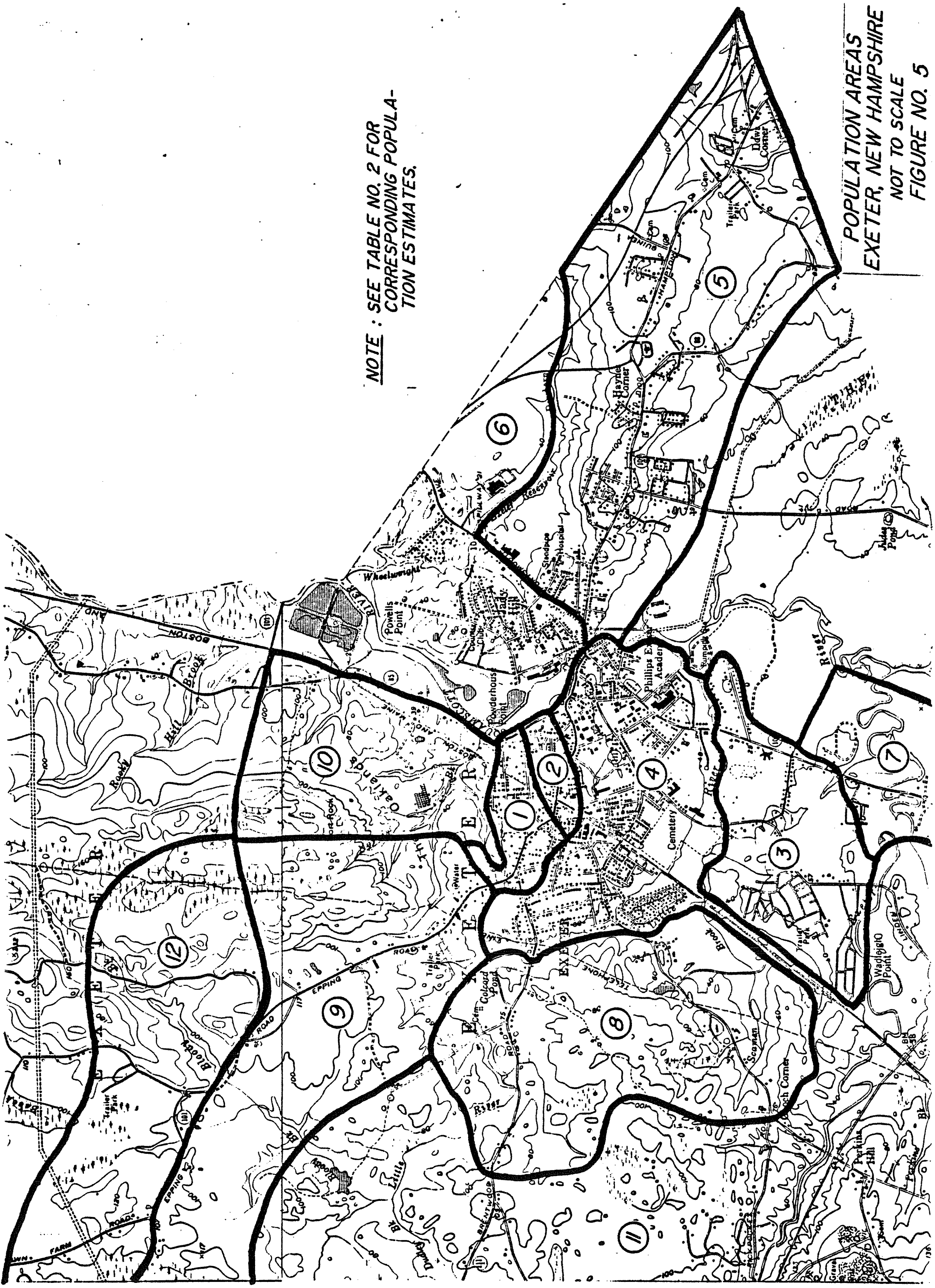
TABLE NO. 2

FUTURE WATER DEMAND

EXETER, NEW HAMPSHIRE

Area	Existing Population Served	Existing Water Demand (gpm)	Population Served Year 2010	Residential(gpm)	Future Water Demand Year 2010 Commercial/Industrial (gpm)	Total (gpm)
1	705	28.53	705	34.27	--	34.27
2	360	14.15	360	17.50	8.33	25.83
3	1,650	114.94	1,900	92.36	20.83	113.19
4	2,700	151.37	2,700	131.25	83.33	214.58
5	2,000	130.75	2,940	142.92	--	142.92
6	990	156.07	1,050	51.04	285.41	336.45
7	--	--	660	32.08	--	32.08
8	550	--	1,800	87.50	--	87.50
9	135	18.16	135	6.56	444.44	451.00
10	--	--	900	43.75	--	43.75
11	97	4.70	850	41.32	--	41.32
12	--	--	--	--	--	--
Totals:	9,187	618.67	14,000	680.55	842.34	1,522.99
		(890.885 gpd)		(979.992 gpd)	(1,212,970 gpd)	(2,192,961 gpd)

NOTE : SEE TABLE NO. 2 FOR CORRESPONDING POPULATION ESTIMATES.



POPULATION AREAS
EXETER, NEW HAMPSHIRE
NOT TO SCALE
FIGURE NO. 5

repair, it is recommended that future sources have a total capacity of 4.0 MGD.

D. Water Distribution System - System Analysis

Exeter's water distribution system was modeled on a micro-computer for the purposes of perfoming a Hardy-Cross network analysis. An overlay node map of the system is located in the Appendix. Pipe sizes, lengths, and ages were obtained from the water department. Meter records were used to estimate water demands at each node. Following completion of network calibration, the program was used to determine expected pressures in the distribution system under varying flow conditions and to evaluate the effect of time and distance on water quality in the system.

As shown on Table No. 3, the estimated arrival times for each of the Town's monthly sampling locations has been noted. The two locations with the greatest arrival time, locations 1 and 2, are also those which give the Town the greatest problems with low chlorine residuals and non-coliform bacteria counts. For location of sampling points, see Figure No. 1.

Another related problem with Exeter's distribution system is the lack of a major water main through the center of Town. At present, water from the treatment plant flows through a network of 6 and 8-inch pipes to reach the west side of Exeter. Much of this network is made up of pipes installed in the 1890's. These pipes deplete the chlorine residual reaching the west side. In order to provide the center with adequate fire protection, it would appear that a 16-inch water main would be necessary to effectively connect the water treatment plant and the Epping Road tank.

Exeter's water distribution system is required to deliver high quality water through 23 miles of water pipes which range from new to very old. Many studies of water distribution systems have noted increases in particulate matter in the water (inorganic turbidity particles and various life forms) introduced via tubercules or other unknown sources inside

TABLE NO. 3

TOWN OF EXETER

MONTHLY SAMPLE LOCATION ESTIMATED ARRIVAL TIMES

Sample Point Location No.	Estimated Arrival Times From WTP (Hours)
1	64.4
2	56.6
3	8.7
4	4.8
5	2.0
6	0.4
7	2.9
8	1.4
9	7.4
10	4.2
11	10.5
12	0.0
13	---
14	2.2
15	1.1
16	---
17	2.6
18	20.3
19	0.6
20	0.9

Notes: (1) Travel time based on average day pumping 1.9 mgd.

(2) Times over 17.0 hours ±, i.e. nodes 1, 2, and 18, would take longer than time shown.

the pipe lines which cause water quality deterioration.

There are five major factors influencing the efficiency of disinfection in preventing water quality deterioration. They are (1) time of contact between organism and disinfectant, (2) concentration and type of disinfectant, (3) number and type of organisms, (4) quality of water (physical, chemical,) and (5) other factors (temperature, mixing).

A relationship between chlorine concentration and bacteria concentration is determined by the Chick-Watson Equation:

$$N=N_0 e^{-k'CT}$$

where: N = number of organisms per unit volume at time t.

No = number of organisms per unit initially present.

C = Chlorine concentration.

n = Coefficient of dilution.

k' = Chlorine decay coefficient.

Chlorine residual concentrations and bacteria populations that occur within a water distribution system are both time and location dependent. It would be very difficult to verify chlorine travel paths and bacteria populations in a system such as Exeter's by hand calculations or visual observations. Therefore, in order to accurately determine these parameters, we are currently working with Worcester Polytechnic Institute on a computer program called "CLNET". Using the Exeter distribution system, this program determines chlorine residual concentrations versus time resulting from either primary or secondary chlorinators placed at various locations within the system. Expected bacteria levels are then determined at each node as a result of chlorine contact and natural regrowth reactions.

Other potential capabilities of the program permit determination of the following:

(a) Water deterioration, as it passes through the distribution system, will be modeled. Increases of turbidity may then be simulated with this model.

(b) A combination of water deterioration and chlorine residuals will be used to predict trihalomethane (THM) production in the system.

(c) To maintain a high quality water, potable water networks must be continuously monitored and often rechlorinated. Although the practice of water quality monitoring and rechlorination has been followed for many years, a diagnostic tool for quantitatively assessing the result of such practices has not been available. Water treatment, once the water has been passed to the pipe network, is largely a "rule-of-thumb" operation. The "last line of defense" against drinking water contamination, therefore, is far less sophisticated than the treatment technologies available at the water treatment facility. Therefore, as a result of modeling Exeter's distribution system on the computer, we will be able to determine the estimated k' factors for each section of pipe in order to recommend a specific pipe replacement program.

IV. Water Quality

Water quality was examined from the perspectives of raw water, plant finished water, and the quality in the distribution system as each contributes to or impacts on the overall water quality delivered to the consumer. Our study included a review of existing water quality data and a comprehensive field and laboratory examination of samples collected from five existing or potential raw water sources, the treatment plant, and twenty-one distribution system locations. (See Tables No. 4 & 5 in the Appendix).

For much of the time, the water delivered to the consumer is of acceptable quality. It is, however, periodically compromised by a number of chemical and physical factors (discussed elsewhere in this report) which cannot presently be fully controlled in the treatment plant.

A. Raw Water Quality

There are presently three sources of raw water available for treatment. The Exeter River and Dearborn Reservoir are used as primary raw water sources for the treatment process. The Skinner Springs are used as a supplementary supply, however, are not a reliable source for year round usage.

1. Dearborn Reservoir

As with any surface water, Dearborn Reservoir is subject to periodic changes in water quality due to natural and unnatural impacts on its system. Normally, during the late fall and early spring, its quality is such that it can be satisfactorily treated (see Table No. 5 for laboratory data). During the winter when the reservoir is ice covered and during the spring when anaerobic conditions exist at the bottom of the reservoir, managanese tends to be reduced to its soluble state and must then be removed by pretreatment. Removal of the soluble manganese can traditionally be accomplished through a variety of oxidation procedures which generally require a minimun contact time to be effective. In the past, pretreatment has been successful using chlorine as an oxidizing agent, however, chlorine also enhances the formation of trihalomethanes, (THM) which are suspected carcinogens. Due to the development of THM's, pretreatment with chlorine has been discontinued. The most widely accepted and effective treatment method for removal of iron and manganese is oxidation by potassium permanganate. This method has been ineffective for pretreating the reservoir water because of the inadequate contact time between pretreatment and the coagulation/flocculation process.

The reservoir is shallow (average depth of 9 feet) which often causes temperature changes exceeding 0.5°c per hour. This characteristic has caused short circuiting through the plant which, if not controlled, can lead to a decrease in finished water quality. The inability to control excessive temperature fluctuations causes short circuiting in treatment units and results in unacceptable levels of color and turbidity in the finished water.

2. Exeter River

The Exeter River has been utilized as the primary source of raw water for the past 16 months (see Table No. 5 for laboratory data). Like the reservoir, the river is also subject to high concentrations of soluble manganese and periodic changes in the water temperature. Temperature changes in the river are not, however, experienced as frequently nor with as great a rate of change as those experienced in the reservoir. As in the reservoir, high concentrations of soluble manganese are also found in the river. As discussed earlier, application of potassium permanganate at the source and contact in the transmission line produces raw water at the plant in which the manganese has been oxidized and is readily removed by the treatment process.

Tastes and odors resulting from algae blooms in the river, are also experienced. Powdered activated carbon, added in the rapid mixer, removes most tastes and odors, however, during the summer months, warmer temperatures often aggravate this problem. Taste and odors, along with less acceptable warm water, often leads to complaints from customers.

Four sources of potential river contamination have been identified which could compromise raw water quality at the river intake. Approximately 130 feet downstream from the intake station and above the dam, an unencased sewer force main crosses under the river. If this force main were to develop a leak, the water at the river intake could become contaminated with raw sewage. During quality testing, arsenic in concentration 0.02 mg/l was detected. While this is below the maximum contaminate level of 0.05 mg/l, steps should be taken to locate and eliminate this contaminant at its source. A second source of potential contamination comes from a recently constructed storm drainage outfall located just upstream of the river intake. The area drained by this outfall is fairly large and quite susceptible to accidental spills, road salt, and other de-icing chemicals, and turbidity during heavy rain storms. Also, the sewer force main discussed above crosses the drainage area. Should the main break or leak, sewage could flow to the river just upstream of the intake.

3. Skinner Springs

Skinner Springs can contribute a maximum of 0.1 MGD to the total plant flow. Presently, the springs are chlorinated weekly and flow by gravity directly to the filters. Because they contribute minimally to total plant flow, we have discounted them as a major source.

4. Stadium, Gilman & Lary Lane Wells

Although not originally included in the scope of our study, we conducted an evaluation of three existing wells for their possible use as sources of treatable water since future growth trends will demand additional raw water sources.

A complete inorganic chemical and bacteriological examination was conducted on each well. (See Table No. 5 - Appendix). An evaluation of the data indicates that each of the supplies is treatable. High iron and manganese concentrations and the presence of hydrogen sulfide prohibit their use as untreated supplies. These constituents, however, are treatable. Such treatment could be accomplished either on site or at the plant. The well casing at the Stadium well is not sealed and has been completely submerged by several feet of standing water resulting in unacceptably high bacteria counts. Reactivation of each well will require sealing of the well casings and thorough disinfection which should correct the bacteriological problem. These sources are also subject to potential contamination by the storm drainage outfall, leakage from the sewer force main or drainage from two existing landfills, although not to the extent found in direct withdrawal from the river.

5. Finished Water Quality

Most of the time finished water quality is acceptable (refer to Table No. 4 for finished water laboratory data). Free residual chlorine and pH are monitored on an hourly basis throughout the day. Other parameters such as turbidity, color, iron, manganese, chlorides, hardness, and coliform bacteria are monitored on a daily and weekly basis. The results of these and other analyses indicate that despite the limitations of the treatment plant, finished water quality is normally maintained at an acceptable level. The successful production of acceptable quality water is attributable to the knowledge and dedication of the plant operators. Given an almost total absence of proper controls, they are required to constantly adjust chemical feed to accomodate radical changes in flow and raw water characteristics.

Although the average raw water manganese concentration for 1985 was 0.24 mg/l, the average finished water manganese concentration was less than 0.01 mg/l. This represents an effective manganese removal of better than 95%. The finished water turbidity since January, 1985, has averaged 0.07

NTU, well below the maximum contaminant level of 1. Coliform counts have been consistently zero and there has been no indication of background bacteria in the finished water at the plant.

6. Distribution System

Water quality in the distribution system was evaluated as it relates to pH, alkalinity, iron, manganese, turbidity, free residual chlorine, total coliform bacteria, background bacteria, standard plate count, and trihalomethane formation. Data from laboratory and field analyses (see Table No. 4), show little change in the distribution system alkalinity, pH, manganese, and total coliform bacteria from levels found in finished water. However, there were changes in iron, turbidity, free residual chlorine, background bacteria, and trihalomethane levels in some of the samples.

Total trihalomethanes (THM's) were determined at three locations in the distribution system (see Table No. 4). Concentrations ranged from 91 parts per billion (ppb) to 97 ppb. The maximum contaminant level (MCL) for total THM's is 100 ppb, thus the concentrations found in the distribution system are just below the MCL. We believe this is a function of two factors -- (1) the treatment plant's inability to remove the precursors for THM formation (humic and fulvic acids) and (2) the high dosage of chlorine that must be applied to assure a minimum free residual chlorine concentration throughout the distribution system. Reducing these levels may be accomplished by improving the treatment plant's ability to remove the precursors and by improving the distribution system with an objective of reducing the chlorine demand in the system.

V. Treatment Plant Study

A. General

Our study of the treatment plant consisted of review of past plant records and water quality records together with site visits to investigate operation of plant and raw water diversions.

B. Problem Assessment

Most of the time the quality of water produced by the existing treatment plant is acceptable primarily due to manual manipulation of the facility throughout the day. The quality can be compromised by a number of chemical and physical factors which impact the treatment processes and water distribution.

Two major sources of raw water are available to supply flow to the plant for treatment. The Exeter River is currently utilized as the plant's primary source of raw water and the Dearborn Reservoir is used as a secondary supply.

Industrial development adjacent to the Dearborn Reservoir has created storm outfalls which can impact water quality. The Town has been carefully monitoring this project since its inception and to date has not observed an adverse impact.

The Exeter River is subject to rapid temperature changes, warm summer temperatures, increases in manganese, high humic and fulvic acid concentrations, and potential contamination from surface drainage, sanitary sewer river crossing and two landfills in the drainage area.

However, it has been utilized as the primary source for two reasons -- first, although manganese is present in the river, the water is treatable using potassium permanganate and secondly, since manganese treatment is successful, the lower intake may be used providing a cooler water supply and one more stable relative to temperature changes.

Although raw water quality from the Dearborn Reservoir is acceptable for treatment, the supply is subject to more rapid temperature change and increases in manganese that cannot be treated. Field testing has consistently shown that oxidation of manganese from the reservoir with potassium permanganate is not possible due to the short detention time (three minutes) between the intake and the coagulation/flocculation process.

Short circuiting of flow through sedimentation basins is a major problem encountered at the plant which regularly impacts the treatment process, causing floc carryover to the filter. If not controlled, turbidity break through at the filters results, thus lowering the quality of the finished water. Short circuiting within the sedimentation basin is largely attributable to rapid water temperature fluctuations, which effectively reduces detention time and inhibits proper settling of floc.

The present rapid mixing process is inadequate for efficient treatment. Air injection forces treated water to bubble up through the center of a plywood cover. This process was installed as a temporary measure which improved the existing rapid mixing capabilities of the plant, however, is still inadequate. Efficient coagulation requires the immediate and uniform mixing of the treatment chemicals with the raw water.

Presently, the flow from the plant is averaging about 1.0 MGD. Projected water needs of the Town for year 2010 indicate an average future flow requirement of 2.2 MGD and maximum demand of 3.4 MGD. The existing facility cannot meet these projected demands. Our study indicates that the facility's present capacity is limited by the clarification units. At the design overflow rate of 2.0 gpm/sq. ft. through the tube settlers, the present maximum daily flow of 1.46 MGD is just below the maximum daily design flow rate of 1.58 MGD. These rates are all based on 24-hour plant operation. In Exeter, the plant is operated over an 18-hour period, thus, in effect, increasing the present average and maximum daily flow rates to 1.35 MGD and 1.95 MGD, respectively.

Presently, all sludge and filter backwash water is discharged to a sludge holding pond. The supernatant is pumped to two lagoons located adjacent to the Dearborn Reservoir, from whence it flows by gravity back to the plant intake. Examination of these lagoons indicates that leakage into the reservoir is occurring which could lead to a serious failure of the lagoon wall. Settled sludge is dredged from the holding pond and from the lagoons and hauled to disposal every few months. This system of handling the sludge and filter backwash water has two major limitations. First, the sludge is poorly settled and not dewatered making its handling and disposal very difficult and expensive. Secondly, recycling of backwash occurs in an uncontrolled manner. Intermittent recovery operation can upset plant processes if there is a temperature differential between the raw water and backwash recycle water. This type of operation requires changing chemical dosages at least four times a day.

The 1972 plant renovations called for automatic constant level/constant flow operation with the automatic pacing of chemical feed pumps. Due to problems encountered during construction, the subsiding basin had to be eliminated from the flow concept together with automatic flow and chemical control, which resulted in the requirement for manually setting filter flow rates. Presently, flow control through the plant is a manual operation. The operator must set both the raw water and filter flow rates, balancing plant flow and meeting system demand. If system demand changes, then the operator must change the plant flow rates to meet the new demand.

During the renovation, provisions were made to protect the finished water pumps against low clearwell level and to prevent both the clearwell and the filters from overflowing.

The chemical feed pumps do not automatically pace with the changing flow rate through the plant, thus chemical feed controllers must be manually reset with any change in flow through the plant. Frequent motor failures suggest that they are not adequately sized to drive the chemical feed pumps. The linear response of these pumps to the manual adjustments is also questionable. No pressure relief or vacuum relief is available on the chemical feed pumps. Also, accurate measurement of chemical storage tank levels is not possible because the tanks do not have operating level site guages. The chemical feed system as it presently exists, invites operator error and seriously reduces the efficiency of the plant chemical treatment.

The chemical storage area for sodium hypochlorite and sodium aluminate is presently located in the garage, remote from the rest of the treatment plant, and thus cannot be inspected as frequently as necessary. No containment for possible chemical spills is provided and the building is poorly secured.

C. Analysis of Alternatives

Water quality and treatment problems confronting the Town of Exeter as a whole cannot be addressed by a single solution, but rather by a treatment approach which utilizes several of the corrective options evaluated during the course of this study. The following is a discussion of various options that were considered to address each of the problems identified above:

1. Raw Water Source

We have identified four sources of potential contamination to the Exeter River raw water supply; the sewer force main crossing the Exeter River just downstream of the river intake, the new storm drain outfall located just upstream of the intake, and two landfill sites located further upstream. Corrective measures that could be taken to reduce the chances of contamination from the sewer force main and the storm drain outfall would be to relocate these facilities to points downstream of the dam. An alternate approach to relocating the sewer force main would be encasing it in its present location. Relocation of the storm drainage and relocation or encasement of the sewer line would be effective but would be an expensive option. Should contamination arise from these sources, then the option of use of existing groundwater sources through the plant would be the most effective short term alternative. Once danger from contamination in the river has passed or corrective action has been taken, then the river can be returned as a viable source.

Two supply approaches were evaluated for controlling the temperature related problem regularly impacting the treatment process. The first would utilize existing wells as a source of water with stable temperature, bringing these water supplies directly to the plant for treatment. As demand increased, the well supplies could be mixed with the Exeter River source in a controlled manner so not to create temperature changes of greater than 1.0 degree C per hour. The second approach would utilize the Dearborn Reservoir and its 60 million gallon volume as a temperature "shock absorber". The critical feature to this approach would be bringing the reservoir to thermal equilibrium through destratification by aeration.

The temperature control option at the plant and river station would require a sophisticated controlling of both flow and temperature. During periods of rapidly fluctuating river water temperature, the mix of river and well water would be constantly altered to maintain a temperature change of less than 1 degree C per hour. While this method of control has been used successfully in other installations, it is cumbersome and with a more viable alternative available, is not recommended.

A number of communities in New England, including the City of Cambridge, Massachusetts, have used a process of reservoir aeration for controlling manganese as well as taste and odor problems. This aeration process is designed to create constant movement of the body of water bringing the water on the bottom to the top for natural aeration and general mixing of the entire body of water. One hundred percent (100%) mixing can be achieved using this process and successfully control the manganese problem. A side benefit to be realized is destratification of the reservoir and thus achieving thermal equilibrium. We believe that this could be beneficial to Exeter in controlling daily water temperature changes. Achievement of thermal equilibrium would allow the reservoir's 60 million gallon volume to absorb the impact of the summer's sun and the temperature differential of supplemental supplies.

The point of discharge of the diversion line from the river and well pumping stations is in close proximity to the plant intake. So that full benefit from reservoir aeration can be acheived, it would be necessary to extend the diversion pipe to a location farther up the reservoir. This point of discharge was recommended by Weston & Sampson in their 1968 report and remains a valid consideration.

By bringing the supplemental supplies to the far side of the reservoir, it would provide at least 15 days of detention time for oxidation of the manganese. This relocation could potentially reduce or eliminate the need for potassium permanganate (KMn04) pretreatment at the river and well sources. Hydrogen Sulfide found in the well supplies would be oxidized as well.

The reactivation and renovation of the existing wells would provide an additional source of raw water for meeting future water supply needs. The combined production of the three wells is approximately 1.9 MGD, thus having the capacity to meet the present total flow requirements of the Town.

An alternative to discharging river and well supplies to the reservoir would be treatment for iron and manganese removal at each source and then flow to the plant for conventional treatment. This would not address the problem of temperature variations and the resulting short circuiting within treatment units. It would also require additional staff time to operate and maintain four individual treatment facilities. The same results could be obtained by relocation of the discharge point at the reservoir and the addition of aeration facilities.

Lary Lane well is currently piped for delivery directly into the distribution system. Without treatment and station improvement, this is not an acceptable source as judged by EPA. By tieing this well with Stadium and Gilman wells, a proven 0.8 MGD source could be treated as a raw water source. Since the pumping equipment at Lary Lane is sized to discharge to distribution system pressure, it would be necessary to install a new pump which would reflect new head conditions at the common raw water transmission main.

2. Treatment Process

As discussed earlier, the facility's rapid mixing process is inefficient. Although the temporary air injection process has improved coagulation, new chemical diffusers and mixer would allow for proper mixing to occur and installation would be relatively easy.

At the present time, the Exeter treatment plant is effectively limited to maximum rate of flow of less than 1.6 MGD by the clarification area. Because this flow is currently being exceeded, we would propose the renovation of the existing flocculation/clarification area and the construction of an additional flocculation/clarification area, which would be located adjacent to the existing basins. These modifications would provide the facilities necessary to meet future flow demands. We have considered two types of flocculation/clarification units. The first type is conventional flocculation/sedimentation and the second is the super-pulsation high rate, upflow clarification process. Super-pulsation is a relatively new process which Whitman & Howard, Inc. successfully utilized in the renovation of the Burlington, Vermont Water Treatment Plant. The high rate process can be housed in a smaller structure and does not require the use of any underwater mechanical equipment, however, head losses through this unit are significant and if used, would require pumping from the reservoir.

Consideration was given to the renovation of the existing flocculation/sedimentation units. This would effectively take the treatment plant out of service for the period of construction. To overcome this problem, there are two alternatives: first, install individual green sand filters at the wells on a temporary basis and secondly, construct a second flocculation/sedimentation unit at the plant. The green sand filter option was rejected because of excessive capital and operation cost for a limited supply. Renovation of the existing flocculation/sedimentation basins and construction of new parallel units would permit full operation of the plant during construction and would provide adequate capacity to meet all demands during the design life of the plant and beyond.

Trihalomethane (THM) concentrations found in the distribution system border on the current maximum contaminant levels established by EPA. It is our opinion that any renovations to the plant should incorporate corrective measures aimed at lowering these levels. To effect a reduction, we would recommend an approach of both reducing the level of precursors (natural organic compounds) required for THM formation and reducing the concentrations of reactive chlorine needed to combine with the precursors.

The level of precursors available for THM formation can be reduced by a number of control and treatment methods. Improved watershed management and optimizing the processes of coagulation, flocculation, and clarification can control both the concentration of precursors entering the raw water supply and improve its removal by conventional means. Utilizing the existing wells as a raw water source would also help to reduce the total concentrations of precursors by providing a source free of precursors. Properly sized and operated treatment units, prior to filtration, should reduce the concentration of precursors and thus THM formation.

Reducing the concentration of reactive chlorine would involve two options. First, recommended improvement to the distribution system would allow for the reduction of chlorine feed dosages presently required to maintain a free residual throughout the system. Second, an alternate method of disinfection could be used to reduce the concentation of "reactive chlorine" needed for formation. One such alternative could be the utilization of chlorine dioxide.

We have considered several options for improving backwash and sludge handling. The basic thrust behind each approach, however, is the separation of filter backwash water and the settled sludge. Separation of the two would improve sludge handling by removing at least 60% of the water now going to the lagoons and thereby simplify the sludge dewatering and drying process.

All filter backwash water should be handled separately from the sludge. Under our concept, filter backwash would flow by gravity to a recycle basin. Backwash water would then be pumped at a controlled rate to the entrance of the plant. The rate of flow would be a function of raw water flow and basin level. Provisions could also be made to decant supernatant from the proposed drying beds to the recycle basin. This method of handling filter backwash water would eliminate the impact of differential temperatures and would allow for constant recycling, eliminate the shock of intermittent operation and allow for improved chemical feed control. To insure aerobic conditions in the recycle basin, provisions should be made to aerate the basin.

An additional improvement could be achieved by reconstruction of the existing sludge holding pond into two separate settling beds and to alter the existing recycle lagoons to settling beds, in which drying could occur.

In addition to the above sludge handling and drying provisions, it would be advantageous to consider additional sludge drying capacity. The possibility of construction of such facilities on land owned by the Town on the north side of Portsmouth Ave. was considered but rejected due to the proximity to wetlands and the resulting adverse environmental impact. A second location adjacent to the sludge holding pond offers an acceptable location for increased drying capacity. Final sizing and location is dependent upon any anticipated widening of Portsmouth Ave.

Automatic chemical feed and flow control is essential in any plant renovation or new construction. Presently the staff must manually balance plant flow and manipulate chemical feed to accommodate constantly changing conditions. In our opinion, the entire chemical feed and flow control system should be renovated providing constant flow operation at new design flow rates; automatic pacing of all chemical feed systems; automatic, 24 hour monitoring of pH, turbidity, and chlorine throughout the treatment process and a computer data acquisition system. In addition to instrumentation improvements to the chemical feed system, all chemical feed pumping equipment should be replaced, properly sizing all pumps and drives to provide chemical feed at defined dosages, linearly over the entire design flow range. Also, in order to provide adequate chemical storage space for sodium aluminate and sodium hypochlorite, a new chemical storage area should be constructed which would provide both security and spill containment.

An option to the concept of improving and expanding the existing treatment facilities is that of construction of an entirely new plant and abandonment of the existing plant. If the new plant concept were to be selected, it would mean that the existing plant would, of necessity, have to continue operation during construction. Due to the lack of space at the present plant site, an entirely new site would be required. The obvious location for a new plant would be at the Exeter River pumping station. At this site, raw water from the river and refurbished pumping stations would serve as raw water sources, however, the availability of substantial storage in the Dearborn Reservoir would be lost. Because of the potential for unanticipated pollution of the Exeter River, this as a source of raw water, could be temporarily interrupted, placing full reliance on the three existing wells which, without the reservoir, could not satisfy future water supply demands, even on a short term basis.

The cost of abandoning the existing treatment plant and construction of a new facility would range between $2,500,000 - $3,000,000.

The final consideration of relative costs of a new plant versus rehabilitation and expanded capacity at the existing plant should make the latter option more attractive to the Town of Exeter.

Beginning in the 1950's, a regional concept of water supply systems for the "Sea Coast" region was developed. This concept, in general terms, involved an area-wide program of source development, treatment capacity, and transmission to the various cities and towns in the area. Over the past 30 years, a number of communities have experienced significant water volume and quality problems but rather than address these problems on a cooperative basis, each has chosen to solve at least their short term needs individually. Thus, the regional concept has not realized any appreciable progress over the three decades.

Watson & Sampson, in a Water Supply Report for Exeter in 1968, rejected the regional concept because of the lack of potential users of substantial water quantities along the route of transmission, thus, Exeter would be responsible for full cost of service to the area. The extensive time frame which would be required to implement the program would mean that Exeter would be faced with very serious water deficiencies before the program could be implemented.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. General

During the course of this study, we have investigated and evaluated the following: (1) water quality at various points in the treatment process, (2) water quality within the distribution system, and (3) the treatment process from raw water source to finished water.

Although it was found that for much of the time water being delivered to consumers is of acceptable quality, in the past there have been periods of complaint concerning taste and odor and excessive iron and manganese concentrations. This less than satisfactory quality can be attributed to a number of factors at the source, in the treatment process, and within the distribution system.

B. Conclusions

1. Source

The total safe yield of ground and surface sources is adequate for current demand and will satisfy average and maximum daily demand through the year 2010. Ground water sources presently connected to the plant, although not being used, total 1.15 MGD. Lary Lane Well represents an additional 0.8 MGD source available for treatment. Surface sources, including Dearborn Reservoir and diversion of flow from the Exeter River, total approximately 2.4 MGD, all sources totalling 4.4 MGD, thus the available raw water provides a more than adequate supply to satisfy the year 2010 average demand of 2.2 MGD and maximum demand of 3.4 MGD.

The Exeter River drainage area encompasses portions of at least ten towns other than Exeter with extensive road networks intercepting the stream, thus exposing this source to potential chemical, petroleum, and other spills. Should such a spill occur, it would probably be necessary to temporarily discontinue withdrawal and rely on ground water and the reservoir to fully supply the Town's needs. If the Lary Lane well were to be connected to the plant, the total available raw water would be approximately equal to the future average demand of 2.2 MGD, with additional supply to satisfy maximum demand available from reservoir storage.

Raw water quality is adversely impacted by rapid fluctuations in temperature and iron and manganese content. While pretreatment of the well and river supplies could effectively reduce iron and manganese concentrations, these constituents cannot presently be effectively removed from the reservoir source.

The location of the discharge pipe from the river pumping station immediately adjacent to the plant intake does not provide for adequate detention time within the reservoir. A relocated point of discharge will provide for longer detention and provide more uniformity in raw water quality.

The difficulty in removal of iron and manganese and the rapid temperature variations can best be addressed by the addition of aeration capability at the reservoir. This will provide for more uniform temperatures, oxidation of iron and manganese, and removal of volatiles responsbile for taste and odor problems.

2. Treatment Plant

The relatively good quality of water, given inadequate plant capacity, lack of effective flow and chemical application controls and other plant deficiencies, is attributable to knowledge and dedication of the operating staff. The following are major areas of plant deficiencies which adversely impact on finished water quality:

a. Inadequate rapid mix facilities resulting in poor dispersion of chemicals without which proper and economical floc formation cannot be achieved. Facilities which are properly sized and which provide for significant agitation, will properly prepare the water for further treatment and make most economical use of chemicals.

b. Capacity of flocculation and sedimentation units is inadequate for current demand largely because treatment is carried out during an 18-hour period rather than 24-hour operation. Future flows will exceed plant capacity by approximately 1.0 MGD even with around-the-clock operation. Additional flocculation and clarification capacity is necessary to properly treat future demand flows.

c. The existing mixed media filters with a design capacity of 4 gpm/sf can meet current average daily demand with one filter being backwashed, however, additional filter capacity will be necessary, and can be provided using presently unused filter space.

d. Chemical feed equipment and plant flow control must currently be adjusted manually. Since flow to the plant from raw water sources and return flow from sludge and backwash supernatant vary during the operating day, plant flow and chemical application must be adjusted at the time of each change in raw water supply.

e. Sludge and filter backwash water are currently discharged to a sludge lagoon for settling and supernatant return to the plant inlet. Return to the plant is intermittent which requires extensive operating changes. Sludge drying is ineffective causing difficult handling and final disposal problems. Separation of the sludge and backwash streams with provisions for relatively constant return of backwash and settled sludge supernatant to the inlet of the plant will result in more constant chemical application and improved finished water quality. Additional sludge drying capacity will provide retention through winter seasons. Freezing and thawing of water treatment alum sludge is a most effective method of sludge concentration and results in greatly simplified handling and more economical final disposal of the sludge.

3. Distribution System

While finished water leaving the plant is normally of acceptable quality, that quality is diminished within the distribution system. Operating personnel are unable to maintain a chlorine residual throughout the system consistently. This is attributable to the configuration of the system with many undersized mains and to the condition of the pipe. The continuation and conclusion of the Worcester Study will permit detailed recommendations as to a program of replacement and extension.

C. RECOMMENDATIONS

1. Raw Water Sources

a. Provide a cross country pipe connection from Lary Lane well to the existing Stadium and Gilman well's discharge pipe.

b. Install new low-head pumping equipment at Lary Lane well to accomodate hydraulic characteristics resulting from changes in discharge pressure within the common well and river pumping station raw water line.

c. Relocate combined well and river discharge line to a greater distance from the plant intake to prevent short circuiting within the reservoir, and to provide detention time for iron and manganese oxidation.

d. So that raw water quality can be maintained at a reasonably consistent level, aeration of the reservoir is strongly recommended, thus eliminating rapid temperature fluctuations and providing for oxidation of iron and manganese constituents enabling plant operations to proceed with relatively constant chemical application.

e. Renovate existing Stadium and Gilman wells.

f. Develop and implement a watershed management program for the Dearborn Reservoir drainage area. Seek agreement with officials in Stratham to effectuate proper watershed controls within that Town so that water quality will not be adversely impacted by uncontrolled development. Exeter should initiate an Exeter River watershed inventory to identify existing and proposed development that could adversely impact on raw water quality.

2. Water Treatment Plant

a. Conduct a geotechnical survey of the plant site to determine feasibility of construction in proximity to dam.

b. Demolish garage to provide necessary space for construction of backwash water holding tank.

c. Construct aerated backwash water holding tank and return pumping facilities.

d. Alter existing sludge and backwash water lagoons to serve as sludge drying facilities and construct additional drying capacity.

e. Construct added filter capacity using presently unused filter structures.

f. After raw water supply line is extended and aeration equipment is in place and operating, determine efficiency and acceptable loading in existing flocculation/clarification unit. At that time decide whether to add similar parallel unit of required capacity or to pilot study a super pulsating flocculation/clarification concept.

g. Assuming acceptable results of use of existing flocculation/clarification unit, reconstruct flash mix unit to provide efficient operation.

h. Assuming unacceptable results of use of existing units and positive pilot study results of super pulsating concept, reconstruct existing flocculation/clarification unit to accomodate super pulsation method and construct new parallel super pulsation unit to provide capacity for future flows.

i. Install new instrumentation and controls based upon constant flow operation. Install telemetering for monitoring distribution tank levels and provide plant start-stop capability together with remote operation of well and river supplies. Provide analyzing and monitoring instrumentation for pH, turbidity,* and chlorine residual.

j. Upgrade entire chemical feed system providing for new feed pumps and drives; relocate chemical storage and feed systems.

h. Provide stand-by power capacity to insure continuous plant operation during power outages.

3. Distribution System

a. Construct a 16-inch water main between the treatment plant and the Epping Road storage tank to provide improved service to the downtown area and to the northwest section of Exeter.

b. Complete the distribution system study currently underway at Worcester Polytech and use the results of that study to plan a program of main replacement and additions.

4. Suggested Phasing of Recommended Improvements

In order to provide early improvements to source and treatment facilities, and to permit early evaluation of alternative flocculation/sedimentation concepts, a suggested phasing of the recommendations is shown in "Construction Cost Estimates", which follows.

EXETER, N.H.
WATER SYSTEM IMPROVEMENTS
CONSTRUCTION COST ESTIMATE

PHASE I

IV	1.	Pipe Connection-Lary Lane Well to Gilman Well 3,000'-12"D.I.@$40/ft.	$120,000	
	2.	Lary Lane Well-New Pump Motor & Controls	30,000	
III	3.	Extension 12" River Raw Water Line up Reservoir 2,500'-12"D.I.@$40/ft.	100,000	
	4.	Aeration Equipment-Reservoir Compressor, Tubing & Controls	25,000	
IV	5.	Stadium & Gilman Wells-Rehabilitation of Pumping Stations & Equipment	20,000	
I	6.	Geotechnical Survey - Treatment Plant Site	30,000	3-11-82
II	7.	Demolish Garage	4,000	
	8.	Construct Backwash Water Basin-Building, Pumps, Piping Controls, etc.	270,000	
	9.	Sludge Drying Beds-Construct New Lagoons & Reconstruct Existing Lagoons	73,000	
	10.	Construct Rapid Mix Facilities - Existing Flocculator	10,000	
		Total:	$682,000	
		30% Engr., & Conting:	205,000	
		Total Phase I:	$887,000	

PHASE II-A-Standard Flocculation-Sedimentation

1.	Complete Construction of Two Filters	$106,000
2.	Renovate Existing & Construct Parallel Flocculation/Sedimentation Units	419,000
3.	Install new Instrumentation Controls & Chemical Feed Systems	120,000
4.	Install Stand-By Power	30,000
	Total:	$675,000
	30% Engr., & Conting:	203,000
	Total Phase II-A:	$878,000

PHASE II-B-Superpulsation Units

1.	Complete Construction of Two Filters	$ 106,000
2.	Reconstruction Existing Flocculation/Sedimentation Units & Construct Parallel Super Pulsation Units	724,000
3.	Install New Instrumentation, Controls & Chemical Feed Systems	120,000
4.	Install Stand-By Power	30,000
	Total:	$ 980,000
	30% Engr., & Conting.	294,000
	Total Phase II-B:	$1,274,000

Total of Phases I & II-A:	$ 887,000
	878,000
	$1,765,000
Total of Phases I & II-B:	$ 887,000
	1,274,000
	$2,161,000

DISTRIBUTION SYSTEM

New 16-inch Water Main
Treatment Plant to
Epping Road Tank

3,000' Urban@$100/ft. =	$ 300,000
9,000' Non-Urban @$75/ft. =	675,000
Total:	$ 975,000
25% Engr., & Conting.:	243,000
	$1,218,000

APPENDIX

Table 4
WATER QUALITY DATA

Paramter	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12/F1**	D13	D14	D15	D16
pH	8.0	8.3	8.1	8.2	7.8	7.8	7.9	7.6	8.1	8.2	8.6	7.7		8.0	7.9	8.4
Alkalinity (mg/e)	27	27	27	29	25	26	26	25	26	26	28	26		27	26	26
Carbon Dioxide (mg/e)	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
Aluminum (mg/e)												<0.03				
Barium (mg/e)												0.02				
Iron (mg/e)	0.09 0.03	0.13 0.06	0.06 0.02	0.57	0.06 0.03	0.04	0.10	0.04	0.03 0.03	0.09 0.06	0.04 0.04	0.03 0.04		0.08 0.05	0.05	0.06 0.04
Manganese (mg/e)	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	-	-	<0.01	<0.01	<0.01	<0.01		<0.01		<0.01
Sodium (mg/e)												12				
Calcium (mg/e)										11.6		9.8		11.4		
Chloride (mg/e)												15.5				
Color (Cu)	5	6	4	39	2	1	6	3	2	5	3	5 3		4 3	4	2
Fluoride (mg/e)										0.02						
Hardness (mg/e)										47						
Nitrate-N (mg/e)										0.25						
Sulfate (mg/e)										22						
TDS (mg/e)											120					
Conductivity (mohm/cm)	175	172	169	172	185	156	171	171	166	172	170	168		167	172	168
Turbidity (NTU)	.23	.30	.24	.28	.22	.17	.24	.17	.09	.38	.20	.13 .44		.17	.13	.24
Dissolved Oxygen (mg/e)	10.4	9.8	10.0	9.5	9.7	10.0	10.7	10.0	8.7	11.2	10.1	10.9		9.8	10.2	10.9
Total Coliform (coli/100 ml)	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
Standard Plate Count (#/ml)	4	2	4		0				11.0	2	7	26		5		8
Cl_2 (Free) (mg/e)	0	0	0.9	.15	.3	1.7	.15	1.5	1.25	.65	0.6	1.8		0.8	1.2	.45
Cl_2 (Total)(mg/e)	.15	.15	1.05	.25	.45	1.85	.25	1.7	1.35	.85	.75	1.9		1.0	1.4	.60
Background Bacteria (#/100 ml)	1	0	0	0	0	0	0	115	0	0	0	0		0	0	0
Total Trihalomethane (ppb)										98				91-97		

* Finished Water - Treatment Plant

Table 4
WATER QUALITY DATA

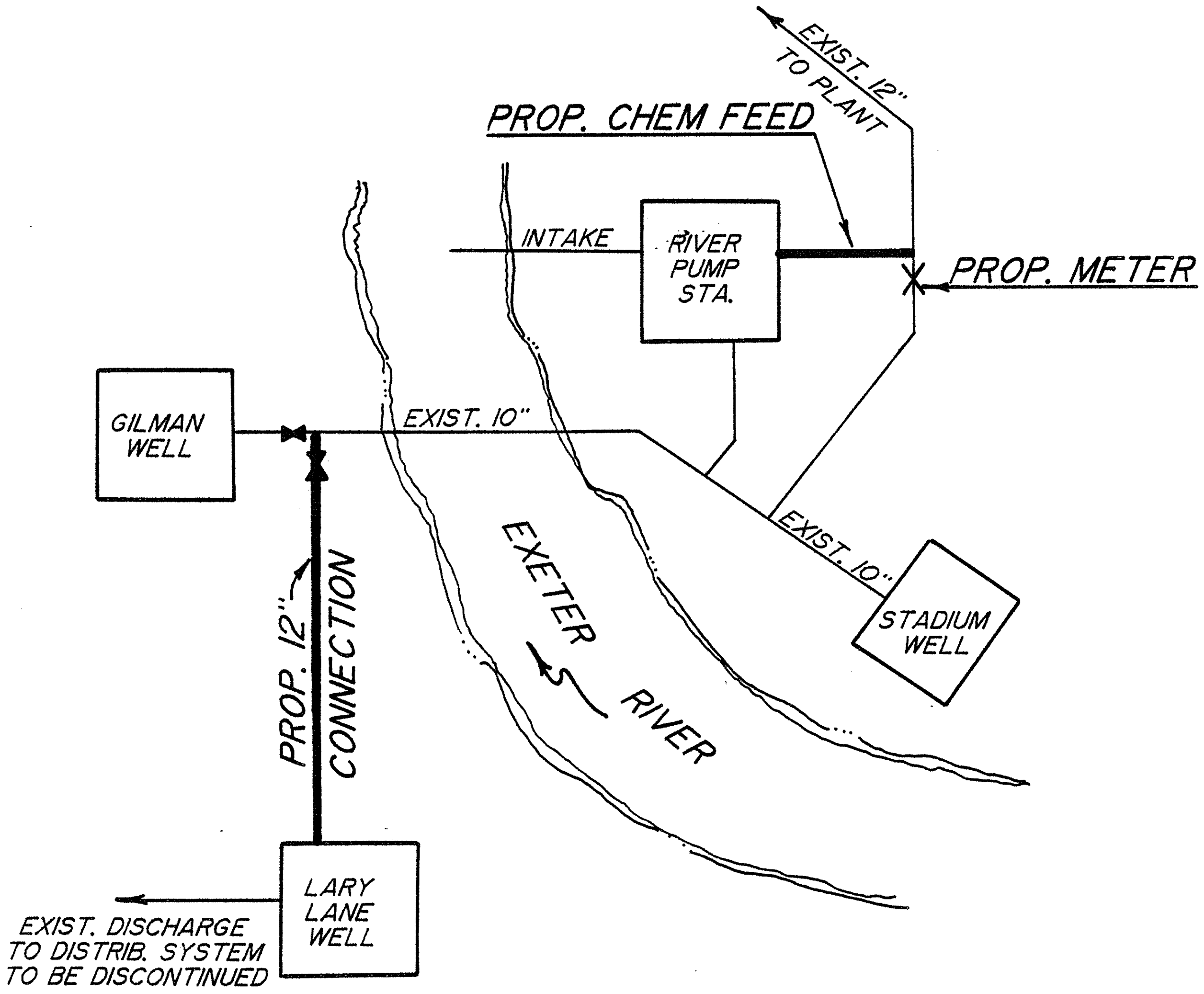
Paramter	D17	D18	D19	D20	D21	D22
pH	7.8	8.8	8.4	7.8	7.5	8.1
Alkalinity	25	28	26	26	27	26
Carbon Dioxide	-	-	-	-	-	-
Aluminum						
Barium						
Iron	0.07	0.04	0.03	0.05		
	0.03	0.03			0.03	0.03
Manganese	<0.01	<0.01			<0.01	<0.01
Sodium						
Calcium	11.2				11.5	11.2
Chloride						
Color	4	2	2	2	5	5
	5					
Fluoride						
Hardness						
Nitrate-N						
Sulfate						
TDS						
Conductivity	176	174	172	166	183	166
Turbidity	.16	.24	.16	.20		
Dissolved Oxygen	9.4	9.9	11.3	10.6	10.9	10.3
Total Coliform	0	0	0	0	0	0
Standard Plate Count	0	3			2	1
Cl_2 (Free)	0.4	.15	1.2	1.6	.15	.65
Cl_2 (Total)	.55	.35	1.35	1.75	.20	0.8
Background Bacteria	0	0	0	1	0	0
Total Trihalomethane	97					

Table 5
WATER QUALITY DATA

Paramter	S1	S2	S3	S4	S5
pH	6.9	7.6	7.9	8.2	9.3
Alkalinity (mg/1)	18	31	133	178	122
Carbon Dioxide (mg/1)	10.6	7.0	-	0	0
Aluminum (mg/1)					
Barium (mg/1)	0.07	0.09	0.10	0.12	0.09
Iron (mg/1)	0.51	0.32	1.06	0.34	0.04
Manganese (mg/1)	0.03	0.02	0.63	0.31	0.12
Sodium (mg/1)	14	18	13	22	8.4
Calcium (mg/1)	8.4	13	40	47	28
Chloride (mg/1)	21	28	20	35	13
Color (CU)	150	75	25	30	5
Fluoride (mg/1)	0.05	0.05	0.07	0.16	0.08
Hardness (mg/1)	35	50	140	160	96
Nitrate-N (mg/1)	.22	0.17	0.17	0.14	0.33
Sulfate (mg/1)	10	12	27	36	29
TDS (mg/1)	67	128	190	270	160
Conductivity (uohm/cm)	88	182	300	410	230
Turbidity (NTU)	2.1	2.0	2.2	6.3	0.11
Dissolved Oxygen (mg/1)	9.4	11.0	4.6	3.2	4.0
Total Coliform (coli/100ml)					
Stnd Plate Count (#/ml)	380	175	1260	105	42
Cl_2 (Free) (mg/1)					
Cl_2 (Total) (mg/)					
Temperature (°C)	15	16.2	7.5	7.5	8.0

Sample Point Locations

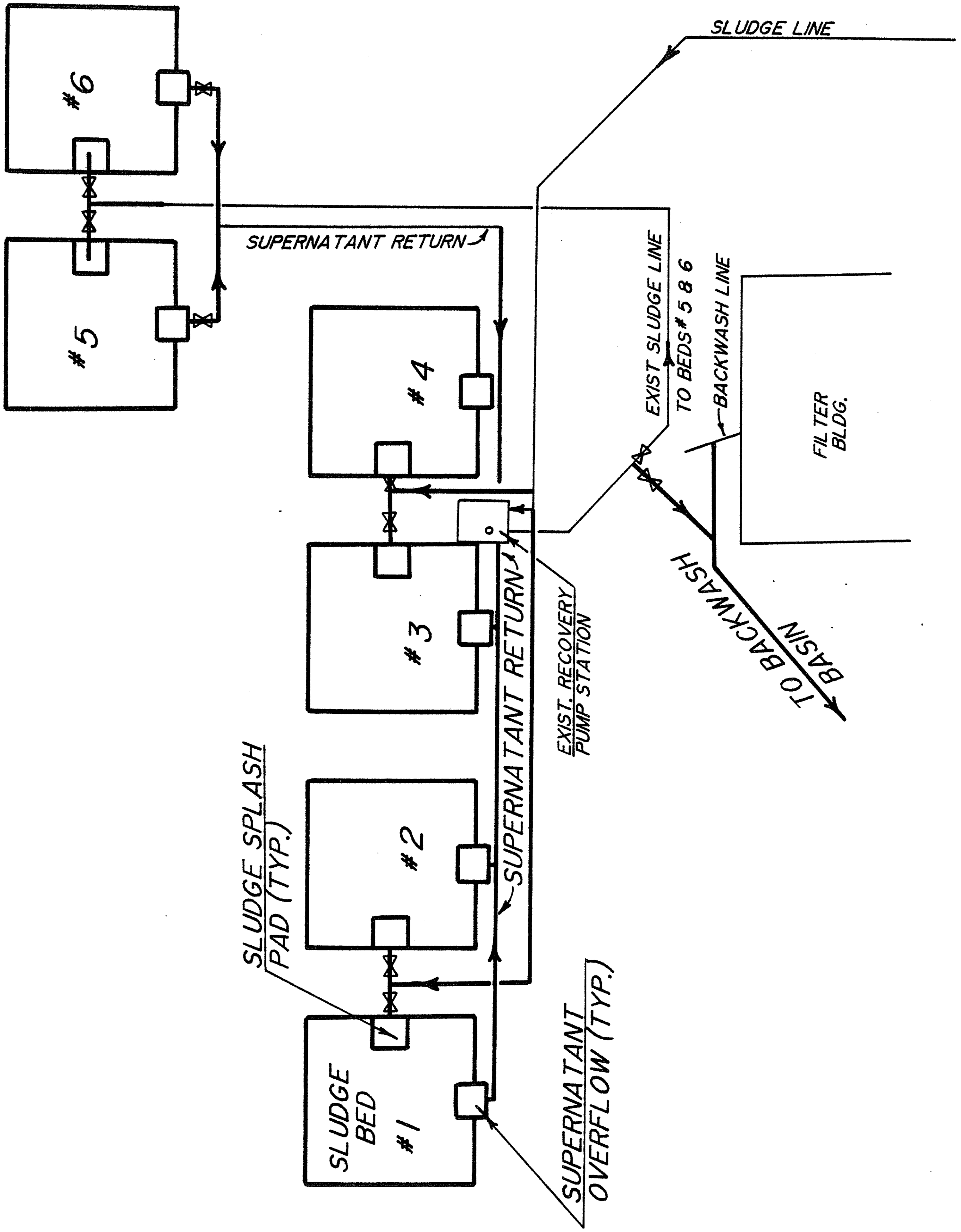
S1	River Pumping Station
S2	Reservoir
S3	Stadium Well
S4	Gilman Well
S5	Lary Lane Well



N.T.S.

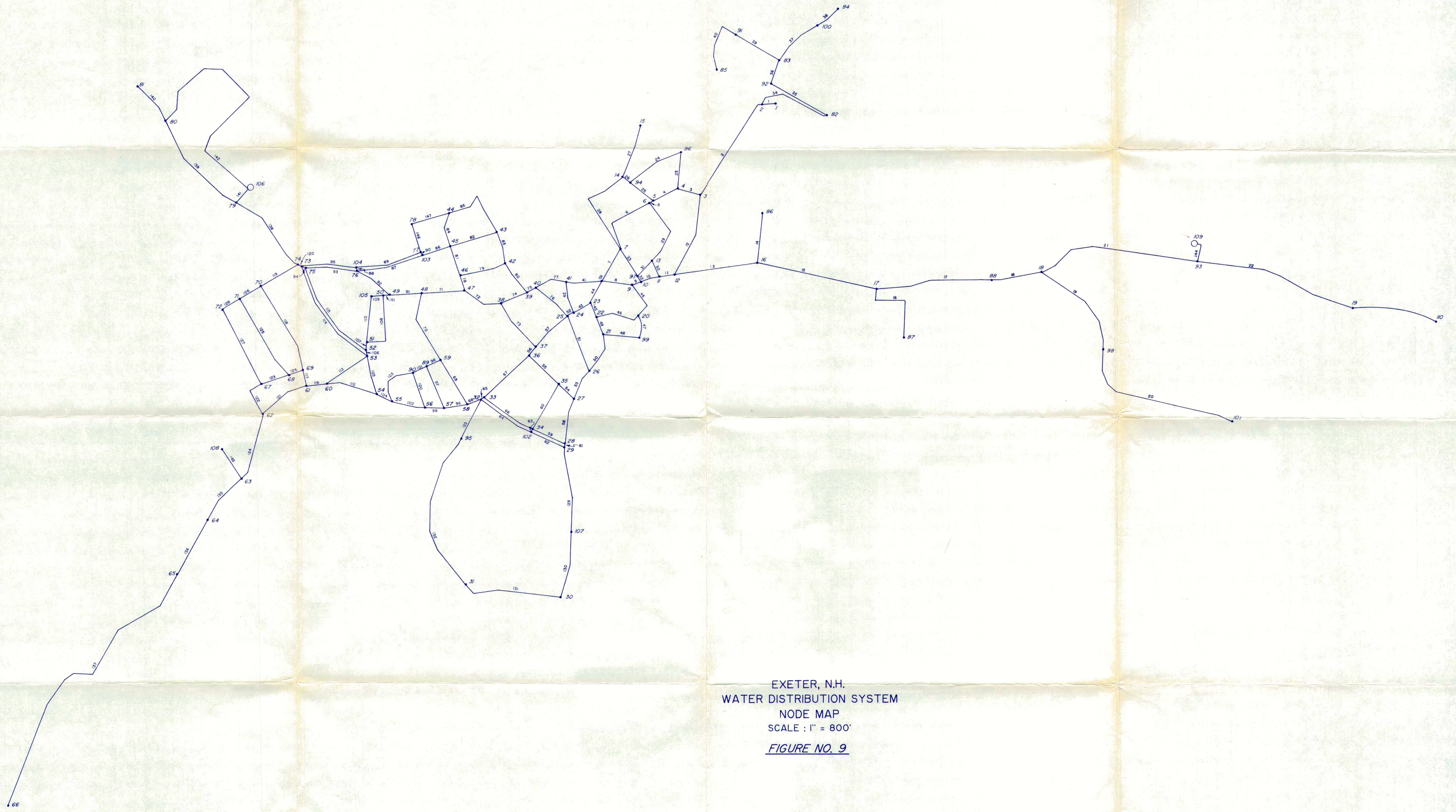
PROPOSED CONNECTION - LARY LANE WELL

FIGURE NO. 6



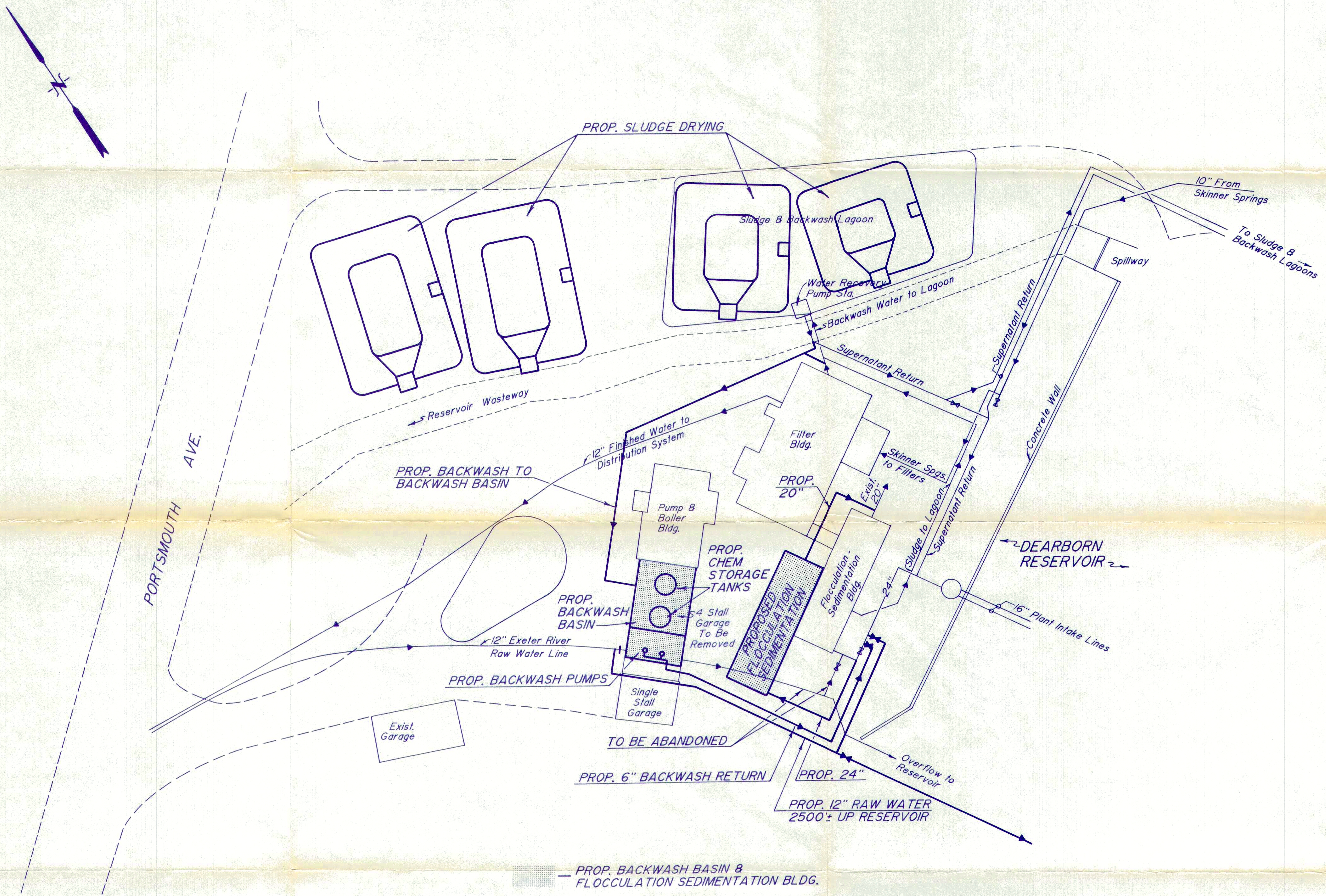
PROPOSED
SLUDGE & SUPERNATANT
RECOVERY
N.T.S.

FIGURE NO. 7



EXETER, N.H.
WATER DISTRIBUTION SYSTEM
NODE MAP
SCALE : 1" = 800'

FIGURE NO. 9



NOTE : FOR PROPOSED SLUDGE AND BACKWASH WATER PIPING SEE FIGURE NO.

EXISTING WATER TREATMENT PLANT

Scale : 1" = 30'±

FIGURE NO. 8