2005 Water System Hydraulic Study

City of Fortuna California

September 2005

Prepared for:

City of Fortuna
621 11th Street
Fortuna, CA 95540

Prepared by:

WINZLER & KELLY
CONSULTING ENGINEERS
633 Third Street, Eureka, CA 95501
707.443.8326 Phone / 707.444.8330 Fax
www.w-and-k.com

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CHAPTER 1 – EXECUTIVE SUMMARY

1.1 Purpose

This 2005 Water System Hydraulic Study has been prepared as an update to the City of Fortuna's (City) 1986 Water System Hydraulic Study. Its purpose is to evaluate the City's water system and make recommendations that would improve the system's performance and allow it to maintain an adequate level of service as the City continues to develop. The 2005 Water System Hydraulic Study provides the following review and update of the City's water system:

- A comprehensive description and mapping of the City's water system facilities;
- Create a hydraulic model of the City's water system that incorporates all reservoirs, tanks, pump stations, and water mains 6 inches and larger;
- An assessment of the water system;
- Identification of existing and future system deficiencies;
- Recommendations on improvements required;
- Opinion of the probable cost of these improvements;
- An upgrade of the City's hydraulic modeling software.

The objective of this study was to develop a hydraulic model of the City's water system, and to use the model to develop system improvements that may be implemented in the future to optimize the water system, identify areas for energy savings and provide adequate flow and pressure throughout the City.

A significant component of this study was the development of a computer hydraulic model that accurately describes the Fortuna water system under a variety of operating conditions. The computer model's development, calibration and usage are discussed in detail in Chapters 2 and 3. This model served as the basis for testing and refining the various recommendations made herein, and will be provided to the City for use in addressing future questions which may arise.

1.2 Background

The City of Fortuna is located on the California North Coast, 225 miles north of San Francisco. The City is located adjacent to the Eel River, which lies to the west, and encompasses approximately 3,060 acres. A location map of the City is shown in Figure 1-1.

Fortuna currently has 4,238 water service connections (water meters) within the service area, which serve 5,229 units. Of those, 4,726 units (90%) are residential and 503 units (10%) are commercial. The service area is shown in Figure 1-2. The service area is characterized by relatively level topography throughout the central portion of the City, with elevations ranging from 40 feet to 80 feet. Areas to the north and east become more hilly and steep, with elevations between 80 feet and 400 feet.

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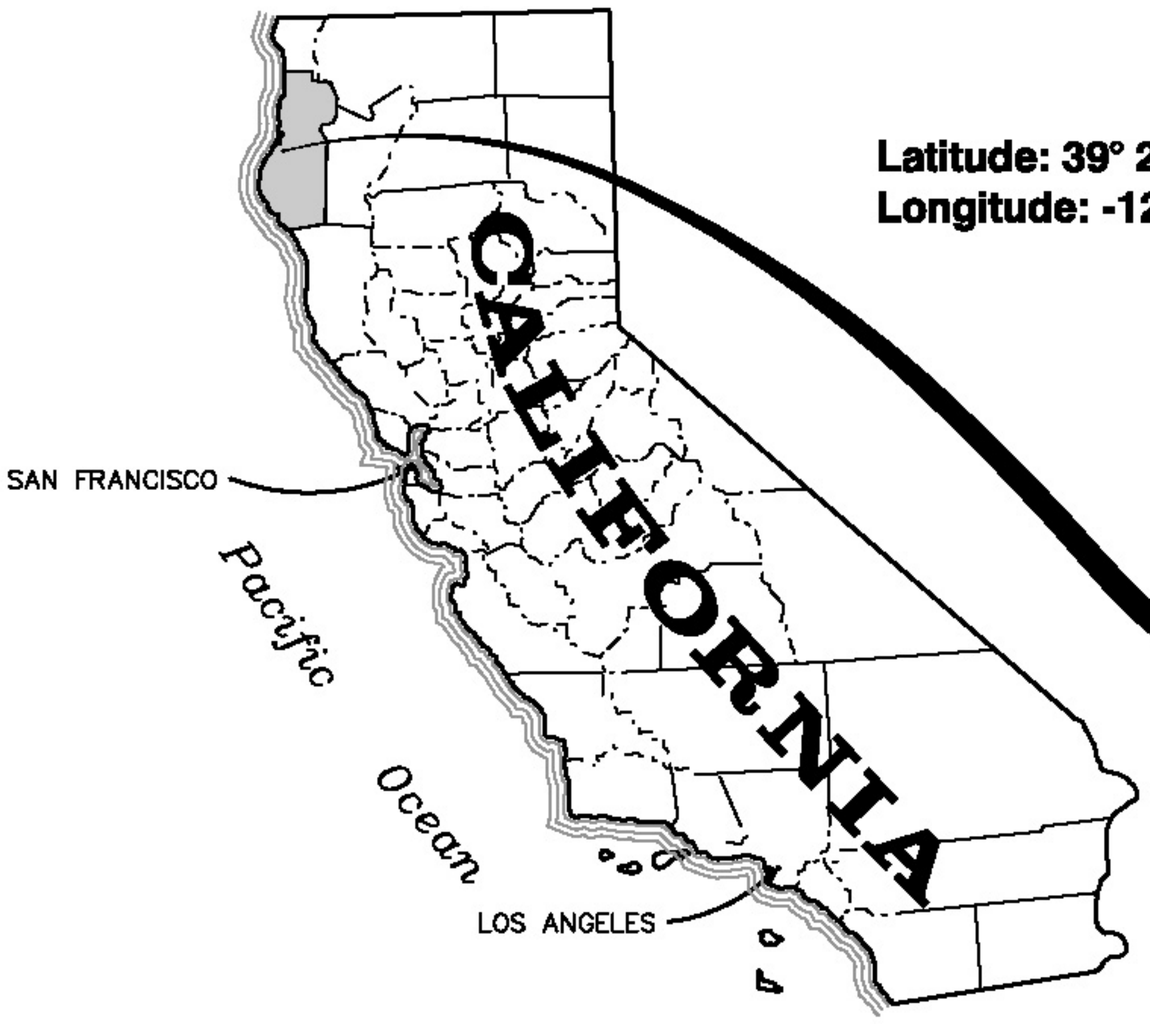

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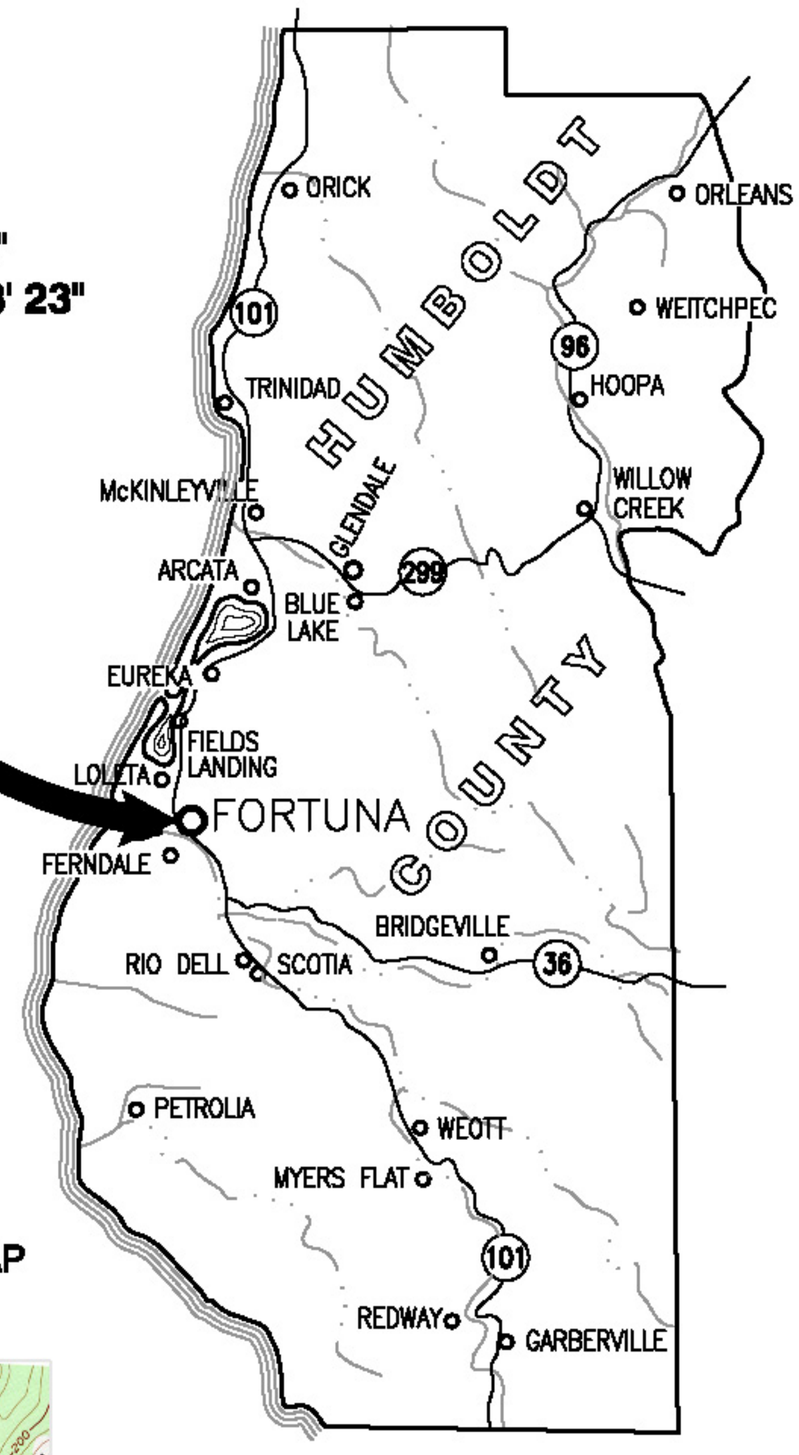

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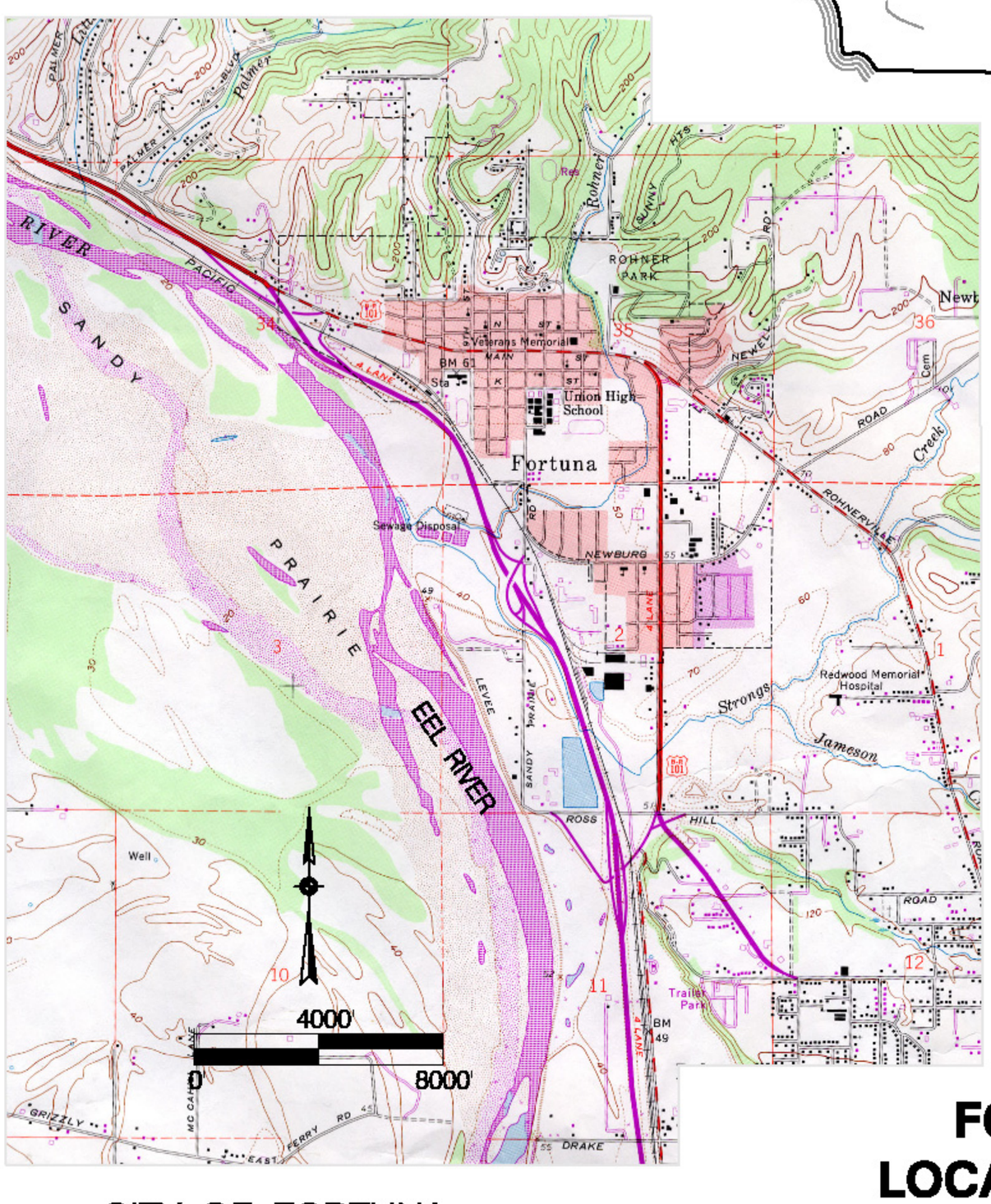

CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY

FORTUNA LOCATION MAP

FIGURE 1-1

WINZLER & KELLY

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The City's water distribution system is divided into 8 pressure zones designated 1 through 8, as shown in Figure 1-2 and summarized in Table 1-2. A pressure zone refers to a portion of a distribution system within which a relatively uniform hydraulic grade would be present if there were no flow in the system. A pressure zone normally consists of interconnected pipes and reservoirs with no intervening booster pump stations and/or valves regulating water flow or pressure. Booster pump stations may be used to boost the pressure within a pressure zone, or they may pump water to a new pressure zone. Pressure reducing valves (PRV) are used to separate pressure zones.

TABLE 1-2 FORTUNA WATER SYSTEM PRESSURE ZONES

Zone	Service Area	Served By	Hydraulic Grade[1]
1	Kenmar Rd. north to P St.	Stewart Reservoirs	226 ft (msl)
2	Vancil southeast to Franklin Ave.	Vancil Reservoir	298 ft (msl)
3	Vancil area	Vancil Pump Station	450 ft (msl)
4	Hillside area	Hillside Reservoir	398 ft (msl)
5	Holman Way and Home Ave.	Holman Tank	424 ft (msl)
6	Kenmar Rd. to Drake Hill Rd.	Campton Heights Reservoir	365 ft (msl)
7	South of Drake Hill Rd.	Drake Hill Pump Station	600 ft (msl)
8	Forest Hills Subdivision	Senneca Pump Station	475 ft (msl)

[1]ft (msl) = feet above mean sea level.

Zone 1 includes the majority of the City service area between downtown Fortuna and Kenmar Road, and is supplied by the two 500,000 gallon Stewart Reservoirs. These reservoirs have a water surface elevation of approximately 226 ft-msl, and are supplied by the pumps at the Corrosion Control Facility.

The Stewart Pump Station, which consists of two 5-hp pumps, boosts water from the Stewart Reservoirs to the 5 million gallon Vancil Reservoir. Zone 2 is the area east of the Vancil Reservoir and northeast of Rohnerville Road. It is served by the Vancil Reservoir, and has a hydraulic grade of 298 ft-msl. Zone 2 loops back to Zone 1 through PRVs at the intersections of Valley View Road and Rohnerville Road and at Franklin Avenue and Newburg Drive.

The Vancil Pump Station, which is located at the Vancil Reservoir, consists of two 5-hp booster pumps, a 20-hp fire pump and two hydropneumatic tanks, and is supplied by the Vancil Reservoir. It serves Pressure Zone 3, which is the area on Vancil Street north of the Stewart Reservoirs. The hydraulic grade of Zone 3 is 450 ft-msl.

The Underhill Pump Station boosts water from Zone 2 up to the Hillside Reservoir. This pump station consists of two 5-hp pumps. The Hillside Reservoir has a volume of 250,000 gallons, and serves Pressure Zone 4. Pressure Zone 4 is the northeastern most portion of the City's water system, and has a hydraulic grade around 398 ft-msl. Zone 4 loops back to Zone 2 through a PRV at the intersection of Franklin Avenue and Boyden Lane.

Pressure Zone 5 is located in the northwestern most area of the City, and is served by the Holman Tank. The Holman Tank is an aging 36,000 gallon elevated tank that supplied by the

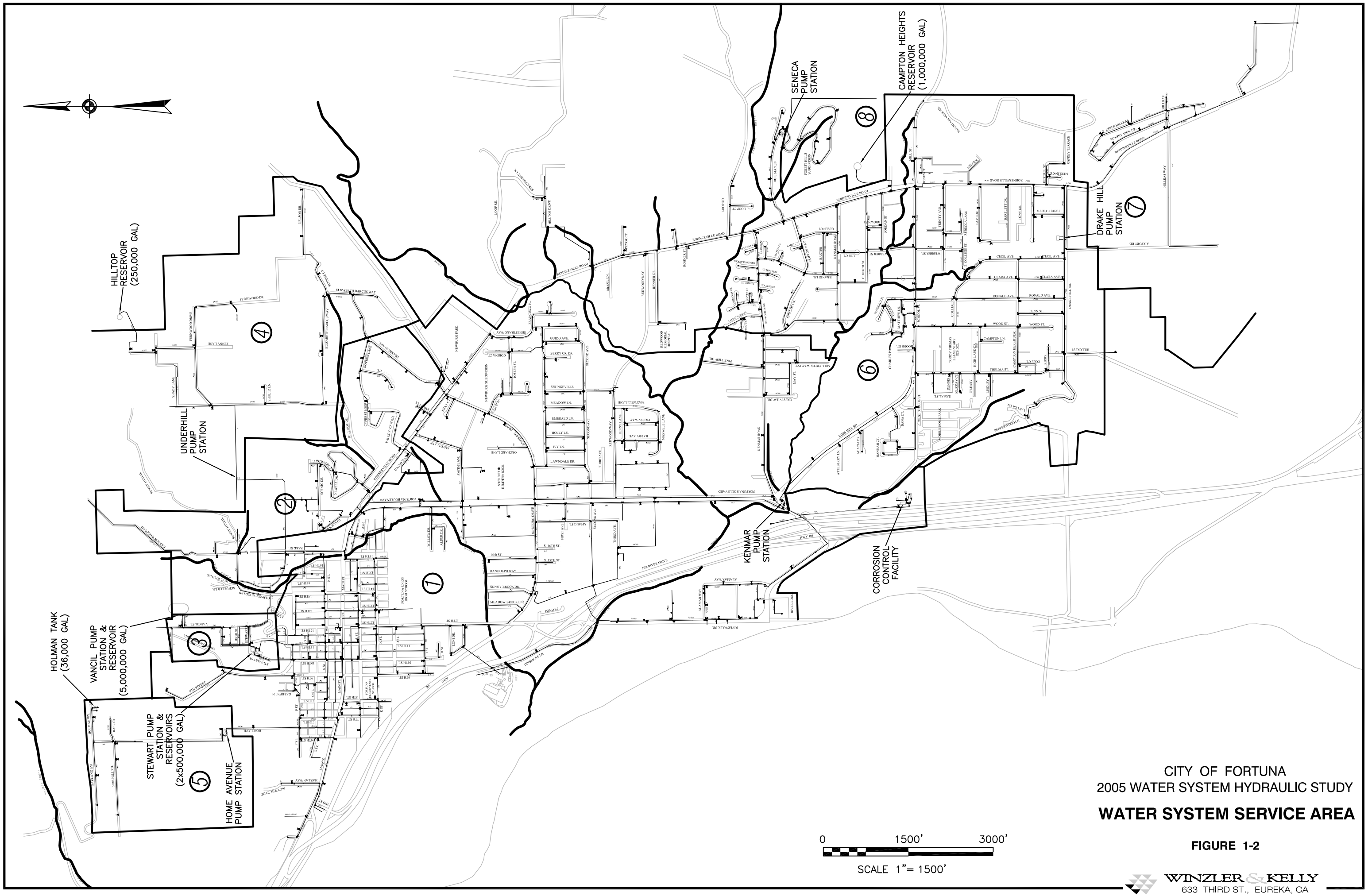
1.2.1 Existing Water System

The City's water source is well water provided through 5 wells located at the Corrosion Control Facility (CCF). Pumps on each well pump water to a 120,000 gallon wet well. From the wet well, a booster station containing three (3) 100 horse power (hp) pumps sends the water into the system. The water distribution system is pressurized by a series of pumps, water tanks and reservoirs, and hydropneumatic tanks. Hydropneumatic tanks are pressure tanks partially full of compressed air which boost the hydraulic grade line higher than the tank's water surface elevation. Table 1-1 provides a summary of Fortuna's water pumping and storage facilities.

TABLE 1-1 FORTUNA WATER SYSTEM PUMPING AND STORAGE FACILITIES

Zone	Pumping/Storage Facility	Power/Capacity
1	Corrosion Control Facility	• 3x100 hp pumps
1	Stewart Reservoirs	• 2x500,000 gallon
1	Stewart Pump Station	• 2x5 hp pumps
2	Vancil Reservoir	• 5,000,000 gallon
3	Vancil Pump Station & Hydropneumatic Tanks	• 2x5 hp domestic pumps • 1x30 hp fire pump • 2x650 gallon
4	Underhill Pump Station	• 2x5 hp pumps
4	Hillside Reservoir	• 250,000 gallon
5	Home Avenue Pump Station	• 2x7.5 hp
5	Holman Elevated Tank	• 36,000 gallon
6	Kenmar Pump Station	• 2x50 hp pumps • 1x30 hp pump
6	Campton Heights Reservoir	• 1,000,000 gallon
7	Drake Hill Pump Station & Hydropneumatic Tanks	• 2x20 hp domestic pumps • 1x30 hp fire pump • 2x650 gallon
8	Senneca Pump Station & Hydropneumatic Tanks	• 2x5 hp domestic pumps • 1x75 hp fire pump • 2x400 gallon

The existing water distribution system contains a mix of old and new components. The oldest portions of the system, which are located north of Kenmar Road, consist of asbestos-cement pipe and cast iron pipe. These pipes are generally between 40 and 75 years old, with the oldest pipes being in the area generally located between 7th Street and 12th Street, and L Street and P Street. Some of the original water mains in this area have been replaced with PVC mains within the last 20 years. New PVC mains in this part of the City have also been added, such as in the Hilltop Reservoir area and Riverwalk Drive. The mains in the southern part of the City, which is bounded by Kenmar Road in the North, Drake Hill Road in the South, Ross Hill Road in the West and Rohnerville Road in the East, are primarily new PVC. Figure 1-2 is a map of the existing water system.



CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY

WATER SYSTEM SERVICE AREA

FIGURE 1-2

WINZLER & KELLY
633 THIRD ST., EUREKA, CA

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The software license agreement is for two years of software upgrades and unlimited technical service and support from Haestad Methods.

Once the new software was obtained, the base hydraulic model was converted to the new version (Version 7.0) for all future simulations. The model was developed using the City's water system utility map as a template, along with plans for some of the City's pump stations and storage reservoirs. The water transmission-distribution network, pump stations, hydropneumatic tanks, elevated tanks, and reservoirs were laid out schematically and approximately to scale with pressure nodes located where demands must be specified and at critical pipe junctions. Only pipes 6 inches and larger, and a few critical 4 inch pipes, were included in the model. Headlosses associated with the system, such as pipe materials, bends, tees, valves, and other appurtenant features, were specified for each pipe. Water demand was estimated for each parcel in Fortuna based on land use classification and typical water use rates for various land use types. Water demands were then summed and specified for each pressure node in the model. Water demand is assumed constant at each pressure node. The complete skeletonized model contains 500 pressure pipes, 364 pressure nodes, 21 pumps and 12 tanks or reservoirs.

During a field visit to Fortuna in November 2004, Winzler & Kelly staff obtained the makes, models and impeller sizes of each pump in the City's water system. Pump curves for each pump were then obtained from pump catalogs and input into the hydraulic model.

In February and April, 2005 City of Fortuna staff collected hydraulic data at each of the City's pump stations and reservoirs. The data consisted of suction and discharge pressure and flow rates at each of the pump stations and tank and reservoir elevations for 18 different pumping scenarios. Additional discharge and pressure data was collected by Winzler & Kelly with the assistance of City staff at the CCF and Vancil pump stations on April 22, 2005, and at the CCF and Kenmar pump stations on July 15, 2005. The City also performed fire hydrant flow and pressure tests at hydrant locations throughout the City between October 28, 2004 and December 9, 2004. All of these data collected by Winzler & Kelly and the City were used in calibrating the hydraulic model.

Task 3 – Technical Memos: In the original Scope of Services Winzler & Kelly agreed to keep the City of Fortuna fully involved in the development and calibration of the hydraulic model by providing three technical memos of the progress of the model development. At the completion of this project, a total of five technical memos were provided detailing the progress of model development, calibration data needs, and other issues. Data collection forms and scenarios were provided to City staff for the data collection effort.

Task 4 – Draft Report: Winzler & Kelly prepared a draft report summarizing the technical memos to date, status of the model, scenarios for improvements and results of runs from the model, and associated cost estimates for the identified improvements.

Task 5 – Training: The project engineer who developed the model will provide a full day of training to teach City of Fortuna staff how to run the model and how to add additional water lines and appurtenances to the system model in the future. The training session will also involve installation of the new software and contact information for technical support from Haestad

Methods. Subsequent to the training we will be available for questions and help if the City of Fortuna chooses. Training for the use of the model will occur in the month of August.

Task 6 – Final Report: Subsequent to the City's review of the draft "Water System Hydraulic Study" report and training session a final report will be developed and submitted based on City of Fortuna comments and any further data developed during the project. The final report will include a CD with the base model and various scenarios developed throughout the project used to optimize the system.

1.4 Proposed Improvements

The analysis of the City's water system has identified 28 recommended improvement projects. The specific recommendations, including figures and opinion of probable costs, are discussed in detail in Chapter 3. Winzler & Kelly's opinion of the probable cost of 28 proposed projects is approximately $11,023,000. It should be noted that, where appropriate, alternatives for the proposed improvements are also included and reflected in the total cost. The reason for the alternatives is to achieve the same purpose of improving system capacity and reliability, but at less cost. Chapter 3 provides a prioritization of these improvements.

1.5 Recommendations

It is recommended that this Water System Hydraulic Study be adopted as a guide for construction of future water system improvements. The Capital Improvement Program, outlined in Chapter 3, provides a prioritized ranking of the recommended projects, outlines the components of each project, and presents the total project cost for all projects. Due to the importance of some projects over others, it is suggested that projects are completed in the order recommended in the Capital Improvement Program.

It should be noted that the recommended water system facilities are based on the City's current 5-Year Capital Improvements Program, results of hydraulic modeling, and suggestions from the City staff. The estimates assume new fire hydrants at approximately 500-ft spacing and has an allowance for new service connections. All costs are in August 2005 dollars.

This study has not evaluated sources for funding these improvements. However, it is suggested that the City develop a "pay-as-you-go" approach for the improvements in Fortuna. The water tank projects are expensive enough that a bond issue or assessment districts should be considered so that all of the improvements can be done as one project. This would tend to reduce costs due to the economies of scale.

1.6 Acknowledgement

The input and feedback from Mr. Bruce Gehrke, Superintendent of Water and Sewer, Mr. Wayne Yazzolino, Superintendent of Streets, Water, and Storm Drains, Mr. Jedd Short, Engineering Technician, Ms. Evelyn Plessinger, Engineering Technician, and Mr. Christian Engelhardt, Engineering Technician, was extremely valuable in completing this document. Thank you all for your assistance.

CHAPTER 2 – HYDRAULIC MODEL

2.1 Introduction

A hydraulic model of the entire City of Fortuna water system was developed using the Haestad Methods WaterCAD v7.0 water distribution modeling and management software. The complete skeletonized model contains 497 pressure pipes, 361 pressure nodes, or junctions between pipes, 21 pumps and 12 tanks or reservoirs. The City's version of this software will accommodate up to 500 pressure pipes. The minimum system requirements to run the software are: Pentium III at 1 GHz, 128 MB of RAM, Windows 2000 or Windows XP, 150 MB of free storage space, with additional room for data files, and 800 x 600 resolution, 256 colors monitor.

The WaterCAD software is very graphical and user-friendly, and allows the user to construct a hydraulic model to scale using an existing AutoCAD utility map. The model can simulate a variety of valve types, reservoir and tank geometries, and it can handle a wide range of pumping conditions, including variable speed pumps and logical controls. This hydraulic modeling software is capable of performing a wide variety of functions, including the following:

- Perform both steady-state and time-varying simulations;
- Execute detailed fire flow analyses to evaluate the system response to critical events;
- Model pressure reducing, pressure sustaining, pressure breaking, flow control, and throttle control valves, as well as simulate reduced pressure backflow preventers, well drawdown behavior, turbines, or any other device or situation with a unique headloss flow relationship;
- Simulate a wide range of pumping configurations from the simplest to the most complex, even for systems with variable speed pumps and rule-based controls;
- Create system head curves to assist with initial design and pump selection, and the optimization of operational inefficiencies;
- Model fire sprinklers, irrigation systems, leakage, or any other situation in which the node demand varies in proportion to the pressure;
- Perform constituent analysis to model chlorine residuals, develop chlorination schedules or simulating mock contamination events;
- Quickly determine the age of water anywhere in the network;
- Simulate a wide range of tank mixing behaviors to assist in mitigating tank-related water quality problems;
- Create contour maps using a variety of variables, such as pressure, elevation, flow, demand or concentration;
- Perform capital cost and energy cost analyses;
- Construct system head curves to demonstrate the changes in hydraulic grade as flowrates change, and build rating curves for fire hydrants and other nodes to show how pressures are impacted as demands change;
- Color code water mains based on over 60 different parameters, including pipe diameter, velocity, headloss, discharge, and water age.
- Create detailed reports for any element or group of elements and generate system-wide summaries and project inventories; and
- Easily manage and export data using tables and scenario controls.

The software can also use U.S. or metric units, and provides the option of using Darcy-Weisbach, Hazen-Williams, or Manning Equation to calculate friction losses.

Software and technical support may be obtained from Haestad Methods through the Bentley SELECT program. This support is included as part of the software license agreement between Bentley and the City of Fortuna. SELECT is Bentley's comprehensive technology and service subscription program that includes continuous product upgrades, comprehensive technical support, training, and other resources. Haestad Methods product support contact information is provided below.

Haestad Methods Product Support:

Phone: (203) 755-1666 or (800) 727-6555
Fax: (203) 597-1488
Email: support@haestad.com
Online: http://www.haestad.com or http://www.bentley.com (near future)
Mail: Haestad Methods, 37 Brookside Road, Waterbury, CT 06708-1499

2.2 Model Development

The development of the hydraulic model began by starting the WaterCAD program and creating a new project. In beginning a new project in WaterCAD, the user first selects pressure friction method, which is the Hazen-Williams formula, the type of liquid (water at 68°F), the model input modes (X-Y coordinate system, hydraulic grades, and tank level elevations), and the drawing scale. The Hazen-Williams formula is an empirically derived formula, and generally only applies to turbulent flow conditions. It is the most common method of calculating head loss in the U.S.

Next, the AutoCAD water system utility map, which was provided by the City of Fortuna, was imported into the model and used as a template upon which the skeletonized model was created to scale. Skeletonization is the process of selecting only the components of a hydraulic network that have a significant impact on the behavior of the system. For this model, pipes with diameters of 6-inches or larger were selected. Some pertinent 4-inch pipes where loops are connected were also included.

The model was created by using the WaterCAD tools to sketch the skeletonized pipe network on the utility map background image. This process results in a 1:1 scale model of the City’s distribution system. Pipe materials were specified for each pipe in the network, and the default C-factors for those materials were used. Table 2-1 summarizes the C-factors for each type of pipe material used in the model. The C-factors were adjusted slightly based on estimated pipe age, and in order to calibrate the model. Each pipe in the model is given a specific name or index number, material type, diameter, C-factor, and minor loss coefficient. Minor loss coefficients for each pipe were estimated based on pipe bends, valves, tees, crosses, and other appurtenances in each pipe line. PRVs were also included and with pressure settings as provided by the City.

Home Avenue Pump Station. This pump station has two 7.5-hp pumps and boosts water from Zone 1. The hydraulic grade of Zone 5 is 424 ft-msl.

The Kenmar Pump Station pumps water from Pressure Zone 1 up to the Campton Heights Reservoir via Ross Hill Road and School Street. The Kenmar Pump Station consists of two 50-hp pumps and a single 30-hp pump. The Campton Heights Reservoir is a 1 million gallon reservoir with a hydraulic grade of about 365 ft-msl, and supplies Pressure Zone 6. Zone 6 encompasses of the majority of the southern part of the City between Kenmar Road, Drake Hill Road and Rohnerville Road. Zone 6 loops back to Zone 1 through a PRV located on Kenmar Road.

Pressure Zone 7 is in the southern most part of the City's service area, and is served by the Drake Hill Pump Station. This pump station consists of two 20-hp pumps, one 30-hp fire pump and two hydropneumatic tanks. The Drake Hill Pump Station boosts water from Pressure Zone 6 to areas out Airport Road and Rohnerville Road south. Zone 7 has the highest hydraulic grade, which is at 600 ft-msl or greater.

The Senneca Pump Station and hydropneumatic tanks serve Pressure Zone 8. This pump station consists of two 5-hp pumps, one 75-hp fire pump and two hydropneumatic tanks. It boosts water from Zone 6 to serve the Forest Hills Subdivision located west of Rohnerville Road and north of the Campton Heights Reservoir. The Senneca Pump Station is supplied by the Campton Heights Reservoir, and has a hydraulic grade of about 475 ft-msl.

1.3 Scope of Work and Summary of Technical Memos

The Scope of Work for the 2005 Water System Hydraulic Study is discussed in this section. A summary of the technical memos provided to the City during this project is also included.

Task 1 – Project Initiation and Background Review: The Winzler & Kelly project team met with City staff who were involved with this project at the City of Fortuna Public Works Department on October 14, 2004. Winzler & Kelly provided an overview of the Scope of Services for the Water System Hydraulic Study. City staff provided an overview of the water system and its components, and discussed its features and how they interrelate. At this time the City had completed approximately 85%-90% of the recommended water system improvements from the 1986 Water System Hydraulic Study performed by Winzler & Kelly.

Task 2 – Modeling Plan: The base hydraulic model of the City's water system was developed using the City's originally purchased version of the Haestad Methods WaterCAD software (Version 4.1). At the beginning of the hydraulic study the former Director of Public Works authorized Winzler & Kelly to purchase the upgrade for this software package as part of this project. While this was not in the original scope of services for this project, Winzler & Kelly contacted Haestad Methods and was able to negotiate a significantly lower price for the new software by upgrading all three of the City's licensed Haestad Methods software products (WaterCAD, SewerCAD, and FlowMaster) together at one time. This negotiation and purchase was made at no additional expense to the City except the cost of the software and state sales tax.

TABLE 2-1 HAZEN-WILLIAMS ROUGHNESS COEFFICIENTS (C-FACTOR)

Pipe Material	Literature C-Factor	Model C-Factor
Asbestos Cement	140	140
Plastic (PVC)	140-150	150
Cast Iron	64-130	100-130

Pressure nodes are located between each pipe and at end of the line pipes. Nodes are locations where water demands are specified and pressure are computed. Each node in the model is given a specific name or index number, elevation, pressure zone and water demand. During the model skeletonization process each node is also assigned a specific X-Y coordinate. The elevation of each node was estimated from the City surveyed elevations of nearby sanitary sewer manhole covers, and assumed to be 3-ft below grade.

2.2.1 Water Demands

Water demand/consumption information was initially estimated for each parcel in the City of Fortuna service area, and was based on the land use classification and typical water use rates for that land use type. Water demands were then summed and specified for each pressure node in the model. Water demand is assumed constant at each pressure node. Total billed water usage was also obtained from the City of Fortuna billing department for calendar year 2004. Total pumped water at the Corrosion Control Facility was also obtained for the months of January – October of 2004. This data was used to adjust the estimated water demands within the model to more closely match actual billed usage and to account for “unaccounted water”. Unaccounted water was estimated as the difference between billed water usage and the pumped water volume at the Corrosion Control Facility. This comparison is summarized in Table 2-2.

TABLE 2-2 WATER PRODUCTION AND USE COMPARISON

Month	Corrosion Control Facility (gal)	Billed Use (gal)	Loss/Gain (gal)	Percent Loss/Gain
January	34,261,000	31,034,223	-3,226,777	-9.4%
February	30,077,000	27,383,874	-2,693,126	-9.0%
March	34,889,000	31,084,889	-3,804,111	-10.9%
April	36,454,000	33,399,393	-3,054,607	-8.4%
May	47,090,000	39,282,776	-7,807,224	-16.6%
June	55,271,000	51,205,990	-4,065,010	-7.4%
July	63,091,000	50,557,999	-12,533,001	-19.9%
August	58,315,000	57,768,827	-546,173	-0.9%
September	49,952,000	47,563,704	-2,388,296	-4.8%
October	40,994,000	42,185,210	1,191,210	2.9%
November	--	32,904,879	--	--
December	--	26,036,935	--	--
Monthly Average	45,039,400	39,200,725	-3,892,712	-8.4%
Daily Average	1,481,559	1,127,307	128,050	-8.6%

The analysis revealed an average daily volume of "unaccounted water" of approximately 128,000 gallons. This amount represents an average of 8.6% of the average daily volume pumped at the CCF. This water is likely unaccounted for as a result of unmetered irrigation, leaks at water storage facilities and leaks in water mains. As a result of this analysis, estimated water demands were increased 50% in the model.

2.2.2 Pump Stations and Reservoirs

Pump stations, reservoirs, water tanks and hydropneumatic tanks were described in the model such that they accurately represent these real system components. During a field visit to each pump station in November 2004, Winzler & Kelly staff obtained the makes, models and impeller sizes of each pump in the City's water system. Pump curves for each pump were then obtained from pump catalogs and input into the model. These pump curves are included in Appendix A of this report. City of Fortuna staff had previously provided hydropneumatic tank pressure settings. Hydropneumatic tanks were modeled as elevated storage reservoirs by converting each tank's pressure setting to feet of water. Water storage tanks were sized in the model based on as-built plans obtained from Winzler & Kelly archives and provided by the City of Fortuna. The elevations of these system components were obtained from the previous Hydraulic Study, as-built plans and the City of Fortuna.

2.3 Model Calibration

Once the model was initially developed it was calibrated to match the hydraulic grade line (HGL) using a series of 18 different scenarios developed by the Winzler & Kelly project team. Each scenario represents a different pumping condition, and is used to ensure that the model represents the City of Fortuna water system behavior as accurately as possible. Winzler & Kelly and City staff collected data for the calibration of the model. Table 2-3 summarizes the 18 calibration scenarios.

Fire hydrant flow test data was also used to test the accuracy of the model. Winzler & Kelly received fire hydrant flow test data collected by City staff at hydrant locations throughout the City between the dates of October 28, 2004 and December 9, 2004. Since the majority of the hydrant tests were performed while no pumps in the system were running, this data was used to assist in the calibration of the model for the Scenario 1 condition (i.e., no pumps running). It is important to note that while this data provides approximate hydraulic conditions throughout the City's water system, the hydraulic conditions at water system control points (i.e. reservoirs and pump stations) were not recorded during the hydrant test. The simultaneous hydraulic conditions at reservoirs and pump stations is necessary information because it provides a correlation between points where water system hydraulics are controlled and other points throughout the system. Therefore, while the hydrant test data represents a general estimate of hydraulic conditions throughout the City's water system, the control point conditions remain unknown and must be estimated.

The system hydraulic grade was selected as the calibration variable instead of system pressure for several reasons. First, it provides a better sense of the accuracy and reliability of the data. If computed and measured hydraulic grade values are significantly different from one another, it is a strong indication that a particular value in the model, such as an elevation, is in error. Hydraulic grades also provide insight into the direction of flow, whereas pressures do not.

TABLE 2-3 HYDRAULIC MODEL CALIBRATION SCENARIOS

Scenario	Corrosion Control P.S.	Kenmar P.S.	Stewart P.S.	Vancil P.S.	Home Ave. P.S.	Underhill P.S.	Senneca P.S.	Drake Hill P.S.
1	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
2	**100HP ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF
3	OFF	**50HP ON**	OFF	OFF	OFF	OFF	OFF	OFF
4	**100HP ON**	**50HP ON**	OFF	OFF	OFF	OFF	OFF	OFF
5	OFF	OFF	**5HP ON**	OFF	OFF	OFF	OFF	OFF
6	OFF	OFF	**(2) 5HP ON**	OFF	OFF	OFF	OFF	OFF
7	OFF	OFF	OFF	**5HP ON**	OFF	OFF	OFF	OFF
8	OFF	OFF	OFF	**(2) 5HP ON**	OFF	OFF	OFF	OFF
9	OFF	OFF	OFF	**ALL ON**	OFF	OFF	OFF	OFF
10	OFF	OFF	OFF	OFF	**7.5HP ON**	OFF	OFF	OFF
11	OFF	OFF	OFF	OFF	**(2) 7.5HP ON**	OFF	OFF	OFF
12	OFF	OFF	OFF	OFF	OFF	**5HP ON**	OFF	OFF
13	OFF	OFF	OFF	OFF	OFF	**(2) 5HP ON**	OFF	OFF
14	OFF	OFF	OFF	OFF	OFF	OFF	**5HP ON**	OFF
15	OFF	OFF	OFF	OFF	OFF	OFF	**(2) 5HP ON**	OFF
16	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**20 HP ON**
17	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**(2) 20HP ON**
18	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**30 HP ON**

Hydraulic grades also make it much easier to track down errors and inconsistencies between observations and results.

The desired level of calibration accuracy of a hydraulic model depends upon the intended use of the model. For this project, the hydraulic model is considered calibrated if the hydraulic grade results of the model are within 5% of the measured hydraulic grades, and the flow results are within 10% of the measured flows made in the field for each scenario. The results for each scenario are summarized in Table 2-4 through Table 2-21. Figure 2-1 shows contours of pressure (psi) for Scenario 1, which represents the static condition of the water system. Comparison of 184 of the measured hydrant static hydraulic grades with those generated with the model at approximately the same locations results in a root-mean-square error of 3.6 psi (8.4 feet), and only 11 nodal locations with hydraulic grades greater than 5 percent of those measured.

The results of the pumping scenarios summarized in Table 2-4 through Table 2-21 also show that the model compares favorably with the measurements, with the exception of the modeled hydraulic grade for Scenarios 2, 3 and 4, and the modeled flow rates for Scenarios 3, 8, 10, 12, and 16. The greater difference between the measured and modeled hydraulic grades and flows may be due to several reasons. Figures of the published pump curves with field measurements are provided in Appendix A.

When a pump has been in operation for many years it tends to operate on a curve that is offset from the published rating curve. This is common with most pumps, and is a result of wear from general use. It can be accurately adjusted by running tests and creating a rating curve specific to that pump's current condition.

New pumps may not operate according to their published curve. Depending on the application, it may be necessary to request a pump-specific curve from the pump manufacturer when the pump is purchased to ensure the pump will perform as designed.

The difference between modeled and measured flows and hydraulic grades can be exacerbated if the pump is continually operated at the lower end of the pump's rating. In this case, the pump is operating at or near the cavitation point. Cavitation occurs at the suction end of a pump when the pressure, or total dynamic head (TDH), drops to the point where the water vaporizes in the pump forming tiny water vapor cavities within the liquid water. Cavitation leads to loss of capacity and pump efficiency, which causes noise, vibration, and damage to many of the pump components.

Individual flow and pressure measurements may also contain errors as a result of improperly calibrated gages and meters, fluctuations within the system, or misreadings. For example, at the Kenmar pump station the discharge was observed to vary by ±20 percent during field measurements, which affects measurements at the CCF due to the proximity of these two stations. This fluctuation may explain the differences in flows and hydraulic grades for Scenarios 3 and 4.

The hydropneumatic tanks at the Vancil Pump Station have been set at an operating pressure of 30-45 psi. This is equivalent to a total dynamic head of 69-104 feet, which forces the pump to operate at the lower end of the rating curve and in the range of cavitation. Pump tests of the 5-hp pumps performed on April 22, 2005 showed that they are operating at 80% to 90% of expected

capacity, and may explain the flow difference observed in Scenario 8. Recommendations are made in Chapter 3.

Measurements made at the Home Avenue Pump Station and the Drake Hill Pump Station indicate that these pumps may be operating at the lower end of their published rating curves. Recommendations to this pump station's operation are made in Chapter 3.

2.4 Model Usage

Once the model was developed and calibrated it was used to assess the ability of the system to provide adequate fire flows, meet minimum system pressure and flow requirements, and identify potential system improvements and areas for energy savings. These results and recommendations are discussed in Chapter 3.

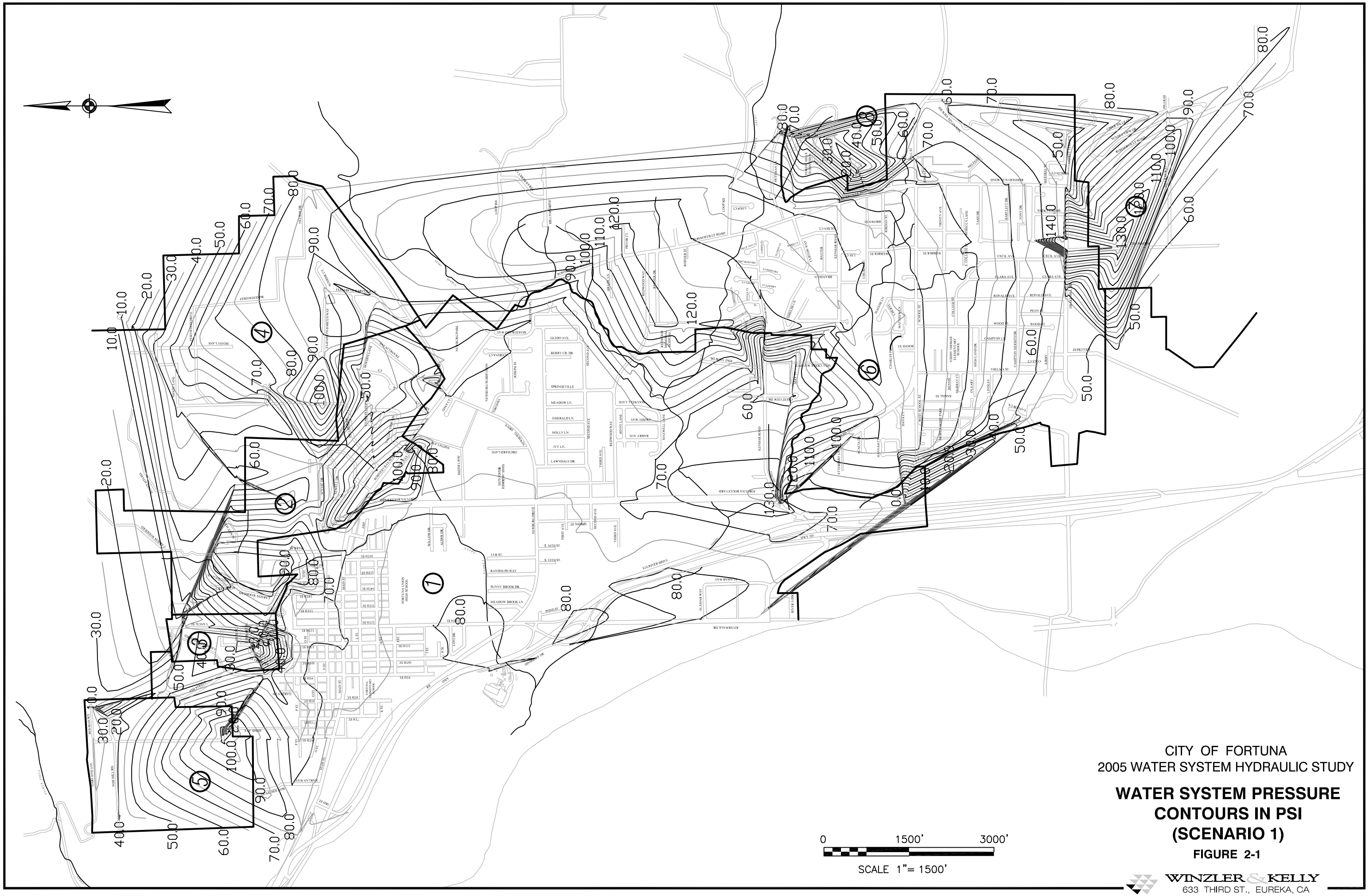
CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
WATER SYSTEM PRESSURE CONTOURS IN PSI (SCENARIO 1)
FIGURE 2-1
0 1500' 3000'
SCALE 1"= 1500'
WINZLER & KELLY
633 THIRD ST., EUREKA, CA
FILE: J:\CAD\JOBS\2004\04105401\dwg\054b-f2-01.dwg DATE: Jun 09 05 @ 8:37am

TABLE 2-4 SCENARIO 1 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	223.8	0	--	226.6	0	--	1.3%	0.0%
Drake Hill P.S.	364.6	572.3	0	367.2	572.3	0	0.7%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	226.5	376.5	0	226.6	367.1	0	0.0%	-2.5%	0.0%
Senneca P.S.	367.0	404.8	0	367.1	404.8	0	0.0%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	295.2	410.5	0	296.2	394.5	0	0.4%	-3.9%	0.0%
Vancil P.S.	293.9	379.3	0	297.0	379.3	0	1.0%	0.0%	0.0%

TABLE 2-5 SCENARIO 2 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	366.9	2129		370.2	2,255.0	--	0.9%	5.9%
Drake Hill P.S.	366.9	563.1	0	367.7	563.1	0	0.2%	0.0%	0.0%
Home Ave. P.S.	231.2	420.4	0	230.0	420.0	0	-0.5%	-0.1%	0.0%
Kenmar P.S.	360.4	376.5	0	340.0	367.7	0	-5.7%	-2.3%	0.0%
Senneca P.S.	367.0	400.9	0	367.8	400.9	0	0.2%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.7	297.0	0	0.2%	-0.3%	0.0%
Underhill P.S.	295.2	410.5	0	296.9	398.5	0	0.6%	-2.9%	0.0%
Vancil P.S.	293.9	377.0	0	297.0	377.0	0	1.0%	0.0%	0.0%

TABLE 2-6 SCENARIO 3 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	205.3	0	--	225.5	0	--	9.8%	0.0%
Drake Hill P.S.	366.9	563.1	0	368.2	563.1	0	0.3%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	203.7	383.7	340	224.4	371.9	376.0	10.2%	-3.1%	10.6%
Senneca P.S.	367.0	394.2	0	367.6	394.2	0	0.2%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	299.8	410.5	0	296.3	393.9	0	-1.2%	-4.1%	0.0%
Vancil P.S.	293.9	370.1	0	297.0	370.1	0	1.0%	0.0%	0.0%

TABLE 2-7 SCENARIO 4 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	330.0	2224	--	281.0	2,068.3	--	-14.9%	-7.0%
Drake Hill P.S.	369.2	556.2	0	371.3	556.2	0	0.6%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	227.2	420.0	0	-0.7%	-0.1%	0.0%
Kenmar P.S.	264.0	427.6	920	245.5	393.3	956.4	-7.0%	-8.0%	4.0%
Senneca P.S.	367.0	392.2	0	369.2	392.2	0	0.6%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	297.0	0	0.1%	-0.3%	0.0%
Underhill P.S.	299.8	410.5	0	296.9	398.5	0	-1.0%	-2.9%	0.0%
Vancil P.S.	293.9	365.5	0	297.0	365.5	0	1.0%	0.0%	0.0%

TABLE 2-8 SCENARIO 5 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	233.1	0	--	226.8	0	--	-2.7%	0.0%
Drake Hill P.S.	366.9	558.5	0	367.6	558.5	0	0.2%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	226.5	376.5	0	226.8	367.6	0	0.1%	-2.4%	0.0%
Senneca P.S.	367.0	388.9	0	367.5	388.9	0	0.1%	0.0%	0.0%
Stewart P.S.	222.3	303.0	162	226.3	299.8	163.7	1.8%	-1.0%	1.1%
Underhill P.S.	292.8	405.9	0	296.7	396.2	0	1.3%	-2.4%	0.0%
Vancil P.S.	293.9	365.5	0	297.0	365.5	0	1.1%	0.0%	0.0%

TABLE 2-9 SCENARIO 6 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	366.9	551.5	0	367.6	551.5	0	0.2%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	228.8	376.5	0	226.8	367.6	0	-0.9%	-2.4%	0.0%
Senneca P.S.	367.0	385.9	0	367.5	385.9	0	0.1%	0.0%	0.0%
Stewart P.S.	222.4	307.5	315	226.3	301.0	318.9	1.7%	-2.1%	1.2%
Underhill P.S.	297.5	405.9	0	297.8	396.7	0	0.1%	-2.3%	0.0%
Vancil P.S.	293.9	383.9	0	297.2	383.9	0	1.1%	0.0%	0.0%

TABLE 2-10 SCENARIO 7 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	366.9	553.8	0	367.6	553.8	0	0.2%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	231.2	376.5	0	226.8	367.6	0	-1.9%	-2.4%	0.0%
Senneca P.S.	367.0	383.2	0	367.5	383.2	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	297.5	405.9	0	296.3	396.0	0	-0.4%	-2.5%	0.0%
Vancil P.S.	292.6	404.1	90	290.9	414.6	91.4	-0.6%	2.6%	1.6%

TABLE 2-11 SCENARIO 8 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	364.6	551.5	0	367.6	551.5	0	0.8%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	231.2	376.5	0	226.8	367.6	0	-1.9%	-2.4%	0.0%
Senneca P.S.	367.0	381.5	0	367.5	381.5	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.6	0	0.1%	-0.4%	0.0%
Underhill P.S.	297.5	405.9	0	296.2	395.9	0	-0.4%	-2.5%	0.0%
Vancil P.S.	291.7	435.3	118	292.7	440.2	138.2	0.4%	1.1%	17.1%

TABLE 2-12 SCENARIO 9 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	223.8	0	--	226.8	0	--	1.4%	0.0%
Drake Hill P.S.	364.6	546.9	0	367.6	546.9	0	0.8%	0.0%	0.0%
Home Ave. P.S.	231.2	420.4	0	226.5	420.0	0	-2.0%	-0.1%	0.0%
Kenmar P.S.	228.8	376.5	0	226.8	367.6	0	-0.9%	-2.4%	0.0%
Senneca P.S.	367.0	380.4	0	367.5	380.4	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	295.9	0	0.1%	-0.7%	0.0%
Underhill P.S.	297.5	405.9	0	295.6	395.5	0	-0.6%	-2.6%	0.0%
Vancil P.S.	289.2	468.5	503	293.5	453.2	469.6	1.5%	-3.3%	-6.6%

TABLE 2-13 SCENARIO 10 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	366.9	540.0	0	367.6	540.0	0	0.2%	0.0%	0.0%
Home Ave. P.S.	230.0	420.5	100	225.9	422.7	84.3	-1.8%	0.5%	-15.7%
Kenmar P.S.	231.2	376.5	0	226.8	367.6	0	-1.9%	-2.4%	0.0%
Senneca P.S.	367.0	379.5	0	367.5	379.5	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	297.5	405.9	0	296.4	396.0	0	-0.4%	-2.4%	0.0%
Vancil P.S.	293.9	441.6	0	297.0	441.6	0	1.0%	0.0%	0.0%

TABLE 2-14 SCENARIO 11 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	366.9	544.6	0	367.6	544.6	0	0.2%	0.0%	0.0%
Home Ave. P.S.	223.1	425.3	178	225.3	427.9	162.4	1.0%	0.6%	-8.8%
Kenmar P.S.	228.8	376.5	0	226.8	367.6	0	-0.9%	-2.4%	0.0%
Senneca P.S.	367.0	379.2	0	367.5	379.2	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	297.5	405.9	0	296.3	396.0	0	-0.4%	-2.5%	0.0%
Vancil P.S.	293.9	425.5	0	297.0	425.5	0	1.0%	0.0%	0.0%

TABLE 2-15 SCENARIO 12 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	223.8	0	--	226.8	0	--	1.4%	0.0%
Drake Hill P.S.	366.9	558.5	0	367.6	558.5	0	0.2%	0.0%	0.0%
Home Ave. P.S.	231.2	420.4	0	226.5	420.0	0	-2.0%	-0.1%	0.0%
Kenmar P.S.	226.5	376.5	0	226.8	367.6	0	0.1%	-2.4%	0.0%
Senneca P.S.	367.0	374.2	0	367.5	374.2	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.2	0	0.1%	-0.5%	0.0%
Underhill P.S.	290.4	412.3	120	288.5	420.3	104.3	-0.6%	1.9%	-13.1%
Vancil P.S.	293.9	404.7	0	296.9	404.7	0	1.0%	0.0%	0.0%

TABLE 2-16 SCENARIO 13 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	366.9	544.6	0	367.6	544.6	0	0.2%	0.0%	0.0%
Home Ave. P.S.	226.5	420.4	0	226.5	420.0	0	0.0%	-0.1%	0.0%
Kenmar P.S.	226.5	376.5	0	226.8	367.6	0	0.1%	-2.4%	0.0%
Senneca P.S.	367.0	373.5	0	367.5	373.5	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	295.9	0	0.1%	-0.7%	0.0%
Underhill P.S.	290.2	426.3	190	285.8	421.1	197.0	-1.5%	-1.2%	3.7%
Vancil P.S.	293.9	383.9	0	296.9	383.9	0	1.0%	0.0%	0.0%

TABLE 2-17 SCENARIO 14 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	366.9	549.2	0	367.4	549.2	0	0.1%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	228.8	376.5	0	226.8	367.3	0	-0.9%	-2.4%	0.0%
Senneca P.S.	355.0	483.1	115	355.1	476.8	105.0	0.0%	-1.3%	-8.7%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	297.5	410.5	0	296.4	396.0	0	-0.4%	-3.5%	0.0%
Vancil P.S.	293.9	377.0	0	297.0	377.0	0	1.0%	0.0%	0.0%

TABLE 2-18 SCENARIO 15 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	223.8	0	--	226.8	0	--	1.4%	0.0%
Drake Hill P.S.	364.6	574.6	0	366.7	574.6	0	0.6%	0.0%	0.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	226.5	376.5	0	226.8	366.6	0	0.1%	-2.6%	0.0%
Senneca P.S.	340.2	352.1	367	349.5	335.4	364.9	2.7%	-4.7%	-0.6%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	290.5	410.5	0	296.4	396.0	0	2.0%	-3.5%	0.0%
Vancil P.S.	293.9	365.5	0	297.0	365.5	0	1.0%	0.0%	0.0%

TABLE 2-19 SCENARIO 16 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	223.8	0	--	226.8	0	--	1.4%	0.0%
Drake Hill P.S.	366.7	619.0	118	366.5	618.9	147.7	0.0%	0.0%	25.1%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	226.5	376.5	0	226.8	367.0	0	0.1%	-2.5%	0.0%
Senneca P.S.	367.0	471.1	0	367.2	471.1	0	0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	295.2	410.5	0	296.4	396.0	0	0.4%	-3.5%	0.0%
Vancil P.S.	293.9	374.7	0	297.0	374.7	0	1.0%	0.0%	0.0%

TABLE 2-20 SCENARIO 17 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	365.9	675.9	250	365.7	674.1	237.6	-0.1%	-0.3%	-5.0%
Home Ave. P.S.	228.8	420.4	0	226.5	420.0	0	-1.0%	-0.1%	0.0%
Kenmar P.S.	228.8	376.5	0	226.8	366.6	0	-0.9%	-2.6%	0.0%
Senneca P.S.	367.0	464.6	0	367.0	464.6	0	0.0%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	290.5	410.5	0	296.4	396.0	0	2.0%	-3.5%	0.0%
Vancil P.S.	293.9	360.8	0	297.0	360.8	0	1.0%	0.0%	0.0%

TABLE 2-21 SCENARIO 18 CALIBRATION RESULTS

Location	Measured			Modeled			Error (%)		
	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL (ft)	Discharge HGL (ft)	Discharge Flow (gpm)	Suction HGL	Discharge HGL	Discharge Flow
Corrosion Control P.S.	--	226.1	0	--	226.8	0	--	0.3%	0.0%
Drake Hill P.S.	359.6	620.5	374	364.6	616.4	339.5	1.4%	-0.7%	-9.2%
Home Ave. P.S.	226.7	420.4	0	226.5	420.0	0	-0.1%	-0.1%	0.0%
Kenmar P.S.	228.8	376.5	0	226.8	366.0	0	-0.9%	-2.8%	0.0%
Senneca P.S.	367.0	462.8	0	366.7	462.8	0	-0.1%	0.0%	0.0%
Stewart P.S.	226.3	297.8	0	226.6	296.7	0	0.1%	-0.4%	0.0%
Underhill P.S.	290.5	410.5	0	296.4	396.0	0	2.0%	-3.5%	0.0%
Vancil P.S.	293.9	370.1	0	297.0	370.1	0	1.0%	0.0%	0.0%

CHAPTER 3 – SYSTEM IMPROVEMENTS

3.1 General

After the water system hydraulic model was developed and calibrated as discussed in Chapter 2, it was used to assist in the development of water system improvement projects. This chapter begins with a discussion of the system improvements recommended in the 1986 Hydraulic Study, then reviews those improvements that have been completed, and finally updates the recommended system improvement projects based on the results of the hydraulic model and components of the current system. Cost estimates for the proposed improvement projects are provided in Appendix C.

A major emphasis was placed on developing a plan that would minimize costs and solve all known existing water system problems. Recommendations have also been made for the replacement or upgrades of existing facilities that the hydraulic model indicates have diminished capacity.

Because this plan is intended as a guide for the development of future water system facilities and it is somewhat uncertain how future development will proceed, it does not attempt to present detailed hydraulic designs for individual areas. It should be noted that detailed designs and construction plans would be required before individual proposed projects are constructed.

3.2 Water System Design

For new water mains, the design consists of proposed pipe locations and dimensions. The California Water Works Standards and American Water Works Standards (AWWA) should be followed for all designs. The California Water Works Standards are excerpts from the California Administrative Code, Title 22. These standards can be modified based upon good design as may be determined by a registered engineer competent in the design of water systems. In general, the Fortuna water system is under the jurisdiction of the California Department of Health Services (DHS), and any changes must meet DHS criteria and should be approved by this department. The DHS Guidance Criteria for Water Mains is located in Appendix B. The following criteria should be used for the design of the City's water distribution system:

- New PVC water mains should be of either Class 150 or Class 200 pipe which meets the requirements of SDR 17 and AWWA C900;
- New HDPE water mains should be SDR 9 with a Working Pressure Rating (WPR) of 200 psi, or SDR 11 with a WPR of 160 psi, and meet the requirements of AWWA C906;
- Distribution mains and pipes feeding hydrants should be a minimum of 6" in diameter, and mains serving to loop the system should be a minimum of 8" in diameter;
- Water mains should be sized for a maximum velocity of not more than 6 ft/s;
- New water mains should be installed:
    - 10 feet horizontally from and 1 foot higher than sanitary sewers located parallel to the main;

    - 1 foot higher than sanitary sewers crossing the main;
    - 10 feet, and preferably 25 feet, horizontally from sewage leach fields, cesspools, seepage pits and septic tanks;
    - Lesser separation is permissible if the water and sewer mains are located as far apart as feasible, they are not installed in the same trench, and the water main is appropriately constructed to prevent contamination of the water in the main by sewer leakage.
- New water mains should be installed at least 4 feet horizontally and 1 foot higher than any parallel pipeline conveying disinfected tertiary recycled water, raw water, and storm water.
- New water mains crossing perpendicular to pipelines conveying disinfected tertiary recycled water, raw water, and storm water should be installed at least 1 foot higher and have no joints within 8 horizontal feet of the fluid pipeline.
- Water valves on mains 12” in diameter and smaller should be located such that water main lengths of not more than 1,000 feet can be isolated by valve closure.
- A flushing valve and blowoff should be installed at the end of each dead-end water main where stagnant conditions are likely to develop.
- Minimum pipe cover of 30” in all roadways and in open country.

The use of horizontal directional drilling (HDD) using fusion welded HDPE water pipe is a new method of water main installation that is becoming more common. Because open trenches are not needed when installing pipelines by HDD, significant cost savings may be realized.

3.3 Development of Opinion of Probable Cost

Our opinion of the probable cost for the proposed projects has been provided. Our opinion is based on the premise that all construction will be accomplished by competitively bid contracts. Our opinions of the probable cost were developed using *Means Construction Cost Data*, recent experience on bids received in Northern California for similar improvements, and costs obtained directly from suppliers. The following items are added to the subtotal amount:

- General Conditions (32.25%)
    - Mobilization/Demobilization (5%)
    - Contractor’s Bond and Insurance (5%)
    - General Contractor’s Overhead and Profit (15%)
    - Sales Tax (7.25%)
- Legal, Administration and Engineering (25%)
- Contingency (20%)
- Bonding (15%)

The general conditions are the sum of mobilization/demobilization, contractor’s bond and insurance, contractor’s overhead and profit, and sales tax, and are added to the construction subtotal. The legal, administration and engineering costs and contingencies are a percent of the total construction cost, and are added to the construction cost total to obtain the total project cost. A 20% contingency is also included. If the City of Fortuna funds water system improvements using bonds, an additional 15% is added to the total project cost to obtain the final opinion of

probable cost. This 15% is to cover the bond costs, interest during construction, and provide reserve funds. Cost estimates for the proposed improvement projects are provided in Appendix C.

It should be noted that all costs are given in August 2005 dollars, with an Engineering News-Record (ENR) Construction Cost Index equal to 7,479.

3.3.1 Project Priority Analysis

The proposed water system improvements will require a number of years to complete. The proposed improvement projects were ranked with the assistance of City staff according to priority for construction. Priority rankings of low, medium, or high based on the following set of critical factors:

- Public health impacts
- Compliance with drinking water regulations
- Storage and supply limitations
- System age and replacement needs
- Rehabilitation or repair
- Cost-effectiveness
- Short-term construction impacts
- Impacts on operation and maintenance
- Potential to influence development, business growth, or create jobs

3.3.2 Development-Driven Projects

The existing land use surrounding proposed improvements was compared to build-out conditions as designated in the current zoning plans. Development was expected in areas where current land use density was significantly less than the current zoning allows. Development-driven projects were considered to be those located in areas where the existing land use was significantly less dense than build-out conditions. Water systems serving new developments are typically paid for by the owner/builder in addition to fees for connecting the new system to the existing City-owned water system.

3.4 Review of 1986 Hydraulic Study Recommendations

Many improvement projects were recommended in the 1986 Hydraulic Study, most of which have been completed. This section reviews the recommended improvement projects and describes those system improvements that have been completed. Improvements are segregated into three categories: tanks and reservoirs, pump stations, and distribution system. All of the Priority 1, 2, 3 and 4 projects listed in Table I of the 1986 Hydraulic Study have been completed, with the exception of Priority 3.3, which was a new 8” line on Renner Drive between Rohnerville Road and Redwood Memorial Hospital. Most of the remaining improvements listed in Table II have been completed, with some exceptions, which are discussed below.

3.4.1 Tank and Reservoir Improvements

At the time of the 1986 Hydraulic Study there were two separate water systems in Fortuna. They were referred to as the Fortuna water system and the Campton Height water system. The Campton Heights system, which was a private water system recently purchased by the City, supplied the Campton Heights and Rohnerville Road area, while the Fortuna system supplied the remainder of the City. In the 1986 Hydraulic Study it was recommended that the City utilize the Fortuna well system (Corrosion Control Facility) as the sole source of water for both the Fortuna system and Campton Heights areas because of its superior water quality and high capacity. The Study recommended connecting the two systems with a new 10” waterline on Ross Hill Road and School Road to Rohnerville Road and up to a new 1 million gallon water storage reservoir located at an elevation of 350-ft (msl). These improvements have been completed.

As demand in the area south of Drake Hill Road increased, the 1986 Hydraulic Study also recommended a new 250,000 gallon reservoir to replace the existing hydropneumatic station on Drake Hill Road. This improvement has not yet been implemented. However, demand in this area is increasing.

An additional 250,000 gallon water storage reservoir was also recommended to serve the Hillside area. At the time of the 1986 Hydraulic Study this area was only served by a hydropneumatic tank. It was recommended that the new reservoir be installed at a water surface elevation of 400-ft (msl). It was also recommended that a new 8” water line be installed along Penny Lane from the reservoir to Fernwood Drive, and a new 6” water line from Fernwood Drive to Cypress Loop where it would tie in with the Vancil system. These improvements have been completed, with pressure reducing valves (PRV) connecting the different pressure zones.

The Hansen Tank, which served the area north of the Stewart tanks, was old has been removed from service by the City. The 1986 Study recommended replacing this tank with a new reservoir with a minimum capacity of 150,000 gallons. The City removed the Hansen Tank, and installed two hydropneumatic tanks at the Vancil Pump Station. The Vancil pump station was also rebuilt.

The 1986 Hydraulic Study recommended replacing the 36,000 gallon elevated Holman Tank with a new tank further up the hill with a capacity of 150,000 gallons, and installing new 8” water lines on Holman Way to Garland Avenue and down to the end of Nob Hill Road to reduce friction losses and increase pressure in this area. The Holman Tank is aging and the City is considering replacing it. It is costly to maintain, and does not provide adequate fire flows. Static pressures in this area are 30 – 40 psi. Neither of these improvements has been completed.

3.4.2 Pump Station Improvements

It was recommended that a booster pump station near the intersection of Ross Hill Road and Fortuna Boulevard be constructed to boost water from the well site (Corrosion Control Facility) to the Campton Heights Reservoir. A booster pump station, named the Kenmar Pump Station, was constructed near the recommended location. This pump station contains two 50-hp pumps and one 30-hp pump. A 10” PVC line was also installed as recommended.

The Vancil Pump Station was rebuilt and is currently contained in a new pump house near the Vancil Reservoir. The pump station contains two 5-hp pumps and one 30-hp fire pump, as well as two hydropneumatic tanks to serve the Vancil area.

The 1986 Study also recommended piping system modifications between the Holman Tank and the Home Avenue Pump Station to improve system pressures. Because of the elevation of the Home Avenue Pump Station, which is approximately 185-ft (msl) pressures along Home Avenue south of the pump station barely meet the minimum pressure requirement of 20 psi. Pressure measurements at the suction end of the Home Avenue Pump Station are consistently at 20 psi, while the pressure at the discharge end is about 100 psi. It was recommended that a 2” bypass with a pressure reducing valve be installed at the booster station to supply the system south of the pump station to an elevation of approximately 155-ft (msl). A mainline check valve must also be installed at this elevation to prevent supply to any lower points.

At the time of the 1986 Hydraulic Study, the Penn Street Pump Station consisted of a well pump, a variable speed pump, a ground-level 250,000 gallon redwood storage tank, and a hydropneumatic tank. The variable speed pump and reservoir served the Campton Heights area, and the hydropneumatic tank served areas south of Drake Hill Road. With the construction of the Campton Heights Reservoir, these facilities were removed from service, and a new pump station with two hydropneumatic tanks was constructed on Drake Hill Road near Cecil Avenue. The pump station contains two 20-hp pumps and one 30-hp fire pump. The Campton Heights Reservoir now serves the Campton Heights area, and the pump station and hydropneumatic tanks serve areas south of Drake Hill Road.

With the creation of the Forest Hill Subdivision on Huffman Lane off Rohnerville Road, a new booster pump station was constructed. The subdivision is located on the hill north of and a nearly the same elevation as the Campton Heights Reservoir. The pump station contains two 5-hp pumps, one 75-hp fire pump and two hydropneumatic tanks.

3.4.3 Distribution System Improvements

Distribution system improvements were recommended to meet current and future fire flow requirements. A general recommendation was that the minimum size required for all new water lines and lines serving fire hydrants should be 6”, and all new water lines that will eventually serve to loop the system are 8”. Based on improvements and additions to the water system that have been made since the 1986 Hydraulic Study, these recommendations have been applied. All new water lines are C900 (PVC).

3.4.3.1 Campton Heights Priority 1 Recommendations

The top priority improvement projects were to install a new booster station at the intersection of Kenmar Road and Fortuna Boulevard, a 10” line from this pump station along Ross Hill Road to School Road and then to Rohnerville Road, and a 12” line from Rohnerville Road to a new 1 million gallon reservoir. The pump station (Kenmar P.S.), 10” and 12” water mains and the reservoir (Campton Heights Reservoir) were completed.

3.4.3.2 Campton Heights Priority 2 Recommendations

The Priority 2 projects recommended in the 1986 Hydraulic Study included the following:

- 8” line on Drake Hill Road from Thelma Street to Rohnerville Road;
- 10” mains on Rohnerville Road from approximately Senestraro Way to Kenmar Road;
- 8” mains on Rohnerville Road from Drake Hill Road to School Street;
- 6” mains on Webber Street from School Street to College Street and on College Street to Clara Avenue;
- 6” mains on Clara Avenue from College Street to Drake Hill Road; and
- 8” mains on Wood Street from School Street to Drake Hill Road.

The above projects have primarily been completed, with some minor modifications to accommodate areas as they developed. New 6” and 8” C900 lines in the Campton Heights area between School Street and Drake Hill Road have been installed, replacing older smaller lines and providing water service as development occurred.

3.4.3.3 Campton Heights Priority 3 Recommendations

The third priority projects were to install 1) a 6” line on Highland Drive from Thelma Street to Campton Lane, 2) a 6” line on Campton Heights Drive from Thelma Street to Wood Avenue, and 3) an 8” line on Renner Drive from Rohnerville Road to Redwood Memorial Hospital. The first two projects were finished, but the new line on Renner Drive was not completed because the hospital has since developed a private well water source to meet all of the hospital’s water demands.

3.4.3.4 Fortuna System Recommendations

The following is a list of priority project recommended in the 1986 Hydraulic Study.

- 8” line on Kenmar Road from Fortuna Boulevard to Pine View Drive (complete);
- 8” line on Fortuna Boulevard from Alder Drive to Newburg Drive (6” installed);
- 10” line on Rohnerville Road from Franklin Avenue to Renner Drive (partially complete);
- 12” line from Stewart Reservoirs to elevation 160-ft (msl) and then 10” on 10th Street to L Street (partially complete);
- 8” line on 7th Street and L Street (partially completed);
- 6” line from 16th Street to the end of Beech Street (partially complete);
- 6” line on 14th Street from N Street to P Street (not complete);
- 8” line on Home Avenue and Garland Street (Home Avenue complete); and
- 6” line on Hillside Drive from the south end of the line to Cypress Loop (not completed);

The 6” line on Hillside Drive from the south end of the line to Cypress Loop was not completed because connecting Pressure Zones 2 and 4 at this location is not necessary, and they are already connected through a PRV on Boyden Lane. The only remaining improvements recommended in the 1986 Hydraulic Study that have not been completed are to eliminate dead ends by creating

loops, and installing a 10” line on Rohnerville Road from Senestraro Way to Pryor Court connecting the Campton Heights pressure zone with the Fortuna pressure zone.

3.5 Recommended System Improvements

During the hydraulic model calibration and pump tests several operational issues were identified which we believe need to be addressed immediately by the City in order to improve the performance of the water system. These issues, as well as proposed storage, pump station, and distribution system improvements are discussed in this section. Figures 3-1 to 3-5 show the locations of the proposed projects. Recommended improvements are shown in **bold blue**.

3.5.1 Operational Improvements

Operational improvements are recommended to improve pump station performance, reduce the risk of pump cavitation, and increase the operational life of pump motors.

3.5.1.1 Corrosion Control Facility

This pump station consists of three centrifugal pumps located above a wet well. When this facility was constructed the City had difficulty keeping the pumps primed and had to install bypasses at each pump to allow a small amount of water to flow back into the wet well to ensure the pumps remained primed. When operating, the pumps draw water from the wet well and send it into the distribution system.

Hydraulic analysis and pump tests at the Corrosion Control Facility (CCF) indicate that the station operates in the cavitation range with only one pump running. During a field visit to this station it was determined that cavitation is occurring with only one pump running, and the impeller in Pump No. 2 has recently been replaced because of cavitation. However, when two pumps are running in parallel, the pumps operate very near the published pump curve and at near peak efficiency. It is recommended that two pumps always be run in parallel while the existing 100-hp centrifugal pumps at this facility remain in operation. This mode of operation will ensure that the pumps do not cavitate. City staff is aware that pump life and operational efficiency are significantly diminished with only one pump operating at a time, and now exclusively run two pumps in parallel at this facility.

3.5.1.2 Vancil Pump Station

Hydraulic analysis and pump tests of the Vancil Pump Station indicate that its operational pressure is too low, and with one pump running the pumps operate off the lower end of the published pump curve near the cavitation range. This pump station and two hydropneumatic tanks serve Pressure Zone 3, the area around the Vancil Reservoir. With two 5-hp pumps running in parallel the station operates on the published pump curve. The pumps are currently set to turn on at a pressure of 30 psi and off at 40 psi. It is recommended that the set points be changed such that the pumps turn on at a pressure of 50 psi and off at 65 psi. This operational modification will allow the pumps to run in the range of peak efficiency, extending their operational life. In addition, it will increase and widen the range of operational pressures, which will require fewer

pump starts saving power costs. The higher system pressures will also improve fire flows in this area.

3.5.1.3 Home Avenue Pump Station

Pump tests of the Home Avenue Pump Station indicate that the existing 7.5-hp pumps are currently being operated at the lower end of the published pump curve and outside their range of peak efficiency. These measurements were corroborated with results from the hydraulic model. The City should monitor pump performance and efficiency at this and all other pump stations and make adjustments and/or upgrades as necessary. This is one way the City may be able to save in power costs.

3.5.2 Storage Facility Improvements

3.5.2.1 Water Tank Replacement: Holman Tank (City Project No. 9621 & 9122)

As discussed in Section 3.2.1, the 1986 Hydraulic Study recommended replacing the existing 36,000 gallon elevated Holman Tank with a new tank further up the hill with a capacity of 150,000 gallons. As part of its 5-year Capital Improvement Program the City is planning to install a new hydropneumatic system at the Home Avenue Pump Station in 2007/2008, and demolish the aging Holman Tank in 2008/2009. While this option would improve pressures and fire flows in the area currently served by the Holman Tank, installing a hydropneumatic system will also limit this area's growth potential and could increase power use and operational costs.

Similar to the recommendation made in the 1986 Study, it is recommended that the existing Holman Tank be demolished (see Figure 3-1). An alternative to installing a new hydropneumatic station at Home Avenue is to construct a new elevated tank at the existing Holman Tank site or further up the hill, northeast of the Holman Tank. The new tank should have a minimum hydraulic grade of approximately 430-ft (msl) to provide adequate pressure to the highest residence. The significance of a new reservoir in this area is it can be used to serve Pressure Zones 3 and 5, eliminating one pressure zone. Zone 3 is served by the Vancil hydropneumatic system, and Zone 5 is served by the Holman Tank. A tank serving both pressure zones would reduce the current number of pressure zones in the City to seven, eliminate the Home Avenue pump station, reduce the amount of off-peak pumping at Vancil, and reduce overall pump station O/M. It would also provide a reliable water supply for the Vancil and Holman areas. The new pressure zone would then tie in with Pressure Zone 1 with PRVs. Based on pumping records, the current average daily demands for Zones 3 and 5 are approximately 20,000 gpd and 35,000 gpd, respectively. Current peak daily demands for Zones 3 and 5 are about 42,000 gpd and 75,000 gpd, respectively. *Considering future growth in these two pressure zones and fire protection needs, a new 250,000 gallon water tank is recommended. If the City decides not to combine Zones 3 and 5, and continue serving Zone 3 with the Vancil Pump Station, a new 175,000 gallon storage tank would serve the current and future demands and fire flows of Zone 5.* The City of Eureka recently installed a new 500,000 gallon elevated steel water tank. The tank is 150-ft tall and cost approximately $1.5 million. This project has been assigned a *medium priority* ranking, and is not development driven. Our opinion of the probable cost of removing the existing

Holman Tank is $174,000. Our opinion of the probable cost of installing a new 250,000 gallon elevated tank is $1,000,000.

3.5.2.2 Reservoir Maintenance: Vancil Reservoir Liner Replacement (City Project No. 9423)

In 2008/2009 the City is planning to replace the aging liner in the 5 million gallon Vancil Reservoir (see Figure 3-1). This project is in response to increased water leakage from this reservoir. As discussed in Chapter 2, approximately 8.5 percent of water produced by the City is unmetered or lost due to leaks in the water system. Although the rate of the Vancil Reservoir leak has not been quantified, it has been described as significant by City staff. This project should significantly reduce overall system water losses. This project has been assigned a *high priority* ranking, and is not development driven. Our opinion of the probable cost of this project is $563,000.

3.5.2.3 New Reservoir and Reservoir Retrofit: Stewart Reservoirs (City Project No. 9327 & 9124)

To improve the water storage capacity and reliability at the Stewart Reservoir site, the City is planning to replace the nearly 100 year old rectangular tank, increase the capacity of the approximately 75 year old round tank, and to make modifications to the site including increasing the pump station capacity and piping (see Figure 3-1). The pump station modifications are discussed in Section 3.5.3.2. It may also be desirable to replace the mains between the Stewart P.S. and the Vancil Reservoir with 10” C900 to increase their capacity. These two 500,000 gallon water tanks are back fed by the Vancil Reservoir, and supply Pressure Zone 1. The City requested proposals from qualified consultants in the summer of 2003, and is planning to begin the design portion of the project in 2005/2006. Construction would occur from 2006 – 2008. This project has been assigned a *high priority* ranking, and is not development driven. Our opinion of the probable cost of this project, which includes the new reservoir, modifications to the existing reservoir, and pump station modifications is $2,100,000.

3.5.2.4 New Water Tank: Future Loop Road Development

The Loop Road area can currently be served by Pressure Zone 6 to an elevation of approximately 210-ft (msl). *In order to meet the future demands resulting from development of higher elevations in the Loop Road area, a new 200,000 gallon water tank is recommended (see Figure 3-3).* The tank should be located on the hillside east of Loop Road at an elevation of approximately 450-ft (msl), and would be supplied by a pump station located on North Loop Road (see Section 3.5.3.4). This new reservoir would create a new pressure zone for the Loop Road area. PRVs should connect this new pressure zone with Zone 6. This project could be financed by the developer or through the creation of a new assessment district. An assessment district could also be used to fund the operation and maintenance costs. This project is development driven, and has been assigned a *low priority* ranking. Our opinion of the probable cost of the new water tank is $458,000.

3.5.2.5 New Water Tank: Future South Fortuna Development

The south Fortuna area east of Rohnerville Road and south of Drake Hill Road is currently experiencing a significant amount of growth. This area is served by the Drake Hill hydropneumatic pump station. When the 1986 Hydraulic Study was performed, the demand in the area served by the Drake Hill Road hydropneumatic station was low enough that the pressure tanks were adequate to supply the average daily demand and meet fire flow requirements. Depending on the possible annexation of lands south of Drake Hill Road and the amount of growth this area experiences, the Drake Hill P.S. may eventually have inadequate capacity to meet domestic and potential industrial needs, as well as provide adequate fire flows. As this area continues to develop a more reliable water supply will be needed. In the 1986 Hydraulic Study a 250,000 gallon reservoir located at an elevation to provide a minimum pressure of 30 psi to the highest home served was recommended. *Depending on extent of development and annexation, a 250,000 gallon reservoir should be constructed to serve this area.* The reservoir should be located on the hillside east of Rohnerville Road and Hillras Road at an elevation of approximately 600-ft (msl) (see Figure 3-5). The existing Drake Hill Road P.S. could be used to boost water to the new reservoir (see Section 3.5.3.6). PRVs should connect this new pressure zone with Zone 6. This project could be financed by the developer or through the creation of a new assessment district. An assessment district could also be used to fund the operation and maintenance costs. This project has been assigned a *low priority* ranking, and is development driven. Our opinion of the probable cost of the new elevated water tank is $544,000.

3.5.2.6 New Water Tank: Future Campton Heights Development

There is high development potential for the area surrounding the Campton Heights Reservoir. Elevations in this area range from approximately 300-ft (msl) to over 400-ft (msl). Because of the elevation of this area, adequate water pressure can not be provided with the Campton Heights Reservoir, which has a hydraulic grade of approximately 365-ft. The capacity and maximum service elevation of the Senneca P.S. is also insufficient to meet the demands of this area (see Section 3.5.3.3). *To meet the demands and fire flow requirements of this area, a new 150,000 gallon elevated tank is recommended (see Figure 3-4).* The new tank should be constructed with a hydraulic grade of approximately 500-ft (msl) in order to provide a minimum pressure of 30 psi to the highest home served. *A new pump station located at the Campton Heights Reservoir should be constructed to boost water to this new elevated tank (see Section 3.5.3.5).* This project would create a new pressure zone. PRVs should connect this new pressure zone with Zone 6. This project could be financed by the developer or through the creation of a new assessment district. An assessment district could also be used to fund the operation and maintenance costs. This project has been assigned a *low priority* ranking, and is development driven. Our opinion of the probable cost of the new water tank and pump station is $941,000.

3.5.3 Pumping Facility Improvements

3.5.3.1 Pump Station Upgrade: Corrosion Control Facility

The cavitation problems previously described at the Corrosion Control Facility are a result of the improper selection and application of centrifugal pumps. Centrifugal pumps are designed for

inline applications where positive pressure exists on both the intake and discharge ends of the pump. Because the pumps at the Corrosion Control Facility are located above a wet well, a positive pressure exists on the discharge side of the pumps and a negative pressure exists on the suction end. Vertical turbine pumps are designed for submersed installation in open sumps and wells. Because they are constantly submersed the impeller is always flooded, which eliminates the need to prime the pumps. Replacement of the existing centrifugal pumps with vertical turbine pumps would allow this facility to operate much more efficiently and without the need to have two pumps operating in parallel (see Figure 3-4). *It is recommended that vertical turbine pumps be installed at the CCF when the City decides to replace the existing centrifugal pumps.* This project is not development driven, and has been assigned a *low priority* ranking. Our opinion of the probable cost of this project is $403,000.

3.5.3.2 Pump Station Upgrade: Stewart Pump Station (City Project No. 9327 & 9124)

As part of the Stewart Reservoir Replacement Project, the existing 5 hp pumps which boost water from the Stewart Reservoirs to the Vancil Reservoir would be upsized to increase their capacity and improve time of use pumping (see Figure 3-1). Currently, this pump station is able to pump water on its own at a rate of approximately 170 gpm. Of this flow, approximately 80 gpm is fed to the Vancil Reservoir, while the remainder flows to Pressure Zones 2 and the Underhill Pump Station, which boosts water to the Hillside Reservoir. When the Stewart P.S. and CCF P.S. operate in parallel, the Stewart P.S. capacity increases to approximately 200 gpm. Over an 8 hour pumping period, the Stewart P.S. is able to pump about 38,000 gallons of water to the Vancil Reservoir. The size and capacity of the replacement pumps should be determined during the pump station design. This project has been assigned a *high priority* ranking. Our opinion of the probable cost of the pump station upgrade is included in the Stewart Reservoir Project (see Section 3.5.2.3).

3.5.3.3 Service Capacity: Senneca Hydropneumatic Station

The Senneca hydropneumatic pump station was designed to serve the Forest Hills Subdivision in Pressure Zone 8 east of Rohnerville Road. The pump station was designed to serve 40 residential homes, and can provide a peak hour domestic flow of approximately 115 gpm, and a fire flow of approximately 1,200 gpm. The two 400 gallon hydropneumatic tanks at this station have a total active storage volume of approximately 100 gallons based on service elevations in this subdivision. Because of the intended use and capacity of this pump station, it is recommended that it serve not more than the intended 40 residential homes, and that homes served by this pump station be located at an elevation of not more than 350-ft (msl). Any additional demand will increase pump cycling decreasing the life of the pump motors. If additional development is planned for the area surrounding the Forest Hills Subdivision, the new water storage tank proposed in Section 3.5.2.4 is recommended.

3.5.3.4 New Pump Station: Loop Road Booster Pump Station

In order to meet the demands of anticipated future growth in the Loop Road area east of Rohnerville Road, the 1986 Hydraulic study recommended a new booster station because of the area's high elevations. This recommendation is again recommended in this study. The new

booster station would pump water from Zone 6 to the area's higher elevations. This area can currently be served by Pressure Zone 6 to an elevation of approximately 210-ft (msl). The booster station should be located on North Loop Road at an elevation of approximately 150-ft (msl) (see Figure 3-3). The pump station could initially operate as a hydropneumatic station depending on anticipated levels of growth, but would eventually serve a new reservoir located on the hillside east of Loop Road (see Section 3.5.2.4). This project could be financed by the developer or through the creation of a new assessment district. An assessment district could also be used to fund the operation and maintenance costs. This project is development driven, and has been assigned a *low priority* ranking. Our opinion of the probable cost of this project is $391,000.

3.5.3.5 New Pump Station: Campton Heights Booster Pump Station

In order to boost water to the new water tank recommended for the hillside area around the Campton Heights Reservoir (see Section 3.5.2.6) a new booster station is proposed (see Figure 3-4). This pump station should be located at the Campton Heights Reservoir site, and would boost water from Pressure Zone 6 to this new pressure zone. This project could be financed by the developer or through the creation of a new assessment district. An assessment district could also be used to fund the operation and maintenance costs. Our opinion of the probable cost of this project is included with the new tank in Section 3.5.2.6.

3.5.3.6 Pump Station Upgrades: Drake Hill Pump Station (City Project No. 9526)

Because of increased demands in Pressure Zone 7, the City is planning to add additional pressure tanks to the Drake Hill P.S. to increase its capacity (see Figure 3-5). The pumps at this station are currently operating more often than they were designed to, and the additional pressure tanks will reduce the amount of pump cycling and increase the life of the pump motors. While this upgrade will provide a temporarily solution to the increased demands in this area, a new tank should eventually be constructed to serve Zone 7 (see Section 3.5.2.5). *When a new tank is built, the Drake Hill P.S. should be modified to operate as a booster station to supply the new tank with water from Zone 6.* This project is development driven, and has been assigned a *low priority* ranking. Our opinion of the probable cost of this project is $78,000.

3.5.4 Distribution System Improvements

This section describes water main replacement projects, and new water main installation projects. There are several reasons for replacing or installing new water mains, including excessive leakage or breaks, low hydraulic capacity or increased demands due to new customers, water quality problems, and infrastructure renewal.

There is a 640-ft length of 4" PVC pipe which crossed under U.S. Highway 101 connecting the 8" C900 main on Dinsmore Drive at the Fortuna Wastewater Treatment Plant with the 6" C900 main on Loni Drive creating a loop that connects mains on the east and west sides of U.S. Highway 101. Hydraulic analysis of this water main show that while the pumps at the CCF are operating, velocities exceed 6 ft/s. Flows in this pipe during this scenario are approximate 240 gpm. Because this is not a critical section of transmission main, does not serve any of the City's

fire hydrants, and would be costly to replace because of its location under the freeway, upsizing is not necessary.

A new fire hydrant is recommended at the Fortuna Wastewater Treatment Plant (see Figure 3-2). There are currently no fire hydrants serving the WWTP. A minimum of one new fire hydrant connected to the existing 6" C900 water main on Dinsmore Drive should be installed at the WWTP to meet the fire protection needs of this critical public facility. This project is not development driven, and has been assigned a *high priority* ranking. Our opinion of the probable cost of this project is $4,000.

3.5.4.1 Uncompleted 1986 Hydraulic Study Recommendations

In follow-up to the recommendations made in the 1986 Hydraulic Study, it is recommended that the remaining uncompleted water main improvements discussed above be completed. These improvements are listed below.

1) New 8" C900 on L Street between 8th Street and 10th Street;
2) New 6" C900 in the alley between 13th Street and 14th Street and between N Street and P Street;
3) New 10" C900 on Rohnerville Road between Senestraro Way and Pryor Court, with a PRV at Senestraro Way;

Improvements 1) and 2) will provide distribution mains where none currently exist, help improve hydraulics and fire flows in the downtown area, and increase the transmission capacity to the Stewart Tanks and the Home Avenue Pump Station (see Figure 3-2). Improvement 2) has also been expanded to L Street by the City (see Section 3.5.4.4). Improvement 3) will connect Pressure Zones 1 and 6 improving supply reliability and allowing for future distribution mains on North Loop Road (see Figure 3-3). A new PRV is also recommended. Improvement 1) is not development driven, and has been assigned a *medium priority* ranking. Our opinion of the probable cost of this project is $121,000. Improvement 3) has also been assigned a *medium priority* ranking, and is not development driven. Our opinion of the probable cost of this project is $450,000.

3.5.4.2 Water Main Replacement: Ivy Lane, Holly Lane and Emerald Lane Projects (City Projects 9221 & 9421)

The City Public Works Department has identified the existing 2" PVC water mains on Holly Lane (City Project No. 9221) and Emerald Lane (City Project No. 9421) for replacement with 6" C900 (see Figure 3-3). The 2" PVC main on Ivy Lane should also be replaced with 6" C900. Hydraulic analyses of these sections of water main indicate that these projects will increase the flow capacity by about 800 percent. The water main replacement on Holly Lane is planned for 2005/2006, and the project on Emerald Lane is planned for 2006/2007. These projects are not development driven, and have each been assigned a *high priority* ranking. Our opinion of the probable cost of each project is $141,000.

3.5.4.3 New Water Main: North 9th Street Project (City Project No. 9622)

The City Public Works Department has plans to replace the aging 4" cast iron water main on 9th Street from P Street to Christian Ridge Road with 6" C900 in 2005/2006 (see Figure 3-1). Hydraulic analysis of this section of water main shows that this project will significantly improve capacity and fire flows in this area. At a minimum residual pressure of 20 psi, the capacity on 9th Street between P Street and Christian Ridge Road would increase by over 200 percent, and the capacity on 9th Street north of Christian Ridge Road would increase by about 150 percent. This project is not development driven, and has been assigned a *medium priority* ranking. Our opinion of the probable cost of this project is $186,000.

3.5.4.4 Water Main Replacement: 14th Street Project (City Project No. 9531)

As described above, the City Public Works Department is planning to install a new 6" C900 main in the alley between 13th Street and 14th Street and between P Street and N Street, and replacing the existing 4" cast iron main on 14th Street between L Street and N Street (see Figure 3-2). This project will significantly improve the flow capacity and hydraulics in this area. Currently, water pumped from the CCF primarily travels up 12th Street and Fortuna Boulevard. Fortuna Boulevard flows travel down L Street joining flows on 12th Street before traveling through various mains in the downtown area to 10th Street and 11th Street and up to the Stewart Reservoirs. The majority of water in the downtown area travels to the Stewart Tanks through mains on 7th Street, 10th Street, 11th Street, 13th Street, L Street, Main Street, N Street and P Street. This project will shift a portion of these flows to 14th Street, decreasing overall system headlosses, and improving fire flows on 14th Street. This project is not development driven, and has been assigned a *high priority* ranking. Our opinion of the probable cost of this project is $228,000.

3.5.4.5 Water Main Replacement: Park Street Project (City Project No. 9820)

The City Public Works Department has identified the existing 4" cast iron water main crossing Rohner Creek on N Street between 16th Street and Park Street for removal (see Figure 3-2). This section of pipe is very old and in an unstable location. In the event of a main break at the creek crossing, chlorinated water would be discharged directly into Rohner Creek, a known salmonid bearing stream. This project would eliminate this potential problem. A new blow off valve should be installed at the end of the 4" cast iron main on N Street. This project is not development driven, and has been assigned a *high priority* ranking. Our opinion of the probable cost of this project is $30,000.

3.5.4.6 Water Main Replacement: Smith Lane Project (City Project No. 9431)

The City Public Works Department had identified the exiting 6" AC at the intersection of Smith Lane and Fortuna Boulevard for replacement with 8" C900 (see Figure 3-2). This project is no longer necessary because of the new 8" C900 main located between 15th Street and Fortuna Boulevard to the western most hydrant on west Smith Lane. The new project on Smith Lane should be to create a new loop between Fortuna Boulevard and Rohnerville by connecting the 6" C900 main at the east end of Smith Lane with the 6" AC main on Rohnerville Road. This Project

would increase capacity and improving the reliability of the water supply in this area. This project is not development driven, and has been assigned a *high priority* ranking. Our opinion of the probable cost of this project is $24,000.

3.5.4.7 Water Main Replacement: Eel River Drive Project (City Project No. 9720)

The City Public Works Department has identified the existing 12" asbestos-cement transmission main on Eel River Drive between the CCF and Kenmar Road for replacement with 14" C900 (see Figure 3-4). Hydraulic analysis of this water main show that with CCF pumps in operation, headloss is approximately 11-ft/100-ft and the velocity is greater than 6.5 ft/s. Using the design criteria outlined in earlier in this chapter, this section of water main is operating at capacity. Completion of this project will reduce headloss by approximately 25 percent and decrease the velocity to about 5 ft/s. Capacity would increase by approximately 40 percent. Maintaining the existing 12" main and operating the new 14" main in parallel would increase capacity by approximately 240 percent. This project is not development driven, and has been assigned a *high priority* ranking. Our opinion of the probable cost of this project is $430,000.

3.5.4.8 Water Main Replacement: Mill Street Project (City Project No. 9620)

The City Public Works Department has identified the existing 2" steel water pipe on Mill Street east of Jones Street for replacement with 6" C900 (see Figure 3-4). This project will eliminate a 550-ft section of old undersized pipe, and increase the capacity of this area by 800 percent. Available fire flows at the east end of Mill Street will increase from less than 80 gpm to approximately 1,000 gpm. This project is not development driven, and has been assigned a *high priority* ranking. Our opinion of the probable cost of this project is $90,000.

3.5.4.9 Water Main Replacement: 12th Street, Newburg Road and PL Mill Yard Project

Hydraulic analysis of the Fortuna water system indicates velocities in excess of 8 ft/s in the 8" asbestos-cement water mains on 12th Street between L Street and Newburg Road, on Newburg Road from 12th Street to Sunny Brook Drive, and from Sunny Brook Drive south through the Pacific Lumber Fortuna Mill Yard to Third Avenue (see Figure 3-2). These sections of water main are one of the primary transmission mains between the CCF and the Stewart Tanks, and have a flowrate of approximately 1,500 gpm when the CCF pump station is running. Approximately 75 percent of water destined for the Stewart Reservoirs travels north on 12th Street, while the remainder travels north on Fortuna Boulevard. The headloss in this section of pipe during this pumping condition is significant. It is recommended that this section of water mains, including mains on 11th Street between N Street and Main Street and Main Street between 11th Street and 12th Street be replaced with 12" C900 to increase the transmission capacity and reduce headloss during pumping. Extending this transmission main to the 10" cast iron main on 11th Street provide a direct route for water to be pumped from the CCF to the Stewart Reservoirs. This project will reduce headloss by approximately 75 percent while increasing the transmission capacity by over 100 percent. This project is not development driven, and has been assigned a *medium priority* ranking. Our opinion of the probable cost of this project is $1,776,000.

3.5.4.10 Water Main Replacement: Stewart Street and Vancil Street Project

With the upgrading the Stewart Reservoirs and P.S. during the Stewart Reservoir Replacement and Retrofit (see Sections 3.5.2.3 and 3.5.3.2) and the possible construction of a new reservoir to serve Pressure Zones 3 and 5 (see Section 3.5.2.1), the existing 8" AC mains on Stewart Street and Vancil Street should be replaced with 10" C900 to increase their capacity with the future increased capacity of the Stewart P.S. (see Figure 3-1) and the need to pump to the new reservoir serving Pressure Zone 3. This improvement will also increase time of use pumping at the Stewart P.S. This project is not development driven, and has been assigned a *low priority* ranking. Our opinion of the probable cost of this project is $258,000.

3.5.4.11 New Water Main: Redwood Way Project

A new 8" C900 water main is proposed for Redwood Way to serve future development in that area (see Figure 3-3). In the future, as development warrants, this new water line could be connected with the 8" AC main at the intersection of Redwood Way and Springville Avenue, creating another link between Zones 1 and 6. This project is development driven, and has been assigned a *low priority* ranking. Our opinion of the probable cost of this project is $178,000.

3.5.4.12 Water Main Replacement: Newburg Drive Project

Hydraulic analysis of the water mains at the intersection of Fortuna Boulevard and Newburg Drive indicates an undersized water transmission main. The 6" AC main crossing this intersection carries approximately 600 gpm when the CCF pumps are operating, and has velocities that exceed 6 ft/s. It is recommended that this section of main be replaced with 10" C900 to increase the transmission capacity serving mains on Newburg Drive, Fortuna Boulevard, and the 8" C900 main located between 15th Street and Fortuna Boulevard (see Figure 3-2). This project would increase transmission capacity through this intersection by approximately 175 percent. This project is not development driven, and has been assigned a *medium priority* ranking. Our opinion of the probable cost of this project is $40,000.

3.5.4.13 Water Main Replacement: 12th Street and O Street Project (City Project No. 9522)

The City Public Works Department has identified the existing 6" AC water mains located downtown between O Street and P Street and 11th Street and 12th Street to be abandoned and rerouted down 12th Street to O Street (see Figure 3-1). The existing mains are located on private property and present issues of accessibility, particularly if a main break in this area were to occur. There are also 2" cast iron service mains on Vista Drive that should be reconnected to the 10" cast iron main 11th Street when the 6" AC main is abandoned. This project is not development driven, and has been assigned a *high priority ranking*. Our opinion of the probable cost of this project is $73,000.

3.5.4.14 Create Closed Loop Systems

It is also recommended to eliminate dead ends in the branched distribution network by creating closed loops. Eliminating dead ends with closed loops will create an additional level of service

reliability and increase system capacity in those areas. In more rural areas or locations where development would limit accessibility, this may be too difficult or cost prohibitive. The following locations are recommended for looped systems:

- Joseph Street and Corina Court area;
- Francisco Place to Senestraro Way;
- Berry Creek Drive to Second Avenue;
- Bartlett Drive to Tami Drive;
- Rebecca Lane and Trinity Avenue, Tami Drive, or Rohnerville Road; and
- Connect other dead ends where feasible.

3.6 Capital Improvement Program

The purpose of the Capital Improvement Program (CIP) is to be a hands-on tool that is used by the City to plan subsequent work. The CIP prioritizes the 28 recommended and proposed water system improvement projects based on the following set of critical factors:

- Public health impacts
- Compliance with drinking water regulations
- Storage and supply limitations
- System age and replacement needs
- Rehabilitation or repair
- Cost-effectiveness
- Short-term construction impacts
- Impacts on operation and maintenance
- Potential to influence development, business growth, or create jobs

This method of assessing the relative value of the improvement projects is in adherence with the guidelines of the Government Accounting Standards Board Statement 34 (GASB-34). Adherence with these guidelines is an important step in protecting the City's bond rating.

The water system improvement projects described in this chapter are summarized in Table 3-1. Figures 3-1 through 3-5 show the locations of the proposed improvements. Improvement projects are shown in **bold blue**. Using the above set of critical factors, the proposed projects were assigned a high, medium or low priority ranking. In addition to these rankings, Table 3-1 shows a recommended grouping of projects, and the order in which they should be completed. It is important to note that this priority ranking may change as conditions within the City change and as future development occurs. Also, developers typically fund development-driven projects in part or in full.

3.7 Pressure Zone Modifications

As a result of the improvements described herein, we recommend that the existing pressure zones, as shown in Figure 1-2, be modified as shown in Figure 3-6. The new tank replacing the Holman Tank would combine Zones 3 and 5 into a single Zone 3, which would also include north 9th Street.

Zones 1, 2, 6, and 7 would essentially remain the same.

Zone 4 could be enlarged to approximately the same service area proposed in the 1986 Hydraulic Study.

Zone 8 would be reduced to include only the Forest Hills Subdivision based on the capacity of the Senneca P.S.

The Loop Road area, east of Rohnerville Road, is expected to be developed in the future. At such time that water service is needed for this area, a separate booster station and water tank will be necessary to serve it because of the area's high elevations. The booster station is recommended to be installed off of Zone 6, thereby creating a new Pressure Zone 5.

The area surrounding the Campton Heights Reservoir is also expected to be developed in the future. When this development occurs, a separate booster station and water tank will be needed to serve it because it is located above the hydraulic grade of the Campton Heights Reservoir. The booster station should be installed off of Zone 6, thereby creating a new Pressure Zone 9.

If all of the improvement projects described in this study were implemented, there would be a net increase of 1 pressure zone within the City of Fortuna.

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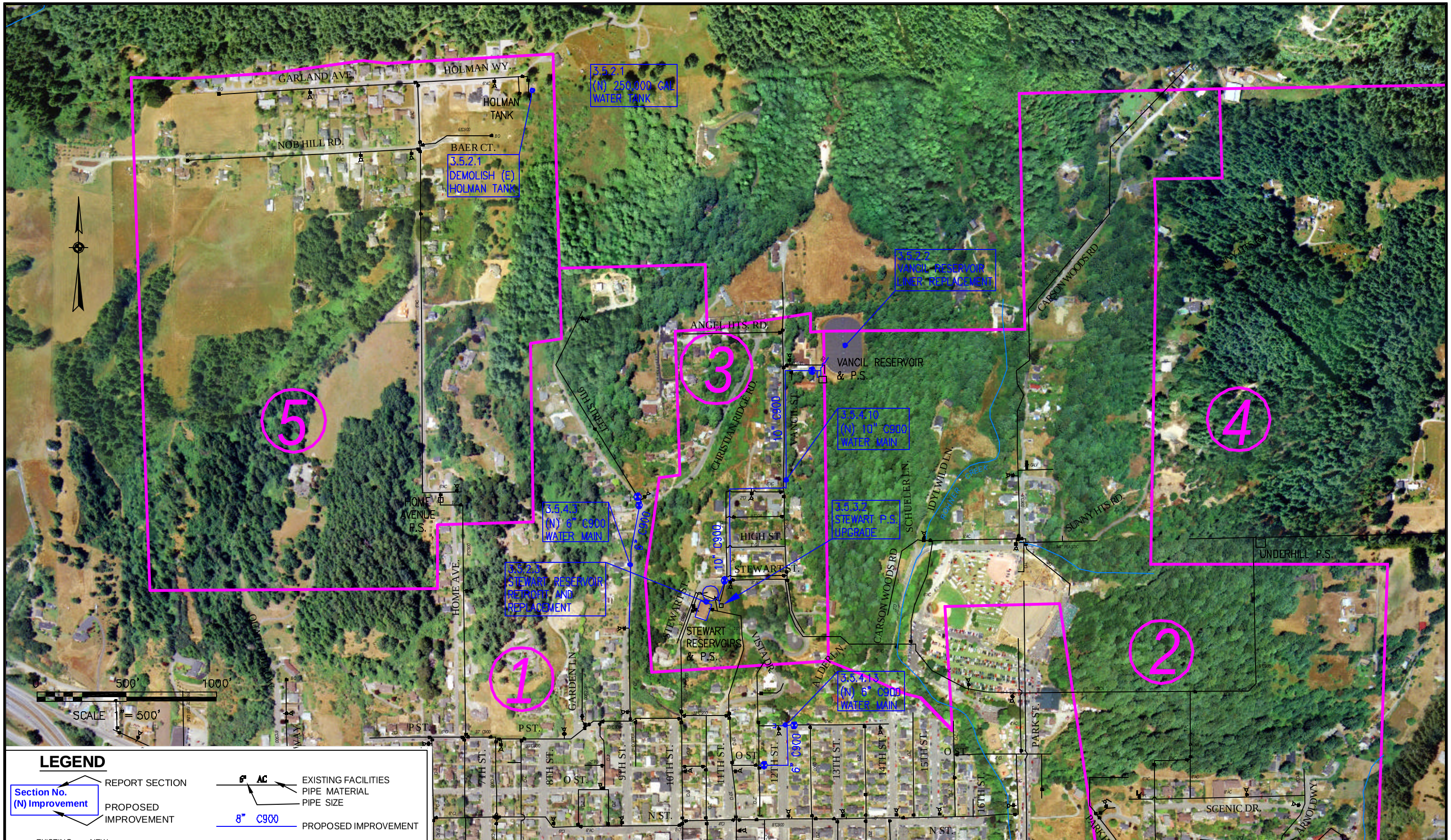

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CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
PROPOSED IMROVEMENTS

NORTH FORTUNA

FIGURE 3-1

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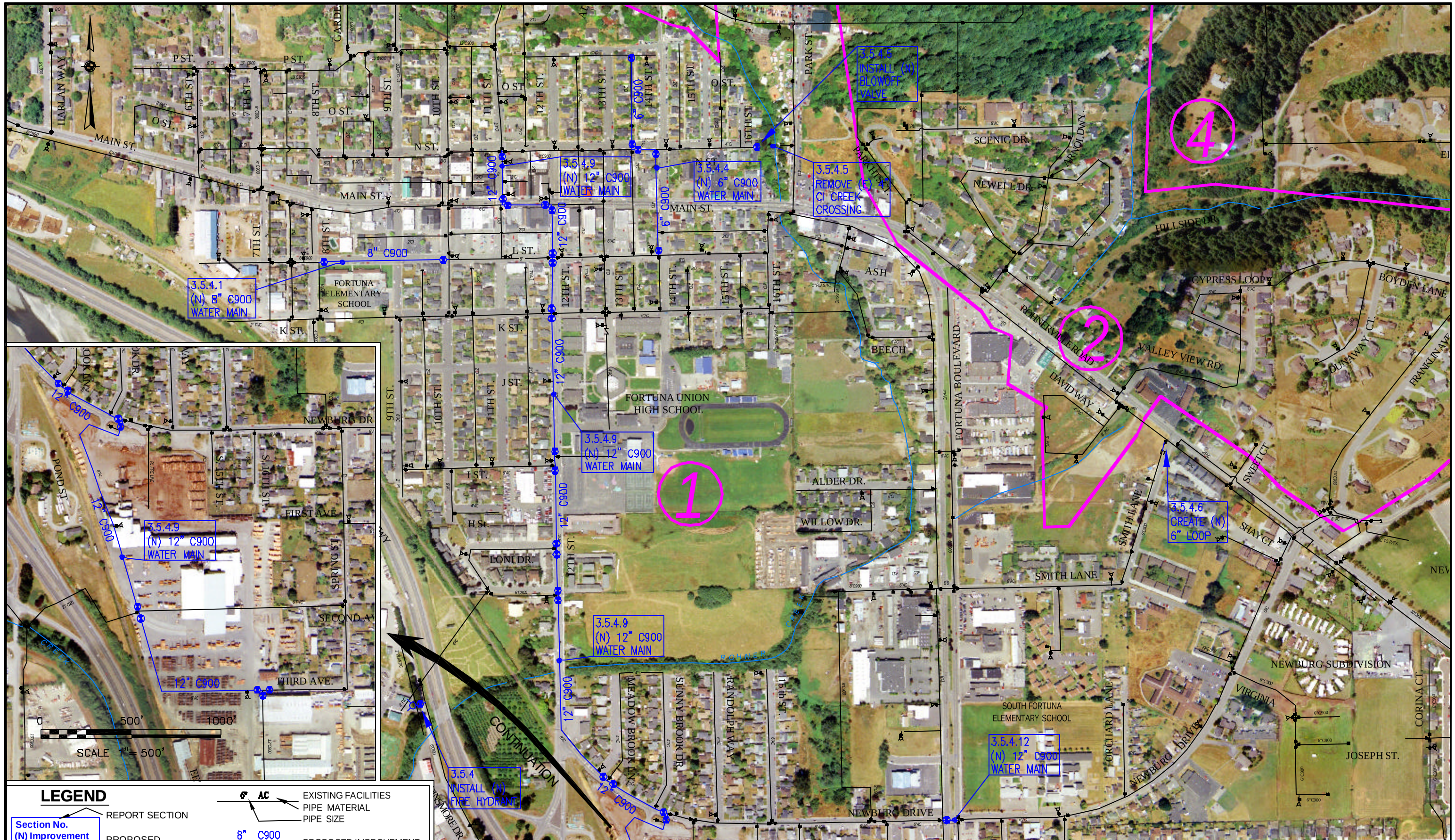

LEGEND

Section No. (N) Improvement	REPORT SECTION / PROPOSED IMPROVEMENT
EXISTING / NEW	GATE VALVE
EXISTING / NEW	PRV
6" AC	EXISTING FACILITIES PIPE MATERIAL PIPE SIZE
8" C900	PROPOSED IMPROVEMENT
	WATERWAY
	PRESSURE ZONE NUMBER & BOUNDARY

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CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
PROPOSED IMROVEMENTS

DOWNTOWN FORTUNA

FIGURE 3-2

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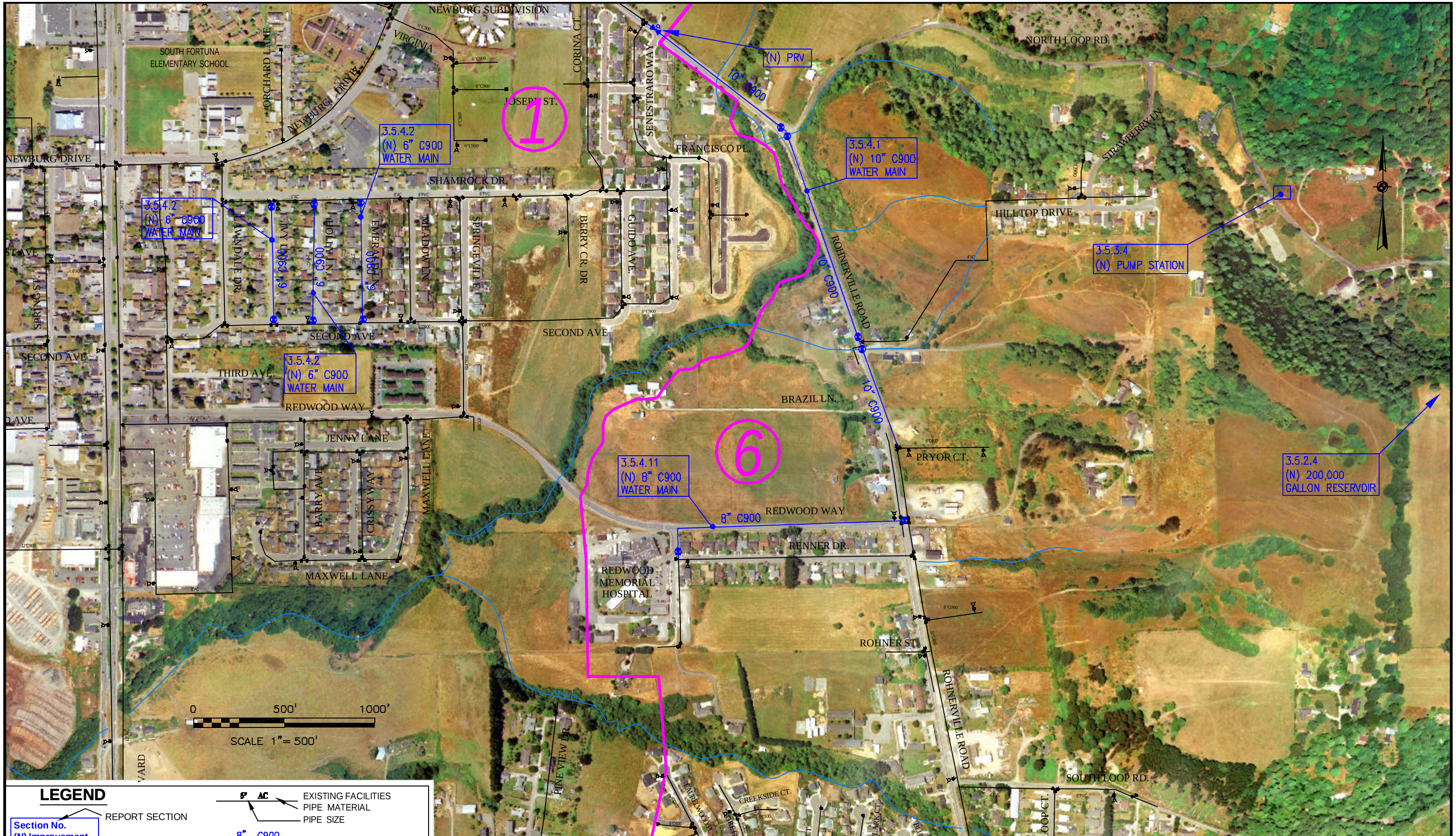

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CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
PROPOSED IMROVEMENTS

EAST CENTRAL FORTUNA

FIGURE 3-3

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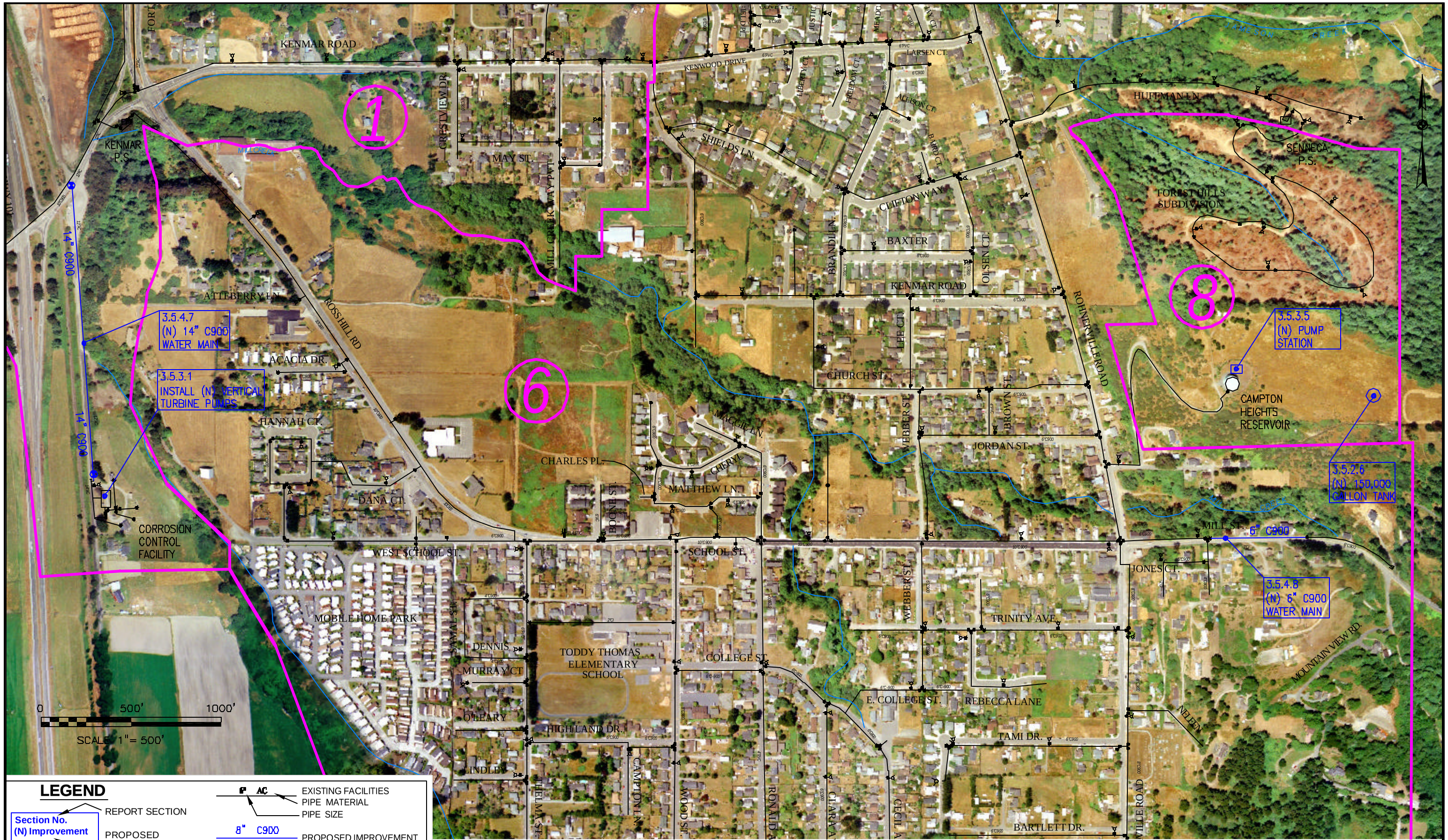

LEGEND

- REPORT SECTION
- Section No. / (N) Improvement — PROPOSED IMPROVEMENT
- EXISTING / NEW — GATE VALVE
- PRV
- 6" AC — EXISTING FACILITIES PIPE MATERIAL PIPE SIZE
- 8" C900 — PROPOSED IMPROVEMENT
- WATERWAY
- PRESSURE ZONE NUMBER & BOUNDARY

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CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
PROPOSED IMROVEMENTS

FORTUNA: CAMPTON HEIGHTS

FIGURE 3-4

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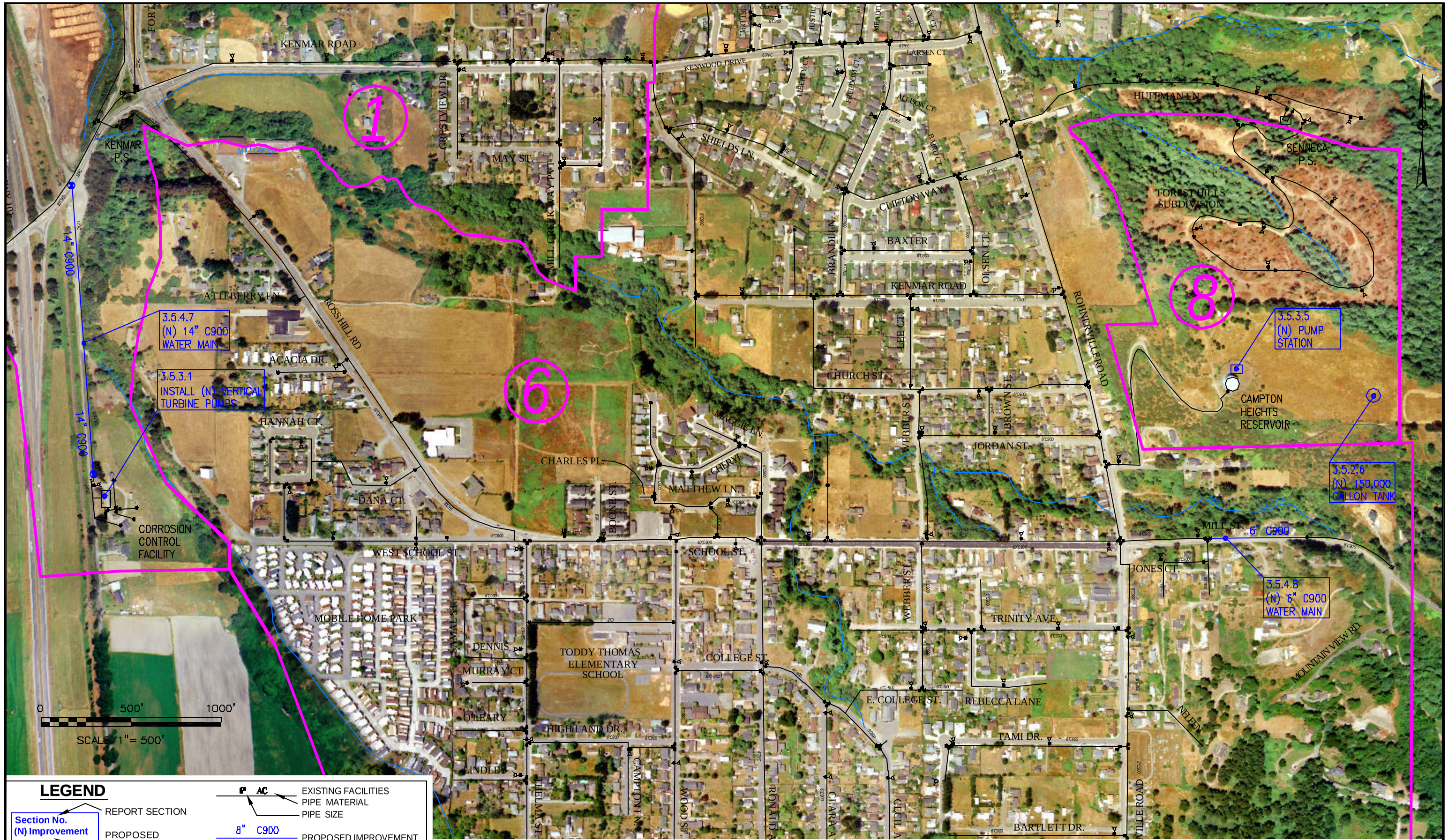

LEGEND

- REPORT SECTION
- Section No. / (N) Improvement — PROPOSED IMPROVEMENT
- EXISTING / NEW — GATE VALVE
- PRV
- 6" AC — EXISTING FACILITIES PIPE MATERIAL PIPE SIZE
- 8" C900 — PROPOSED IMPROVEMENT
- WATERWAY
- PRESSURE ZONE NUMBER & BOUNDARY

JOB # 04105401
DESIGN MK
DRAWN MK

CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
PROPOSED IMROVEMENTS

FORTUNA: CAMPTON HEIGHTS

FIGURE 3-4

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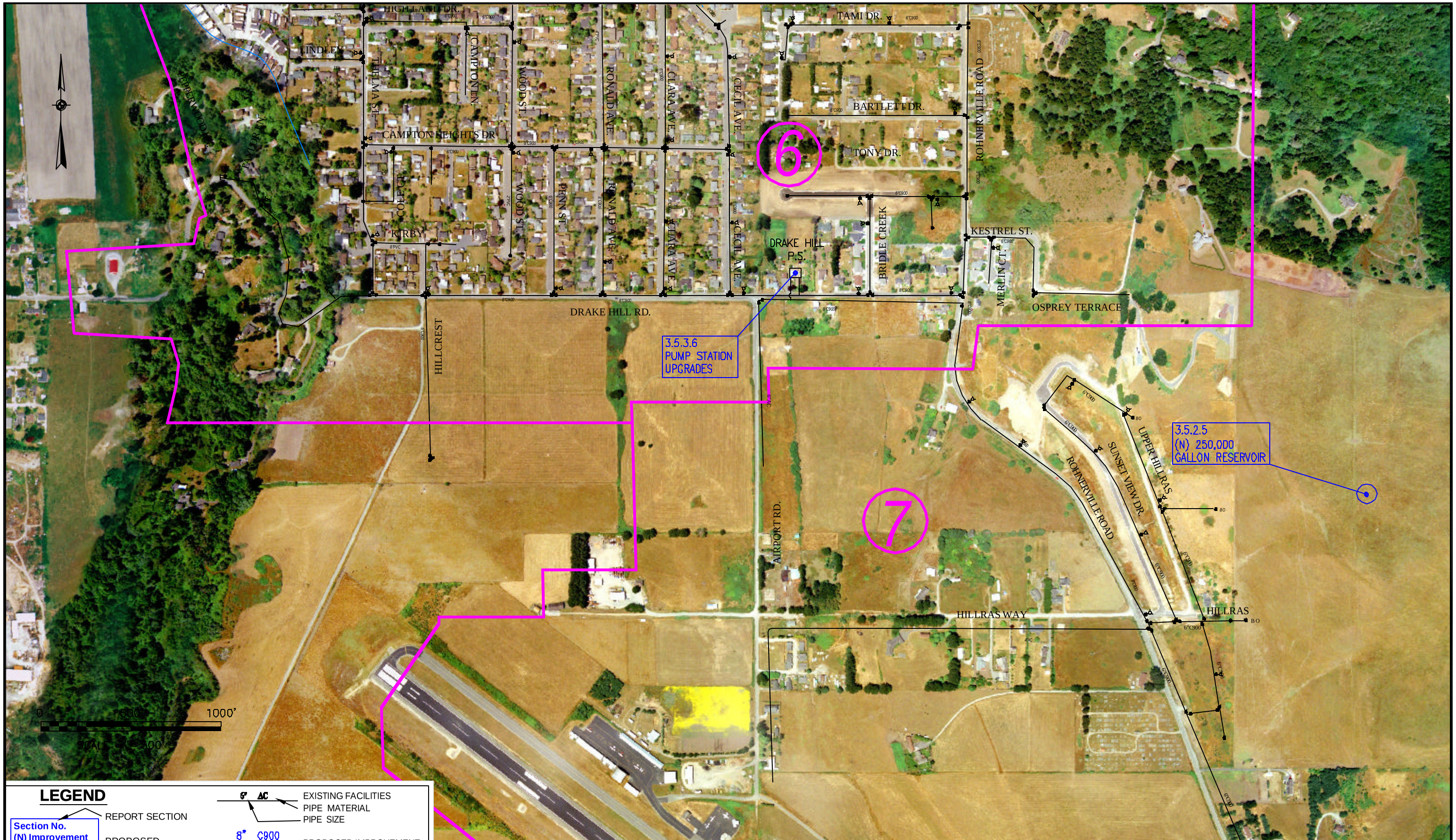

LEGEND

Section No.
(N) Improvement

REPORT SECTION

PROPOSED IMPROVEMENT

EXISTING	NEW	
		GATE VALVE
		PRV

6" AC — EXISTING FACILITIES PIPE MATERIAL PIPE SIZE

8" C900 — PROPOSED IMPROVEMENT

WATERWAY

PRESSURE ZONE NUMBER & BOUNDARY

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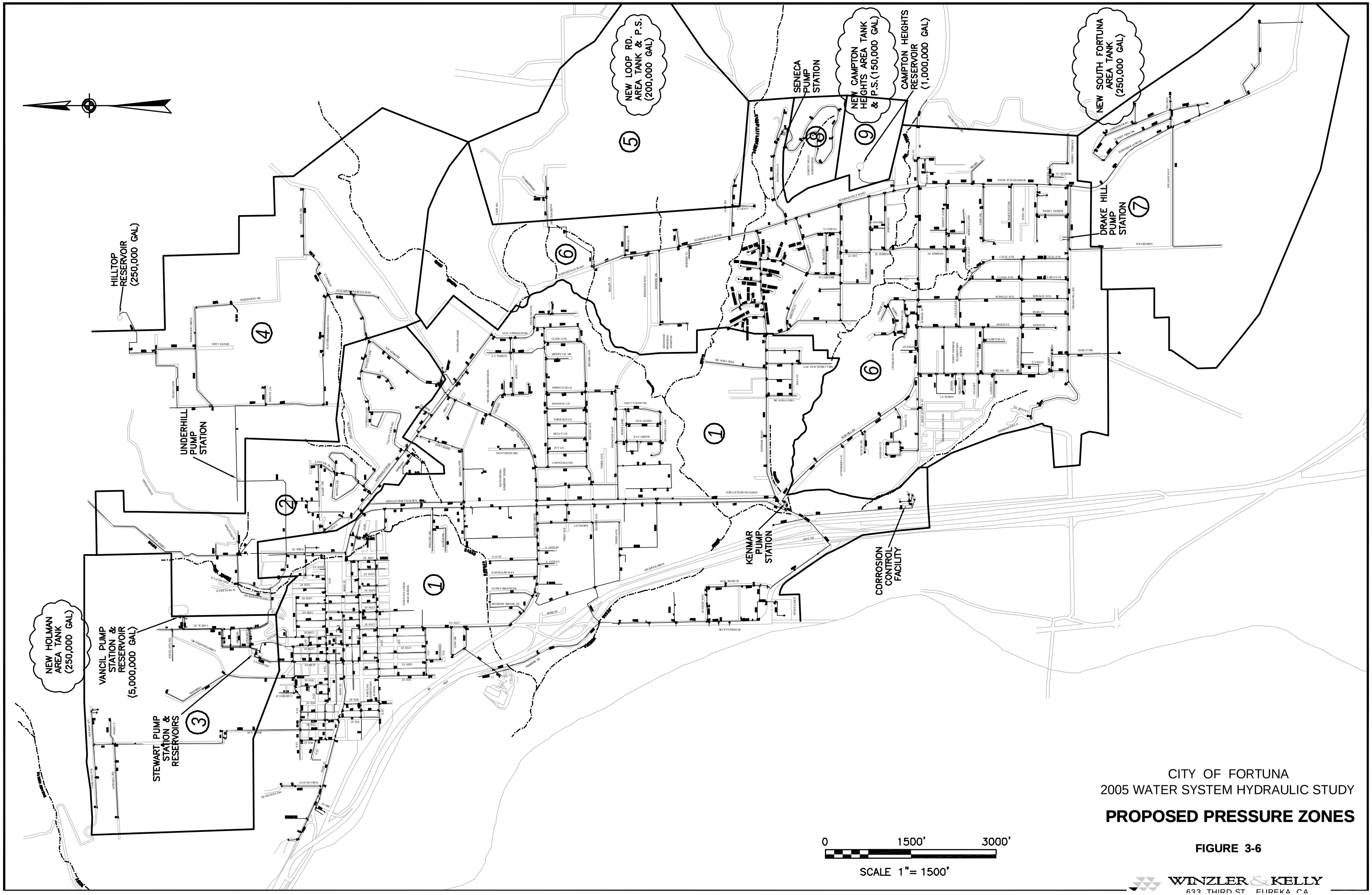
CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY
PROPOSED IMROVEMENTS

ROHNERVILLE/SOUTH FORTUNA

FIGURE 3-5

WINZLER & KELLY



CITY OF FORTUNA
2005 WATER SYSTEM HYDRAULIC STUDY

PROPOSED PRESSURE ZONES

FIGURE 3-6

WINZLER & KELLY
633 THIRD ST. EUREKA, CA

FILE: J:\CAD\JOBS\2004\04105401\dwg\054b-f3-06.dwg DATE: Aug 12 05 @ 4:59pm

TABLE 3-1 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA WATER SYSTEM

Ranking H = High M = Medium L = Low Numbers indicate project order	**Report Section**	**Location**	**Existing Water Facility**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
H-1	3.5.3.6	Drake Hill P.S.	2x650 Gallon Pressure Tanks	2 New Pressure Tanks	YES	$60,000
H-2	3.5.4.5	Park St.	4” Cast Iron	Remove Rohner Creek Crossing	NO	$30,000
H-3	3.5.4.13	12th St. & O St.	6” AC	Reroute w/6” C900	NO	$73,000
H-4	3.5.4	Disnmore Dr.	No Fire Hydrant	New Fire Hydrant	NO	$4,000
H-5	3.5.4.6	Smith Ln.	6” C900	Tie to 6” AC on Rohnerville Rd.	NO	$24,000
H-6	3.5.2.3	Stewart Reservoirs	Two 500,000 Gallon Reservoirs	Replace Rectangular Reservoir & Increase Capacity of Circular Reservoir	NO	$2,100,000
H-6	3.5.3.2	Stewart P.S.	2x5 Hp Centrifugal Pumps	Increase Pumping Capacity	NO	See 3.5.2.3
H-7	3.5.2.2	Vancil Reservoir	5 Million Gallon Reservoir	Replace Liner	NO	$563,000
H-8	3.5.4.8	Mill St.	2” Steel	Replace w/6” C900	NO	$90,000
H-9	3.5.4.4	14th St.	None	Install New 6” C900	NO	$228,000
H-10	3.5.4.2	Holly Ln.	2” Cast Iron	Replace w/6” C900	NO	$141,000
H-11	3.5.4.2	Emerald Ln.	2” Cast Iron	Replace w/6” C900	NO	$141,000
H-12	3.5.4.2	Ivy Ln.	2” Cast Iron	Replace w/6” C900	NO	$141,000
H-13	3.5.4.7	Eel River Dr.	12” AC	Replace w/14” C900	NO	$430,000

TABLE 3-1 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA WATER SYSTEM (CONTINUED)

Ranking H = High M = Medium L = Low Numbers indicate project order	**Report Section**	**Location**	**Existing Water Facility**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
M-14	3.5.4.9	11th St., Main St., 12th St.	8” Cast Iron, 6” Cast Iron, 8” AC	Replace w/12” C900	NO	$1,776,000
M-14	3.5.4.9	Newburg Rd.	8” AC	Replace w/12” C900	NO	See 3.5.4.9
M-14	3.5.4.9	Pacific Lumber Mill	8” AC	Replace w/12” C900	NO	See 3.5.4.9
M-15	3.5.4.3	North 9th St.	4” Cast Iron	Replace w/6” C900	NO	$186,000
M-16	3.5.4.12	Newburg Dr.	6” AC	Replace w/10” C900	NO	$40,000
M-17	3.5.4.1	L St.	None	Install New 8” C900	NO	$121,000
M-18	3.5.2.1	Holman Tank	36,000 Gallon Elevated Steel Tank	Demolish Tank	NO	$174,000
M-19	3.5.2.1	Holman Way Area	36,000 Gallon Elevated Steel Tank	New 250,000 Gallon Reservoir	NO	$1,000,000
M-20	3.5.2.6	Campton Heights	None	150,000 Gallon Reservoir	YES	$941,000
M-20	3.5.3.5	Campton Heights	None	New Booster Pump Station	YES	See 3.5.3.5
M-21	3.5.4.1	Rohnerville Rd.	None	Install New 10” C900	NO	$450,000
L-22	3.5.3.1	Corrosion Control Facility	3x100 Hp Centrifugal Pumps	3 New Vertical Turbine Pumps	NO	$403,000

TABLE 3-1 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA WATER SYSTEM (CONTINUED)

Ranking H = High M = Medium L = Low Numbers indicate project order	**Report Section**	**Location**	**Existing Water Facility**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
L-23	3.5.4.11	Redwood Way	None	Install New 8” C900	YES	$178,000
L-24	3.5.3.4	Loop Rd.	None	New Booster Pump Station	YES	$391,000
L-25	3.5.2.4	Loop Rd.	None	New 200,000 Gallon Reservoir	YES	$458,000
L-26	3.5.4.10	Stewart St.	8” AC	Replace w/10” C900	NO	$258,000
L-26	3.5.4.10	Vancil St.	8” AC	Replace w/10” C900	NO	See 3.5.4.10
L-27	3.5.3.6	Drake Hill P.S.	2x20 Hp and 1x50 Hp Centrifugal Pumps	Retrofit P.S. as Booster Station For New Reservoir	YES	$78,000
L-28	3.5.2.5	East of Hillras Rd.	None	New 250,000 Gallon Reservoir	YES	$544,000

Appendix A
Pump Curves

Well Field P.S.

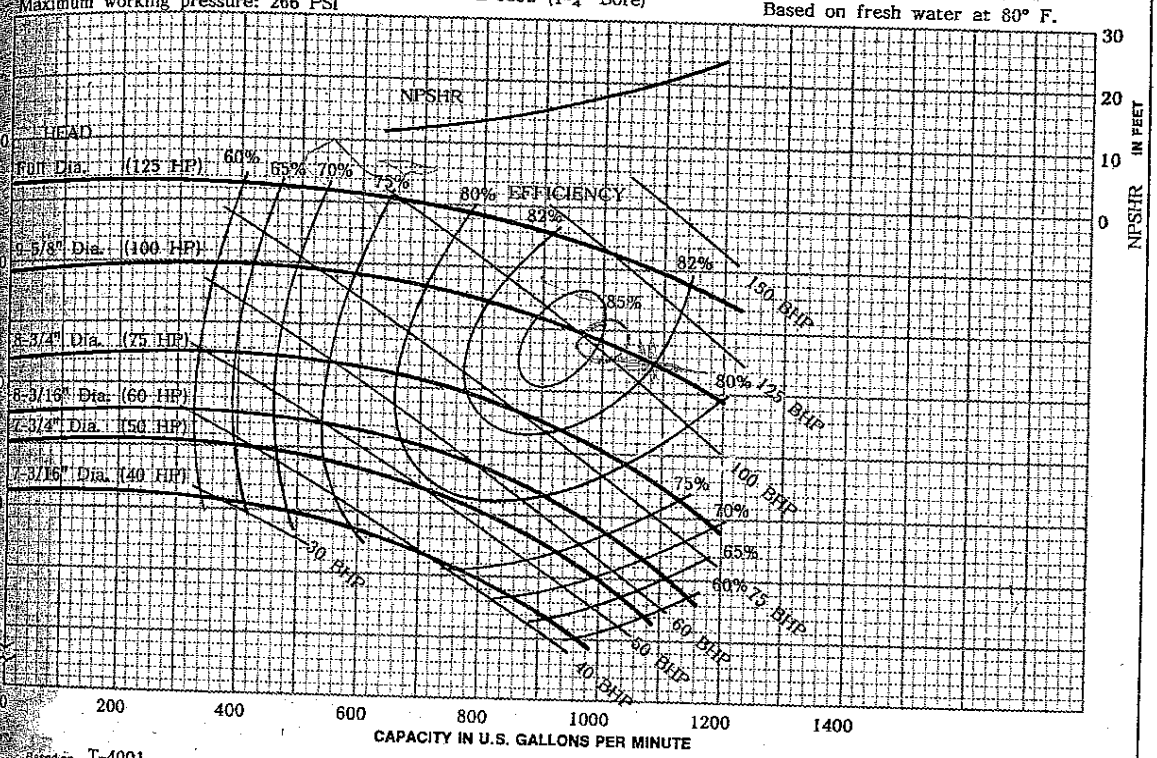
BERKELEY PUMPS
Pumptron Division—Transamerica Delaval, Inc.

BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

CURVE	4075
DATE	4-1-85
PAGE	4.03
SUPERSEDES	
Curve 4075 Page 4.03	
Dated 1-15-82	

Case: Material C.I. Patt. No. H-1939 Mach. No. H-1939
Impeller: Material C.I. Patt. No. L-5889 Mach. No. L-5889 (1-5/8" Bore) L-5892 (1-¼" Bore)
3600 Nominal R.P.M. 60 Cycles
Dia. 10-7/16" (Full)
Maximum working pressure: 266 PSI
Based on fresh water at 80° F.



Based on T-4001 Supersedes New Dated - - Date 10-20-84 MODEL B4EPBM

Kenmar P.S.

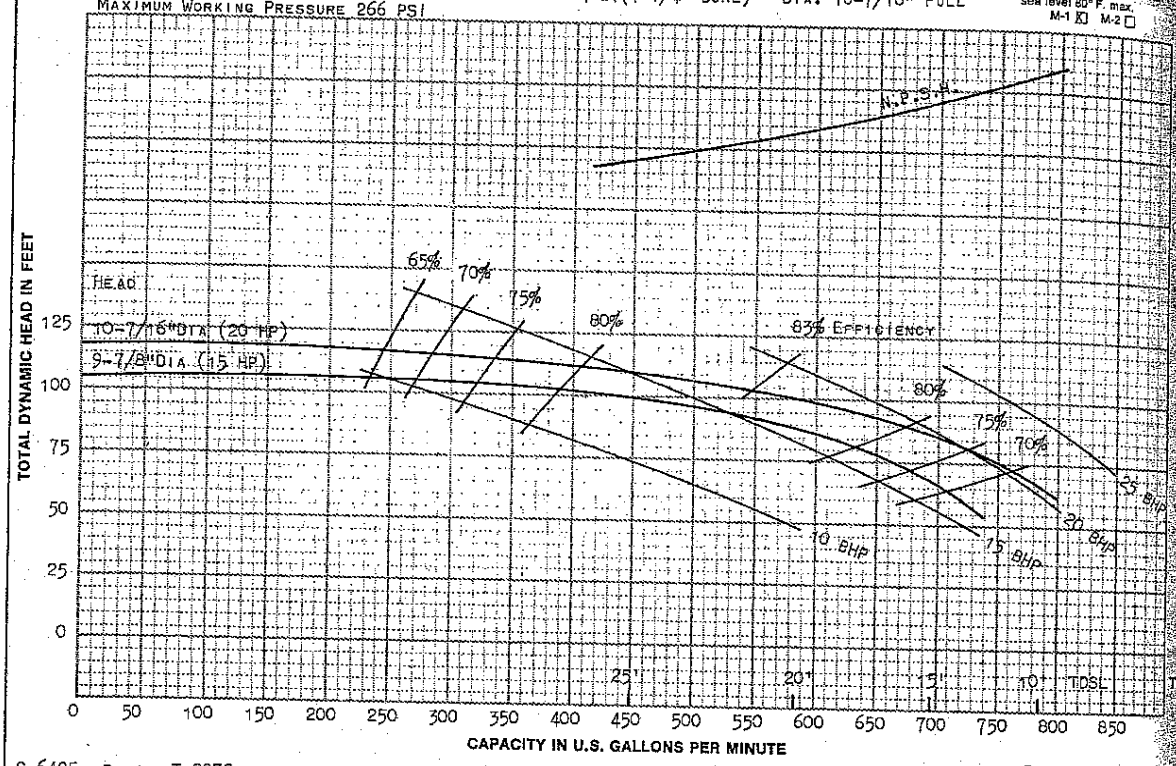
BERKELEY PUMPS
Pumptron Division—Transamerica Delaval, Inc.

BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

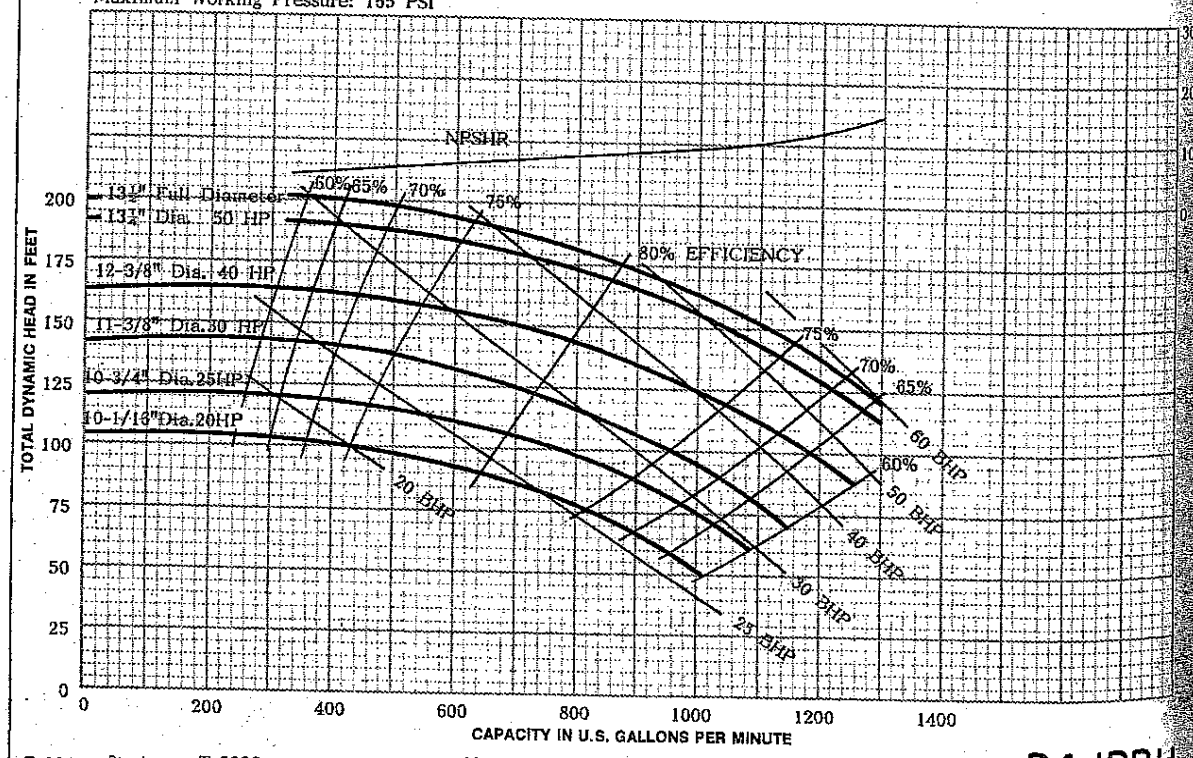
CURVE
DATE
PAGE
SUPERSEDES
Curve 4075 Page
Dated 10-9-

Case: Material C.I. Patt. No. H-1939 Mach. No. H-1939
Impeller: Material C.I. Patt. No. M-2319 Mach. No. M-4821(1-1/4" Bore) Dia. 10-7/16" Full
1800 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐
Maximum Working Pressure 266 PSI



C-6425 Based on T-2875 Supersedes C-6425 Dated 7-11-67 Date 3-9-72 MODEL B4EPM

Case: Material C.I. Patt. No. H-809 Mach. No. H-3869
Impeller: Material C.I. Patt. No. L-5807 Mach. No. L-5807 Dia. 13½" (Full)
1800 NOMINAL R.P.M. 60 Cycles
Based on Fresh Water @ 80° F.
Maximum Working Pressure: 165 PSI



C-9013 Based on T-3986 Supersedes New Date MODEL B4 IPRH

Kenmar R.S.

BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

BERKELEY®

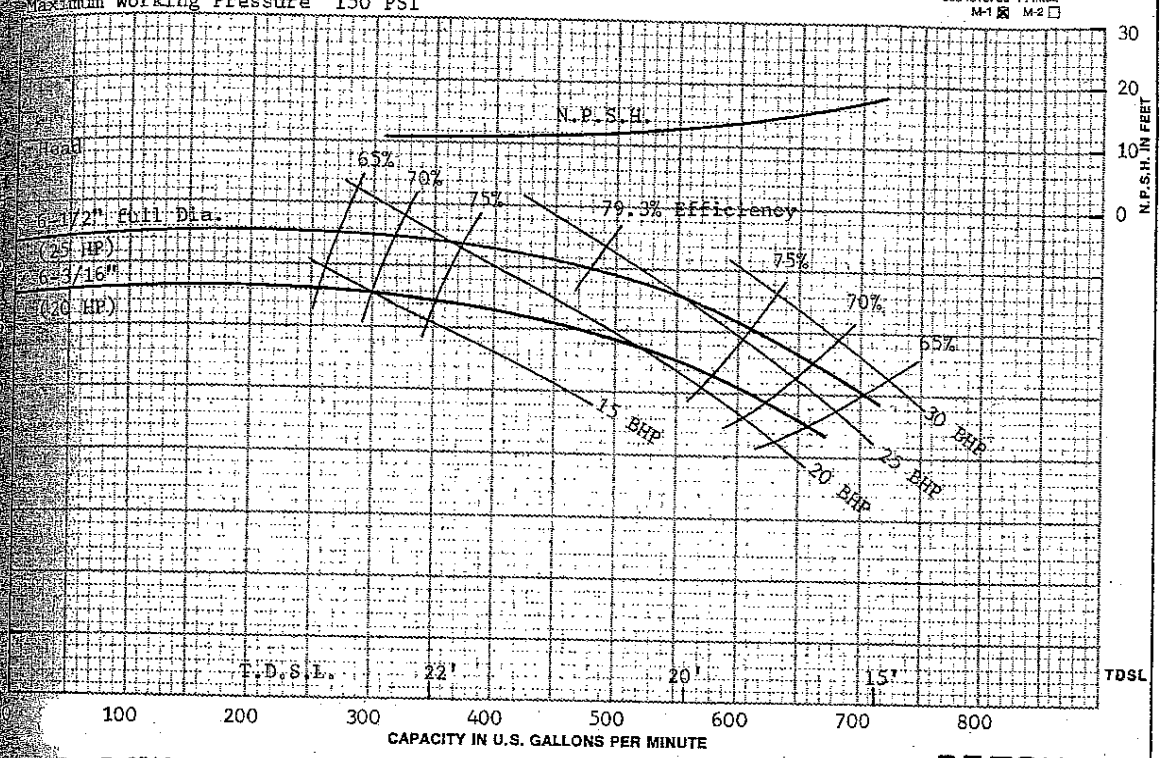
TYPE "B" RATING CURVES
MOTOR DRIVE

CURVE	4075
DATE	4-1-84
PAGE	4.01
SUPERSEDES	
Curve 4075 Page 4.01	
Dated 8-17-81	

Case Material C.I. Patt. No. L-1104 Mach. No. L-1104
Impeller Material C.I. Patt. No. M-6830 Mach. No. M-6830 Dia. 6-1/2" full
Maximum Working Pressure 150 PSI

3600 NOMINAL

R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

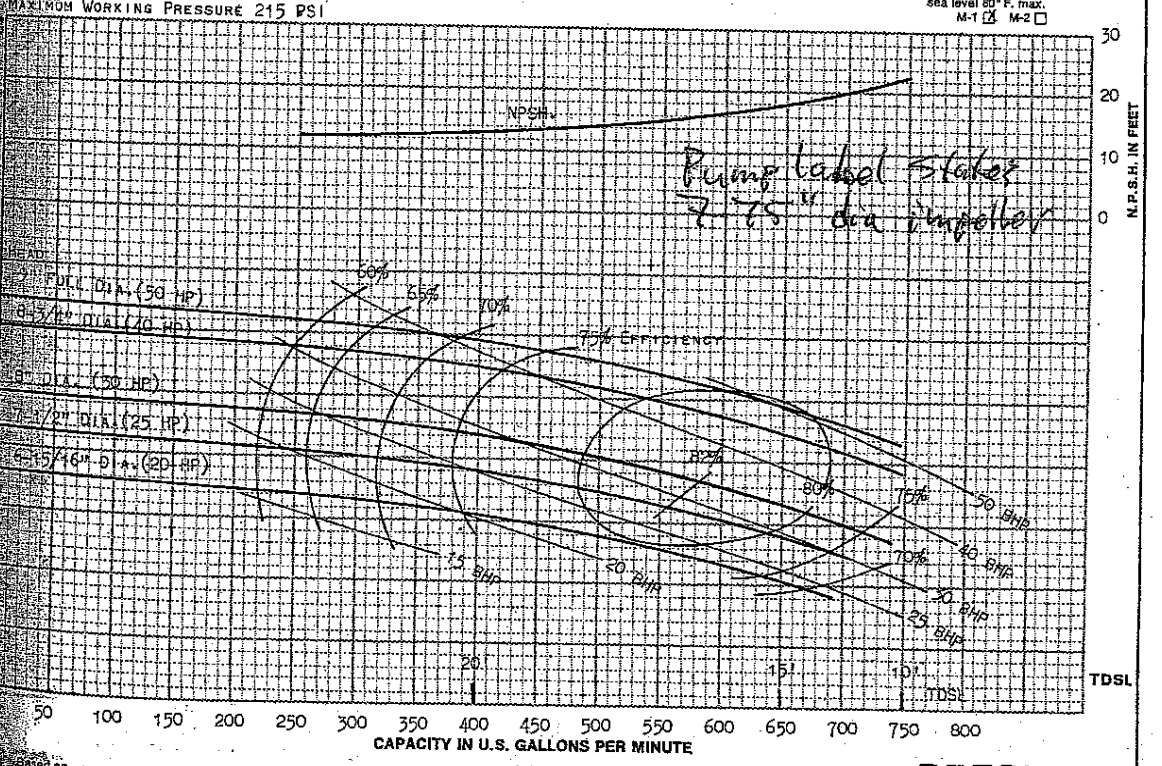


Based on T-3742 Supersedes new Dated —— Date 6-1-79 MODEL B3TPH

Case Material C.I. Patt. No. H-689 Mach. No. H-689
Impeller Material Brz Patt. No. M-3380 Mach. No. M-3380 Dia. 9" FULL
MAXIMUM WORKING PRESSURE 215 PSI

3600 NOMINAL

R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐



Based on T-3184 Supersedes C-5006 Dated 10-30-64 Date 5-19-71. MODEL B3ZPL

Stewart P.S.

BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

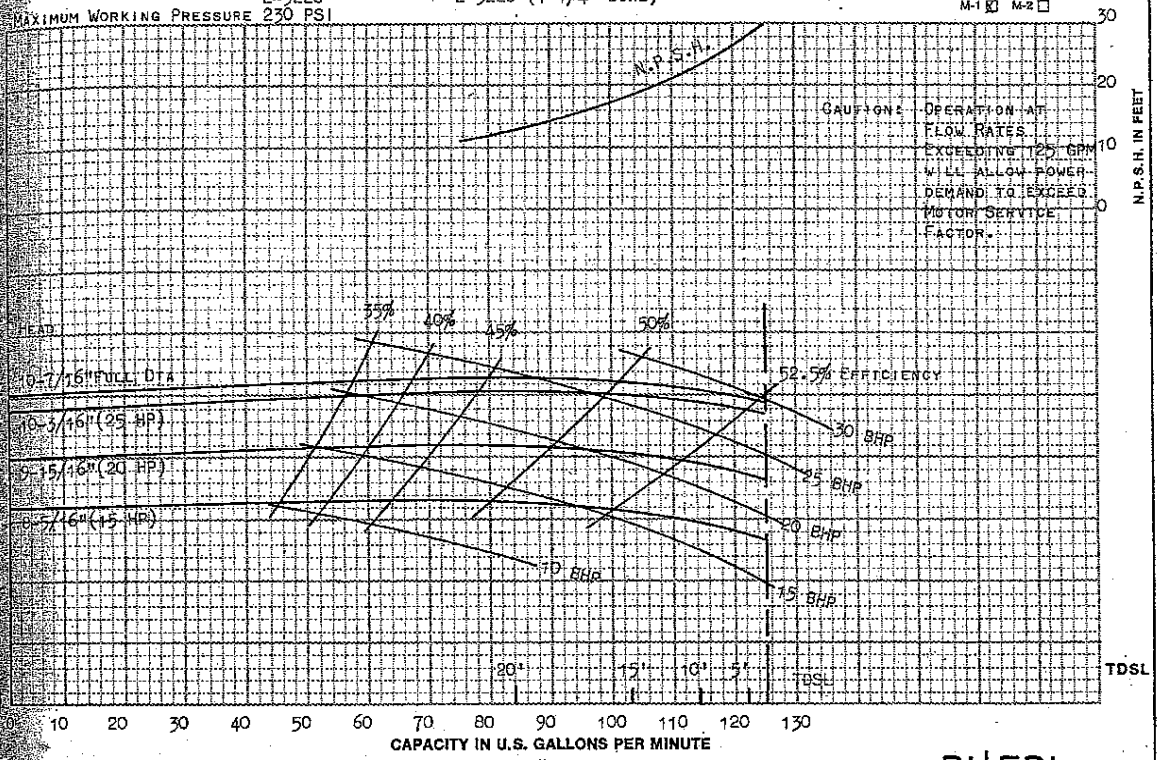
CURVE	4075
DATE	7-30-84
PAGE	2.01
SUPERSEDES	
Curve 4075 Page 2.01	
Dated 8-15-80	

60 Cycles
for fresh water at 80° F. max.
M-1 ☒ M-2 ☐

Case: Material C.I. Patt. No. L-3093 Mach. No. L-3093
Impeller: Material C.I. Patt. No. L-3096 Mach. No. L-3096 (7/8" Bore) Dia. 10-7/16" Full
L-3220 L-3220 (1-1/4" Bore)

3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

MAXIMUM WORKING PRESSURE 230 PSI



½TPL

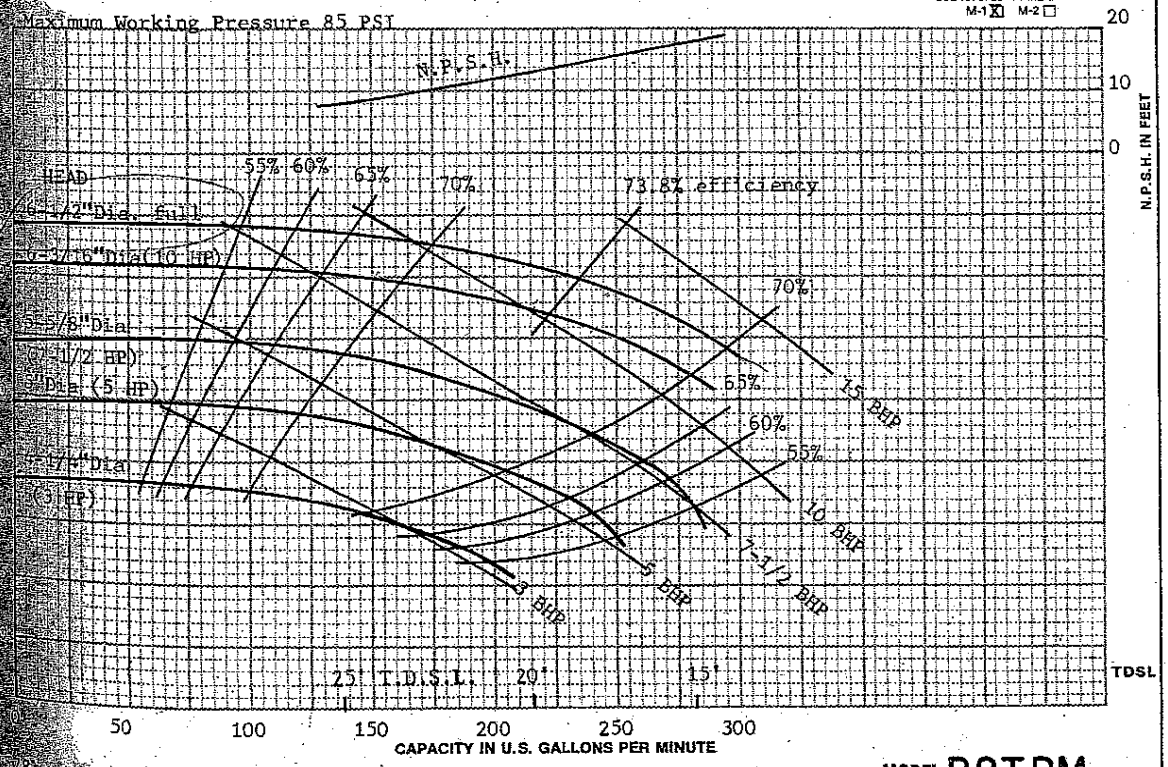
Based on T-2694 Supersedes C-6529 Dated 11-16-70 Date 2-29-72 MODEL BI½EPL

60 Cycles
for fresh water at 80° F. max.
M-1 ☒ M-2 ☐

Case: Material C.I. Patt. No. L-1022 Mach. No. L-1022
Impeller: Material C.I. Patt. No. S-7369 Mach. No. S-7369 Dia. 6-1/2" full

3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

Maximum Working Pressure 85 PSI



BI½TPM

Based on T-3775 Supersedes C-5038 Dated 1-28-77 Date 4-23-80 MODEL B2TPM

Vancil P.S.

BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

BERKELEY®

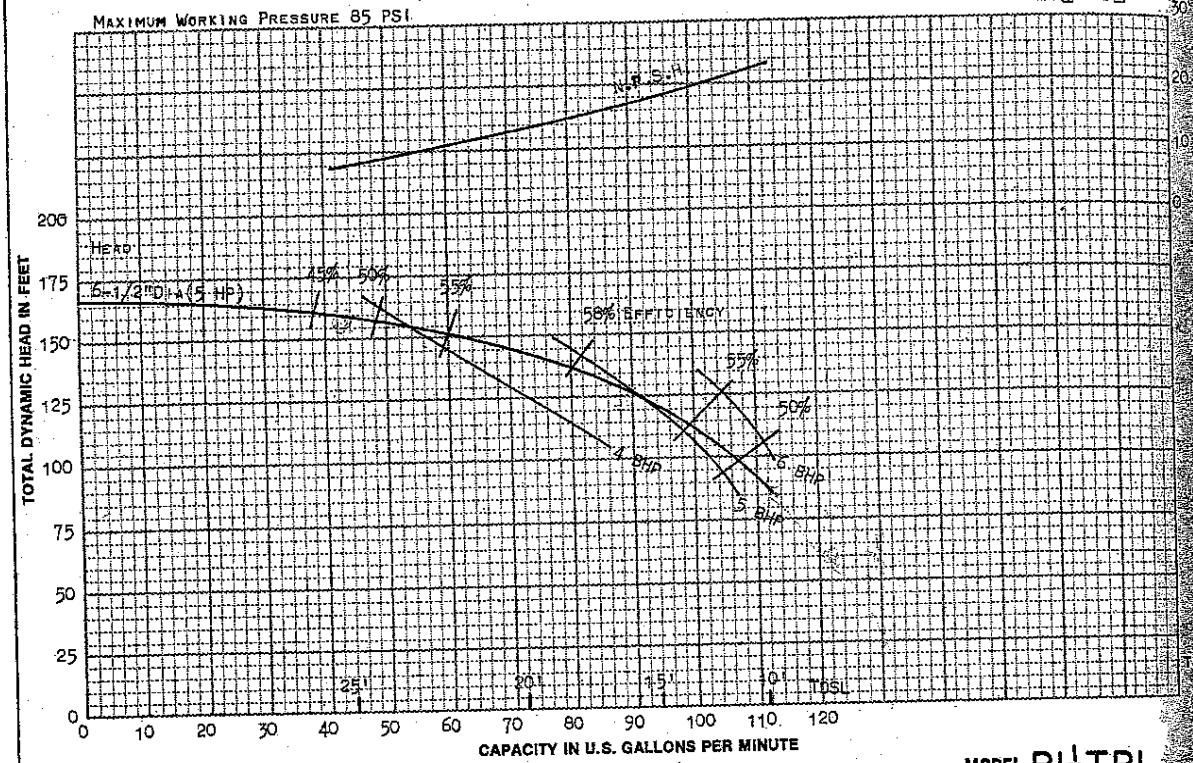
TYPE "B" RATING CURVES
MOTOR DRIVE

CURVE	4075
DATE	4-1-84
PAGE	1.02
SUPERSEDES	
Curve 4075 Page 1.02	
Dated 7-15-74	

Case: Material C.I. Patt. No. L-1018 Mach. No. L-1018
Impeller: Material C.I. Patt. No. S-7367 Mach. No. S-7367 Dia. 6-1/2" FULL

3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

MAXIMUM WORKING PRESSURE 85 PSI

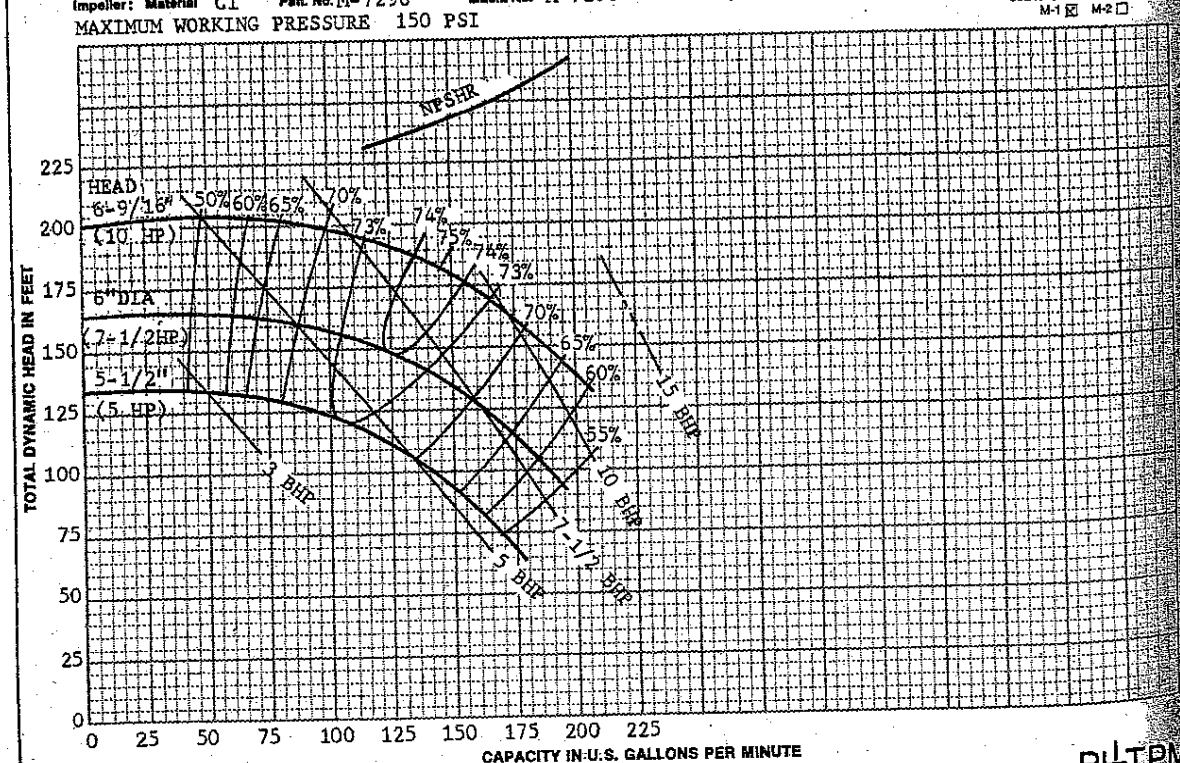


C-5035 Based on T-3207 Supersedes C-5035 Dated 9-27-71 Date 3-1-72 MODEL BI½TPL

Case: Material CI Patt. No. L-1018 Mach. No. L-5824
Impeller: Material CI Patt. No. M-7298 Mach. No. M-7298 Dia. 6-9/16 FULL

3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

MAXIMUM WORKING PRESSURE 150 PSI



C-8888 Based on T-3957,-1,&-2 Supersedes NEW Dated -- Date 12/7/83 MODEL BI½TPM

Vancil P.S.

BERKELEY PUMP COMPANY

BERKELEY®

TYPE "B" RATING CURVES

MOTOR DRIVE

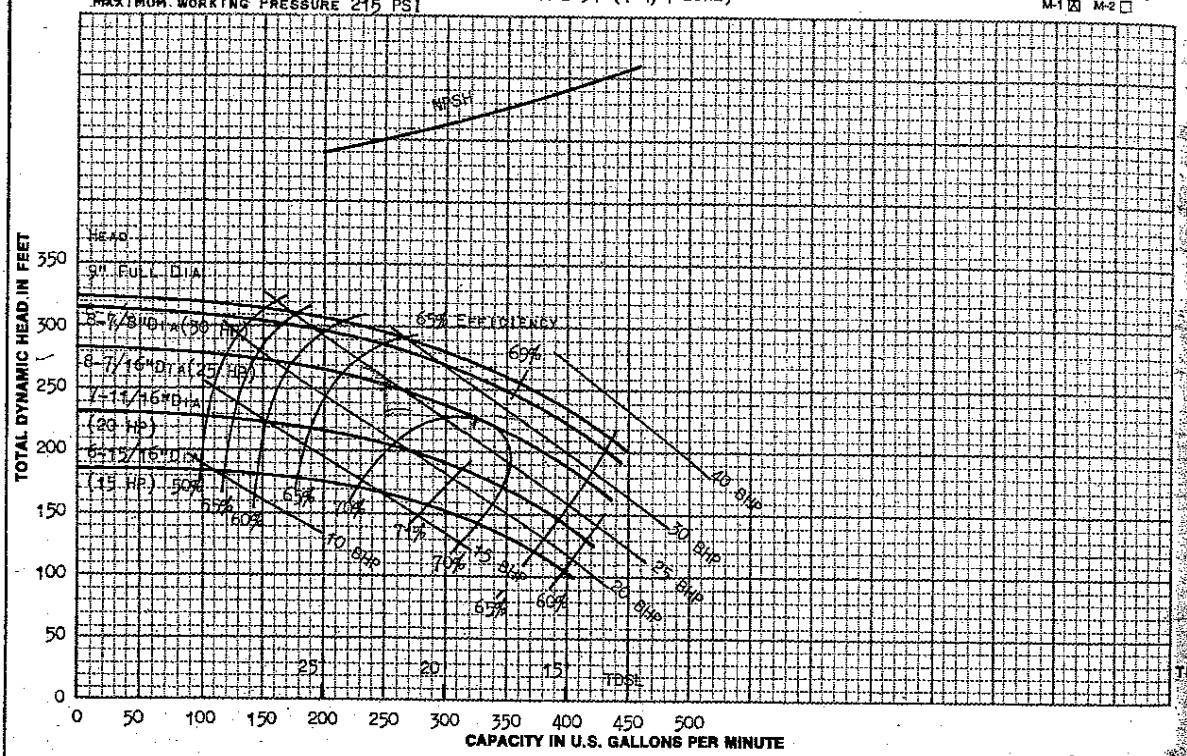
CURVE	
DATE	8-17-
PAGE	
SUPERSEDES	
Curve 4075	Page
Dated 10-9-79	

Case: Material C.I. Patt. No. L-1027 Mach. No. L-1027 3600 NOMINAL R.P.M. 60 Cycles

Impeller: Material C.I. Patt. No. M-2691 Mach. No. M-2894 (7/8 Bore) M-2691 (1-1/4 Bore) Dia 9" Full

T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐

Maximum Working Pressure 215 PSI



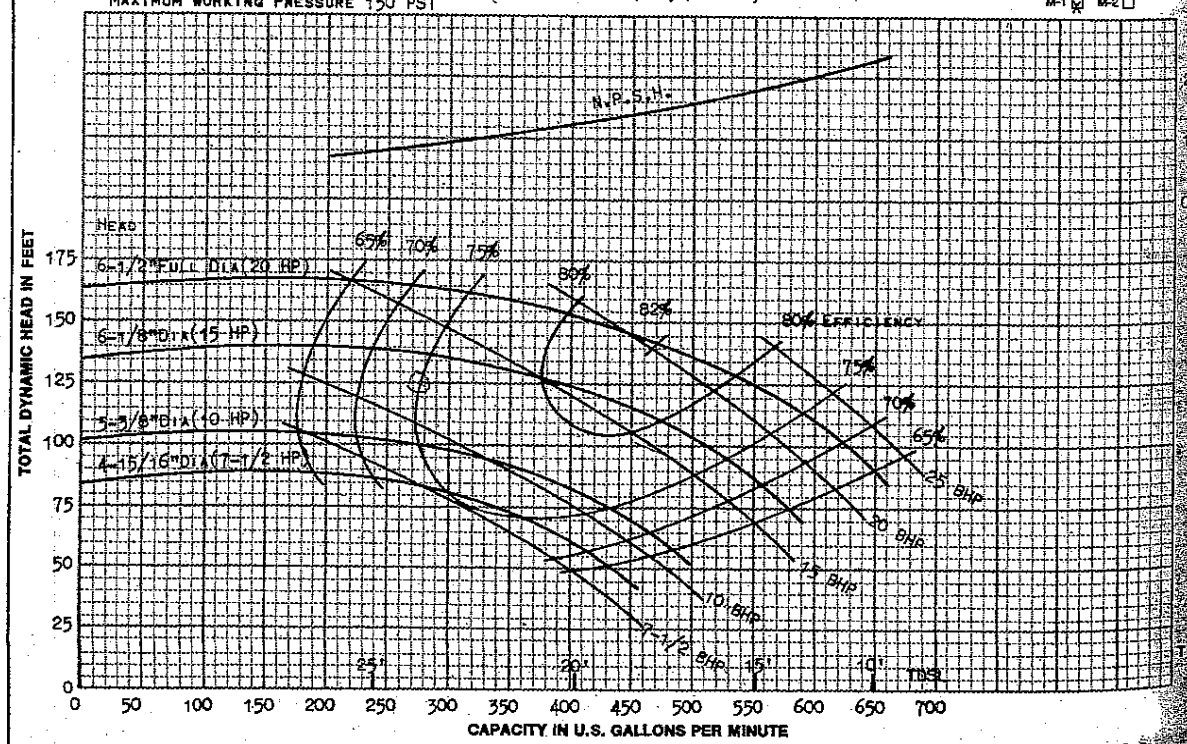
C-5040 Based on T-3093 Supersedes C-5040 Dated 6-14-62 Date 5-1-70 **MODEL B2½ZPL**

Case: Material C.I. Patt. No. L-1104 Mach. No. L-1104 3600 NOMINAL R.P.M. 60 Cycles

Impeller: Material C.I. Patt. No. M-2959 M-2960 Mach. No. M-2959 (7/8" Bore) M-2960 (1-1/4" Bore) Dia. 6-1/2" Full

T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐

Maximum Working Pressure 150 PSI



C-5005 Based on T-2126 Supersedes C-5005 Dated 10-6-70 Date 3-1-72 **MODEL B3TPM**

Home Ave. P.S.

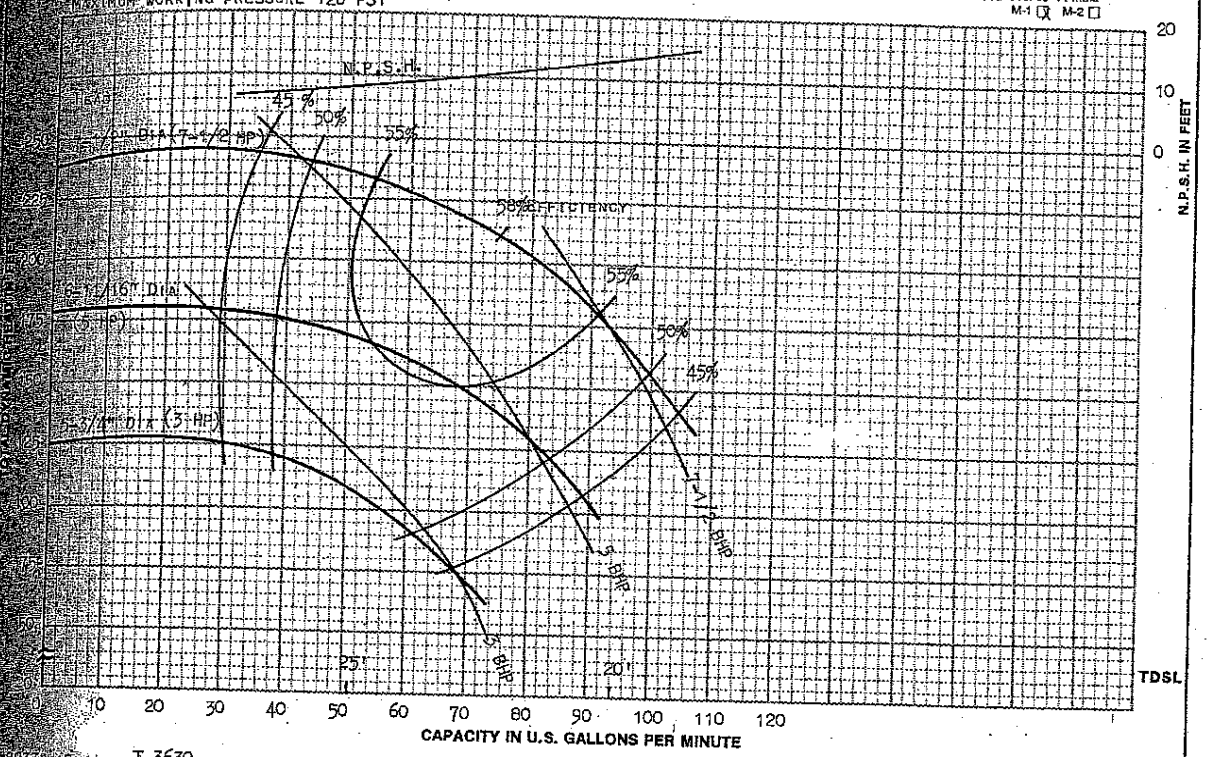
BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

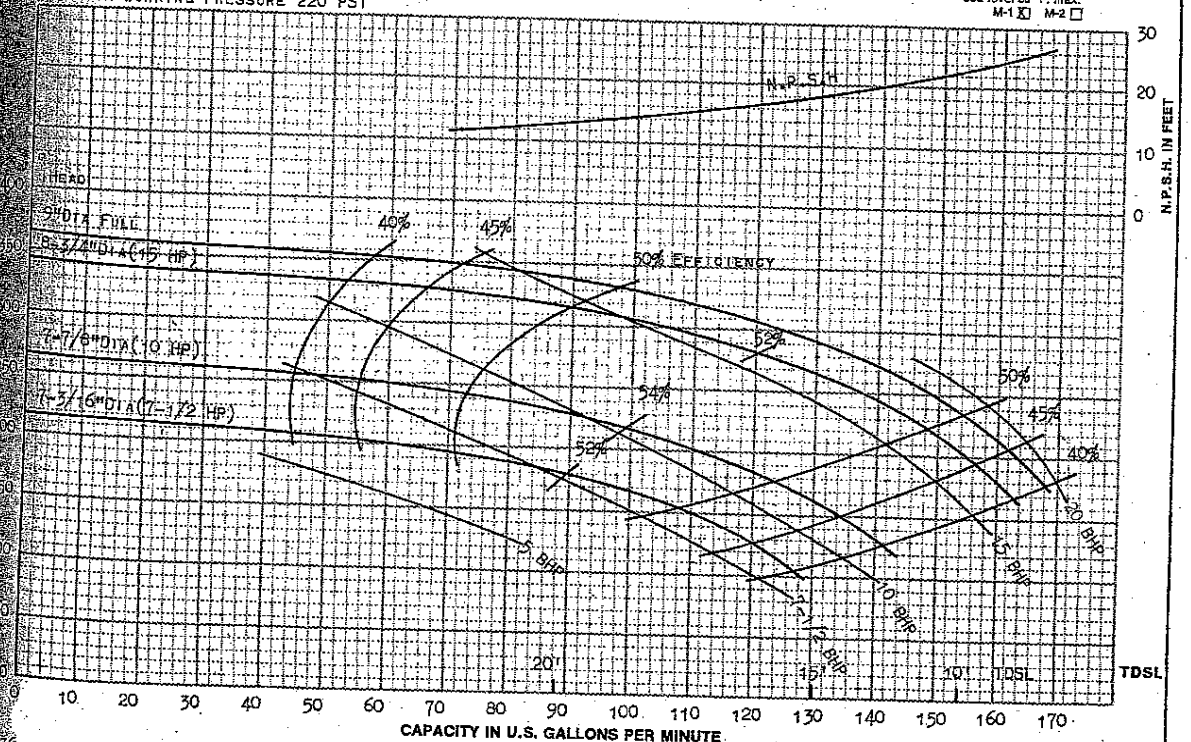
CURVE	4075
DATE	4-1-84
PAGE	0.75
SUPERSEDES	
Curve 4075 Page 0.75	
Dated 6-1-78	

Case: Material C.I. Patt. No. L-4022 Mach. No. L-4022
Impeller: Material BRZ. Patt. No. M-269 Mach. No. S-8534 Dia. 7-1/2" FULL
3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐
MAXIMUM WORKING PRESSURE 120 PSI



C-8233 Based on T-3630 Supersedes C-8233 Dated 10-6-76 Date 10-7-77 MODEL BIWP

Case: Material C.I. Patt. No. L-1025 Mach. No. L-1025
Impeller: Material C.I. Patt. No. M-1828 Mach. No. M-2191 Dia. 9" FULL
3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐
MAXIMUM WORKING PRESSURE 220 PSI

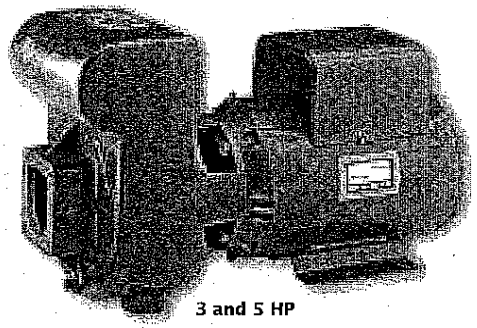


C-5036 Based on T-1733 Supersedes C-5036 Dated 9-2-70 Date 3-1-72 MODEL BI½ZPL

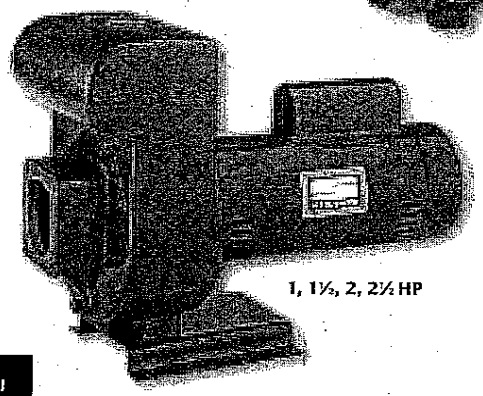
Underhill P.S.

STA-RITE®

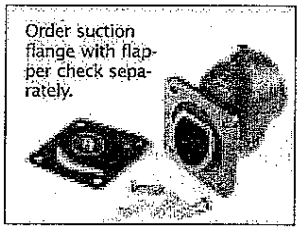
self-priming centrifugal pumps



3 and 5 HP



1, 1½, 2, 2½ HP



This product is Listed to UL Standards for Safety by Underwriters Laboratories Inc. (UL). (1, 1½, 2, 2½ HP)

Some of the fastest priming pumps on the market. Available in high head or medium head series. Feature leak-proof mechanical seals, easy service design, heavy-duty motors, rugged construction. Available in 1 through 5 HP.

Optional 6" and 8" Trap Packages are available.

APPLICATIONS

- **Lawn Sprinkling...** operate from 1 to 30 or more heads. Can be safely operated by timer or other automatic device.
- **Contractors...** for dewatering excavation, jetting, water transfer and supply operations.
- **Agriculture...** seed bed and plot irrigation, stock watering, fire protection.
- **Industrial...** sump drainage, fire protection, marine pumping, liquid transfer and supply operations.

D SERIES

SPECIFICATIONS

Body and Base – Close-grained cast iron

Impeller – Noryl® on 1 through 2-1/2 HP, bronze on 3 and 5 HP

Diffuser – Cast iron

Shaft – *1 through 2-1/2 HP:* 416 stainless steel; *3 and 5 HP:* Carbon steel inside removable shaft sleeve of stainless steel.

FEATURES

1 through 5 HP – Both high head and medium head models offer heavy-duty motors, easy service design, and air volume control tapping.

Drain Port – Provided for easy winterizing.

Medium Head Models – Deliver up to 115' of head with capacities to 159 GPM.

High Head Models – Deliver up to 138' of head with capacities to 162 GPM.

Easy Serviceability – Normal wearing parts are easily accessible for service and replacement, without disturbing piping or mounting.

Heavy-duty Motors – Designed for continuous operation. Capacitor start, will not cause electrical interference with TV or other appliances. Nationally known motors have ball bearing, stainless steel shaft. For single- and three-phase operation, 3450 RPM.

Noryl® is a registered trademark of General Electric Co.

In order to provide the best products possible, specifications are subject to change.

STA-RITE®

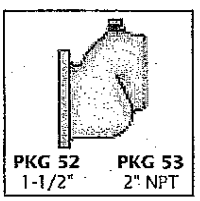
self-priming centrifugal pumps

ORDERING INFORMATION

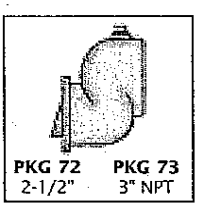
Catalog Number	HP	Pipe Tapping Sizes		Motor Voltage	Phase	Max. Load Amps	Approx. Wt. Lbs.
		Suction Flanges	Pump Discharge				
HIGH HEAD							
DHE	1	Pkg52	1-1/2"	115/230	1	14.8/7.4	65
DHE3	1	Pkg52	1-1/2"	208-230/460	3	3.6/1.8	65
DHF	1-1/2	Pkg52	1-1/2"	115/230	1	19.2/9.6	72
DHF3	1-1/2	Pkg52	1-1/2"	208-230/460	3	4.7/2.35	72
DHG	2	Pkg53	2"	230	1	12.0	113
DHG3	2	Pkg53	2"	208-230/460	3	6.8/3.4	113
DHHG	2-1/2	Pkg53	2"	230	1	12.0	120
DHHG3	2-1/2	Pkg53	2"	208-230/460	3	8.5/4.25	120
DHH	3	Pkg53	1-1/2"	230	1	13.4	144
DHH3	3	Pkg53	1-1/2"	208-230/460	3	8.6/4.3	144
DHJ	5	Pkg72	2"	230	1	22	184
DHJ3	5	Pkg72	2"	208-230/460	3	13.2/6.6	184
MEDIUM HEAD							
DMG	2	Pkg52	1-1/2"	230	1	12.0	86
DMG3	2	Pkg52	1-1/2"	208-230/460	3	6.8/3.4	86
DMMG	2-1/2	Pkg53	2"	230	1	12.0	93
DMMG3	2-1/2	Pkg53	2"	208-230/460	3	8.5/4.25	93
DMH	3	Pkg72	2"	230	1	13.4	137
DMH3	3	Pkg72	2"	208-230/460	3	8.6/4.3	137
DMJ	5	Pkg73	2-1/2"	230	1	22	184
DMJ3	5	Pkg73	2-1/2"	230/460	3	13.2/6.6	184

SUCTION FLANGES (order separately - required for suction tap sizes)

Package 52 -	Package 53 -	Package 72 -	Package 73 -
1-1/2"	2"	2-1/2"	3"



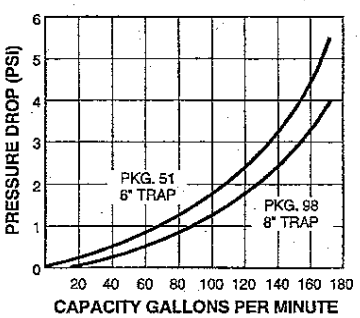
PKG 52 1-1/2" PKG 53 2" NPT

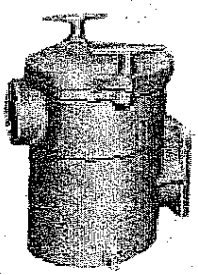


PKG 72 2-1/2" PKG 73 3" NPT

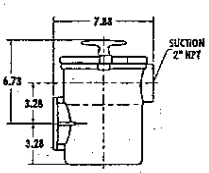
6" AND 8" TRAP PACKAGES

Catalog Number	Description	Suction Port Size	Approx. Wt. Lbs.
PKG 51	6" Cast Iron Trap with Basket (For C, CC, and D Series Pumps)	2" NPT	20
PKG 76	Cast Iron Flange for Remote Installation	3" NPT	4
PKG 98	8" Cast Iron Trap with Basket (For C, CC, and D Series Pumps)	3" NPT	40

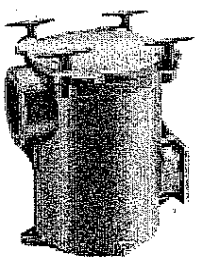




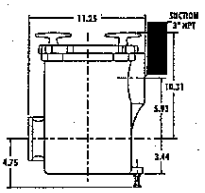
PKG 51
6"



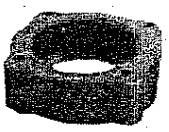
PKG 51
6 INCH TRAP



PKG 98
8"



PKG 98
8 INCH TRAP

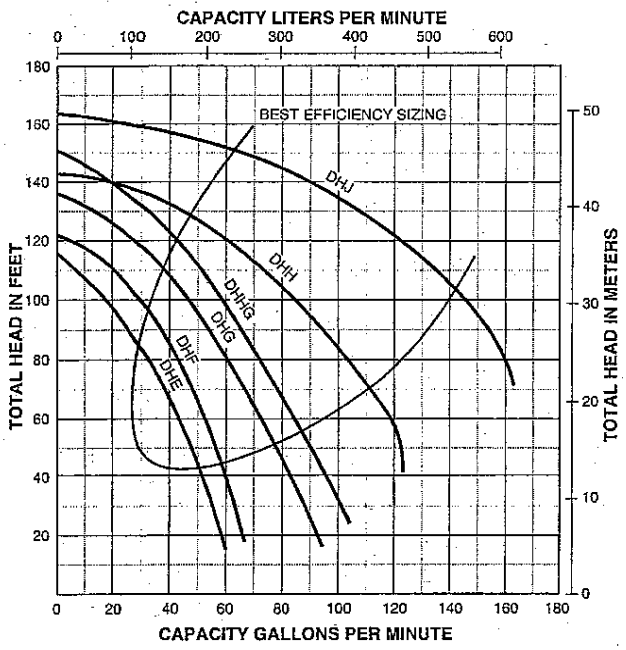


PKG 76

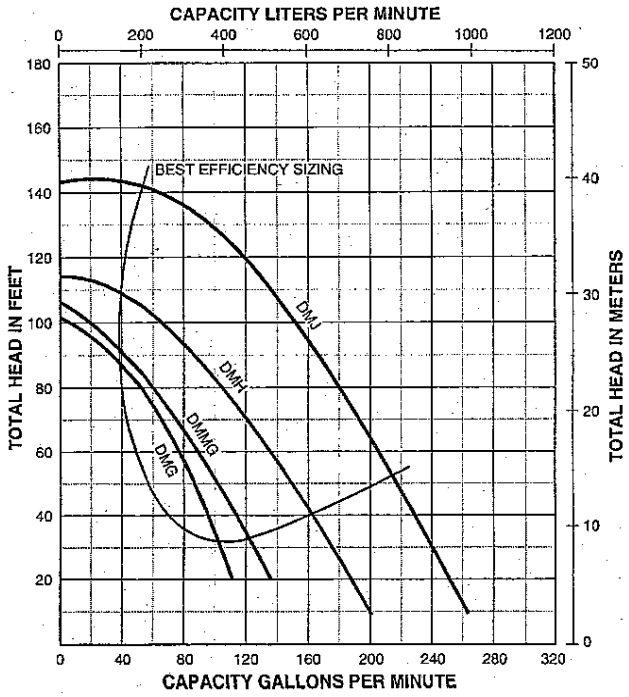
STA-RITE®

self-priming centrifugal pumps

PUMP PERFORMANCE – HIGH HEAD



PUMP PERFORMANCE – MEDIUM HEAD



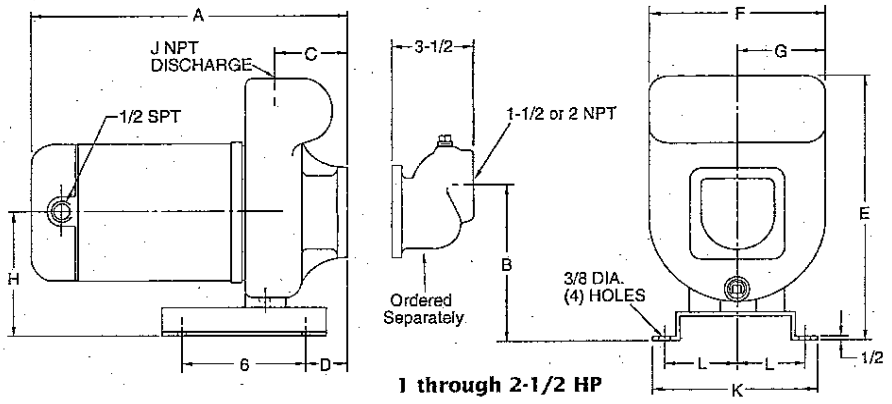
PUMP PERFORMANCE *(Capacity in Gallons Per Minute)*

Cat. No.	HP	Discharge PSI	Discharge Feet Head	Suction Lift in Feet 5'	10'	15'	20'	25'
HIGH HEAD								
DHE	1	20	46.2	46	43	41	40	38
		30	69.3	35	32	29	25	21
		40	92.4	19	15	–	–	–
		50	115.5	–	–	–	–	–
		60	138.6	–	–	–	–	–
DHF	1-1/2	20	46.2	55	53	51	49	48
		30	69.3	45	42	39	36	32
		40	92.4	31	27	22	15	–
		50	115.5	–	–	–	–	–
		60	138.6	–	–	–	–	–
DHG	2	20	46.2	77	74	71	68	65
		30	69.3	63	60	56	53	49
		40	92.4	48	44	40	36	30
		50	115.5	30	20	13	–	–
		60	138.6	–	–	–	–	–
DHHG	2-1/2	20	46.2	89	85	82	80	76
		30	69.3	75	72	68	64	60
		40	92.4	60	57	51	49	42
		50	115.5	42	37	31	25	20
		60	138.6	14	–	–	–	–
DHH	3	20	46.2	–	–	–	112	109
		30	69.3	109	103	98	92	89
		40	92.4	90	75	74	69	62
		50	115.5	62	51	42	32	20
DHJ	5	20	46.2	–	–	–	–	–
		30	69.3	–	–	–	–	–
		40	92.4	146	141	136	130	122
		50	115.5	122	114	105	99	85
		60	138.6	81	70	50	30	–
MEDIUM HEAD								
DMG	2	20	46.2	84	79	74	69	63
		30	69.3	60	53	46	35	20
		40	92.4	22	–	–	–	–
		50	115.5	–	–	–	–	–
DMMG	2-1/2	20	46.2	103	96	90	80	70
		30	69.3	70	60	50	46	30
		40	92.4	30	18	5	–	–
		50	115.5	–	–	–	–	–
DMH	3	20	46.2	149	140	136	124	119
		30	69.3	116	108	99	85	76
		40	92.4	75	65	51	26	–
DMJ	5	20	46.2	214	209	202	194	182
		30	69.3	185	179	172	165	158
		40	92.4	153	146	139	130	120
		50	115.5	119	107	95	80	50

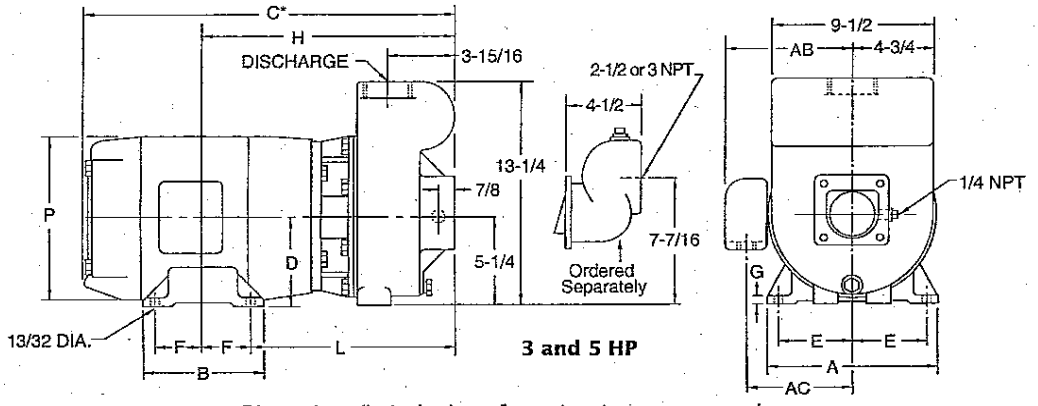
STA-RITE®

self-priming centrifugal pumps

OUTLINE DIMENSIONS



1 through 2-1/2 HP



3 and 5 HP

Dimensions (in inches) are for estimating purposes only.

DIMENSIONS IN INCHES – 1 THROUGH 2-1/2 HP

Catalog Number	HP	A	B	C	D	E	F	G	H	J	K	L
DHE	1	15-13/16	7-1/16	3-1/2	4	11-7/8	7-7/8	3-15/16	5-13/16	1-1/2	7-1/2	3-3/8
DHF	1-1/2	16-11/16	7-1/16	3-1/2	4	11-7/8	7-7/8	3-15/16	5-13/16	1-1/2	7-1/2	3-3/8
DHG	2	18-11/16	7-13/16	3-15/16	3-13/16	14-3/8	9-1/2	4-3/4	6-9/16	2	7-1/2	3-3/8
DHHG	2-1/2	19-11/16	7-13/16	3-15/16	3-13/16	14-3/8	9-1/2	4-3/4	6-9/16	2	7-1/2	3-3/8
DMG	2	17-15/16	7-1/16	3-1/2	4	11-7/8	7-7/8	3-15/16	5-13/16	1-1/2	7-1/2	3-3/8
DMMG	2-1/2	18-15/16	7-1/16	3-1/2	4	11-7/8	7-7/8	3-15/16	5-13/16	2	7-1/2	3-3/8

DIMENSIONS IN INCHES – 3 AND 5 HP

Catalog Number	HP	A	B	C*	D	E	F	G	H	L	P	AB	AC
DHH	3	9	6	20-3/4	4-1/2	3-3/4	2-1/4	1/2	15	12-3/4	9-3/4	8-1/8	6-1/2
DHJ	5	9	7	21-3/4	4-1/2	3-3/4	2-3/4	1/2	15-1/2	12-3/4	9-3/4	9	7
DMH	3	9	6	20-3/4	4-1/2	3-3/4	2-1/4	1/2	15	12-3/4	9-3/4	8-1/8	6-1/2
DMJ	5	9	7	21-3/4	4-1/2	3-3/4	2-3/4	1/2	15-1/2	12-3/4	9-3/4	9	7

*Overall length (C) is shown for single-phase motors. Three-phase motors are slightly smaller. Dimensions are for estimating purposes only.

Seneca P.S.

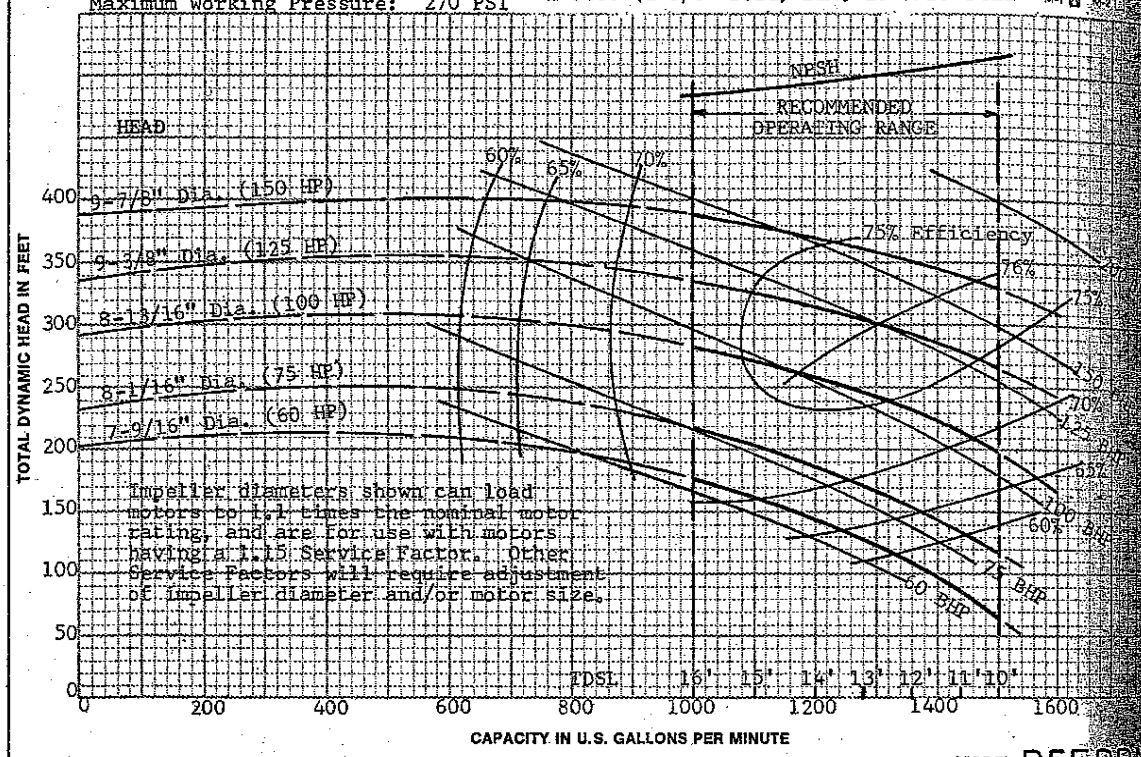
BERKELEY PUMPS
Pumptron Division—Transamerica Delaval, Inc.

BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

CURVE
DATE
PAGE
SUPERSEDES
Curve 407
Dated

Case: Material CI Patt. No. H-2692 Mach. No. H-2692 **3600 NOMINAL** R.P.M. 60
Impeller: Material Brz Patt. No. L-5609 Mach. No. L-5641 (1-1/4" Bore)
L-5609 (1-5/8" Bore) DIA. 10-7/16" FULL
T.D.S.L. for fresh water sea level 80° F. max. M-1 ☒ M-2
Maximum Working Pressure: 270 PSI



C-8726 Based on T-3822 Supersedes C-8591 Dated 10-30-80 Date 10-8-81 **MODEL B5EPBM**

The Model B5EPBM is part of a broad line of centrifugal pumps designed and manufactured by Berkeley Pump Company. Each different model is intended for a particular range of performance and some are more critical than others to operation outside the range.

The B5EPBM is intended to operate between 1000 GPM and 1500 GPM. If the system operation requires operation at capacities outside the intended capacity range, even for short duration, DO NOT USE THIS PUMP. Other Berkeley pump models are available for either lower and higher capacity requirements.

To verify satisfactory suction conditions, add together the vertical lift from the surface of the water source to the pump center plus the friction loss through the suction pipe and fittings, plus the velocity head in 6" pipe. Adjust this total for altitude 1.2 feet for each 1000 feet above sea level.

If the final adjusted number is greater than the TDSL value shown on this curve, DO NOT OPERATE THIS PUMP.

El modelo B5EPBM es parte de la gran selección de bombas diseñadas y construídas por la Compañia Berkeley Pump. Cada modelo está diseñado para satisfacer ciertos límites en su rendimiento siendo algunos modelos mas críticos que otros cuando tienen que operar fuera de estos límites.

El modelo B5EPBM ha sido diseñado para operar entre 1000 GPM y 1500 GPM. Si el sistema requiere una operación a caudales fuera de los prefijados aunque sea por un corto lapso, "NO USE ESTA BOMBA".

Hay otros modelos para producir menores y mayores caudales.

Para verificar las condiciones de succión satisfactoriamente, sumar la altura de succión desde la supercicie del agua al centro de la bomba, más la pérdida por fricción en el caño de succión y en los codos, más la carga de velocidad en un caño de 6 pulgadas.

Corregir el total logrado de acuerdo a la altura del sistema sumando 1.2 piés por cada 1000 piés sobre el nivel del mar.

Si el resultado final es mayor que el valor de la altura de succión dinámica total (TDSL) indicada en esta curva, "NO USE ESTA BOMBA".

Seneca P.S.

BERKELEY

BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

TYPE "B" RATING CURVES

MOTOR DRIVE

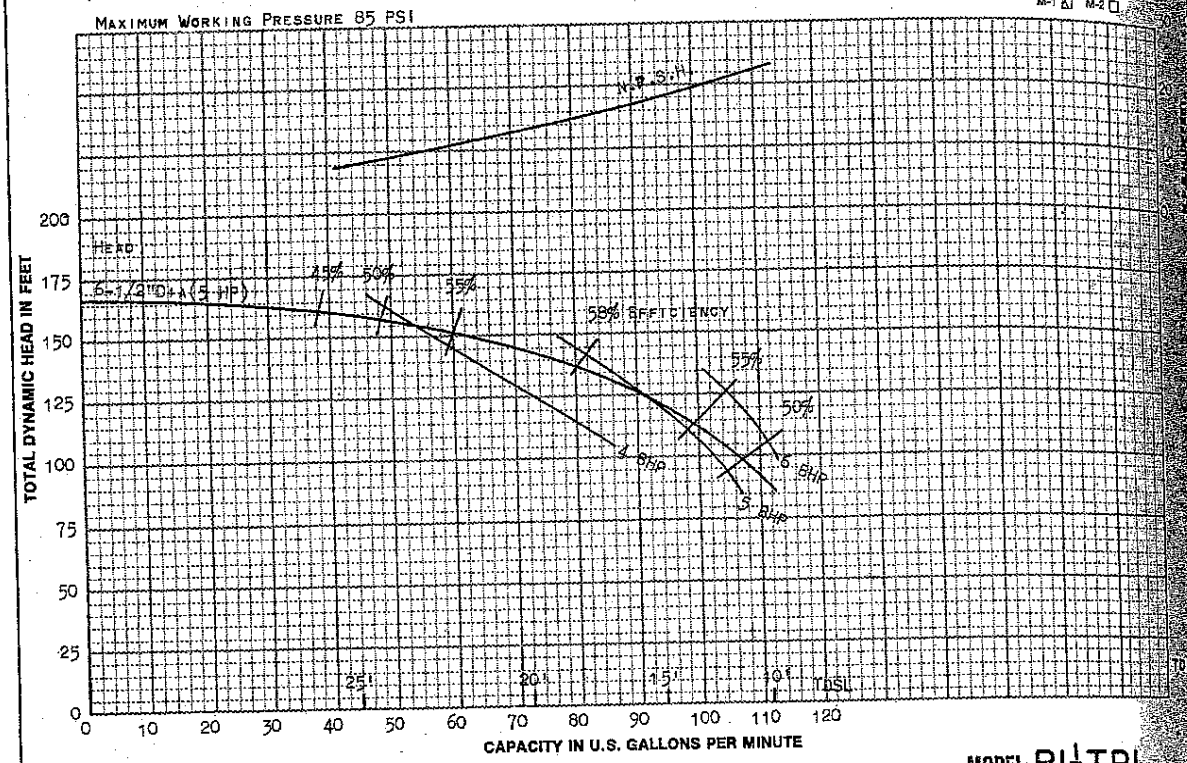
CURVE
DATE
PAGE

SUPERSEDES
Curve 4075 Page
Dated 7-15

Case: Material C.I. Patt. No. L-1018 Mach. No. L-1018
Impeller: Material C.I. Patt. No. S-7367 Mach. No. S-7367 Dia. 6-1/2" FULL

3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

MAXIMUM WORKING PRESSURE 85 PSI

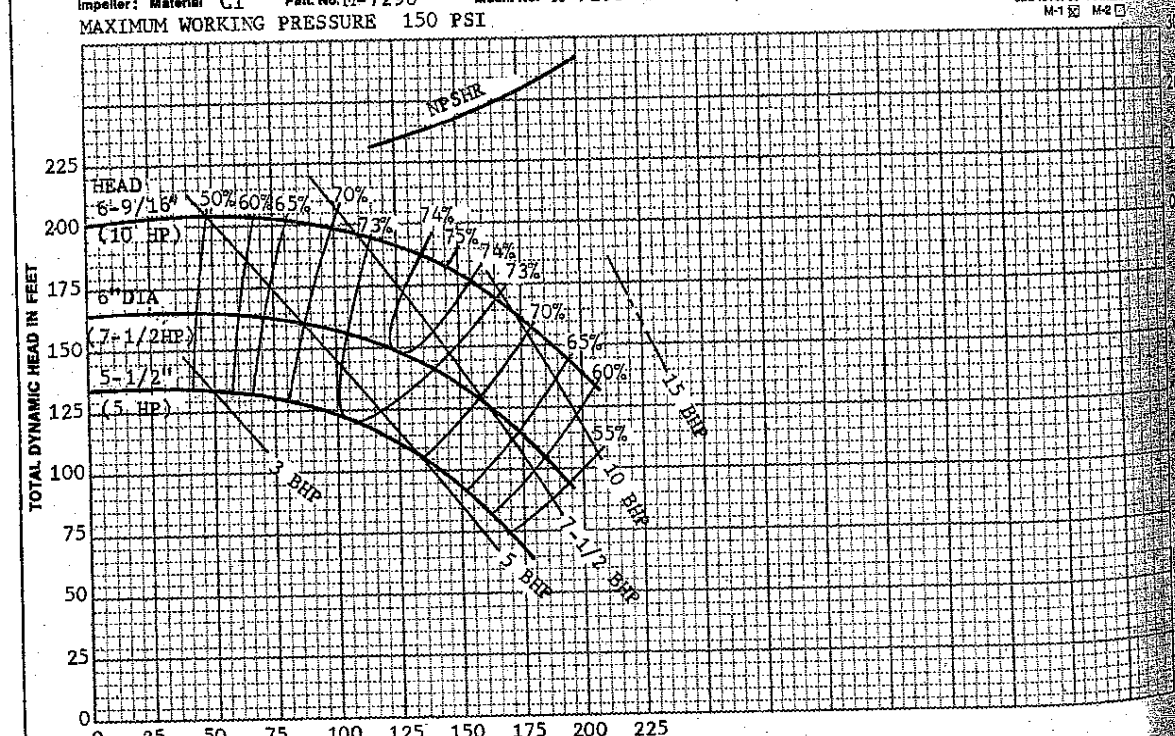


C-5035 Based on T-3207 Supersedes C-5035 Dated 9-27-71 Date 3-1-72 MODEL BI½TPL

Case: Material CI Patt. No. L-1018 Mach. No. L-5824
Impeller: Material CI Patt. No. M-7298 Mach. No. M-7298 Dia. 6-9/16 FULL

3600 NOMINAL R.P.M. 60 Cycles
T.D.S.L. for fresh water at sea level 80° F. max.
M-1 ☒ M-2 ☐

MAXIMUM WORKING PRESSURE 150 PSI



C-8888 Based on T-3957,-1,&-2 Supersedes NEW Dated -- Date 12/7/83 MODEL BI½TPM

Drake Hill P.S.

BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

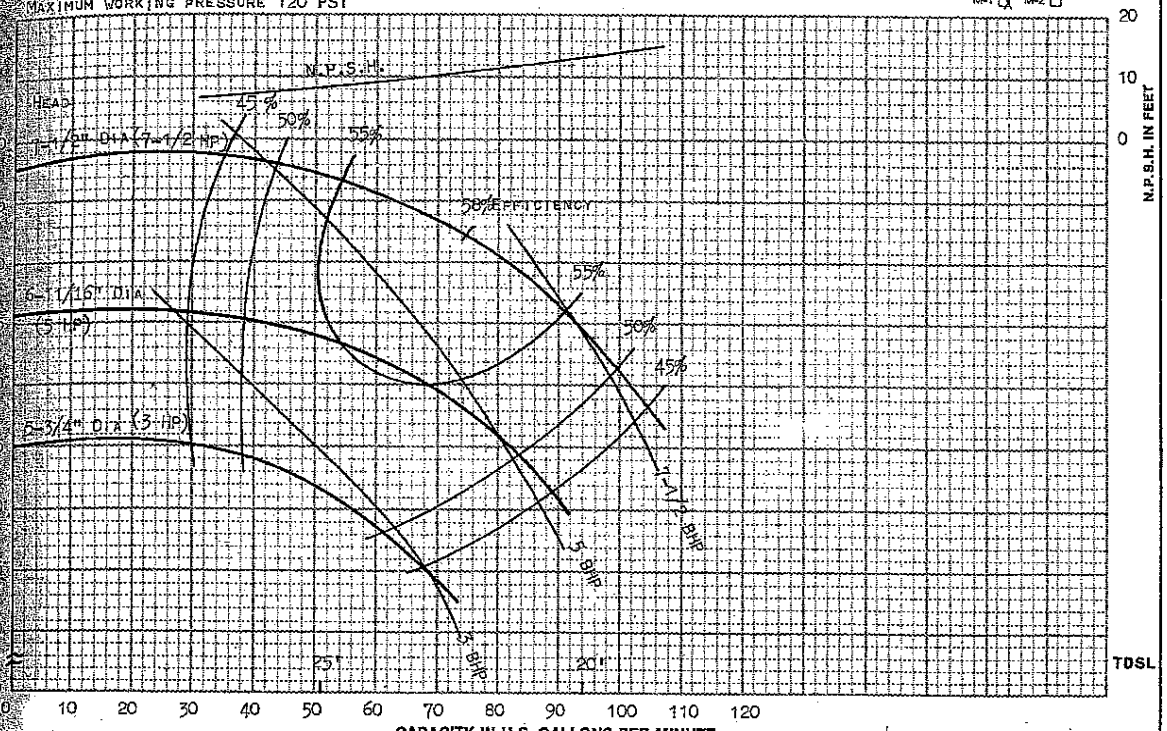
BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

CURVE	4075
DATE	4-1-84
PAGE	0.75
SUPERSEDES	
Curve 4075 Page 0.75	
Dated 6-1-78	

Case: Material C.I. Patt. No. L-4022 Mach. No. L-4022 3600 NOMINAL R.P.M. 60 Cycles
Impeller: Material BRZ. Patt. No. M-269 Mach. No. S-8534 Dia. 7-1/2" FULL
T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐

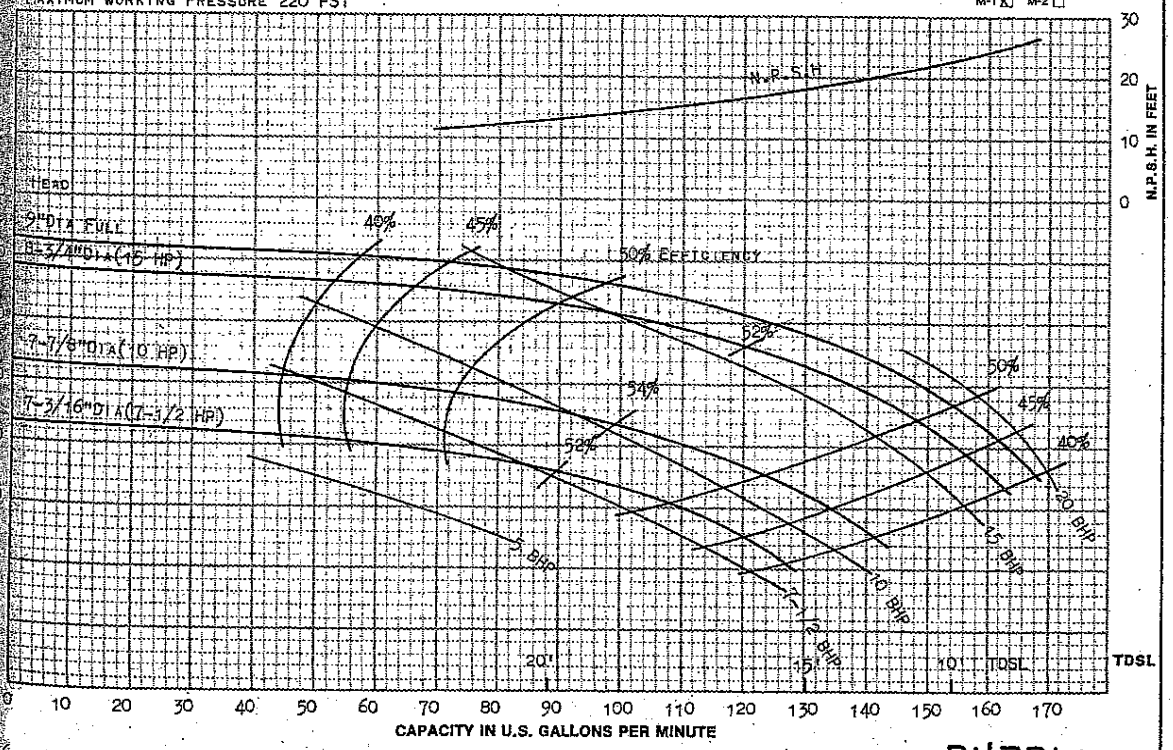
MAXIMUM WORKING PRESSURE 120 PSI



Based on T-3630 Supersedes C-8233 Dated 10-6-76 Date 10-7-77 MODEL BIWP

Case: Material C.I. Patt. No. L-1025 Mach. No. L-1025 3600 NOMINAL R.P.M. 60 Cycles
Impeller: Material C.I. Patt. No. M-1828 Mach. No. M-2191 Dia. 9" FULL
T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐

MAXIMUM WORKING PRESSURE 220 PSI



Based on T-1733 Supersedes C-5036 Dated 9-2-70 Date 3-1-72 MODEL BI½ZPL

Drake Hill P.S.

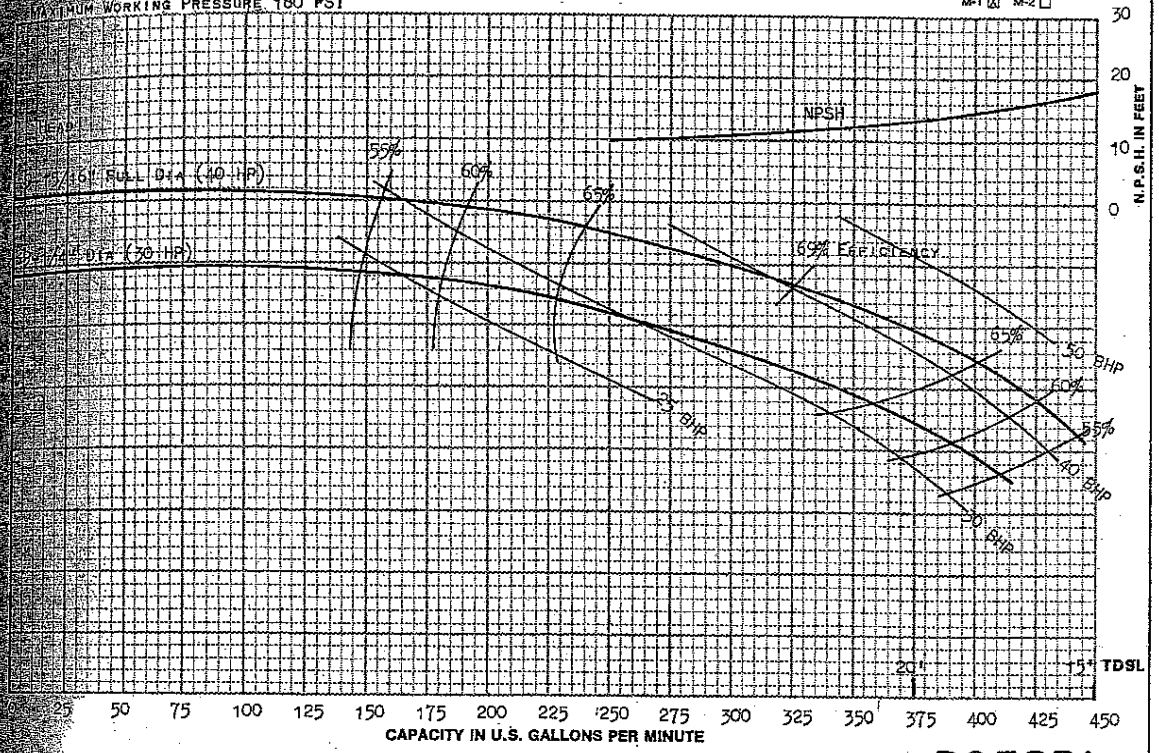
BERKELEY PUMP COMPANY
Division of Transamerica Delaval, Inc.

BERKELEY®

TYPE "B" RATING CURVES
MOTOR DRIVE

CURVE	4075
DATE	7-30-84
PAGE	2.03
SUPERSEDES	
NEW	

Case Material C.I. Patt. No. L-3482 Mach. No. L-3482 3600 NOMINAL R.P.M. 60 Cycles
Impeller Material C.I. Patt. No. M-666 Mach. No. M-5060 Dia. 9-15/16" FULL
T.D.S.L. for fresh water at sea level 80° F. max. M-1 ☒ M-2 ☐
MAXIMUM WORKING PRESSURE 180 PSI

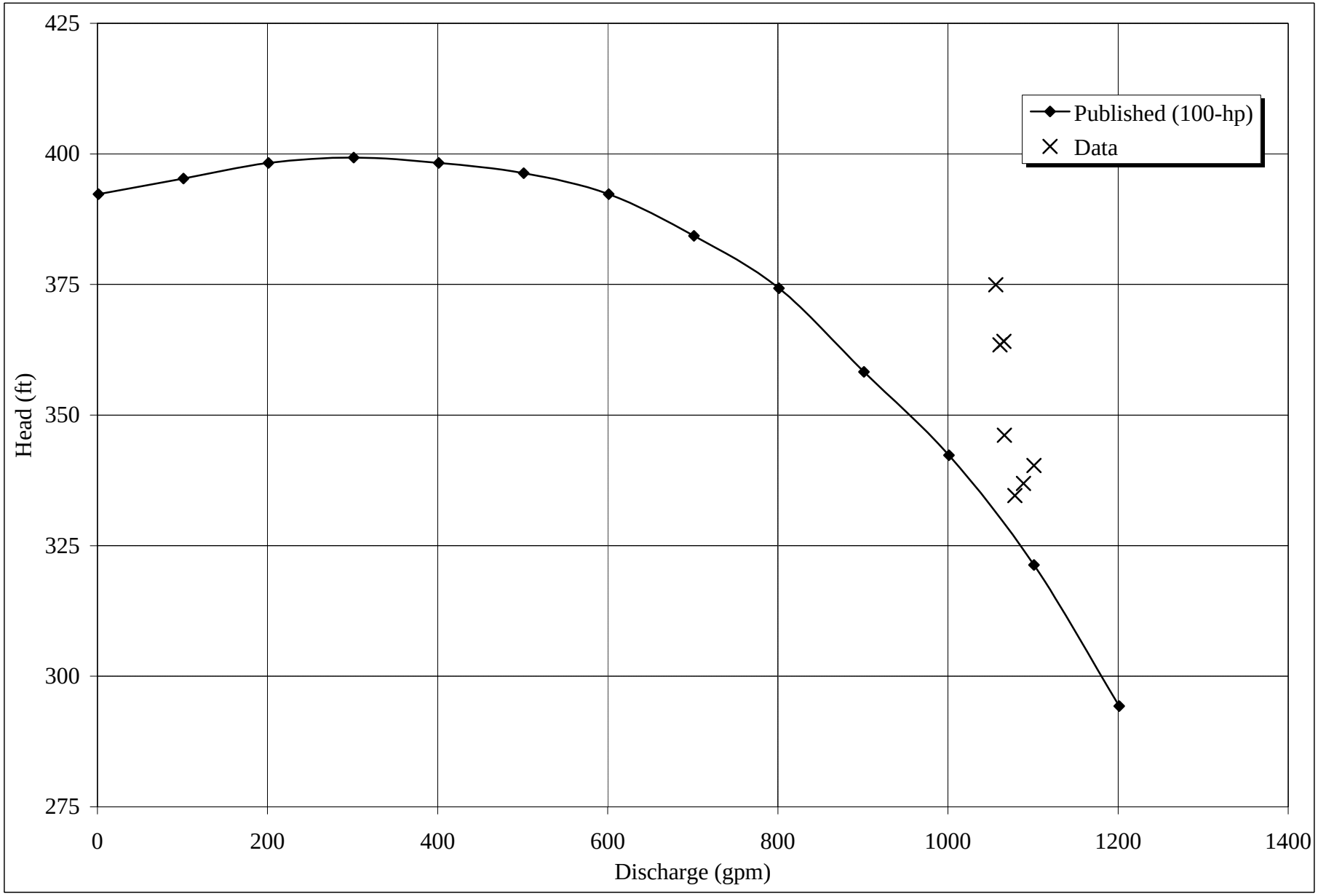


Based on T-2913 Supersedes C-6541 Dated 7-21-67 Date 9-21-70 MODEL B2EPBL

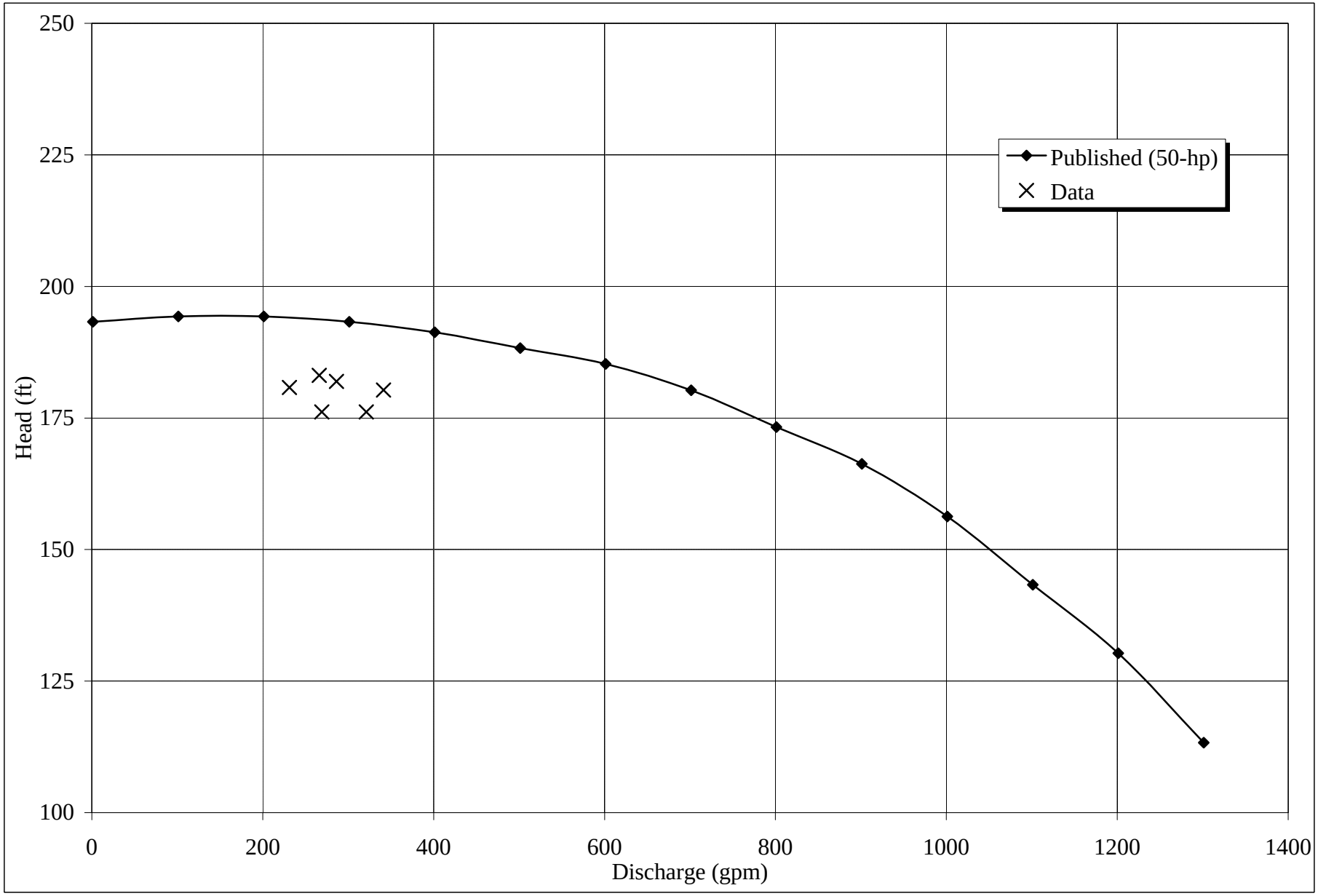
Hydraulic Model Calibration: Data Collection Scenarios

Scenario	Corrosion Control P.S.	Kenmar P.S.	Stewart P.S.	Vancil P.S.	Home Ave. P.S.	Underhill P.S.	Seneca P.S.	Drake Hill P.S.
1	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
2	**100HP ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF
3	OFF	**50HP ON**	OFF	OFF	OFF	OFF	OFF	OFF
4	**100HP ON**	**50HP ON**	OFF	OFF	OFF	OFF	OFF	OFF
5	OFF	OFF	**5HP ON**	OFF	OFF	OFF	OFF	OFF
6	OFF	OFF	**(2) 5HP ON**	OFF	OFF	OFF	OFF	OFF
7	OFF	OFF	OFF	**5HP ON**	OFF	OFF	OFF	OFF
8	OFF	OFF	OFF	**(2) 5HP ON**	OFF	OFF	OFF	OFF
9	OFF	OFF	OFF	**ALL ON**	OFF	OFF	OFF	OFF
10	OFF	OFF	OFF	OFF	**7.5HP ON**	OFF	OFF	OFF
11	OFF	OFF	OFF	OFF	**(2) 7.5HP ON**	OFF	OFF	OFF
12	OFF	OFF	OFF	OFF	OFF	**5HP ON**	OFF	OFF
13	OFF	OFF	OFF	OFF	OFF	**(2) 5HP ON**	OFF	OFF
14	OFF	OFF	OFF	OFF	OFF	OFF	**5HP ON**	OFF
15	OFF	OFF	OFF	OFF	OFF	OFF	**(2) 5HP ON**	OFF
16	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**20 HP ON**
17	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**(2) 20HP ON**
18	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**ALL ON**

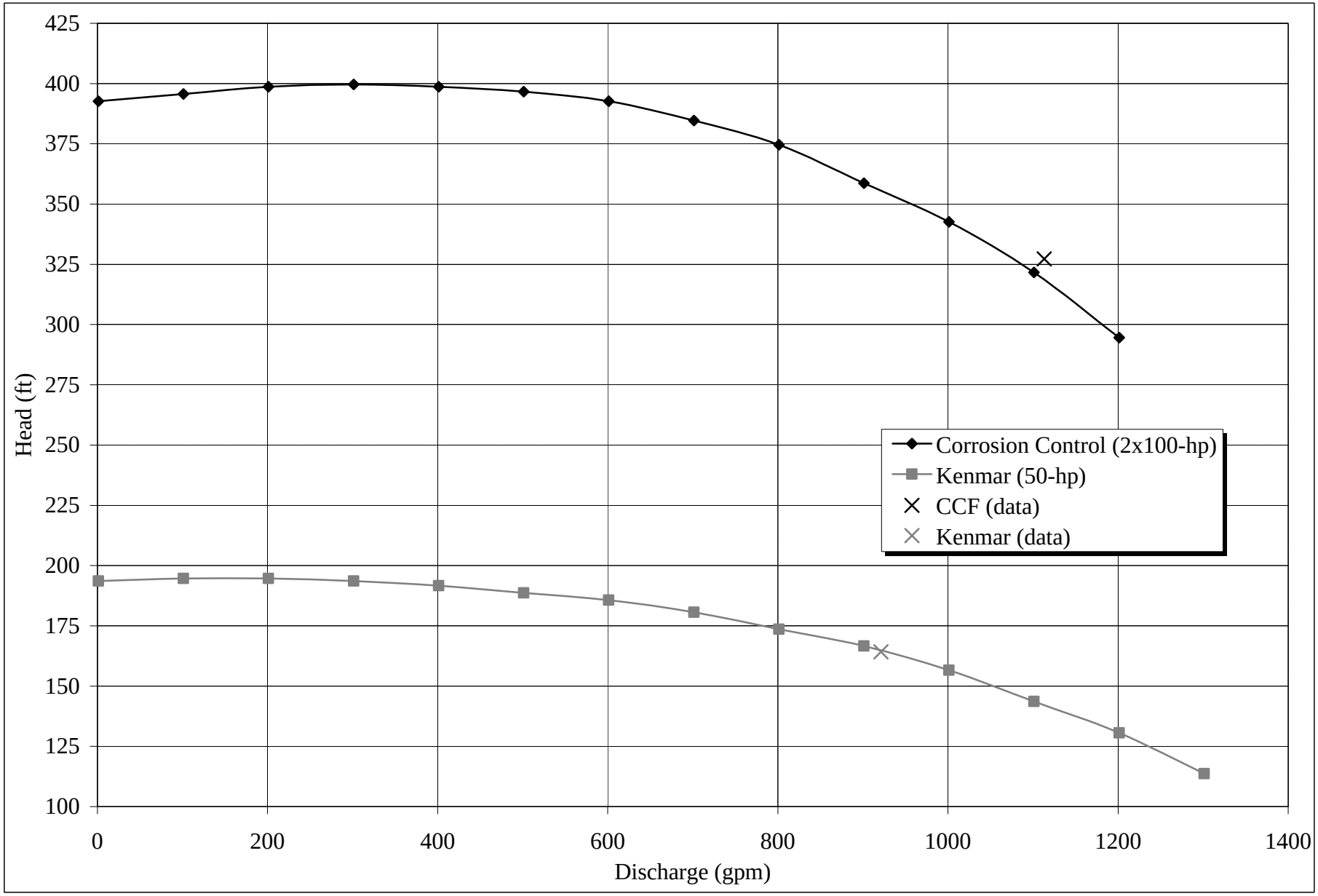
Scenario 2


425
400
375
350
325
300
275
Head (ft)
0
200
400
600
800
1000
1200
1400
Discharge (gpm)
Published (100-hp)
Data

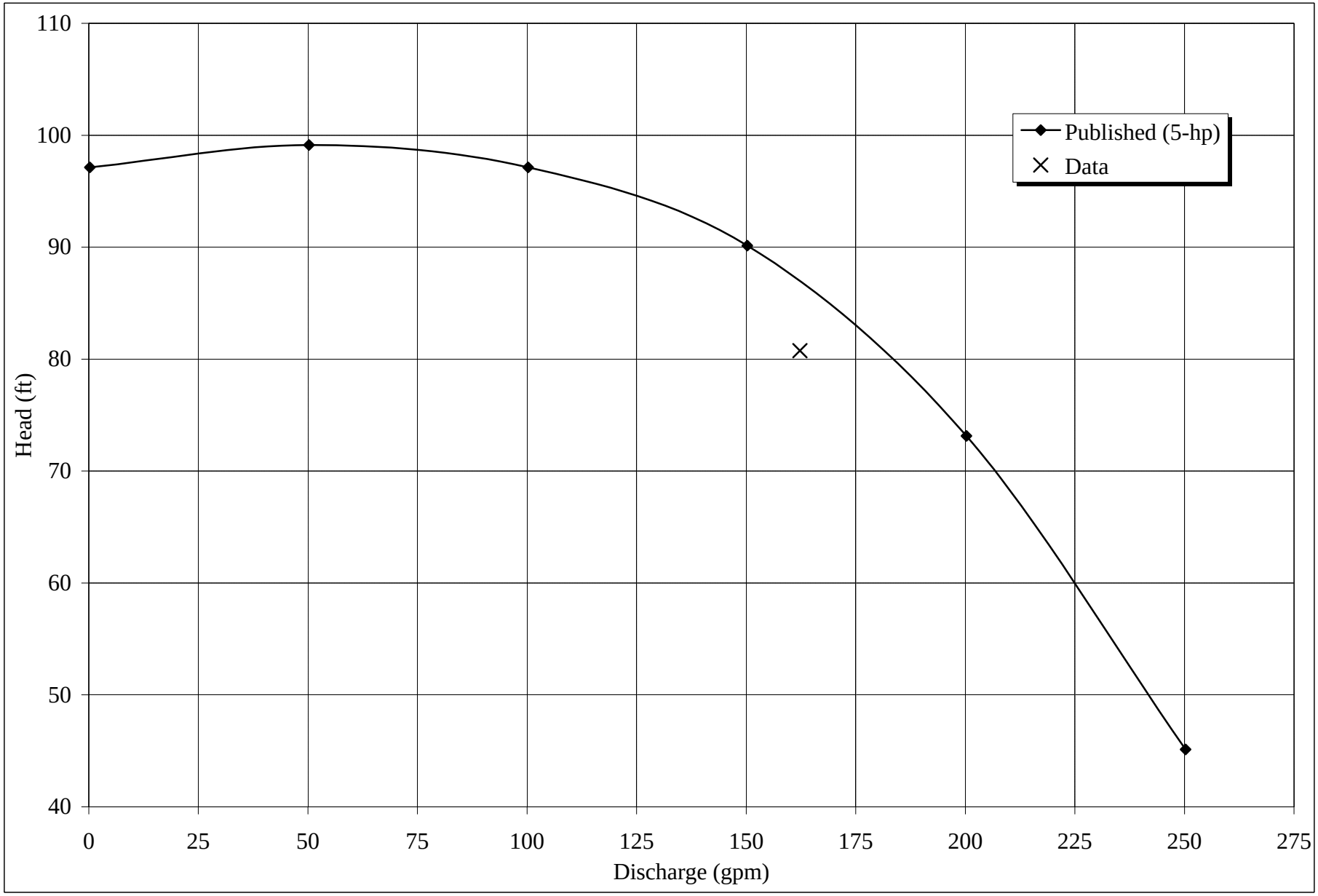
Scenario 3


250
225
200
175
150
125
100
Head (ft)
0
200
400
600
800
1000
1200
1400
Discharge (gpm)
Published (50-hp)
Data

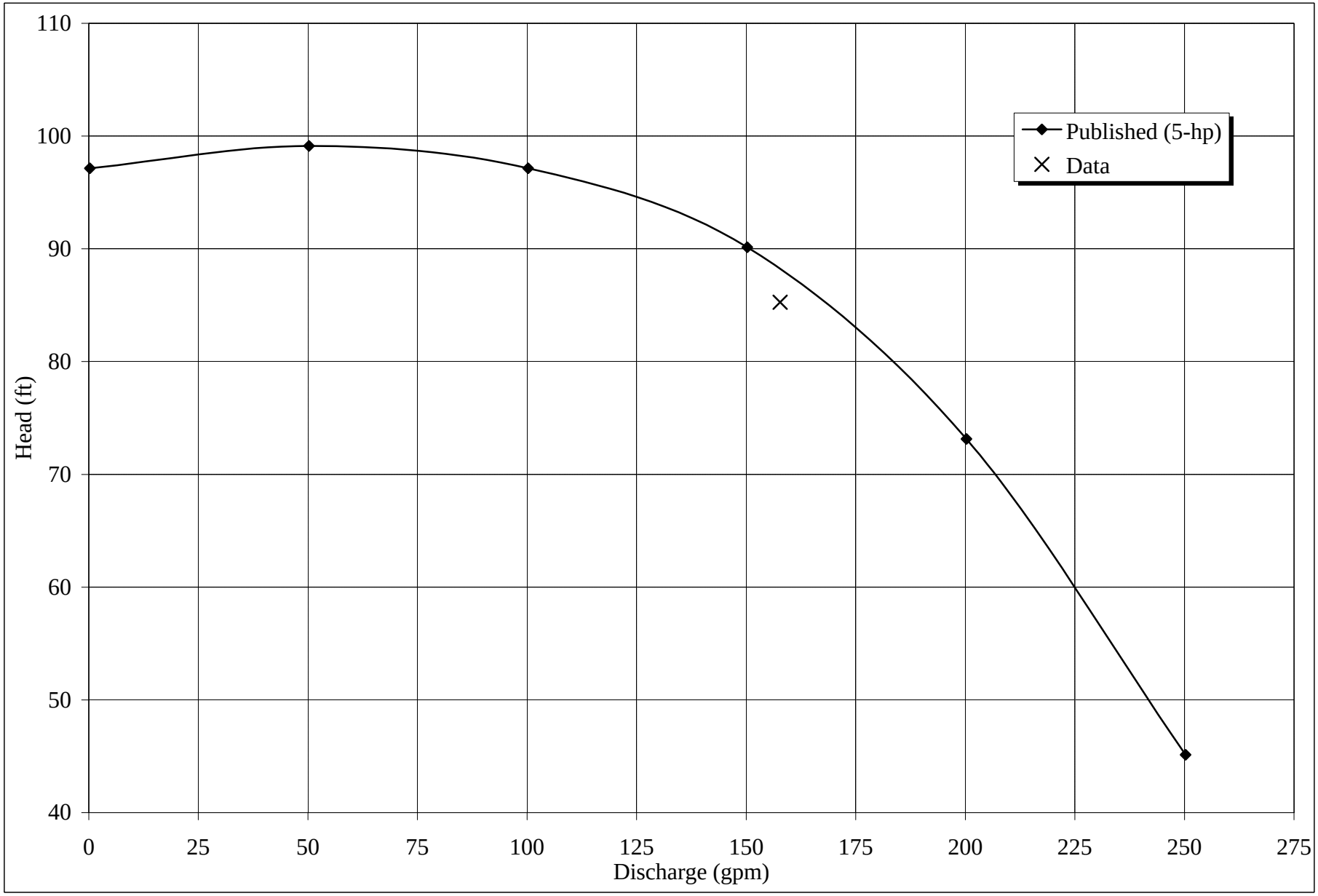
Scenario 4


425
400
375
350
325
300
275
250
225
200
175
150
125
100
Head (ft)
0
200
400
600
800
1000
1200
1400
Discharge (gpm)
Corrosion Control (2x100-hp)
Kenmar (50-hp)
CCF (data)
Kenmar (data)

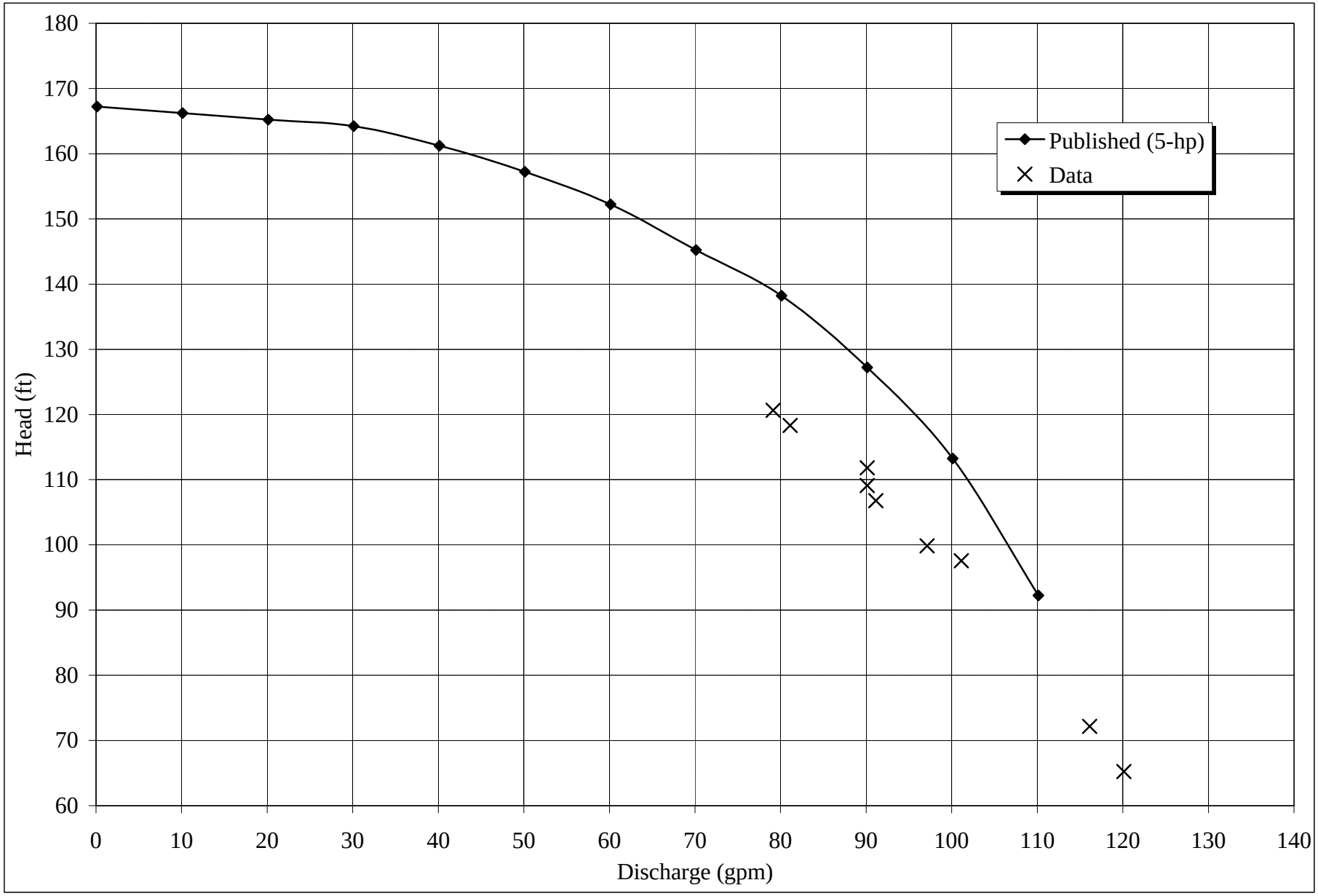
Scenario 5


110
100
90
80
70
60
50
40
Head (ft)
0
25
50
75
100
125
150
175
200
225
250
275
Discharge (gpm)
Published (5-hp)
Data

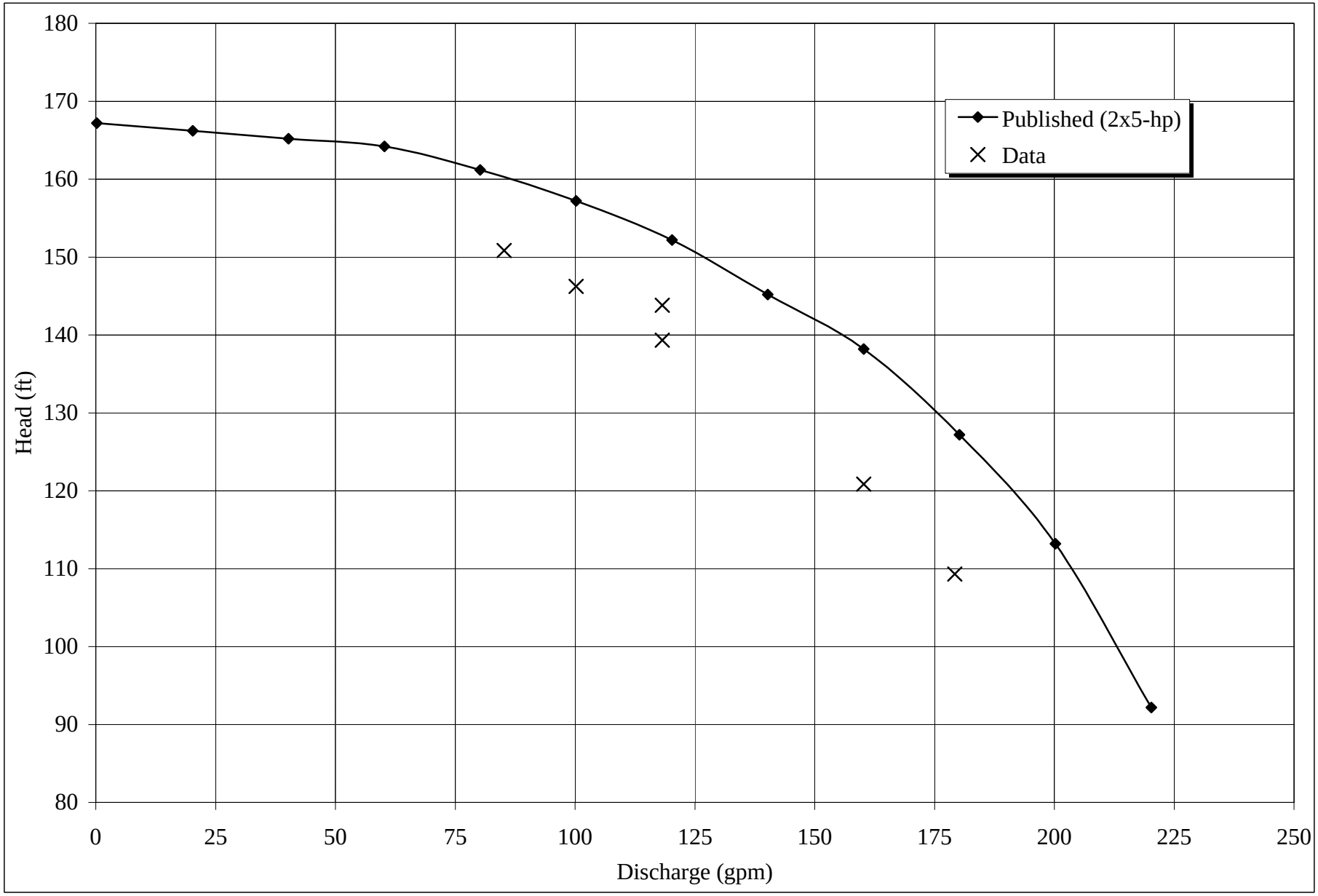
Scenario 6


110
100
90
80
70
60
50
40
Head (ft)
0
25
50
75
100
125
150
175
200
225
250
275
Discharge (gpm)
Published (5-hp)
Data

Scenario 7


Published (5-hp)
Data
Head (ft)
Discharge (gpm)
180
170
160
150
140
130
120
110
100
90
80
70
60
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

Scenario 8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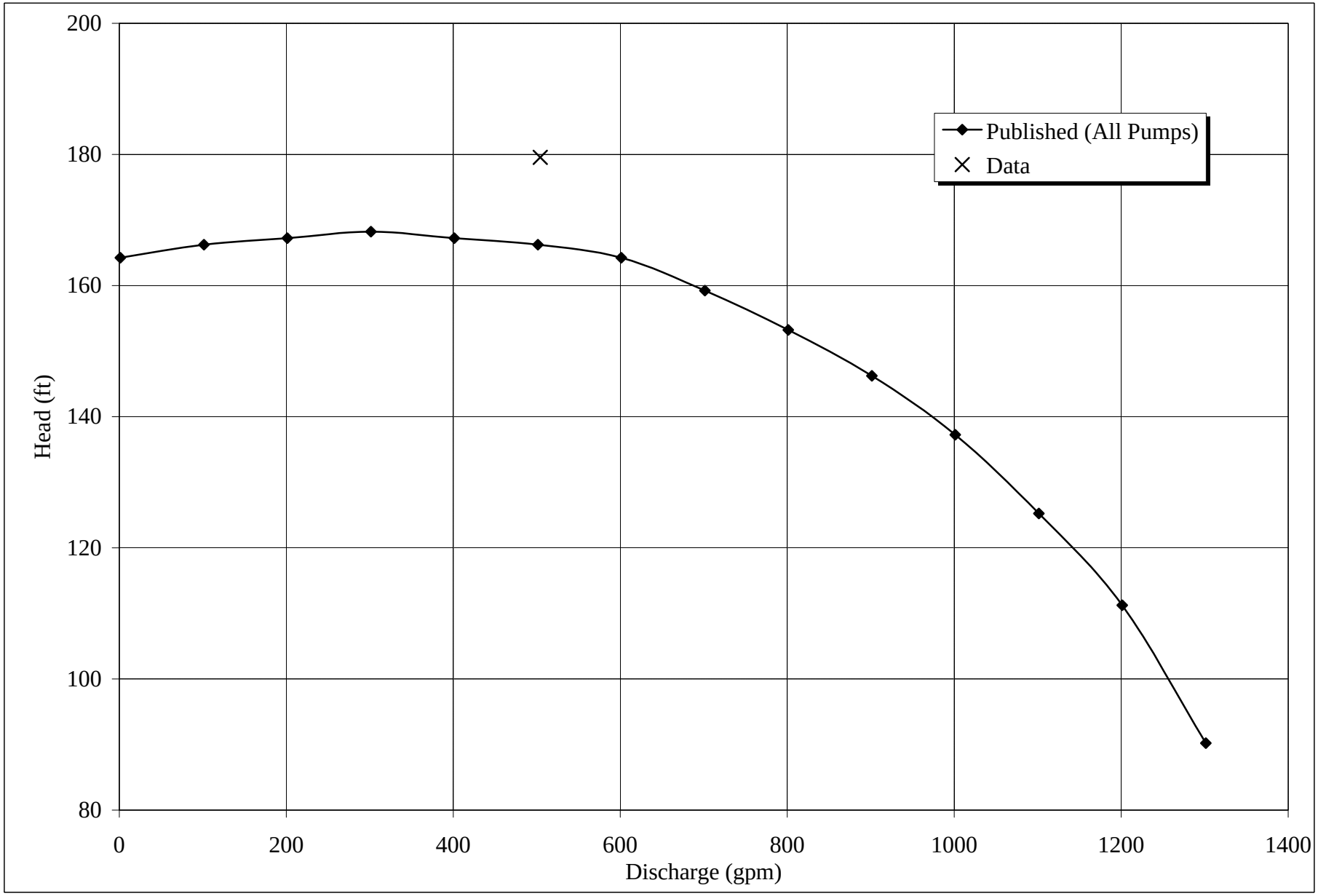
170
160
150
140
130
120
110
100
90
80
Head (ft)
0
25
50
75
100
125
150
175
200
225
250
Discharge (gpm)
Published (2x5-hp)
Data

Scenario 9


200
180
160
140
120
100
80
Head (ft)
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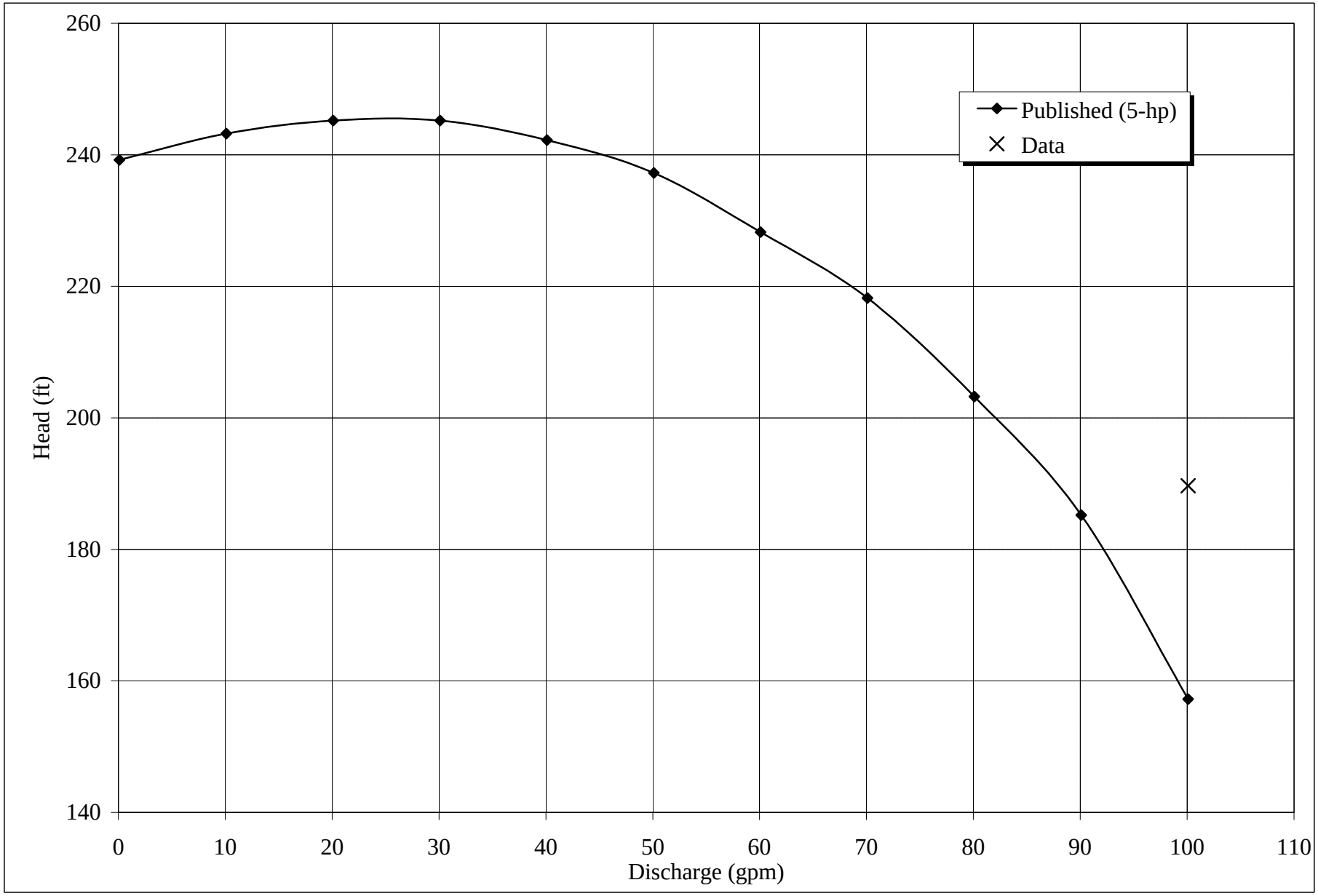
200
400
600
800
1000
1200
1400
Discharge (gpm)
Published (All Pumps)
Data

Scenario 10


260
240
220
200
180
160
140
Head (ft)
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40
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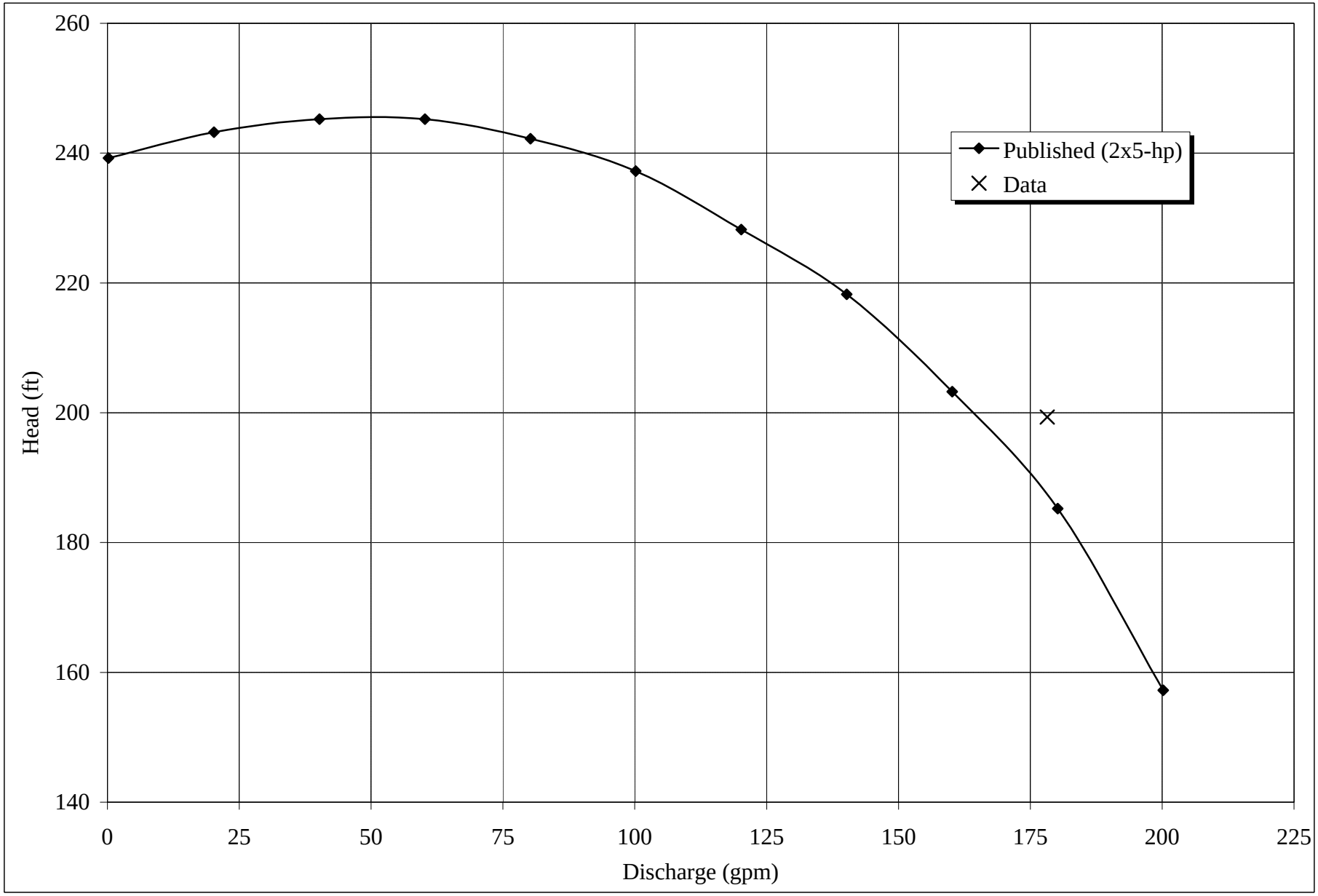
90
100
110
Discharge (gpm)
Published (5-hp)
Data

Scenario 11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240
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180
160
140
Head (ft)
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200
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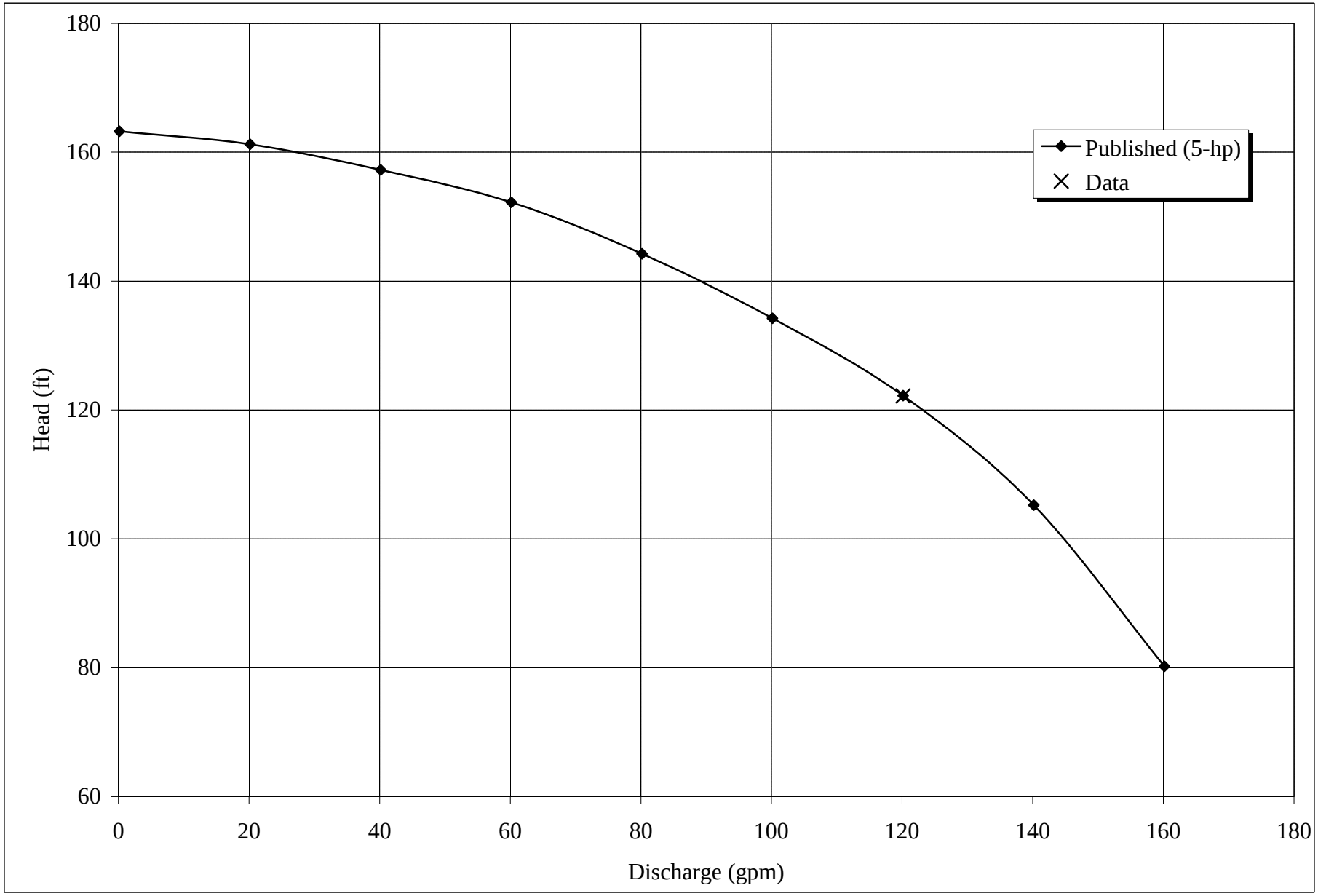
Discharge (gpm)
Published (2x5-hp)
Data

Scenario 12


180
160
140
120
100
80
60
Head (ft)
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20
40
60
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120
140
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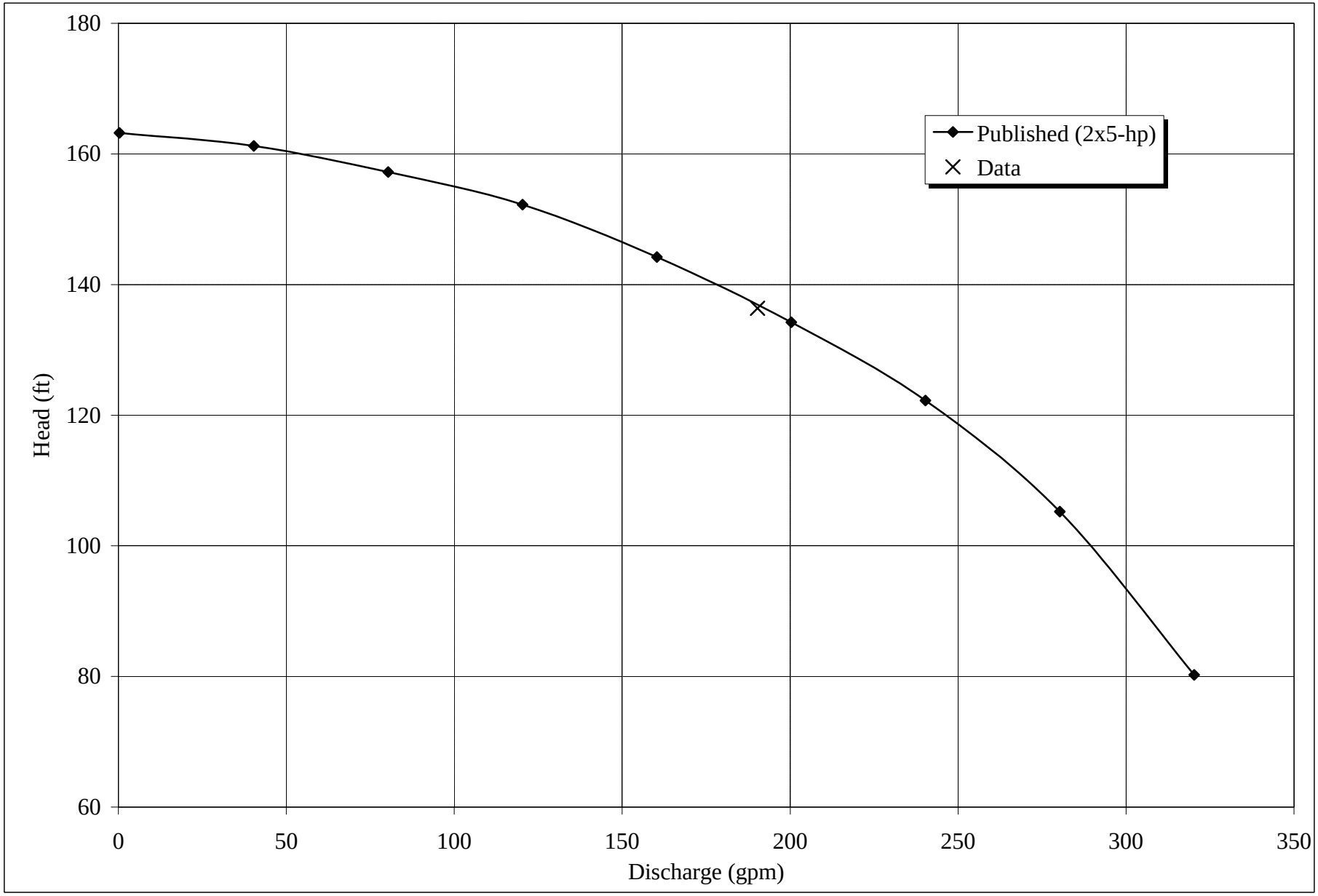
180
Discharge (gpm)
Published (5-hp)
Data

Scenario 13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160
140
120
100
80
60
Head (ft)
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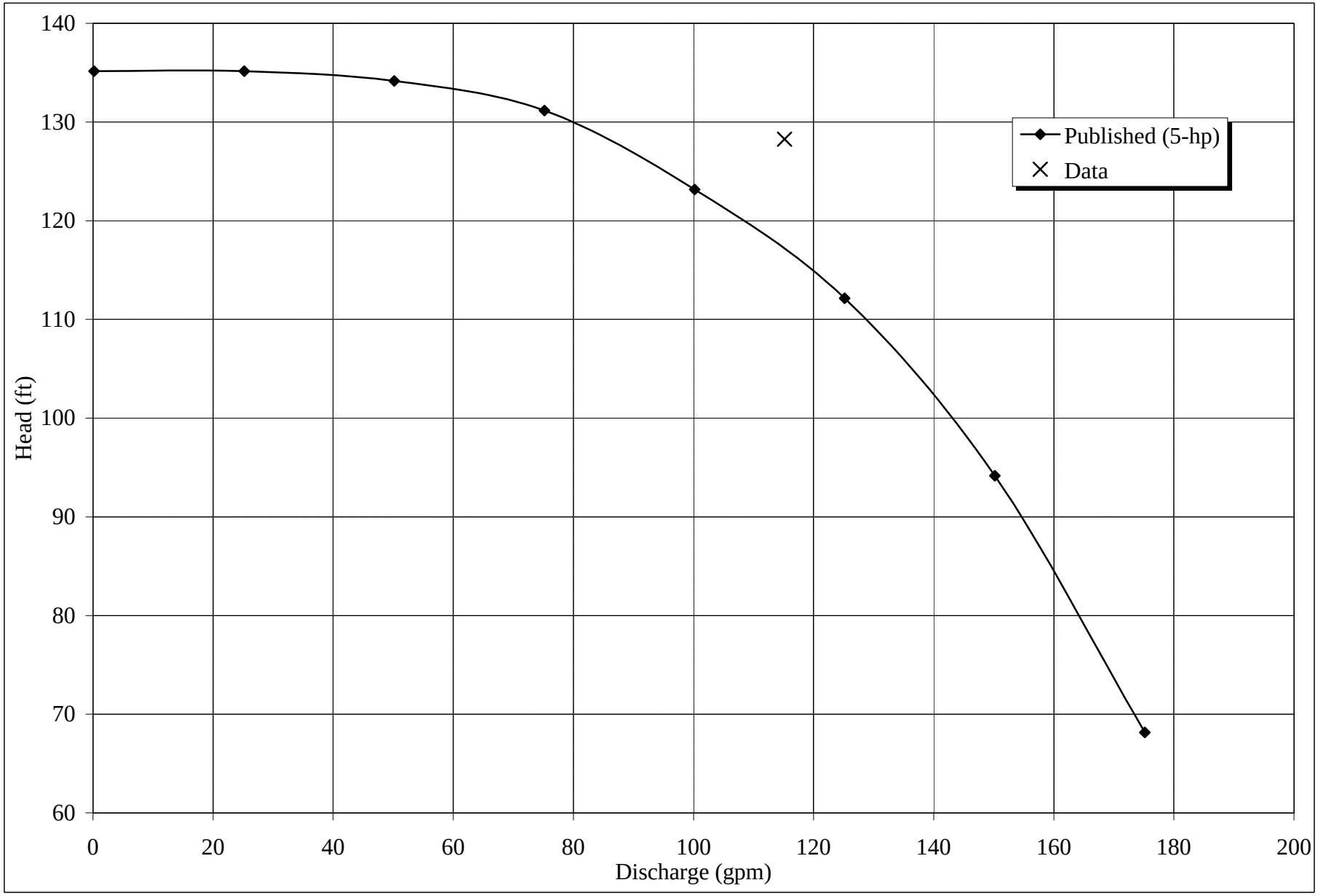
50
100
150
200
250
300
350
Discharge (gpm)
Published (2x5-hp)
Data

Scenario 14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130
120
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90
80
70
60
Head (ft)
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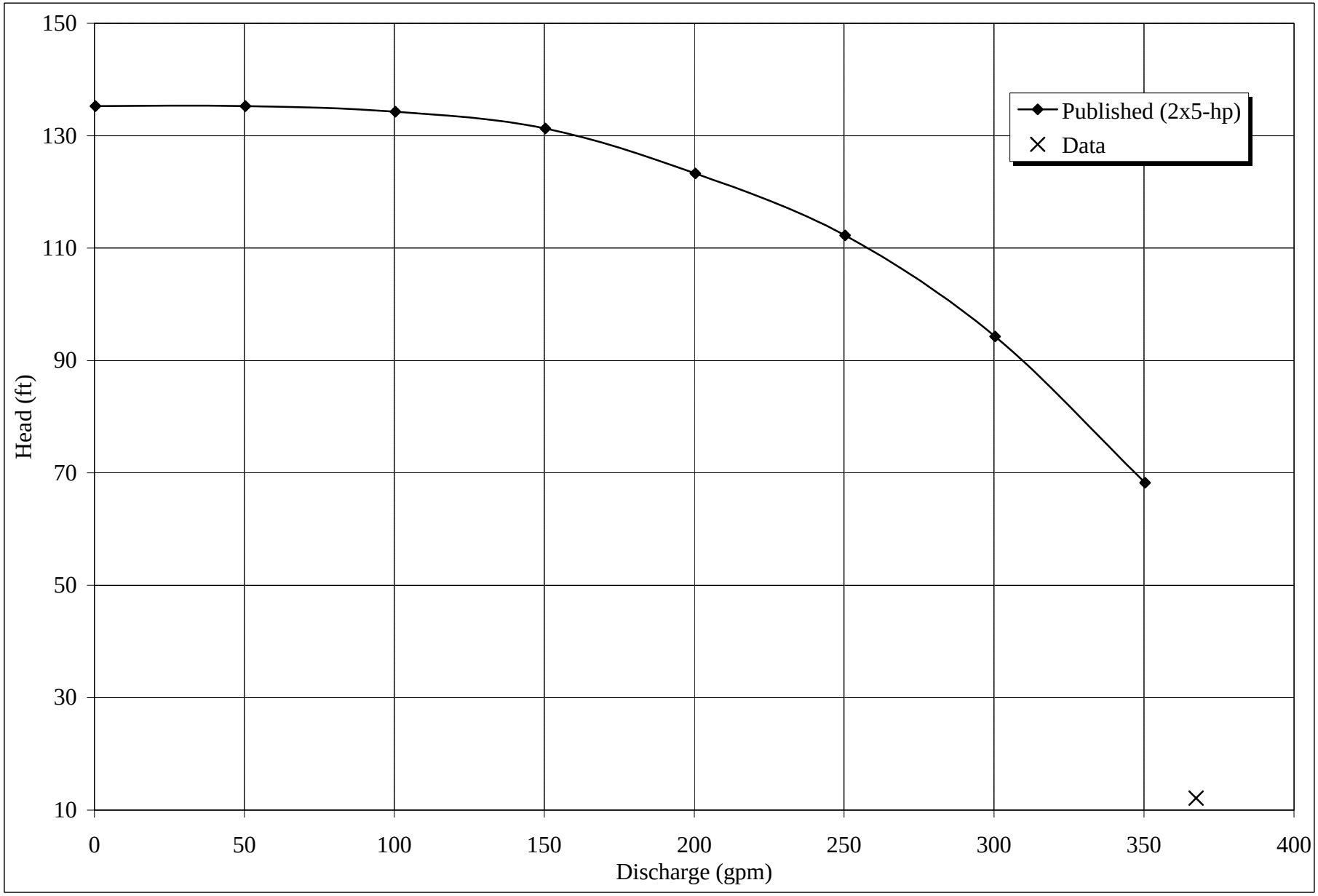
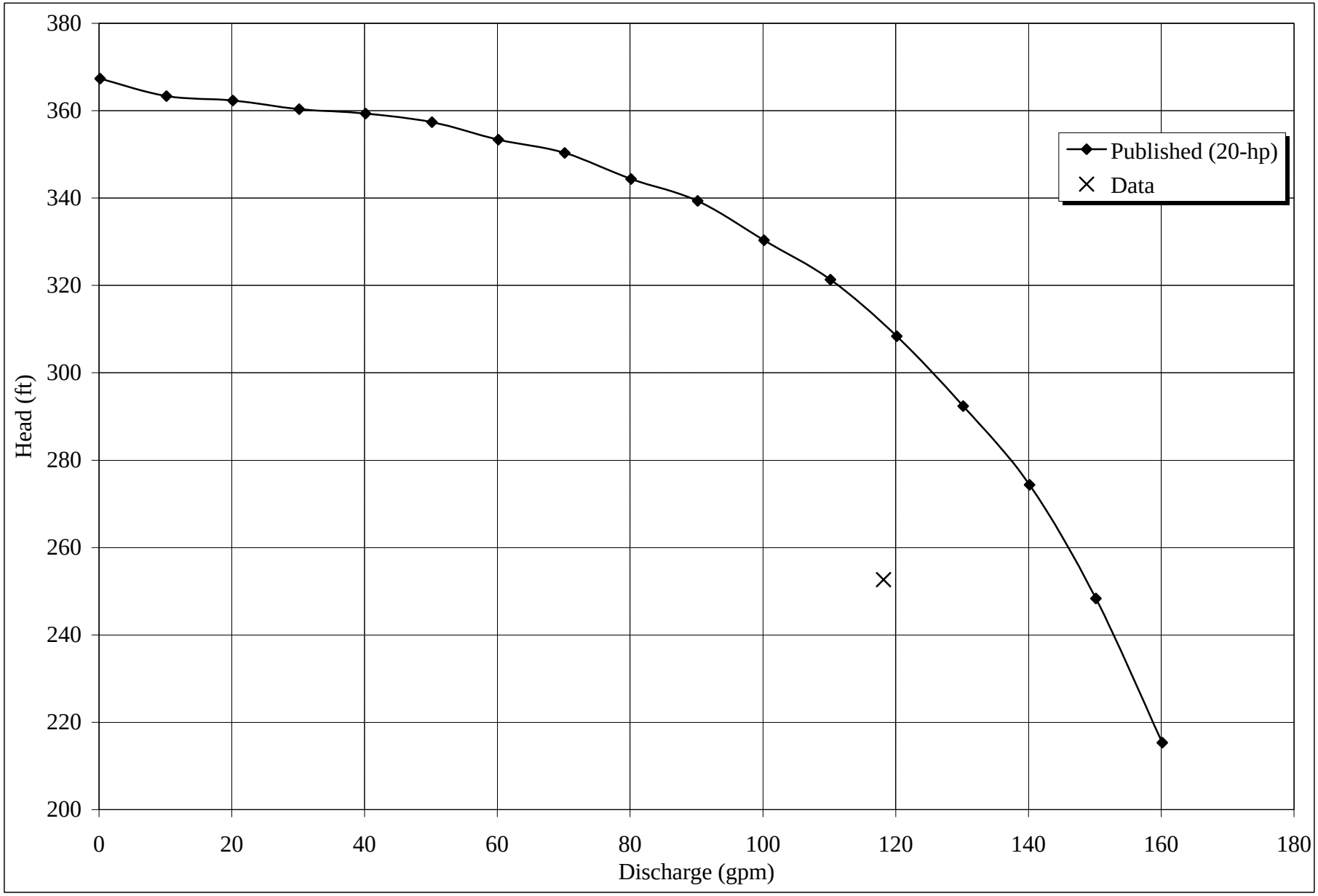
20
40
60
80
100
120
140
160
180
200
Discharge (gpm)
Published (5-hp)
Data

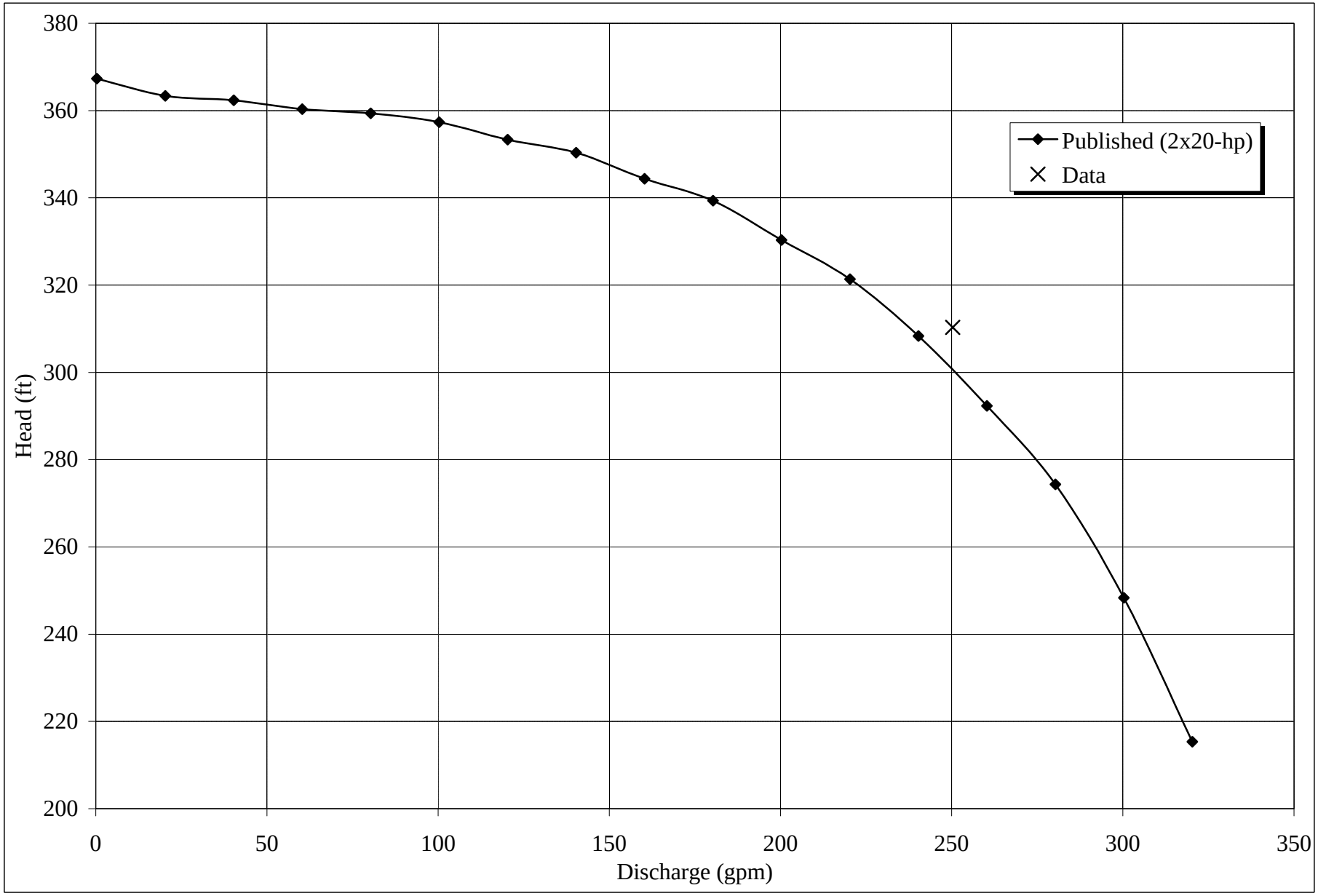
Scenario 15


150
130
110
90
70
50
30
10
Head (ft)
0
50
100
150
200
250
300
350
400
Discharge (gpm)
Published (2x5-hp)
Data

Scenario 16


380
360
340
320
300
280
260
240
220
200
Head (ft)
0
20
40
60
80
100
120
140
160
180
Discharge (gpm)
Published (20-hp)
Data

Scenario 17


380
360
340
320
300
280
260
240
220
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Head (ft)
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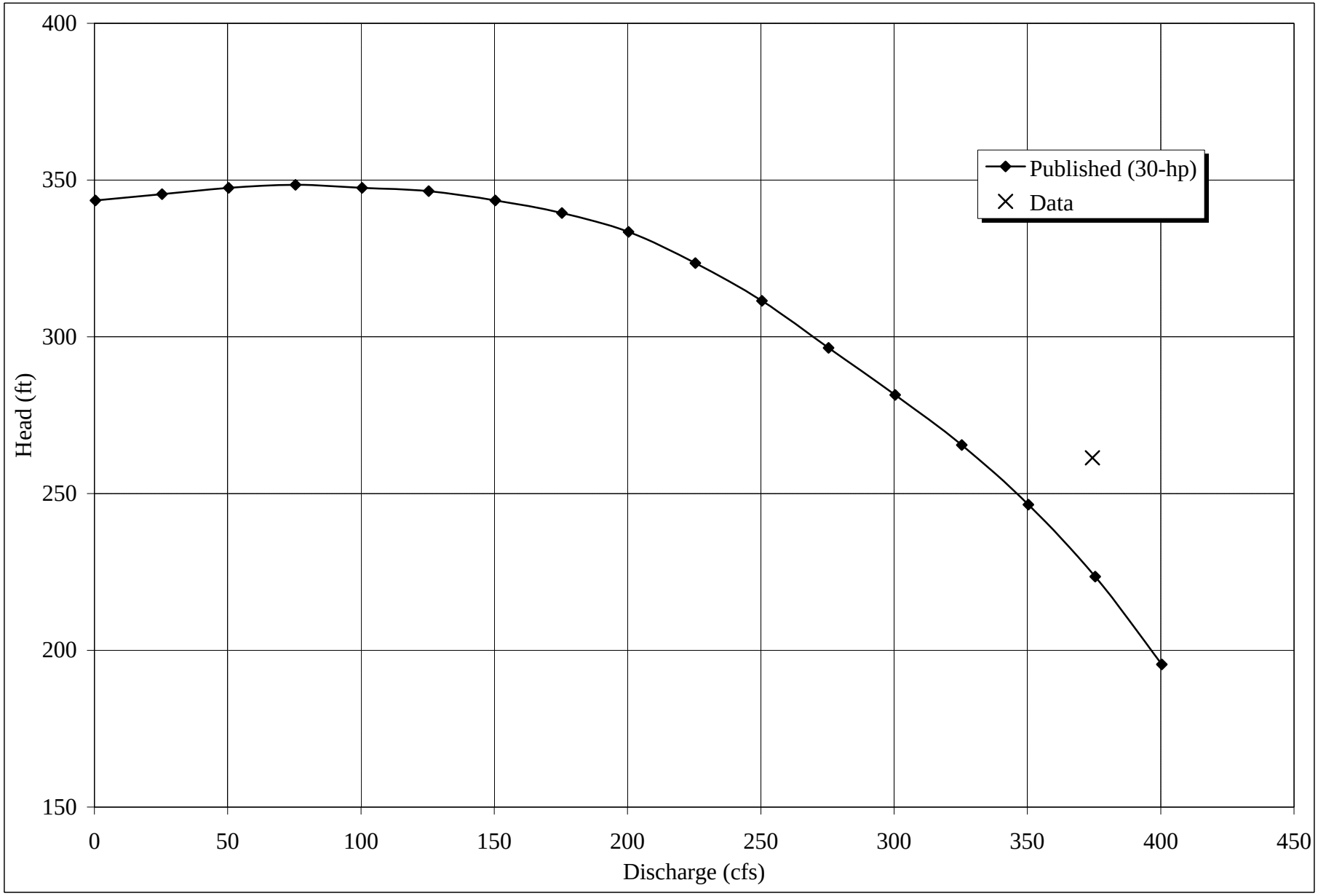
50
100
150
200
250
300
350
Discharge (gpm)
Published (2x20-hp)
Data

Scenario 18


400
350
300
250
200
150
Head (ft)
0
50
100
150
200
250
300
350
400
450
Discharge (cfs)
Published (30-hp)
Data

Appendix B

California Department Of Health Services (DHS) Guidance Criteria For Water Mains

State of California

Department of Health Services

Memorandum

Date: April 14, 2003 **(Revised Date: October 16, 2003)**

To: Regional and District Engineers

From: David P. Spath, Ph.D., Chief *(Original signed by Dave)*
Drinking Water and Environmental Management
601 North 7th Street, MS 216
Sacramento, CA 95814
(916) 322-2308

Subject: **GUIDANCE MEMO NO. 2003-02: GUIDANCE CRITERIA FOR THE SEPARATION OF WATER MAINS AND NON-POTABLE PIPELINES**

The purpose of this memo is to update guidance dated April 5, 1983 for consistency with proposed 2003 regulations. Should there be any modification to the proposed Water Works Standards that may impact the content of this guidance, the guidance will be amended accordingly.

GUIDANCE: CRITERIA FOR THE SEPARATION OF WATER MAINS AND NON-POTABLE PIPELINES

BACKGROUND

When buried water mains are in close proximity to non-potable pipelines, the water mains are vulnerable to contamination that can pose a risk of waterborne disease outbreaks. For example, sewers (sanitary sewer mains and sewage force mains) frequently leak and saturate the surrounding soil with sewage due to structural failure, improperly constructed joints, and/or subsidence or upheaval of the soil encasing the sewer. If a nearby water main is depressurized and no pressure or negative pressure occurs, that situation is a public health hazard that is compounded if an existing sewer is broken during the installation or repair of the water main. Further, failure of a water main in close proximity to other pipelines may disturb their bedding and cause them to fail. In the event of an earthquake or other disaster, simultaneous failure of all pipelines could occur.

The most effective protection against this type of drinking water contamination is adequate construction and separation of non-potable pipelines and water mains. The Waterworks Standards (Title 22, Chapter 16, Section 64572) provide separation criteria for new construction. However, when these criteria cannot be met, the risk of contamination can be reduced by increasing the structural integrity of pipe materials and joints, and ensuring minimum separation requirements are met. Therefore, the following guidance details construction criteria for the installation of water mains and non-potable pipelines to minimize the risk of contamination of drinking water.

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DEFINITIONS

- COMPRESSION JOINT - A push-on joint that seals by means of the compression of a rubber ring or gasket between the pipe and a bell or coupling.

- CONTINUOUS SLEEVE - A protective tube of high-density-polyethylene (HDPE) pipe with heat fusion joints or other non-potable metallic casing without joints into which a pipe is inserted.

- DISINFECTED TERTIARY RECYCLED WATER - Wastewater that has been filtered and subsequently disinfected in accordance with Section 60301.230, Chapter 3 (Water Recycling Criteria), Title 22, California Code of Regulations.

- HOUSE LATERAL - A sewer line connecting the building drain and the sanitary sewer main serving the street.

- SUPPLY LINE - Pipelines conveying raw water to be treated for drinking purposes in accordance with Section 64572 ©, **proposed** Water Works Standards.

- WATER MAIN – Means any pipeline, except for user service lines, within the distribution system in accordance with Section 64551.70, **proposed** Water Works Standards.

- RATED WORKING WATER PRESSURE - A pipe classification system based on internal working pressure of the fluid in the pipe, type of pipe material, and the thickness of the pipe wall.

- SANITARY SEWER MAIN - A gravity sewer conveying untreated municipal wastewater.

- SEWAGE FORCE MAIN - A pressurized sewer conveying untreated municipal wastewater.

APPLICABILITY

Note that the construction criteria presented in this document apply to house laterals that cross above a water main, but not to those house laterals that cross below a water main.

Water mains or non-potable pipelines that are 24-inches in diameter or larger may pose a higher degree of public health concern because of the large volumes of flow involved. Therefore, installation of water mains or non-potable pipelines 24-inches in diameter or larger should be reviewed and approved in writing by the Department on a case-by-case basis prior to construction.

In no case, should water mains and non-potable pipelines conveying sewage or other liquids be installed in the same trench.

REGULATORY REQUIREMENTS

Any new development project in which all the underground facilities are being constructed for the first time must comply with the following regulatory requirements:

Existing requirements:

Section 64630.(Title 22 CA Code of Regulations) Water Main Installation"

(c) Water mains shall be installed at least:

(1) Ten feet (3 meters) horizontally from and 1 foot (0.3 meters) higher than sanitary sewer mains located parallel to the main.

(2) One foot (0.3 meters) higher than sanitary sewer mains crossing the main.

(3) Ten feet (3 meters), and preferably 25 feet (7.5 meters), horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) Separation distances specified in (c) shall be measured from the nearest outside edges of the facilities.

(e) Where the requirements of (c) and (d) cannot be met due to topography, inadequate right-of-way easements, or conflicts with other provisions of these regulations, lesser separation is permissible if:

(1) The water main and the sewer are located as far apart as feasible within the conditions listed above.

(2) The water main and the sewer are not installed within the same trench.

(3) The water main is appropriately constructed to prevent contamination of the water in the main by sewer leakage.

(f) Water mains shall be disinfected according to AWWA Standard C601-81 before being placed in service.

(g) Installation of water mains near the following sources of potential contamination shall be subject to written approval by the Department on a case-by-case basis:

(1) Storage ponds or land disposal sites for wastewater or industrial process water containing toxic materials or pathogenic organisms.

(2) Solid waste disposal sites.

(3) Facilities such as storage tanks and pipe mains where malfunction of the facility would subject the water in the main to toxic or pathogenic contamination.

Although the following requirements have not yet been adopted, they should be within the next two years and should be used as guidance for future construction.

Proposed requirements as of the date of this document:

Section 64572. Water Main Separation

(a) New water mains and new supply lines shall not be installed in the same trench as, and shall be at least 10 feet horizontally from, and one foot vertically above, any parallel pipeline conveying:

(1) Untreated sewage,
(2) Primary or secondary treated sewage,
(3) Disinfected secondary-2.2 recycled water (defined in section 60301.220),
(4) Disinfected secondary-23 recycled water (defined in section 60301.225), and
(5) Hazardous fluids such as fuels, industrial wastes, and wastewater sludge.

(b) New water mains and new supply lines shall be installed at least 4 feet horizontally from, and one foot vertically above, any parallel pipeline conveying:

(1) Disinfected tertiary recycled water (defined in section 60301.230), and
(2) Storm drainage.

(c) New supply lines conveying raw water to be treated for drinking purposes shall be installed at least 4 feet horizontally from, and one foot vertically below, any water main.

(d) If crossing a pipeline conveying a fluid listed in subsection (a) or (b), a new water main shall be constructed perpendicular to and at least one foot above that pipeline. No connection joints shall be made in the water main within eight horizontal feet of fluid pipeline.

(e) The vertical separation specified in subsections (a), (b), and (c) is required only when the horizontal distance between a water main and pipeline is ten feet or less.

(f) New water mains shall not be installed within 100 horizontal feet of any sanitary landfill, wastewater disposal pond, or hazardous waste disposal site, or within 25 feet of any cesspool, septic tank, sewage leach field, seepage pit, or groundwater recharge project site.

(g) The minimum separation distances set forth in this section shall be measured from the nearest outside edge of each pipe barrel.

ALTERNATIVE CRITERIA FOR CONSTRUCTION

Water Mains, and Sewers and Other Non-potable Fluid-carrying Pipelines

When new water mains, new sanitary sewer mains, or other non-potable fluid-carrying pipelines are being installed in existing developed areas, local conditions (e.g., available space, limited slope, existing structures) may create a situation in which there is no alternative but to install water mains, sanitary sewer mains, or other non-potable pipelines at a distance less than that required by the regulations [existing Section 64630 (proposed Section 64572)]. In such cases, through permit action, the Department may approve

alternative construction criteria. The alternative approach is allowed under the proposed regulation Section 64551(c):

> "A water system that proposes to use an alternative to the requirements in this chapter shall demonstrate to the Department how it will institute additional mitigation measures to ensure that the proposed alternative would not result in an increased risk to public health."

Appropriate alternative construction criteria for two different cases in which the regulatory criteria for sanitary sewer main and water main separation cannot be met are shown in **Figures 1 and 2.**

- **Case 1** - New sanitary sewer main and a new or existing water main; alternative construction criteria apply to the sanitary sewer main.
- **Case 2** - New water main and an existing sanitary sewer main; alternative construction criteria may apply to either or both the water main and sanitary sewer main.

Case 1: New Sanitary Sewer Main Installation (Figures 1 and 2)

Zone	***Special Construction Required for Sanitary Sewer Main***
A	Sanitary sewer mains parallel to water mains shall not be permitted in this zone without prior written approval from the Department and public water system.
B	If the water main paralleling the sanitary sewer main does not meet the Case 2 Zone B requirements, the sanitary sewer main should be constructed of one of the following: 1. High-density-polyethylene (HDPE) pipe with fusion welded joints (per AWWA C906-99); 2. Spirally-reinforced HDPE pipe with gasketed joints (per ASTM F-894); 3. Extra strength vitrified clay pipe with compression joints; 4. Class 4000, Type II, asbestos-cement pipe with rubber gasket joints; 5. PVC sewer pipe with rubber ring joints (per ASTM D3034) or equivalent; 6. Cast or ductile iron pipe with compression joints; or 7. Reinforced concrete pressure pipe with compression joints (per AWWA C302-95).

C If the water main crossing below the sanitary sewer main does not meet the requirements for Case 2 Zone C, the sanitary sewer main should have no joints within ten feet from either side of the water main (in Zone C) and should be constructed of one of the following:

1. A continuous section of ductile iron pipe with hot dip bituminous coating; or

2. One of the Zone D options 1, 3, 4, or 5 below.

D If the water main crossing above the sanitary sewer main does not meet the Case 2 Zone D requirements, the sanitary sewer main should have no joints within four feet from either side of the water main (in Zone D) and be constructed of one of the following:

1. HDPE pipe with fusion-welded joints (per AWWA C906-99);

2. Ductile iron pipe with hot dip bituminous coating and mechanical joints (gasketed, bolted joints);

3. A continuous section of Class 200 (DR 14 per AWWA C900-97) PVC pipe or equivalent, centered over the pipe being crossed;

4. A continuous section of reinforced concrete pressure pipe (per AWWA C302-95) centered over the pipe being crossed; or

5. Any sanitary sewer main within a continuous sleeve.

Case 2: New water mains Installation (Figures 1 and 2)

Zone Special Construction Required for Water Main

A No water mains parallel to sanitary sewer mains shall be constructed without prior written approval from the Department.

B If the sanitary sewer main paralleling the water main does not meet the Case 1 Zone B requirements, the water main should be constructed of one of the following:

1. HDPE pipe with fusion welded joints (per AWWA C906-99);

2. Ductile iron pipe with hot dip bituminous coating;

3. Dipped and wrapped one-fourth-inch-thick welded steel pipe;

4. Class 200, Type II, asbestos-cement pressure pipe;

5. Class 200 pressure rated PVC water pipe (DR 14 per AWWA C900-97 & C905-97) or equivalent; or

6. Reinforced concrete pressure pipe, steel cylinder type, per AWWA (C300-97 or C302-99 or C303-95).

C If the sanitary sewer main crossing above the water main does not meet the Case 1 Zone C requirements, the water main should have no joints within ten feet from either side of the sanitary sewer main (in Zone C) and be constructed of one of the following:

1. HDPE pipe with fusion-welded joints (per AWWA C906-99);

2. Ductile iron pipe with hot dip bituminous coating;

3. Dipped and wrapped one-fourth-inch-thick welded steel pipe;

4. Class 200 pressure rated PVC water pipe (DR 14 per AWWA C900-97 & C905-97); or

5. Reinforced concrete pressure pipe, steel cylinder type, per AWWA (C300-97 or C301-99 or C303-95).

D If the sanitary sewer main crossing below the water main does not meet the requirements for Case 1 Zone D, the water main should have no joints within eight feet from either side of the sanitary sewer main (in Zone D) and should be constructed as for Zone C.

Water Mains and Pipelines Conveying Non-potable Fluids

When the basic separation criteria cannot be met between water mains and pipelines conveying non-potable fluids, the requirements described above for sanitary sewer mains should apply. This includes the requirements for selecting special construction materials and the separation requirements shown in Figures 1 and 2. Note that not all construction materials allowed for sanitary sewer mains will be appropriate for other non-potable fluid lines. For example, certain plastic lines may not be appropriate for the transport of some fuel products. The selection of compatible materials of construction for non-potable fluids is a decision to be made by the project engineer.

Water Mains and Sewage Force Mains

- Sewage force mains shall not be installed within ten feet (horizontally) of a water main.

- When a sewage force main must cross a water main, the crossing should be as close as practical to the perpendicular. The sewage force main should be at least one foot below the water main.

- When a new sewage force main crosses under an existing water main, and a one-foot vertical separation cannot be provided, all portions of the sewage force main within eight feet (horizontally) of the outside walls of the water main should be enclosed in a continuous sleeve. In these cases, a minimum vertical separation distance of 4 inches should be maintained between the outside edge of the bottom of the water main and the top of the continuous sleeve.

- When a new water main crosses over an existing sewage force main, the water main should be constructed of pipe materials with a minimum rated working pressure of 200 psig or the equivalent.

Water Mains and Tertiary Treated Recycled Water or Storm Drainage

The basic separation criteria for water mains and pipelines conveying tertiary treated recycled water or storm drainage lines are a 4-foot horizontal separation where lines are running parallel and a 1-foot vertical separation (water line above recycled or storm drainage) where the lines cross each other.

When these criteria cannot be met, the Zone A criteria apply where lines are running parallel, and the Zone C and Zone D criteria apply where the lines cross each other as shown on Figures 1 and 2. For these situations, the Zone "P" criteria are in effect and prohibit construction less than 1 foot in parallel installations and less than 4 inches in vertical (crossing) situations.

For tertiary treated recycled water and storm drainage lines, the Zone B criteria (requirements for special pipe) do not apply as the basic separation criteria is a four-foot horizontal separation criteria for parallel lines. The tertiary treated recycled water lines should be constructed in accordance with the color-coding, and labeling requirements per Section 116815, California Health and Safety Code of Regulations.

MISCELLANEOUS GUIDANCE

- More stringent requirements may be necessary if conditions such as high groundwater exist. HDPE or similar pipe may be required to provide flexibility to move without potential joint leaks.

- Sanitary sewer mains should not be installed within 25 feet horizontally of a low head (5 psig or less pressure) water main.

- New water mains and sanitary sewer mains should be pressure tested in accordance with manufacturer's specifications.

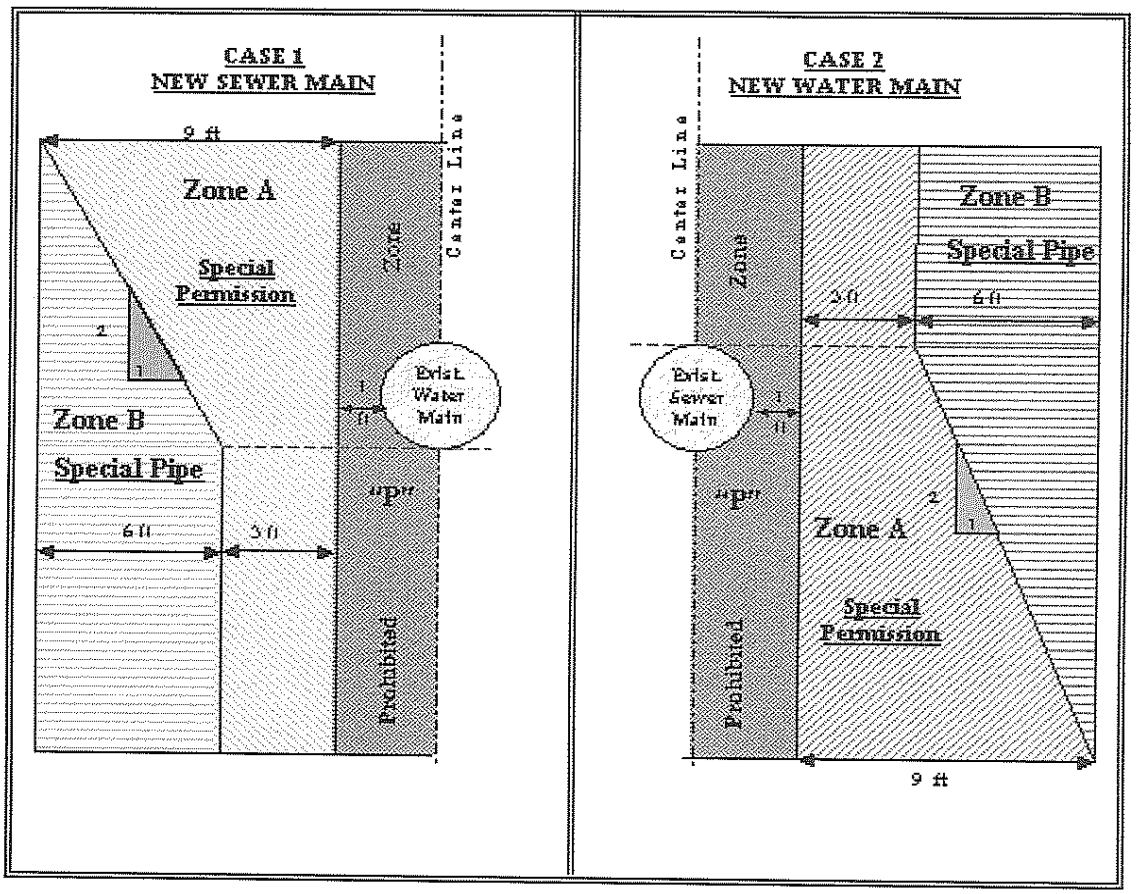
- When installing water mains, sewers, or other pipelines, measures should be taken to prevent or minimize disturbances of existing pipelines. Disturbance of the conduit's supporting base could eventually result in pipeline failure.

- Special consideration should be given to the selection of pipe materials if corrosive conditions are likely to exist. These conditions may be due to soil type and/or the nature of the fluid conveyed in the conduit, such as a septic sewage producing corrosive hydrogen sulfide.

NOTE: Dimensions are from the outside of the water main to the outside of the other pipeline, manhole, or sleeve.

FIGURE 1 PARALLEL CONSTRUCTION

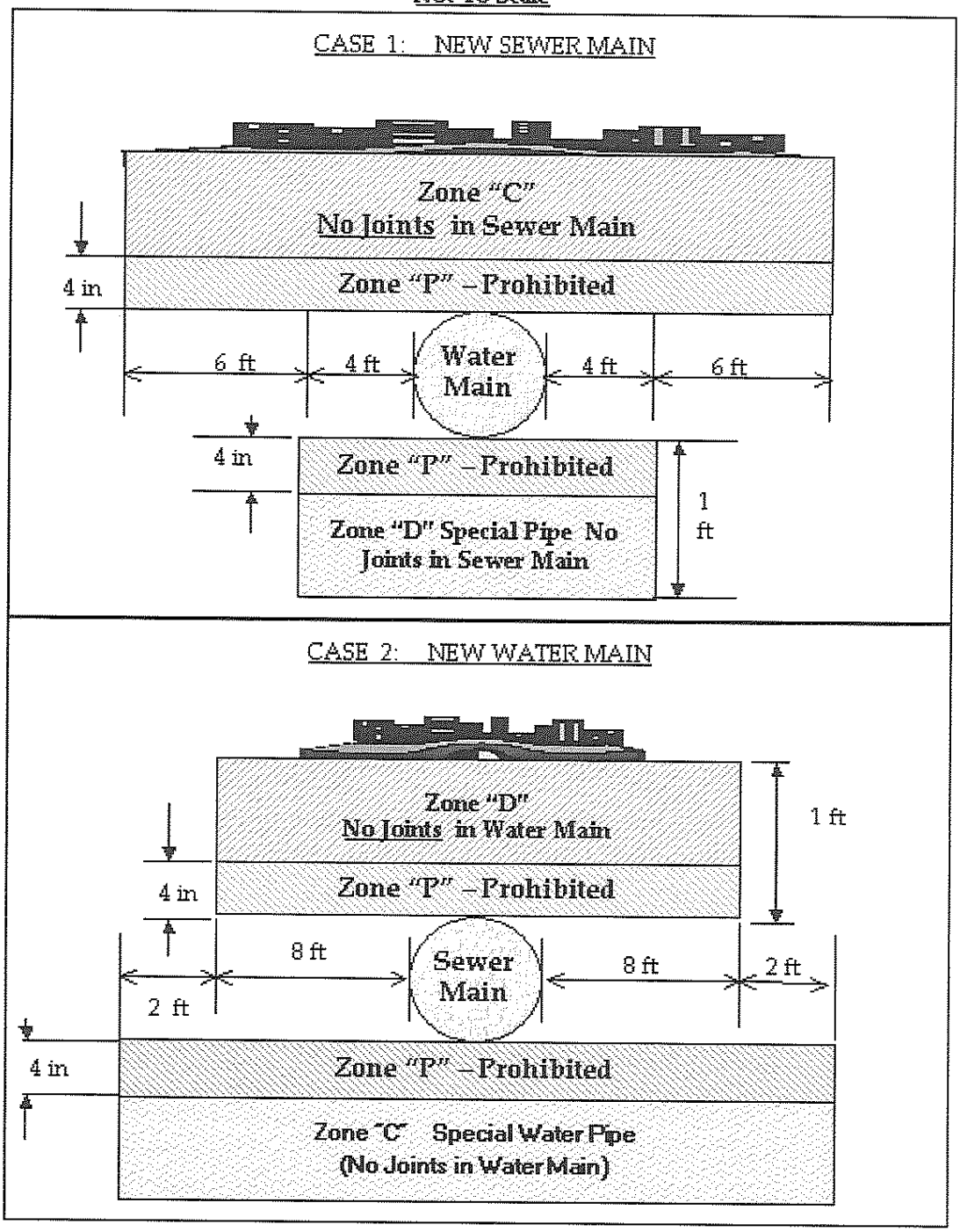
Not To Scale



Note: Zones identical on either side of center lines.

Zones "P" is a prohibited zone. Section 64630 (e) (2) California Code of Regulations, Title 22 (Current); or Section 64572 (a) California Code of Regulations, Title 22 (Proposed).

FIGURE 2 CROSSINGS
Not To Scale



Appendix C
Project Cost Estimate Details

Storm Drain, Water, and Associated Prices (Installed)

Description (installed)	Unit	NEW ESTIMATES Used In Estimates $/Unit	Maximum $/Unit	Minimum $/Unit	Median $/Unit	Mean $/Unit	Stdev $/Unit
Class II Aggregate Base (3/4")	TON	30.00	184.91	14.25	60.32	63.51	44.82
Sand Bedding	TON	20.00	45.96	17.65	26.24	27.56	9.98
AC Pavement (3")	TON	90.00	184.91	14.05	67.10	72.43	37.16
Concrete Sidewalk	SF	5.30	6.50	3.52	5.01	5.01	2.11
Type II Concrete Curb	LF	16.00	21.00	5.65	13.06	12.63	4.69
Concrete Curb/Gutter	LF	19.20	18.00	16.22	17.11	17.11	1.26
Storm Drain Drop Inlet	EA	3000.00	8063.01	1200.00	2115.48	2566.57	1387.52
Storm Drain Curb Inlet	EA	3000.00	3172.74	1780.64	1884.51	2144.01	546.89
Storm Drain Junction Box	EA	0.00	46843.73	456.00	19867.88	19906.34	13965.24
Storm Drain Man Hole (48")	EA	5000.00	20000.00	1028.41	3802.25	4647.95	3065.03
Adjust Manholes	EA	1000.00	1151.11	350.00	559.15	692.22	339.67
12" HDPE Storm Drain	LF	21.30	111.83	38.00	67.10	68.35	22.45
18" HDPE Storm Drain	LF	26.60	428.11	19.33	95.06	128.17	89.09
24" HDPE Storm Drain	LF	37.30	511.27	27.79	117.61	161.50	124.32
30" HDPE Storm Drain	LF	53.30	238.59	44.75	187.81	166.35	67.41
36" HDPE Storm Drain	LF	69.30	301.94	54.25	178.93	168.33	76.40
42" HDPE Storm Drain	LF	85.30	266.02	70.65	168.34	168.34	138.15
48" HDPE Storm Drain	LF	106.60	85.40	85.40	85.40	85.40	
54" HDPE Storm Drain	LF	122.60	0.00	0.00			
60" HDPE Storm Drain	LF	133.20	0.00	0.00			
14" Class 150 PVC Water Main	LF	100.00	150.00	0.00			
12" Class 150 PVC Water Main	LF	90.00	135.00	0.00			
10" Class 150 PVC Water Main	LF	53.00	110.00	70.00	76.00	83.00	18.24
8" Class 150 PVC Water Main	LF	46.00	82.00	64.00	68.50	70.75	8.30
6" Class 150 PVC Water Main	LF	43.00	65.00	60.00	63.50	63.00	2.45
Bolted Steel Water Tank	GAL	0.75	1.34	0.80	1.26	1.17	0.25
Elevated Water Storage Tank	GAL	1.50	0.00	0.00			
Fire Hydrant Assembly	EA	3025.00	4500.00	3500.00	4050.00	4025.00	411.30
Water Service Connection	EA	1135.00	1700.00	1250.00	1592.50	1533.75	197.63
14" Gate Valve	EA	1890.00	0.00	0.00			
12" Gate Valve	EA	1510.00	0.00	0.00			
10" Gate Valve	EA	1210.00	1800.00	1400.00	1625.00	1612.50	193.11
8" Gate Valve	EA	1060.00	1500.00	1100.00	1150.00	1225.00	189.30
6" Gate Valve	EA	760.00	1000.00	900.00	950.00	950.00	57.74
Pressure Reducing Valve	EA	900.00	0.00	0.00			
Rock Slope Protection	CY	138.60	63.52	60.00	62.00	61.84	1.77
Excavation (backhoe)	CY	6.40	278.35	4.83	43.87	61.11	65.68
Backfill	CY	7.50	200.00	1.53	9.45	40.82	56.54
Compacting	CY	5.30	2.60	2.29	2.45	2.45	0.22
Hauling/Disposal	CY	10.70	14.25	7.30	11.58	11.21	2.50
Grading	LF						
Traffic Control	LS	10658.40	44732.36	559.15	10000.00	14005.97	12483.03
Thermoplastic Street Stripes (6")	LF	1.60	1.50	1.10	1.30	1.30	0.28

Earthwork Costs

Description	Unit	Used In Estimates $/Unit
Laborer	HR	45.00
Foreman	HR	60.00
Driver/Operator	HR	50.00
Dump Truck Rental	HR	70.00
Back Hoe Rental	HR	70.00
Rock Slope Protection	TON	57.15
Rock Slope Protection	CY	100.00

Assumptions:

Weight of Aggregate: 110 lb/ft^3
Weight of Dirt: 110 lb/ft^3
Weight of Sand: 110 lb/ft^3
Weight of AC Pave: 145 lb/ft^3
Weight of Rock: 1.75 ton/yd^3

Old Date	14-Apr-04
Old ENR	7,017
New Date	15-Aug-05
New ENR	7,479

OLD ESTIMATES			Enterra Inc.	Northern Aggr.	Bedrock, Inc.	Includes Frieght Granite Const.	Main/Laurel St.
Used In Estimates	MEANS	Baxman Gravel	Willits	Willits	Gualala	Willits	FB (2003)
$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit
22.00	17.04	57.02				24.00	60.00
18.00	45.96	17.65	27.24	20.24	25.24	29.00	
80.00	58.12	25.99	17.85	15.15	14.05	57.00	110.00
5.00	3.52						
15.00	5.65						
18.00	16.22						
2500.00							
2500.00							
3500.00	1028.41						
600.00							400.00
20.00							
25.00							
35.00							
50.00							
65.00							
80.00							
100.00							
115.00							
125.00							
130.00	63.52						
6.00	4.83						50.00
7.00	1.53						
5.00	2.29						
10.00	7.30						
10.00							
10000.00							7500.00
1.50	1.10						1.50

Willits (2003) $/Unit	Adjusted 2004 FB (1991-09) $/Unit	Adjusted 2004 FB (2002-04) $/Unit	Riverside Co (2004) $/Unit	Mountain Cascade $/Unit	McGuire & Hester $/Unit	Terracon Pipelines, Inc. $/Unit	Cany
18.25			24.31				
79.00		79.10	47.80				
6.50							
21.00							
18.00							
1200.00	1250.39		1800.00				
2000.00	3172.74		1800.00				
2000.00			456.00				
	3453.32	10640.87	4500.00	5000.00	5700.00	4800.00	
350.00	1151.11	638.45					
38.00							
38.00	54.68						
51.00	58.99						
120.00							
	69.07						
		266.02					

on Heights Sewer Project (2003) Bids from Neal (Waterfront Drive I

K. J. Woods	Pacific Underground	Lowery Engr. Constr.	Winzler & Kelly	Richard Cox	RAO Const.	Contri Const.
$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit
			100.00	15.43	18.99	19.59
				52.23	53.42	48.86
				13.06	14.25	13.06
				1869.67	1899.35	2849.02
				1869.67	1899.35	2849.02
7000.00	2300.00	20000.00	3750.00	4579.80	4748.37	2492.89
10.00	100.00	200.00	17.50	11.28	14.25	11.87
10.00	100.00	200.00	17.50	3.56	8.31	5.94
				13.06	14.25	11.28
4000.00	10000.00	40000.00	5000.00			

Extension, 1997; Adjusted to 2004)			Santa Rosa 2000: College/Mendocino Intersection Project (Adjusted 2004)					
John Peterson	Redwood Empire Agg.	Famillian (material)	Engineer	Ghilotti Brothers	Ghilotti Construction	Argonaut	Michael Paul	Engineer
$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit	$/Unit
16.03	14.25		104.78	184.91	96.15	129.44	99.85	
48.86	48.86		123.27	184.91	154.09	123.27	112.18	
9.50	11.87							
1780.64	1780.64		3354.93	1901.13	2907.60	2124.79	8063.01	2460.28
1780.64	1780.64							
								20129.56
2967.73	4748.37		4249.57	2683.94	3802.25	5815.21	8286.67	3354.93
			1118.31	503.24	391.41	559.15	1118.31	
		19.33						156.56
		27.79	409.01	286.31	434.58	511.27	209.96	178.93
		44.75	238.59	153.38	191.55	228.37	187.81	
		54.25						201.30
		70.65						
		85.40						
5.95	10.68		109.87	73.25	278.35	87.90	158.22	
8.90	3.56							
9.50	11.87							
			33549.27	19626.32	44732.36	22366.18	43614.05	13419.71

Santa Rosa 2000: Dennis Lane/Elwin Lane Storm Drain Project (Adjusted 2004)

Ashlin Pacific $/Unit	Dama Const. $/Unit	Ghilotti Const. $/Unit	Ghilotti Bros. $/Unit	Sonoma Engr. $/Unit	Pipeline Excavators $/Unit	Bill Schalich $/Unit	Sebastopol Const. $/Unit	Controlled Env. $/Unit
2236.62	2115.48	1565.63	1789.29	2633.62	1509.72	4025.91	5367.88	3742.98
39627.28	16036.55	14538.02	46843.73	10154.25	20017.73	29970.68	31536.31	19867.88
7269.01	4677.33	2795.77	3019.43	2633.62	4920.56	3914.08	9505.63	2075.02
39.14	117.65	178.93	173.34	316.48	95.06	111.83	190.11	428.11
44.73	123.39	156.56	128.61	106.24	109.59	111.83	178.93	157.51
55.92	157.42	197.94	178.93	279.58	139.79	167.75	201.30	183.08
8946.47	8018.28	11183.09	5591.54	12916.47	3354.93	10288.44	559.15	6709.85

Santa Rosa 2000: Gold Lake Dr./Oak Dr. Storm Drain Project (Adjusted 2004)								Santa Rosa 2001: Pe		
Rege Const. $/Unit	Engineer $/Unit	Argonaut $/Unit	Michael Paul $/Unit	Pipeline $/Unit	Siri Grading $/Unit	North Bay Const. $/Unit	LJ Const. $/Unit	Engineer $/Unit	Argonaut $/Unit	Pipeline $/Unit
								82.26	60.32	82.26
	95.06	67.10	65.98	71.57	61.51	69.34	64.86	87.74	55.94	76.78
6038.87	2236.62	1845.21	2795.77	1453.80	1957.04	1855.27	2348.45	3290.40	1864.56	1809.72
7604.50										
7380.84	3354.93	2236.62	3243.10	3131.27	5367.88	2180.70	3131.27	5484.00	3290.40	3509.76
	111.83	74.93	44.73	67.10	67.10	64.86	78.28			
223.66	134.20	91.70	50.32	71.57	72.69	89.46	81.64	164.52	82.26	84.45
246.03	167.75	95.06	69.34	82.75	74.93	76.05	101.77			
301.94										
								49.36	36.19	26.32
24602.80	6709.85	7375.25	2236.62	3914.08	16495.06	32571.87	2795.77	10968.00	14806.79	13161.60

ach Street Project (Adjusted 2004)

North Bay Const. $/Unit	Terracon $/Unit	Ghilotti Const. $/Unit
74.58	82.26	78.97
73.49	71.29	75.68
2522.64	1974.24	2742.00
2895.55	4167.84	3071.04
175.49	76.78	142.58
43.87	43.87	34.00
34609.51	5813.04	22484.39

	Report Section	Project Cost
1	3.5.2.1a	$174,000
2	3.5.2.1b	$1,000,000
3	3.5.2.2	$563,000
4	3.5.2.3	$2,100,000
5	3.5.2.4	$458,000
6	3.5.2.5	$544,000
7	3.5.2.6	$941,000
8	3.5.3.1	$403,000
9	3.5.3.4	$391,000
10	3.5.3.6a	$60,000
11	3.5.3.6b	$78,000
12	3.5.4	$4,000
13	3.5.4.1a	$121,000
14	3.5.4.1b	$450,000
15	3.5.4.2a	$141,000
16	3.5.4.2b	$141,000
17	3.5.4.2c	$141,000
18	3.5.4.3	$186,000
19	3.5.4.4	$228,000
20	3.5.4.6	$24,000
21	3.5.4.5	$30,000
22	3.5.4.7	$430,000
23	3.5.4.8	$90,000
24	3.5.4.9	$1,776,000
26	3.5.4.10	$258,000
28	3.5.4.11	$178,000
29	3.5.4.12	$40,000
30	3.5.4.13	$73,000
Total		**$11,023,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Tank Removal: Holman Tank Demolition (City Project No. 9621)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type:
- [X] **Conceptual**
- [ ] **Preliminary (w/o plans)**
- [ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	4,000	4,000
		Insurance	1	LS	0.025	2,000	2,000
		Bonding	1	LS	0.025	2,000	2,000
		Contractor O&P	1	LS	0.150	12,000	12,000
Subtotal						20,000	20,000
		Site Work/Tank Demo					
		Demolish Tank	1	LS	55,000.00	55,000	55,000
		Material Disposal	1	LS	20,000.00	20,000	20,000
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						80,000	80,000

Subtotal	$80,000
Division 010	$20,000
Construction Subtotal	$100,000
20% Contingency	$20,000
25% Legal, Admin., Engineering	$25,000
Project Subtotal	$145,000
20% Bonding	$29,000
New Subtotal	$174,000
Engineers Opinion of Probable Construction Cost **CALL**	**$174,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Tank Replacement: Holman Tank (City Project No. 9122)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	21,750	21,750
		Insurance	1	LS	0.025	10,875	10,875
		Bonding	1	LS	0.025	10,875	10,875
		Contractor O&P	1	LS	0.150	65,250	65,250
		Sales Tax	1	LS	0.0725	30,088	30,088
Subtotal						138,838	138,838
		Site Work/New Tank					
		Site Work	1	LS	20,000.00	20,000	20,000
		Elevated Tank	250,000	GAL	1.50	375,000	375,000
		Yard Piping	1	LS	25,000.00	25,000	25,000
		Telemetry	1	LS	15,000.00	15,000	15,000
Subtotal						435,000	435,000

Subtotal	$435,000
Division 010	$138,838
Construction Subtotal	$573,838
Cost per Gallon Installed	$2.30
20% Contingency	$114,768
25% Legal, Admin., Engineering	$143,459
Project Subtotal	$832,064
20% Bonding	$166,413
New Subtotal	$998,477
Opinion of Probable Cost per Gallon	**$3.99**
Engineers Opinion of Probable Construction Cost **CALL**	**$1,000,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Reservoir Maintenance: Vancil Reservoir Liner Replacement
(City Project No. 9423)

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	12,500	12,500
		Insurance	1	LS	0.025	6,250	6,250
		Bonding	1	LS	0.025	6,250	6,250
		Contractor O&P	1	LS	0.150	37,500	37,500
		Sales Tax	1	LS	0.0725	10,875	10,875
Subtotal						73,375	73,375
		Site Work/Liner					
		Site Work	1	LS	20,000.00	20,000	20,000
		Tank Modifications	1	LS	80,000.00	80,000	80,000
		New Liner (Installed)	1	LS	150,000.00	150,000	150,000
Subtotal						250,000	250,000

Subtotal	$250,000
Division 010	$73,375
Construction Subtotal	$323,375
20% Contingency	$64,675
25% Legal, Admin., Engineering	$80,844
Project Subtotal	$468,894
20% Bonding	$93,779
New Subtotal	$562,673
Engineers Opinion of Probable Construction Cost **CALL**	**$563,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Reservoir & Reservoir Retrofit: Stewart Reservoirs

(City Project No. 9327 & 9124)

Estimate Type: [X] **Conceptual**

[ ] **Preliminary (w/o plans)**

[ ] **Design Development @** 0 **% Complete**

Winzler & Kelly Consulting Engineers

Prepared By: MGK

Date Prepared: 11-Aug-05

W&K Proj. No. **04-105401-010**

ENR: August 2005 7,479

Escalated to ENR

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	46,300	46,300
		Insurance	1	LS	0.025	23,150	23,150
		Bonding	1	LS	0.025	23,150	23,150
		Contractor O&P	1	LS	0.150	138,900	138,900
		Sales Tax	1	LS	0.0725	49,010	49,010
Subtotal						280,510	280,510
		Site Work/Tank Work/P.S.					
		Provide Temporary Water Supply	1	LS	75,000.00	75,000	75,000
		Site Work	1	LS	75,000.00	75,000	75,000
		Demolish Existing 500K Tank	1	LS	100,000.00	100,000	100,000
		New 500K Tank	500,000	GAL	0.75	375,000	375,000
		Modify Existing 500K Tank	1	LS	250,000.00	250,000	250,000
		Modify Pump Station	1	LS	10,000.00	10,000	10,000
		Replace Pumps	2	EA	8,000.00	16,000	16,000
		Yard Piping	1	LS	25,000.00	25,000	25,000
Subtotal						926,000	926,000

Subtotal	$926,000
Division 010	$280,510
Construction Subtotal	$1,206,510
20% Contingency	$241,302
25% Legal, Admin., Engineering	$301,628
Project Subtotal	$1,749,440
20% Bonding	$349,888
New Subtotal	$2,099,327
Engineers Opinion of Probable Construction Cost **CALL**	**$2,100,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Tank: Future Loop Road Development

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 12-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	10,000	10,000
		Insurance	1	LS	0.025	5,000	5,000
		Bonding	1	LS	0.025	5,000	5,000
		Contractor O&P	1	LS	0.150	30,000	30,000
		Sales Tax	1	LS	0.0725	13,050	13,050
Subtotal						63,050	63,050
		Site Work/New Tank					
		Site Work	1	LS	20,000.00	20,000	20,000
		Water Tank	200,000	GAL	0.75	150,000	150,000
		Yard Piping	1	LS	15,000.00	15,000	15,000
		Telemetry	1	LS	15,000.00	15,000	15,000
Subtotal						200,000	200,000

Subtotal	$200,000
Division 010	$63,050
Construction Subtotal	$263,050
Cost per Gallon Installed	$1.32
20% Contingency	$52,610
25% Legal, Admin., Engineering	$65,763
Project Subtotal	$381,423
20% Bonding	$76,285
New Subtotal	$457,707
Opinion of Probable Cost per Gallon	**$2.29**
Engineers Opinion of Probable Construction Cost **CALL**	**$458,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Tank: Future South Fortuna Development

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 12-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	11,875	11,875
		Insurance	1	LS	0.025	5,938	5,938
		Bonding	1	LS	0.025	5,938	5,938
		Contractor O&P	1	LS	0.150	35,625	35,625
		Sales Tax	1	LS	0.0725	15,769	15,769
Subtotal						75,144	75,144
		Site Work/New Tank					
		Site Work	1	LS	20,000.00	20,000	20,000
		Water Tank	250,000	GAL	0.75	187,500	187,500
		Yard Piping	1	LS	15,000.00	15,000	15,000
		Telemetry	1	LS	15,000.00	15,000	15,000
Subtotal						237,500	237,500

Subtotal	$237,500
Division 010	$75,144
Construction Subtotal	$312,644
Cost per Gallon Installed	$1.25
20% Contingency	$62,529
25% Legal, Admin., Engineering	$78,161
Project Subtotal	$453,333
20% Bonding	$90,667
New Subtotal	$544,000
Opinion of Probable Cost per Gallon	**$2.18**
Engineers Opinion of Probable Construction Cost **CALL**	**$544,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Tank: Future Campton Heights Development

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 12-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	20,500	20,500
		Insurance	1	LS	0.025	10,250	10,250
		Bonding	1	LS	0.025	10,250	10,250
		Contractor O&P	1	LS	0.150	61,500	61,500
		Sales Tax	1	LS	0.0725	28,275	28,275
Subtotal						130,775	130,775
		Site Work/New Tank/P.S.					
		Site Work	1	LS	20,000.00	20,000	20,000
		Elevated Tank	150,000	GAL	1.50	225,000	225,000
		Piping	1	LS	15,000.00	25,000	25,000
		Pump Station	1	LS	125,000.00	125,000	125,000
		Telemetry	1	LS	15,000.00	15,000	15,000
Subtotal						410,000	410,000

Subtotal	$410,000
Division 010	$130,775
Construction Subtotal	$540,775
Cost per Gallon Installed	$3.61
20% Contingency	$108,155
25% Legal, Admin., Engineering	$135,194
Project Subtotal	$784,124
20% Bonding	$156,825
New Subtotal	$940,949
Opinion of Probable Cost per Gallon	**$6.27**
Engineers Opinion of Probable Construction Cost **CALL**	**$941,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Pump Station Upgrade: Corrosion Control Facility

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 12-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	8,750	8,750
		Insurance	1	LS	0.025	4,375	4,375
		Bonding	1	LS	0.025	4,375	4,375
		Contractor O&P	1	LS	0.150	26,250	26,250
		Sales Tax	1	LS	0.0725	12,688	12,688
Subtotal						56,438	56,438
		Site Work/New Pumps					
		Pump House Piping Modifications	1	LS	35,000.00	35,000	35,000
		150 Hp Vertical Turbine Pumps	3	EA	40,000.00	120,000	120,000
		Electrical Modfications	1	LS	20,000.00	20,000	20,000
Subtotal						175,000	175,000

Subtotal	$175,000
Division 010	$56,438
Construction Subtotal	$231,438
20% Contingency	$46,288
25% Legal, Admin., Engineering	$57,859
Project Subtotal	$335,584
20% Bonding	$67,117
New Subtotal	$402,701
Engineers Opinion of Probable Construction Cost **CALL**	**$403,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Pump Station: Loop Road Booster Pump Station

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 12-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type:
- [X] **Conceptual**
- [ ] **Preliminary (w/o plans)**
- [ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	8,500	8,500
		Insurance	1	LS	0.025	4,250	4,250
		Bonding	1	LS	0.025	4,250	4,250
		Contractor O&P	1	LS	0.150	25,500	25,500
		Sales Tax	1	LS	0.0725	12,325	12,325
Subtotal						54,825	54,825
		Pump Station					
		Pump Station	1	LS	130,000.00	130,000	130,000
		Piping	1	LS	25,000.00	25,000	25,000
		Telemetry	1	LS	15,000.00	15,000	15,000
Subtotal						170,000	170,000

Subtotal	$170,000
Division 010	$54,825
Construction Subtotal	$224,825
20% Contingency	$44,965
25% Legal, Admin., Engineering	$56,206
Project Subtotal	$325,996
20% Bonding	$65,199
New Subtotal	$391,196
Engineers Opinion of Probable Construction Cost **CALL**	**$391,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Pump Station Upgrade: Drake Hill Pressure Tanks

(City Project No. 9526)

Estimate Type: [X] **Conceptual**

[ ] **Preliminary (w/o plans)**

[ ] **Design Development @** 0 **% Complete**

Winzler & Kelly Consulting Engineers

Prepared By: MGK

Date Prepared: 12-Aug-05

W&K Proj. No. **04-105401-010**

ENR: August 2005 7,479

Escalated to ENR

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	1,300	1,300
		Insurance	1	LS	0.025	650	650
		Bonding	1	LS	0.025	650	650
		Contractor O&P	1	LS	0.150	3,900	3,900
		Sales Tax	1	LS	0.0725	1,160	1,160
Subtotal						7,660	7,660
		Pump Station					
		2x650 Gallon Pressure Tanks	2	EA	8,000.00	16,000	16,000
		Installation	1	LS	10,000.00	10,000	10,000
Subtotal						26,000	26,000

Subtotal	$26,000
Division 010	$7,660
Construction Subtotal	$33,660
20% Contingency	$6,732
25% Legal, Admin., Engineering	$8,415
Project Subtotal	$48,807
20% Bonding	$9,761
New Subtotal	$58,568
Engineers Opinion of Probable Construction Cost **CALL**	**$60,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Pump Station Upgrade: Drake Hill Booster Pump Station

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 12-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	1,750	1,750
		Insurance	1	LS	0.025	875	875
		Bonding	1	LS	0.025	875	875
		Contractor O&P	1	LS	0.150	5,250	5,250
		Sales Tax	1	LS	0.0725	1,088	1,088
Subtotal						9,838	9,838
		Pump Station					
		Demo Pressure Tanks	4	EA	5,000.00	20,000	20,000
		Piping/Pumps	1	LS	15,000.00	15,000	15,000
Subtotal						35,000	35,000

Subtotal	$35,000
Division 010	$9,838
Construction Subtotal	$44,838
20% Contingency	$8,968
25% Legal, Admin., Engineering	$11,209
Project Subtotal	$65,014
20% Bonding	$13,003
New Subtotal	$78,017
Engineers Opinion of Probable Construction Cost **CALL**	**$78,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Main: L Street Project

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	2,636	2,636
		Insurance	1	LS	0.025	1,318	1,318
		Bonding	1	LS	0.025	1,318	1,318
		Contractor O&P	1	LS	0.150	7,909	7,909
		Sales Tax	1	LS	0.0725	3,823	3,823
Subtotal						17,004	17,004
		Water Main Installation					
		8" Class 150 C900 Water Main	720	LF	46.00	33,120	33,120
		New 8" Gate Valve	2	EA	1,060.00	2,120	2,120
		Water Service Connections	11	EA	1,135.00	12,485	12,485
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						52,725	52,725

Subtotal	$52,725
Division 010	$17,004
Construction Subtotal	$69,729
Cost per LF C900 Installed	$97
20% Contingency	$13,946
25% Legal, Admin., Engineering	$17,432
Project Subtotal	$101,107
20% Bonding	$20,221
New Subtotal	$121,328
Opinion of Probable Cost per LF C900	**$169**
Engineers Opinion of Probable Construction Cost **CALL**	**$121,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Main: Rohnerville Road Project

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	9,743	9,743
		Insurance	1	LS	0.025	4,872	4,872
		Bonding	1	LS	0.025	4,872	4,872
		Contractor O&P	1	LS	0.150	29,230	29,230
		Sales Tax	1	LS	0.0725	14,128	14,128
Subtotal						62,844	62,844
		Water Main Installation					
		10" Class 150 C900 Water Main	2,850	LF	53.00	151,050	151,050
		New 10" Gate Valve	4	EA	1,210.00	4,840	4,840
		New Pressure Reducing Valve	1	EA	900.00	900	900
		Water Service Connections	15	EA	1,135.00	17,025	17,025
		Fire Hydrants	2	EA	3,025.00	6,050	6,050
		Traffic Control	1	LS	15,000.00	15,000	15,000
Subtotal						194,865	194,865

Subtotal	$194,865
Division 010	$62,844
Construction Subtotal	$257,709
Cost per LF C900 Installed	$90
20% Contingency	$51,542
25% Legal, Admin., Engineering	$64,427
Project Subtotal	$373,678
20% Bonding	$74,736
New Subtotal	$448,414
Opinion of Probable Cost per LF C900	**$157**
Engineers Opinion of Probable Construction Cost **CALL**	**$450,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Ivy Lane Project

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	3,066	3,066
		Insurance	1	LS	0.025	1,533	1,533
		Bonding	1	LS	0.025	1,533	1,533
		Contractor O&P	1	LS	0.150	9,197	9,197
		Sales Tax	1	LS	0.0725	4,445	4,445
Subtotal						19,774	19,774
		Water Main Installation					
		6" Class 150 C900 Water Main	720	LF	43.00	30,960	30,960
		New 6" Gate Valve	2	EA	760.00	1,520	1,520
		Water Service Connections	21	EA	1,135.00	23,835	23,835
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						61,315	61,315

Subtotal	$61,315
Division 010	$19,774
Construction Subtotal	$81,089
Cost per LF C900 Installed	$113
20% Contingency	$16,218
25% Legal, Admin., Engineering	$20,272
Project Subtotal	$117,579
20% Bonding	$23,516
New Subtotal	$141,095
Opinion of Probable Cost per LF C900	**$196**
Engineers Opinion of Probable Construction Cost **CALL**	**$141,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Holly Lane Project (City Project No. 9221)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	3,066	3,066
		Insurance	1	LS	0.025	1,533	1,533
		Bonding	1	LS	0.025	1,533	1,533
		Contractor O&P	1	LS	0.150	9,197	9,197
		Sales Tax	1	LS	0.0725	4,445	4,445
Subtotal						19,774	19,774
		Water Main Installation					
		6" Class 150 C900 Water Main	720	LF	43.00	30,960	30,960
		New 6" Gate Valve	2	EA	760.00	1,520	1,520
		Water Service Connections	21	EA	1,135.00	23,835	23,835
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						61,315	61,315

Subtotal	$61,315
Division 010	$19,774
Construction Subtotal	$81,089
Cost per LF C900 Installed	$113
20% Contingency	$16,218
25% Legal, Admin., Engineering	$20,272
Project Subtotal	$117,579
20% Bonding	$23,516
New Subtotal	$141,095
Opinion of Probable Cost per LF C900	**$196**
Engineers Opinion of Probable Construction Cost **CALL**	**$141,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Emerald Lane Project (City Project No. 9421)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	3,066	3,066
		Insurance	1	LS	0.025	1,533	1,533
		Bonding	1	LS	0.025	1,533	1,533
		Contractor O&P	1	LS	0.150	9,197	9,197
		Sales Tax	1	LS	0.0725	4,445	4,445
Subtotal						19,774	19,774
		Water Main Installation					
		6" Class 150 C900 Water Main	720	LF	43.00	30,960	30,960
		New 6" Gate Valve	2	EA	760.00	1,520	1,520
		Water Service Connections	21	EA	1,135.00	23,835	23,835
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						61,315	61,315

Subtotal	$61,315
Division 010	$19,774
Construction Subtotal	$81,089
Cost per LF C900 Installed	$113
20% Contingency	$16,218
25% Legal, Admin., Engineering	$20,272
Project Subtotal	$117,579
20% Bonding	$23,516
New Subtotal	$141,095
Opinion of Probable Cost per LF C900	**$196**
Engineers Opinion of Probable Construction Cost **CALL**	**$141,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Main: North 9th Street Project (City Project No. 9622)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	4,041	4,041
		Insurance	1	LS	0.025	2,021	2,021
		Bonding	1	LS	0.025	2,021	2,021
		Contractor O&P	1	LS	0.150	12,123	12,123
		Sales Tax	1	LS	0.0725	5,859	5,859
Subtotal						26,064	26,064
		Earth/Site Work					
		6" Class 150 C900 Water Main	1,200	LF	43.00	51,600	51,600
		New 6" Gate Valve	2	EA	760.00	1,520	1,520
		Water Service Connections	20	EA	1,135.00	22,700	22,700
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						80,820	80,820

Subtotal	$80,820
Division 010	$26,064
Construction Subtotal	$106,884
Cost per LF C900 Installed	$89
20% Contingency	$21,377
25% Legal, Admin., Engineering	$26,721
Project Subtotal	$154,982
20% Bonding	$30,996
New Subtotal	$185,979
Opinion of Probable Cost per LF C900	**$155**
Engineers Opinion of Probable Construction Cost **CALL**	**$186,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: 14th Street Project (City Project No. 9531)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 6-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	4,945	4,945
		Insurance	1	LS	0.025	2,473	2,473
		Bonding	1	LS	0.025	2,473	2,473
		Contractor O&P	1	LS	0.150	14,835	14,835
		Sales Tax	1	LS	0.0725	7,170	7,170
Subtotal						31,895	31,895
		Earth/Site Work					
		6" Class 150 C900 Water Main	1,240	LF	43.00	53,320	53,320
		New 6" Gate Valve	5	EA	760.00	3,800	3,800
		Water Service Connections	28	EA	1,135.00	31,780	31,780
		Traffic Control	1	LS	10,000.00	10,000	10,000
Subtotal						98,900	98,900

Subtotal	$98,900
Division 010	$31,895
Construction Subtotal	$130,795
Cost per LF C900 Installed	$105
20% Contingency	$26,159
25% Legal, Admin., Engineering	$32,699
Project Subtotal	$189,653
20% Bonding	$37,931
New Subtotal	$227,584
Opinion of Probable Cost per LF C900	**$184**
Engineers Opinion of Probable Construction Cost **CALL**	**$228,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Smith Lane Project (City Project No. 9431)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	514	514
		Insurance	1	LS	0.025	257	257
		Bonding	1	LS	0.025	257	257
		Contractor O&P	1	LS	0.150	1,542	1,542
		Sales Tax	1	LS	0.0725	745	745
Subtotal						3,315	3,315
		Earth/Site Work					
		6" Class 150 C900 Water Main	70	LF	43.00	3,010	3,010
		Water Service Connections	2	EA	1,135.00	2,270	2,270
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						10,280	10,280

Subtotal	$10,280
Division 010	$3,315
Construction Subtotal	$13,595
Cost per LF C900 Installed	$194
20% Contingency	$2,719
25% Legal, Admin., Engineering	$3,399
Project Subtotal	$19,713
20% Bonding	$3,943
New Subtotal	$23,656
Opinion of Probable Cost per LF C900	**$338**
Engineers Opinion of Probable Construction Cost **CALL**	**$24,000**

ENGINEER'S OPINION OF PROBABLE COST

Winzler & Kelly Consulting Engineers

Project: **FORTUNA HYDRAULIC STUDY**

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Water Main Replacement: Eel River Drive Project
(City Project No. 9720)

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	9,339	9,339
		Insurance	1	LS	0.025	4,670	4,670
		Bonding	1	LS	0.025	4,670	4,670
		Contractor O&P	1	LS	0.150	28,017	28,017
		Sales Tax	1	LS	0.0725	13,542	13,542
Subtotal						60,237	60,237
		Earth/Site Work					
		14" Class 150 C900 Water Main	1,680	LF	100.00	168,000	168,000
		New 14" Gate Valve	2	EA	1,890.00	3,780	3,780
		Traffic Control	1	LS	15,000.00	15,000	15,000
Subtotal						186,780	186,780

Subtotal	$186,780
Division 010	$60,237
Construction Subtotal	$247,017
Cost per LF C900 Installed	$147
20% Contingency	$49,403
25% Legal, Admin., Engineering	$61,754
Project Subtotal	$358,174
20% Bonding	$71,635
New Subtotal	$429,809
Opinion of Probable Cost per LF C900	**$256**
Engineers Opinion of Probable Construction Cost **CALL**	**$430,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Mill Street Project (City Project No. 9620)

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	1,946	1,946
		Insurance	1	LS	0.025	973	973
		Bonding	1	LS	0.025	973	973
		Contractor O&P	1	LS	0.150	5,839	5,839
		Sales Tax	1	LS	0.0725	2,822	2,822
Subtotal						12,553	12,553
		Earth/Site Work					
		6" Class 150 C900 Water Main	525	LF	43.00	22,575	22,575
		Water Service Connections	10	EA	1,135.00	11,350	11,350
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						38,925	38,925

Subtotal	$38,925
Division 010	$12,553
Construction Subtotal	$51,478
Cost per LF C900 Installed	$98
20% Contingency	$10,296
25% Legal, Admin., Engineering	$12,870
Project Subtotal	$74,644
20% Bonding	$14,929
New Subtotal	$89,572
Opinion of Probable Cost per LF C900	**$171**
Engineers Opinion of Probable Construction Cost **CALL**	**$90,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: 12th Street, Newburg Road & PL Mill Yard

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type:
- [X] **Project Conceptual**
- [ ] **Preliminary (w/o plans)**
- [ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	38,583	38,583
		Insurance	1	LS	0.025	19,292	19,292
		Bonding	1	LS	0.025	19,292	19,292
		Contractor O&P	1	LS	0.150	115,750	115,750
		Sales Tax	1	LS	0.0725	55,946	55,946
Subtotal						248,862	248,862
		Earth/Site Work					
		12" Class 150 C900 Water Main	6,625	LF	90.00	596,250	596,250
		New 12" Gate Valve	24	EA	1,510.00	36,240	36,240
		Water Service Connections	105	EA	1,135.00	119,175	119,175
		Traffic Control	1	LS	20,000.00	20,000	20,000
Subtotal						771,665	771,665

Subtotal	$771,665
Division 010	$248,862
Construction Subtotal	$1,020,527
Cost per LF C900 Installed	$154
20% Contingency	$204,105
25% Legal, Admin., Engineering	$255,132
Project Subtotal	$1,479,764
20% Bonding	$295,953
New Subtotal	$1,775,717
Opinion of Probable Cost per LF C900	**$268**
Engineers Opinion of Probable Construction Cost **CALL**	**$1,776,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Stewart Street & Vancil Street Project

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	5,610	5,610
		Insurance	1	LS	0.025	2,805	2,805
		Bonding	1	LS	0.025	2,805	2,805
		Contractor O&P	1	LS	0.150	16,831	16,831
		Sales Tax	1	LS	0.0725	8,135	8,135
Subtotal						36,186	36,186
		Earth/Site Work					
		10" Class 150 C900 Water Main	1,870	LF	53.00	99,110	99,110
		New 10" Gate Valve	2	EA	1,210.00	2,420	2,420
		Water Service Connections	5	EA	1,135.00	5,675	5,675
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						112,205	112,205

Subtotal	$112,205
Division 010	$36,186
Construction Subtotal	$148,391
Cost per LF C900 Installed	$79
20% Contingency	$29,678
25% Legal, Admin., Engineering	$37,098
Project Subtotal	$215,167
20% Bonding	$43,033
New Subtotal	$258,201
Opinion of Probable Cost per LF C900	**$138**
Engineers Opinion of Probable Construction Cost **CALL**	**$258,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

New Water Main: Redwood Way Project

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	3,861	3,861
		Insurance	1	LS	0.025	1,931	1,931
		Bonding	1	LS	0.025	1,931	1,931
		Contractor O&P	1	LS	0.150	11,584	11,584
		Sales Tax	1	LS	0.0725	5,599	5,599
Subtotal						24,905	24,905
		Earth/Site Work					
		8" Class 150 C900 Water Main	1,450	LF	46.00	66,700	66,700
		New 8" Gate Valve	2	EA	1,060.00	2,120	2,120
		Water Service Connections	3	EA	1,135.00	3,405	3,405
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						77,225	77,225

Subtotal	$77,225
Division 010	$24,905
Construction Subtotal	$102,130
Cost per LF C900 Installed	$70
20% Contingency	$20,426
25% Legal, Admin., Engineering	$25,533
Project Subtotal	$148,089
20% Bonding	$29,618
New Subtotal	$177,706
Opinion of Probable Cost per LF C900	**$123**
Engineers Opinion of Probable Construction Cost **CALL**	**$178,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: Newburg Drive Project

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	874	874
		Insurance	1	LS	0.025	437	437
		Bonding	1	LS	0.025	437	437
		Contractor O&P	1	LS	0.150	2,621	2,621
		Sales Tax	1	LS	0.0725	1,267	1,267
Subtotal						5,634	5,634
		Earth/Site Work					
		8" Class 150 C900 Water Main	90	LF	46.00	4,140	4,140
		New 8" Gate Valve	1	EA	1,060.00	1,060	1,060
		Water Service Connections	2	EA	1,135.00	2,270	2,270
		Traffic Control	1	LS	10,000.00	10,000	10,000
Subtotal						17,470	17,470
Subtotal							$17,470
Division 010							$5,634
Construction Subtotal							$23,104
Cost per LF C900 Installed							$257
20% Contingency							$4,621
25% Legal, Admin., Engineering							$5,776
Project Subtotal							$33,501
20% Bonding							$6,700
New Subtotal							$40,201
Opinion of Probable Cost per LF C900							**$447**
Engineers Opinion of Probable Construction Cost						**CALL**	**$40,000**

ENGINEER'S OPINION OF PROBABLE COST

Project: **FORTUNA HYDRAULIC STUDY**

Water Main Replacement: 12th Street & O Street Project
(City Project No. 9522)

Estimate Type: [X] **Conceptual**
[ ] **Preliminary (w/o plans)**
[ ] **Design Development @** 0 **% Complete**

Winzler & Kelly Consulting Engineers

Prepared By: MGK
Date Prepared: 11-Aug-05
W&K Proj. No. **04-105401-010**
ENR: August 2005 7,479
Escalated to ENR

Division	Item No.	Description	Qty	Units	Equipment $/Unit	Equipment Total	Total
010 000		**General Requirements**					
		Mobilization/Demobilization	1	LS	0.050	1,577	1,577
		Insurance	1	LS	0.025	789	789
		Bonding	1	LS	0.025	789	789
		Contractor O&P	1	LS	0.150	4,732	4,732
		Sales Tax	1	LS	0.0725	2,287	2,287
Subtotal						10,173	10,173
		Earth/Site Work					
		6" Class 150 C900 Water Main	450	LF	43.00	19,350	19,350
		New 6" Gate Valve	2	EA	760.00	1,520	1,520
		Water Service Connections	5	EA	1,135.00	5,675	5,675
		Traffic Control	1	LS	5,000.00	5,000	5,000
Subtotal						31,545	31,545

Subtotal	$31,545
Division 010	$10,173
Construction Subtotal	$41,718
Cost per LF C900 Installed	$93
20% Contingency	$8,344
25% Legal, Admin., Engineering	$10,430
Project Subtotal	$60,491
20% Bonding	$12,098
New Subtotal	$72,590
Opinion of Probable Cost per LF C900	**$161**
Engineers Opinion of Probable Construction Cost **CALL**	**$73,000**