J1402

KENT COUNTY WATER AUTHORITY
WEST WARWICK, RHODE ISLAND

2014 HYDRAULIC MODEL
UPDATE REPORT

KCWA

Kent County Water Authority

Prepared By:

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CIVIL ENGINEERS. ENVIRONMENTAL PROJECTS.

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1.0 Introduction

1.1 Project Background

In June 2004, C&E Engineering Partners, Inc. (C&E) completed a computerized hydraulic model of the Kent County Water Authority's (KCWA) Supply, Transmission and Distribution System. This project consisted of the development of an accurate and calibrated computerized hydraulic model of the major infrastructure facilities and pipelines of the water transmission and distribution system.

All of the major facilities of the KCWA water distribution system are represented in this hydraulic model. This includes all sources of supply (including wholesale interconnections), booster pumping and storage facilities, well stations, pressure reducing valve stations and transmission and distribution pipelines. Information describing the characteristics of each of the water system facilities was acquired from available records of the KCWA and from field surveys of infrastructure facilities. This also included information derived from KCWA staff during development of the model to verify system geometry including water main layout and configuration, size, age, material, etc. A general overview of the operation of the system including pump sequencing, booster pump operation, manual and automatic operation of facilities, etc., was also obtained from KCWA staff in order to properly establish initial operating conditions for model scenarios.

Since completion, the hydraulic model has been successfully utilized to complete various studies for the KCWA water supply system involving future planning, infrastructure sizing, development analysis, future demand analysis and evaluation of fire flow capability.

C&E has previously performed an update of the hydraulic model in February 2006 and at the request of the KCWA, C&E has also performed this 2014 update to the computer model whereby new and replaced infrastructure components, changes in operation, etc., were included in the computer model. This update included incorporating all water facility improvements that have taken place since completion of the February 2006 update of the model and updating the geometry of the hydraulic model. This 2014 update also included an update of consumer demand data and a review of the water system's major users (i.e. those singly identified consumers that use upwards of several million gallons of water per year). The consumer demands and water demands for the major users were updated in the model accordingly.

In addition, all of the water mains that were incorporated in the model update were also included in spreadsheets that represent the full system pipeline database maintained by the KCWA. This pipeline database is utilized by the KCWA to assist in identifying pipeline infrastructure replacement projects and provides for a comprehensive cataloging of all pipelines in the water system by location, size, material, year of installation and length.

1.2 Purpose and Scope

The performance of this computer hydraulic model update consisted of the following specific tasks:

- Meet with KCWA staff to gather information relating to water system improvements including obtaining copies of available record drawings, design plans and sketches for water system improvement projects.
- Review with the KCWA staff any changes to system operations and procedures that may alter the manner in which the water system is operated and maintained.
- Obtain the most current list of KCWA Board approved projects and include in the model update. These projects are included (even if not yet constructed or operational) as they are considered to be an allocation of water demands and should be considered when performing future analysis with the model. Appropriately, the consumer demands associated with these developments are also included.
- Modify the hydraulic model geometry and pipeline and junction node database files. This was performed consistent with the naming and identification sequence that was developed as part of the original model.
- Review the most recent consumer demand data including data for the large water users in the water system and revise the model demand database files accordingly.

- Perform average day, maximum day and peak hour simulations with the latest modifications to the system geometry and system operational changes.
- Update the existing model diurnal flow curves for each pressure zone within the water system based upon hourly water production and tank level data obtained from system SCADA data provided by KCWA staff.
- Update the model Node and Pipeline Plan and provide a hard copy of the plan at a suitable scale which is color-coded by pipe diameter.
- Calibration of the updated hydraulic model.
- Prepare a report that presents the work completed and results of completed computer modeling. Summarize the update and modifications to the hydraulic model including results presentation and summary for each scenario.

It is intended that this updated hydraulic model will accurately depict the average day, maximum day and peak hour demand conditions of the KCWA existing water supply and distribution system.

2.0 Water System Updates

2.1 General Service Area Description

The KCWA serves customers in the Towns of Coventry, East Greenwich, West Greenwich, West Warwick and the City of Warwick. In addition, the KCWA serves customers in isolated areas of Cranston, North Kingstown and Scituate. There are approximately 27,700 service accounts (including residential, commercial/industrial and governmental users) in these locales. The two (2) primary sources of water supply for the KCWA system are wholesale interconnections through Providence Water and the City of Warwick (which also receives water from Providence Water) and groundwater from wellfields that are owned and operated by the KCWA.

KCWA's existing piping system consists of approximately 471 miles of water main with pipe sizes ranging from 2-inches to 24-inches in diameter (exclusive of customer service connections). For purposes of the model, transmission mains are defined as water mains that directly supply the water system distribution mains and do not have customer services along them and are 12-inches or greater in diameter.

Elevations throughout the KCWA water system range from 5 feet Mean Sea Level (MSL) along coastal areas to 474 feet MSL in Coventry in the northwestern portion of the water system. There are two (2) main transmission booster pump stations and three (3) system booster pump stations in the KCWA water system. The transmission pump stations boost water from the wholesale interconnections into the system while the system booster pump stations increase pressure in localized areas with high elevations to prevent these areas from experiencing low pressure problems.

Based on historical data, the KCWA serves a residential population of more than 88,000 people. A total of twenty (20) of the largest water consumers (i.e. consumers that use upwards of several million gallons of water or greater per year) were identified and included in this updated model. A majority of the large users consist of residential entities (trailer parks, condominium associations, apartment complexes, elderly housing developments, etc.), large industrial enterprises and a hospital.

2.2 Distribution and Transmission Pipeline Updates

C&E met with KCWA staff to identify those water mains that have been abandoned or replaced as part of the ongoing Infrastructure Replacement Plan. In addition, new water mains, which have been installed as part of the Capital Improvement Program, were also identified. Information relating to the location, size, length, interconnection of the main into the system, etc., was obtained from available record drawings, design plans, sketches, etc. This information was then utilized to update the geometry of the hydraulic model in the computer model. Pipelines that were added to the system were also included in the hydraulic model database and pipelines that were removed from the system were completely removed from the hydraulic model database. The following represents the significant changes in pipeline infrastructure that have occurred as part of either the KCWA's Infrastructure Replacement Plan or Capital Improvement Program since the February 2006 model update which are broken down by City and Town and have also been included in this update of the geometry of the hydraulic model.

COVENTRY			
LOCATION	**DESCRIPTION**	**FROM**	**TO**
Potter St.	Replaced 1,000 feet of 6" AC pipe with 12" DI pipe	Main St.	Highland Ave.
Highland Ave.	Replaced 403 feet of 6" DI pipe with 12" DI pipe Replaced 100 feet of 2" PVC pipe with 12" DI pipe Installed 77 feet of 12" DI pipe	Potter St. Potter St. Potter St.	Harris St. Harris St. Harris St.
Harris St.	Replaced 137 feet of 2" GALV pipe with 12" DI pipe Installed 93 feet of 12" DI pipe	North Pleasant St. North Pleasant St.	Highland Ave. Highland Ave.
Broad St.	Replaced 600 feet of 6" CI pipe with 12" DI pipe	Main St.	WW Town Line
Peninsula Ct.	Replaced 525 feet of 6" AC pipe with 8" DI pipe	Wood Cove Dr.	West on Peninsula Ct.
Hill Farm Rd.	Replaced 200 feet of 12" DI pipe with 12" DI pipe	Isle of Capri Rd.	Hill Farm Rd. Bridge
Lincoln Ave.	Installed 550 feet of 16" DI pipe	Howard Ave.	Main St.
Ames St.	Replaced 250 feet of 6" CI pipe with 16" DI pipe Installed 850 feet of 16" DI pipe	Lincoln Ave. Lincoln Ave.	Mumford St. Mumford St.
Phillip St.	Replaced 765 feet of 6" CI pipe with 8" DI pipe Replaced 230 feet of 6" AC pipe with 8" DI pipe Installed 290 feet of 8" DI pipe	Shippee Ave. Shippee Ave. Shippee Ave.	Read Ave. Read Ave. Read Ave.
Tiffany Rd.	Installed 780 feet of 12" DI pipe	New London Tpk.	Old North Rd.
Old North Rd.	Replaced 2,095 feet of 12" AC pipe with 12" DI pipe Installed 1,855 feet of 12" DI pipe	Tiffany Rd. Angus St.	Angus St. Tiogue Ave.
Tiogue Ave.	Installed 1,590 feet of 12" DI pipe Installed 60 feet of 8" DI pipe	Tiogue PRV Easement Tiogue PRV Easement	Old North Rd. Tiogue Tank
Angus St.	Replaced 1,450 feet of 6" AC pipe with 12" DI pipe	New London Tpk.	Old North Rd.

COVENTRY (cont.)			
LOCATION	**DESCRIPTION**	**FROM**	**TO**
Flat River Rd.	Replaced 2,625 feet of 12" AC pipe with 16" DI pipe Installed 800 feet of 16" DI pipe Replaced 1,715 feet of 12" AC pipe with 20" DI pipe	Industrial Dr. Industrial Dr. Industrial Dr.	Leader St. Leader St. Read Schoolhouse Rd.
Read Schoolhouse Rd.	Replaced 2,115 feet of 12" AC pipe with 20" DI pipe Installed 3,370 feet of 20" DI pipe	Flat River Rd. Old Read Schoolhouse Tank	Old Read Schoolhouse Tank New Read Schoolhouse Tank
Hillside Ave.	Replaced 160 feet of 12" CI pipe with 8" DI pipe Replaced 455 feet of 6" AC pipe with 8" DI pipe	Brown St. Yeaton St.	Yeaton St. Bee St.
Yeaton St.	Replaced 595 feet of 12" CI pipe with 8" DI pipe	Hillside Ave.	West on Yeaton St.
Fones St.	Replaced 355 feet of 6" AC pipe with 8" DI pipe	Hillside Ave.	West on Fones St.
Bee St.	Installed 298 feet of 8" DI pipe	Hillside Ave.	Dennis St.
Dennis St.	Installed 215 feet of 8" DI pipe	Fones St.	Bee St.
Creighton Pl.	Replaced 291 feet of 6" AC pipe with 8" DI pipe Installed 328 feet of 8" DI pipe	Sheffield Ave. Sheffield Ave.	Fenland Dr. Fenland Dr.
Eileen Dr.	Replaced 390 feet of 6" AC pipe with 8" DI pipe	Pulaski St.	Windsor Park Dr.
Fenland Dr.	Replaced 308 feet of 6" AC pipe with 8" DI pipe	Sheffield Ave.	Wilshire Way
Harley St.	Replaced 217 feet of 8" AC pipe with 8" DI pipe	Sheffield Ave.	Wilshire Way
Harvest Dr.	Replaced 367 feet of 6" AC pipe with 8" DI pipe Installed 196 feet of 8" DI pipe	Eileen Dr. Eileen Dr.	Windsor Park Dr. Windsor Park Dr.
Kathy Ave.	Replaced 370 feet of 6" AC pipe with 8" DI pipe	Roundway Dr.	Windsor Park Dr.
Kennington Ave.	Replaced 544 feet of 6" AC pipe with 8" DI pipe	Windsor Park Dr. East	Windsor Park Dr. West
Kimberly Ave.	Replaced 489 feet of 6" AC pipe with 8" DI pipe	Windsor Park Dr. East	Windsor Park Dr. West
Roundway Dr.	Replaced 979 feet of 6" AC pipe with 8" DI pipe	Kimberly Ave.	WW Town Line
Sheffield Ave.	Replaced 1,172 feet of 6" AC pipe with 8" DI pipe	Creighton Pl.	Harley St.
Sidney St.	Replaced 272 feet of 6" AC pipe with 8" DI pipe	Sheffield Ave.	Wilshire Way
Wilshire Way	Replaced 904 feet of 6" AC pipe with 8" DI pipe	Fenland Dr.	Harley St.
Windsor Park Dr.	Replaced 2,487 feet of 6" AC pipe with 8" DI pipe Replaced 177 feet of 6" DI pipe with 8" DI pipe Installed 280 feet of 8" DI pipe	Kimberly Ave. Pulaski St. Sophia's Way	Roundway Dr. Sophia's Way Roundway Dr.

CRANSTON			
LOCATION	**DESCRIPTION**	**FROM**	**TO**
Amanda St.	Replaced 1,563 feet of 6" AC pipe with 8" DI pipe Installed 107 feet of 8" DI pipe	Loring St. Loring St.	South on Amanda St. South on Amanda St.
Warren Ave.	Replaced 2,233 feet of 6" AC pipe with 8" DI pipe	Wilbur Ave.	South on Warren Ave.
Allard St.	Replaced 600 feet of 6" AC pipe with 8" DI pipe Replaced 150 feet of 2" CU pipe with 8" DI pipe Replaced 150 feet of 1" CU pipe with 8" DI pipe	Warren Ave. Warren Ave. Warren Ave.	West on Allard St. East on Allard St. East on Allard St.
Benjamin St.	Replaced 497 feet of 6" AC pipe with 8" DI pipe	Warren Ave.	Ellison St.
Esther St.	Replaced 227 feet of 6" AC pipe with 8" DI pipe	Warren Ave.	West on Esther St.
Loring St.	Replaced 470 feet of 6" AC pipe with 8" DI pipe	Warren Ave.	Ellison St.
Amanda Ct.	Replaced 226 feet of 6" AC pipe with 8" DI pipe	Amanda St.	East on Amanda Ct.

CRANSTON (cont.)			
LOCATION	DESCRIPTION	FROM	TO
Redfern Dr.	Replaced 92 feet of 6" AC pipe with 8" DI pipe Installed 137 feet of 8" DI pipe	Burdick Dr. Burdick Dr.	North on Redfern Dr. North on Redfern Dr.
Fruit St.	Replaced 275 feet of 6" CI pipe with 8" DI pipe	Wilbur Ave.	South on Fruit St.
Stoneham St.	Replaced 545 feet of 6" CI pipe with 8" DI pipe	Fruit St.	Warren Ave.
Hope Rd.	Replaced 1,618 feet of 4" DI pipe with 8" DI pipe Replaced 1,243 feet of 6" CI pipe with 8" DI pipe Replaced 645 feet of 12" CI pipe with 8" DI pipe Installed 445 feet of 8" DI pipe	East on Hope Rd. East on Hope Rd. Seven Mile Rd. East on Hope Rd.	West on Hope Rd. West on Hope Rd. West on Hope Rd. West on Hope Rd.

EAST GREENWICH			
LOCATION	DESCRIPTION	FROM	TO
Upland Ave.	Replaced 300 feet of 2" PVC pipe with 8" DI pipe Installed 300 feet of 8" DI pipe	Rocky Hollow Rd. Rocky Hollow Rd.	South on Upland Ave. South on Upland Ave.
Sleepy Hollow Rd.	Replaced 1,185 feet of 6" AC pipe with 8" DI pipe Installed 572 feet of 8" DI pipe	South County Tr. South County Tr.	Pequot Tr. Pequot Tr.
Ayrault Rd.	Replaced 396 feet of 6" PVC pipe with 8" DI pipe Replaced 153 feet of 6" AC pipe with 8" DI pipe Installed 266 feet of 8" DI pipe	Wildwood Tr. Wildwood Tr. Wildwood Tr.	West on Ayrault Rd. West on Ayrault Rd. West on Ayrault Rd.
Valley Rd.	Replaced 1,144 feet of 6" AC pipe with 8" DI pipe Installed 56 feet of 8" DI pipe	Sleepy Hollow Rd. Sleepy Hollow Rd.	Pequot Tr. Pequot Tr.
Ridge Rd.	Replaced 511 feet of 6" AC pipe with 8" DI pipe Installed 129 feet of 8" DI pipe	South County Tr. South County Tr.	Valley Rd. Valley Rd.
Wildwood Tr.	Replaced 1,115 feet of 6" AC pipe with 8" DI pipe	Ayrault Rd.	Pequot Tr.
Laurel Ln.	Installed 262 feet of 8" DI pipe	Wildwood Tr.	South on Laurel Ln.
Pequot Tr.	Replaced 1,274 feet of 8" AC pipe with 8" DI pipe Replaced 1,650 feet of 6" AC pipe with 8" DI pipe Installed 331 feet of 8" DI pipe	Wildwood Tr. Ayrault Rd. King Phillip Tr.	South on Pequot Tr. Wildwood Tr. Canonicus Tr.
Canonicus Tr.	Replaced 460 feet of 6" AC pipe with 8" DI pipe	King Phillip Tr.	Pequot Tr.
Canonchet Tr.	Replaced 320 feet of 6" AC pipe with 8" DI pipe	King Phillip Tr.	South on Canonchet Tr.
King Phillip Tr.	Replaced 520 feet of 8" AC pipe with 8" DI pipe	South County Tr.	Pequot Tr.
Bicknell Ave.	Replaced 375 feet of 4" CI pipe with 12" DI pipe	Division St.	Wine St.
Duke St.	Replaced 1,775 feet of 4" CI pipe with 8" DI pipe	Division St.	London St.
Crop St.	Replaced 265 feet of 4" CI pipe with 12" DI pipe	Wine St.	King St.
Wine St.	Replaced 40 feet of 4" CI pipe with 8" DI pipe Installed 195 feet of 8" DI pipe Installed 30 feet of 12" DI pipe	Duke St. Duke St. Bicknell Ave.	Bicknell Ave. Bicknell Ave. Crop St.
London St.	Installed 210 feet of 8" DI pipe Replaced 30 feet of 12" AC pipe with 12" DI pipe	Marlborough St. Main St.	Duke St. Marlborough St.

SCITUATE			
LOCATION	DESCRIPTION	FROM	TO
Brown St.	Replaced 181 feet of 6" CI with 8" DI pipe	Goddard St.	South on Brown St.
Goddard St.	Replaced 236 feet of 6" CI pipe with 8" DI pipe	Main St.	West on Goddard St.

WARWICK			
LOCATION	DESCRIPTION	FROM	TO
Greenwich Ave.	Replaced 4,200 feet of 12" CI pipe with 12" DI pipe	Veterans Memorial Dr.	Potters Ave.
Hall St.	Replaced 420 feet of 4" CI pipe with 12" DI pipe	Arnold Ave.	Division St.
Arnold Ave.	Replaced 285 feet of 4" CI pipe with 12" DI pipe	Post Rd.	Hall St.
Williams St.	Replaced 587 feet of 4" CI pipe with 8" DI pipe	Post Rd.	Blackmore St.
North Marlborough St.	Replaced 120 feet of 4" CI pipe with 8" DI pipe Installed 720 feet of 8" DI pipe	Ladd St. Williams St.	South on N. Marlborough St. Division St.
Duane St.	Replaced 1,050 feet of 4" CI pipe with 8" DI pipe	Williams St.	Division St.
Blackmore St.	Replaced 590 feet of 4" CI pipe with 8" DI pipe	Williams St.	Ladd St.
Ladd St.	Replaced 505 feet of 4" CI pipe with 8" DI pipe	Post Rd.	Blackmore St.
Division St.	Replaced 525 feet of 8" CI pipe with 12" DI pipe	Marlborough St.	Bicknell Ave.
Adelaide Ave.	Replaced 1,022 feet of 6" CI pipe with 8" DI pipe Replaced 284 feet of 6" AC pipe with 8" DI pipe	O'Donnell Ave. South on Adelaide Ave.	South on Adelaide Ave. Jambray Ave.
Dongay Ave.	Replaced 246 feet of 6" AC pipe with 8" DI pipe	O'Donnell Ave.	Levesque St.
Jambray Ave.	Replaced 1,324 feet of 8" AC pipe with 8" DI pipe Replaced 300 feet of 6" AC pipe with 8" DI pipe Installed 10 feet of 8" DI pipe	Levesque St. Levesque St. Levesque St.	Adelaide Ave. North on Jambray Ave. North on Jambray Ave.
Levesque St.	Replaced 1,004 feet of 6" AC pipe with 8" DI pipe Replaced 300 feet of 8" AC pipe with 8" DI pipe Installed 20 feet of 8" DI pipe	Dongay Ave. Dongay Ave. Dongay Ave.	Adelaide Ave. Jambray Ave. Jambray Ave.
O'Donnell Ave.	Replaced 424 feet of 6" CI pipe with 8" DI pipe Replaced 175 feet of 2" GALV pipe with 8" DI pipe	Providence St. Dongay Ave.	Dongay Ave. East on O'Donnell Ave.
Wallace Ave.	Installed 384 feet of 8" DI pipe	Providence St.	Adelaide Ave.

WEST WARWICK			
LOCATION	DESCRIPTION	FROM	TO
North Pleasant St.	Installed 1,445 feet of 12" DI pipe	Harris St.	Summit Ave.
Broad St.	Installed 455 feet of 12" DI pipe	Lanphear St.	North Pleasant St.
Summit Ave.	Replaced 1,070 feet of 6" CI pipe with 12" DI pipe	North Pleasant St.	Parker St.
Aberdeen St.	Replaced 170 feet of 6" CI pipe with 12" DI pipe Replaced 380 feet of 6" CI pipe with 8" DI pipe	Alpine St. Woodbine St.	Woodbine St. North on Aberdeen St.
Alpine St.	Replaced 450 feet of 6" CI pipe with 12" DI pipe	Parker St.	Aberdeen St.
Woodbine St.	Replaced 442 feet of 6" CI pipe with 12" DI pipe Installed 318 feet of 12" DI pipe	Aberdeen St. Aberdeen St.	Phenix Ave. Phenix Ave.
Phenix Ave.	Replaced 1,882 feet of 6" CI pipe with 12" DI pipe Installed 178 feet of 12" DI pipe Installed 778 feet of 8" DI pipe	Woodbine St. Woodbine St. Harding St.	Harding St. Harding St. North on Phenix Ave.
Harding St.	Replaced 1,140 feet of 6" AC pipe with 12" DI pipe Installed 183 feet of 12" DI pipe Replaced 783 feet of 6" AC pipe with 16" DI pipe Installed 187 feet of 16" DI pipe	Horta Dr. Phenix Ave. Wakefield St. Wakefield St.	South on Harding St. Horta Dr. North on Harding St. North on Harding St.
Main St.	Replaced 1,520 feet of 8" CI pipe with 20" DI pipe Replaced 590 feet of 10" CI pipe with 20" DI pipe	Fairview Ave. Westly St.	Wakefield St. Clyde St.
Knight St.	Replaced 880 feet of 6" CI pipe with 20" DI pipe	Wakefield St.	Westly St.
Westly St.	Replaced 185 feet of 6" CI pipe with 20" DI pipe	Main St.	Knight St.
Ames St.	Replaced 400 feet of 6" CI pipe with 16" DI pipe	Fairview Ave.	Mumford St.
Gareau St.	Replaced 239 feet of 6" CI pipe with 8" DI pipe	McNiff St.	East on Gareau St.

WEST WARWICK (cont.)			
LOCATION	DESCRIPTION	FROM	TO
Tobin St.	Installed 211 feet of 8" DI pipe Installed 28 feet of 6" DI pipe	Gough Ave. Gough Ave.	North on Tobin St. North on Tobin St.
Bank St.	Replaced 260 feet of 6" CI pipe with 8" DI pipe Installed 40 feet of 8" DI pipe	Main St. McElroy St.	McElroy St. St. James St.
McElroy St.	Replaced 365 feet of 4" CI pipe with 8" DI pipe Installed 35 feet of 8" DI pipe	Bank St. Bank St.	North on McElroy St. North on McElroy St.
St. James St.	Installed 199 feet of 8" DI pipe	Bank St.	St. Mary St.
St. Mary St.	Replaced 405 feet of 6" CI pipe with 8" DI pipe	Main St.	St. James St.
Fairview Ave.	Replaced 1,496 feet of 12" CI pipe with 16" DI pipe Replaced 239 feet of 12" CI pipe with 12" DI pipe	Hillside Ave. Ames St.	Ames St. Main St.
Crossland Rd.	Replaced 1,300 feet of 6" AC pipe with 8" DI pipe Installed 425 feet of 8" DI pipe	Enfield Dr. Enfield Dr.	Oakland Dr. Oakland Dr.
Maywood Dr.	Replaced 490 feet of 6" AC pipe with 8" DI pipe	Providence St.	Crossland Rd.
Fernwood Dr.	Replaced 300 feet of 6" AC pipe with 8" DI pipe Installed 180 feet of 8" DI pipe	Providence St. Providence St.	Crossland Rd. Crossland Rd.
Maryland Dr.	Replaced 490 feet of 6" AC pipe with 8" DI pipe	Providence St.	Crossland Rd.
Linden Dr.	Replaced 340 feet of 6" AC pipe with 8" DI pipe Installed 150 feet of 8" DI pipe	Providence St. Providence St.	Crossland Rd. Crossland Rd.
Enfield Dr.	Replaced 1,460 feet of 6" AC pipe with 8" DI pipe	Providence St.	Glendale Dr.
Overhill Dr.	Replaced 490 feet of 6" AC pipe with 8" DI pipe Replaced 325 feet of 1" CU pipe with 8" DI pipe Installed 205 feet of 8" DI pipe	Providence St. Crossland Rd. Crossland Rd.	Crossland Rd. Oakland Dr. Oakland Dr.
Alden Dr.	Replaced 1,615 feet of 6" AC pipe with 8" DI pipe Installed 420 feet of 8" DI pipe	Providence St. Providence St.	West on Alden Dr. West on Alden Dr.
Hopedale Dr.	Replaced 1,225 feet of 6" AC pipe with 8" DI pipe	Providence St.	Glendale Dr.
Glendale Dr.	Replaced 1,825 feet of 6" AC pipe with 8" DI pipe	Enfield Dr.	South on Glendale Dr.
Shortway Dr.	Replaced 152 feet of 6" AC pipe with 8" DI pipe Installed 138 feet of 8" DI pipe	Midway Dr. Midway Dr.	Glendale Dr. Glendale Dr.
Midway Dr.	Replaced 304 feet of 6" AC pipe with 8" DI pipe Installed 113 feet of 8" DI pipe	Shortway Dr. Shortway Dr.	Enfield Dr. Enfield Dr.
Aldrich St.	Replaced 1,001 feet of 6" AC pipe with 8" DI pipe Installed 132 feet of 8" DI pipe	Pulaski St. Pulaski St.	Sidney St. Sidney St.
Barnold St.	Replaced 879 feet of 6" AC pipe with 8" DI pipe Installed 171 feet of 8" DI pipe	Pulaski St. Pulaski St.	Sidney St. Sidney St.
Bryant Pl.	Replaced 441 feet of 6" AC pipe with 8" DI pipe	Harley St.	Lada Dr.
Coaches Ct.	Replaced 205 feet of 6" AC pipe with 8" DI pipe	Harley St.	Sidney St.
Eileen Dr.	Replaced 463 feet of 6" AC pipe with 8" DI pipe	Pulaski St.	Windsor Park Dr.
Emile St.	Installed 204 feet of 8" DI pipe	Harley St.	Sidney St.
Harley St.	Replaced 2,334 feet of 8" AC pipe with 8" DI pipe	Pulaski St.	Wilshire Way
Koch St.	Installed 257 feet of 8" DI pipe	Aldrich St.	Barnold St.
Kowalik Dr.	Replaced 600 feet of 6" AC pipe with 8" DI pipe	Sidney St.	Harley St.
Lada Dr.	Replaced 454 feet of 6" AC pipe with 8" DI pipe	Sidney St.	Harley St.
Sheffield Ave.	Replaced 1,699 feet of 6" AC pipe with 8" DI pipe	Roundway Dr.	Harley St.
Sherwood Dr.	Replaced 757 feet of 6" AC pipe with 8" DI pipe	Roundway Dr.	Sheffield Ave.
Sidney St.	Replaced 1,072 feet of 6" AC pipe with 8" DI pipe	Wilshire Way	Coaches Ct.
Windsor Park Dr.	Replaced 168 feet of 6" DI pipe with 8" DI pipe Installed 290 feet of 8" DI pipe	Pulaski St. Sophia's Way	Sophia's Way Roundway Dr.

WEST WARWICK (cont.)			
LOCATION	DESCRIPTION	FROM	TO
Industrial Ln.	Replaced 1,795 feet of 8" CI pipe with 8" DI pipe	Clyde St.	North on Industrial Ln.
J.P. Murphy Hwy.	Replaced 7,855 feet of 16" AC pipe with 16" DI pipe	Quaker Ln.	J.P. Murphy Hwy. Easement
Ottawa St.	Replaced 240 feet of 4" CI pipe with 4" DI pipe Installed 274 feet of 6" DI pipe	Mill St. Robert St.	Robert St. Washington St.
Auburn St.	Replaced 437 feet of 6" AC pipe with 8" DI pipe	Blossom St.	Circle Dr.
Ball Ave.	Replaced 505 feet of 6" CI pipe with 8" DI pipe	Providence St.	Gage St.
Blossom St.	Replaced 690 feet of 6" AC pipe with 8" DI pipe Replaced 423 feet of 6" AC pipe with 8" DI pipe	Providence St. Auburn St.	Auburn St. Circle Dr.
Burns St.	Installed 376 feet of 8" DI pipe	Providence St.	Blossom St.
Circle Dr.	Replaced 259 feet of 6" AC pipe with 8" DI pipe Installed 90 feet of 8" DI pipe	Blossom St. Auburn St.	State St. North on Circle Dr.
Diaz Ct.	Installed 211 feet of 8" DI pipe	Prospect Hill Ave.	South on Diaz Ct.
DiMasi Ct.	Installed 306 feet of 8" DI pipe	Tripoli St.	Wilson St.
Fiume St.	Replaced 893 feet of 6" CI pipe with 8" DI pipe	Prospect Hill Ave.	West & North on Fiume St.
Gage St.	Replaced 355 feet of 6" CI pipe with 8" DI pipe	Providence St.	Ball Ave.
Lancelotta St.	Replaced 448 feet of 6" CI pipe with 8" DI pipe Installed 258 feet of 8" DI pipe	Prospect Hill Ave. Prospect Hill Ave.	North on Lancelotta St. South on Lancelotta St.
McTeers Ct.	Replaced 372 feet of 6" CI pipe with 8" DI pipe	Prospect Hill Ave.	North on McTeers Ct.
Prospect Hill Ave.	Replaced 458 feet of 6" AC pipe with 8" DI pipe Replaced 1,317 feet of 8" CI pipe with 12" DI pipe	Tripoli St. McTeers Ct.	Lancelotta St. Tripoli St.
Providence St.	Replaced 225 feet of 8" CI pipe with 8" DI pipe Replaced 1,032 feet of 8" AC pipe with 8" DI pipe	O'Donnell Ave. Gage St.	Gage St. Blossom St.
State St.	Installed 339 feet of 8" DI pipe	Auburn St.	Circle Dr.
Tripoli St.	Replaced 360 feet of 6" CI pipe with 12" DI pipe	Prospect Hill Ave.	North on Tripoli St.
Wakefield St.	Installed 255 feet of 16" DI pipe	Wilson St.	East on Wakefield St.
Wilson St.	Replaced 965 feet of 6" CI pipe with 12" DI pipe Installed 698 feet of 12" DI pipe	Prospect Hill Ave. Wakefield St.	North on Wilson St. South on Wilson St.

2.3 Pressure Zone Updates

The existing KCWA water distribution system is divided into eight (8) distinct pressure zones operating at varying hydraulic pressure gradients and five (5) of which service the majority of the KCWA service territory. These five (5) pressure zones are as follows:

- Low Service (334 foot) Pressure Gradient
- Reduced Low Service (280 foot) Pressure Gradient
- High Service South (500 foot) Pressure Gradient
- Reduced High Service South (430 foot) Pressure Gradient
- High Service North (500 foot) Pressure Gradient

There also exist three (3) pressure service areas that provide service to isolated areas of the system and include the following:

- Warwick Tanks (231 foot) Pressure Gradient
- Oaklawn Service (231 foot) Pressure Gradient
- Tiogue (425 foot) Pressure Gradient

Since completion of the 2006 model update, the hydraulic grade of the Read School House Road Pressure Gradient has been increased from 430 feet to 500 feet. The increase in hydraulic grade of this pressure zone is a result of the construction of the new 1.5 million gallon Read School House Road Water Storage Tank which is located approximately 3,400 feet north of the previous tank site. The new Read School House Road Water Storage Tank has an overflow elevation of 500 feet and replaces the former Read School House Road Water Storage Tank which had a capacity of 1.5 million gallons and an overflow elevation of 430 feet. The older tank has been taken out of service and shall be demolished in the near future. The new Read School House Road Pressure Gradient encompasses generally the same area as the lower 430 foot pressure gradient and is also currently known as the High Service North Pressure Gradient.

The Knotty Oak Booster Pump Station that serviced the Read School House Road Pressure Gradient at a hydraulic grade of 430 feet has been taken out of service and new High Service pumps were installed at the Clinton Avenue Pump Station. The new High Service pumps at the Clinton Avenue Pump Station were designed to boost the water to a hydraulic grade of 500 feet from the Providence Water Interconnection into the High Service North (Read School House Road) pressure zone. The Clinton Avenue Pump Station contains two (2) High Service pumps each with a rated capacity of 2,080 gallons per minute (gpm) at 300 feet total dynamic head (TDH) and these pumps were incorporated into this model update. Control of the pump(s) is by the water level in the Read School House Road Water Storage Tank.

2.4 Sources of Supply Updates

The KCWA maintains three (3) wellfields within its water supply and distribution system and three (3) primary interconnections that supply the source water to the system. These wellfields include the Mishnock Wells, the Coventry/Spring Lake Well and the East Greenwich Well that are owned and operated by the Authority. The three (3) interconnections include the Clinton Avenue Pump Station, which is supplied from Providence Water, the Quaker Lane Pump Station, which is supplied from the City of Warwick (indirectly from Providence Water) and the Oaklawn Avenue Interconnection, which is supplied from Providence Water and serves only an isolated area in Cranston and West Warwick.

The Clinton Avenue Pump Station underwent construction in 2006 for rehabilitation to increase the pumping capacity to the Low Service Pressure Gradient. The new facility went on line in 2007 and the improvements to the pumping supply have been included in this update. In 2013, variable frequency controlled drives (VFD's) were installed on two (2) of the Low Service pumps at the Clinton Avenue Pump Station. These VFD's are set to operate on the pressure head at the pump station and are also included in the model update. The Quaker Lane Pump Station has recently undergone construction for rehabilitation to increase the pumping capacity to the Low Service Pressure Gradient. The rehabilitation of the Quaker Lane Pump Station was completed in August 2014 and the improvements have been included in this model update. The recent improvements to the Quaker Lane Pump Station included the installation of three (3) new Low Service pumps each with a capacity of 1,875 gpm at 130 feet TDH. There are future plans for improvements that involve installing new High Service pumps in the Quaker Lane Pump Station but these improvements are not included in this update as they will be dependent upon the construction of related infrastructure (i.e. water mains).

KCWA personnel have indicated that the Coventry/Spring Lake Well has been taken out of normal service to the gradient due to water quality issues. This well station is currently an active registered source of supply with the Rhode Island Department of Health (RIDOH) but is not utilized in any of the hydraulic model simulations because of its standby in case of emergency status and will continue to remain as such in the model until further notice from the KCWA. The East Greenwich Well is currently undergoing rehabilitation and is temporarily off line. It is anticipated that the East Greenwich Well will be off line for a minimal amount of time and returned to daily operation in a timely manner. Therefore it is utilized in the hydraulic model simulations of this update. A water treatment plant was recently constructed at the Mishnock

Wellfield. After being off line due to water quality issues for several years, the Mishnock Wells were returned to service in 2013 when the water treatment plant came on line and are utilized in the hydraulic model simulations of this update. KCWA personnel have indicated that the Mishnock Wells are used on a daily basis and have an output averaging approximately 400,000 gallons per day. There are future plans for the Mishnock Wells to supply water to the High Service South Pressure Gradient. This project is awaiting the installation of a necessary transmission main on Mishnock Road.

The following table describes the capacity of each supply source (wells and pump stations) and the total supply available to the water system. The Coventry/Spring Lake Well is included as it is anticipated that it will be returned to service in the future once water quality issues have been resolved. It should be noted that all sources directly supply water to the Low Service Pressure Gradient. The Clinton Avenue Pump Station supplies water directly to both the Low Service Pressure Gradient and High Service North Pressure Gradient.

TRANSMISSION SUPPLY SYSTEM PUMPING STATIONS

SUPPLY SOURCE	PUMP / WELL CAPACITY	SUPPLY CAPACITY IN GPM (MGD)
Mishnock Wells [(1)]	2 at 1,000 gpm	1,000 gpm (1.44 MGD)
Coventry/Spring Lake Well	1 at 350 gpm	350 gpm (0.50 MGD)
East Greenwich Well	1 at 1,200 gpm	1,200 gpm (1.73 MGD)
Clinton Avenue Pump Station [(1)]	5 at 3,820 gpm 2 at 2,080 gpm	17,360 gpm (25.0 MGD)
Quaker Lane Pump Station [(1)]	3 at 1,875 gpm	3,750 gpm (5.40 MGD)
TOTAL SUPPLY		**23,660 gpm (34.07 MGD)**

[1] One of the largest pumps at these facilities is considered to be an in line spare / backup and is not considered in the total available supply capacity.

2.5 Interconnection Updates

The primary source of water supply for the KCWA is through wholesale interconnections through Providence Water and the City of Warwick. The wholesale interconnections directly through Providence Water include the Clinton Avenue Pump Station and the Oaklawn Avenue Interconnection. The Oaklawn Avenue Interconnection provides service to a segregated small portion of the system in Cranston and the Brookfield Plat in West Warwick and is not affected by the operations of the other supply sources in the KCWA water system. The wholesale interconnections through the City of Warwick consist of the Quaker Lane Pump Station and the Potowomut Interconnection. The Potowomut Interconnection is for the sale of water to Warwick. No updates of the Oaklawn Avenue and Potowomut Interconnections were required to the model as there have been no modifications to these interconnection facilities. Updates of the Clinton Avenue and Quaker Lane Pump Stations have been included in this 2014 model update.

The Clinton Avenue Pump Station underwent rehabilitation in 2006 to increase the pumping capability to the Low Service Pressure Gradient and to provide service to the new High Service North Pressure Gradient. The new facility went on line in 2007 and the improvements to the Low Service and High Service North Pressure Gradients pumping supplies have been included in this update. VFD's were installed on two (2) of the Low Service pumps at the Clinton Avenue Pump Station in 2013. The VFD's are set to operate on the pressure head at the pump station or the Frenchtown Road Tank level and have also been included in this update. The Quaker Lane Pump Station has recently undergone rehabilitation to increase the pumping capability to the Low Service Pressure Gradient. This rehabilitation was completed in August 2014 and the improvements were included in this 2014 model update. The pumps at the Quaker Lane Pump Station are set to operate off of the Setian Lane Tank.

Since the completion of the 2006 model update and the 2006 rehabilitation of the Clinton Avenue Pump Station, the KCWA has installed an emergency interconnection with Providence Water located in West Warwick. The Providence Water Emergency Interconnection is located off of Harding Street along the 102-inch Providence Water aqueduct. This emergency interconnection contains two (2) pumps each rated at 2,800 gpm at 170 feet TDH designed to pump from the free water surface of the Providence Water aqueduct at a hydraulic grade of 222 feet directly into the KCWA's Low Service Pressure Gradient at a hydraulic grade of 334 feet to serve as a redundant source of supply to the KCWA during emergency demand conditions. The Providence Water Emergency Interconnection has been included in this update of the model but was not utilized in any model simulations due to the fact that the KCWA only uses this interconnection during emergency situations.

2.6 Water Storage Facility Updates

The KCWA water supply system currently contains five (5) active storage facilities and three (3) inactive storage facilities for a total of eight (8) water storage facilities. The Seven Mile Road Reservoirs (Fiskeville Tanks) have recently been shutdown and capped and are no longer represented in the hydraulic model. The West Street Tank and Tiogue Tank are off line and isolated from the system and maintain a similar status in this update. The West Street Tank was taken off line because this tank is continuously maintained in a locked up condition due to the fact that it does not float on the system due to its proximity to the Clinton Avenue Pump Station. The Tiogue Tank was taken off line so that the pressures in the area surrounding this tank could be increased by a pressure reducing valve station that is serviced directly by the High Service South Pressure Gradient. The Wakefield Tank was recently taken off line in 2013 due to poor water quality in the tank as a result of inconsistencies in cycling stored volumes of water back into the distribution system. Therefore, the model simulations conducted as part of this update are done so with the Wakefield Water Storage Tank off line and isolated from the system.

As indicated in Section 2.3, the KCWA has completed a project to increase the hydraulic grade of the Read School House Road Pressure Gradient so that the pressure gradient is maintained with the overflow elevation of the newly constructed Read School House Road Water Storage Tank. The new Read School House Road Water Storage Tank has a capacity of 1.5 million gallons and an overflow elevation of 500 feet and replaces the older Read School House Road Water Storage Tank which had a capacity of 1.5 million gallons and an overflow elevation of 430 feet. The old Read School House Road Water Storage Tank has been taken out of service and is no longer represented in the hydraulic model. The model simulations conducted as part of this 2014 model update were performed with the new Read School House Road Water Storage

Tank on line and servicing the Read School House Road (High Service North) Pressure Gradient at a hydraulic grade of 500 feet.

2.7 Distribution System Pumping Facility Updates

The KCWA owns and operates a total of three (3) distribution system booster pump stations (Setian Lane, West Warwick Industrial Park and Johnson Boulevard) and two (2) transmission booster pump stations located at the primary wholesale interconnections. The Hope Road Booster Pump Station has been taken out of service and this area is now serviced by the Read School House Road Pressure Gradient with the replacement of several water mains in this area. The supply capacity of the transmission pumping stations was previously discussed in Section 2.4. The following tables depict the capacity of each distribution system pumping facility including the pressure zone to which it supplies. The total available source of supply was previously evaluated under Sections 2.4 and 2.5. These facilities are not considered a source of supply to the system as they are utilized to boost pressure from the Low Service Gradient to the identified Pressure Service Gradients.

DISTRIBUTION SYSTEM PUMPING STATIONS

High Service South (500 foot) Pressure Gradient

BOOSTER PUMP STATION *	TOTAL PUMP CAPACITY	RATED CAPACITY IN GPM (MGD)
Johnson Boulevard Pump Station	1 at 1,100 gpm 2 at 2,300 gpm	3,450 gpm (4.97 MGD)
W. Warwick Industrial Park Pump Station	2 at 800 gpm	800 gpm (1.15 MGD)
Setian Lane Pump Station	3 at 700 gpm	1,400 gpm (2.02 MGD)
TOTAL PUMPING		**5,650 gpm (8.14 MGD)**

* One of the largest pumps at these facilities is considered to be an in line spare / backup and is not considered in the total available supply capacity.

2.8 Pressure Reducing Valve Station Updates

The KCWA water system contains a total of nine (9) pressure reducing valve (PRV) stations. There are six (6) PRV stations controlling the Reduced Low Service Pressure Gradient which reduce pressure from the Low Service Pressure Gradient. Two (2) PRV stations control the Reduced High Service Pressure Gradient that reduce pressure from the High Service South Pressure Gradient. The one (1) PRV station that controls the Tiogue Pressure Gradient was installed in 2009 and reduces pressure from the High Service South Pressure Gradient. No other updates were required to the model as there have been no additional modifications since the 2006 model update to these PRV stations. The following tables depict the hydraulic grade setting of each PRV including the pressure zone to which it supplies.

PRESSURE REDUCING VALVE STATIONS

Reduced Low Service (280 foot) Pressure Gradient

PRESSURE REDUCING VALVE STATION	HYDRAULIC GRADE SETTINGS
Centerville Road	268.93 ft
Division Street	270.15 ft
Middle Road	272.48 ft
Cowesett Road	275.87 ft
Love Lane	269.08 ft
Post Road	271.45 ft

Reduced High Service (430 foot) Pressure Gradient

PRESSURE REDUCING VALVE STATION	HYDRAULIC GRADE SETTINGS
Mishnock Road	438.42 ft
Helen Avenue	431.73 ft

Tiogue (425 foot) Pressure Gradient

PRESSURE REDUCING VALVE STATION	HYDRAULIC GRADE SETTINGS
Tiogue Avenue	410.00 ft

3.0 System Demand Updates

3.1 Consumer Demand Updates

An update of the consumer demands in the hydraulic model is typically performed at 3 to 5 year intervals. At the time that the February 2006 model update was completed, an update of the consumer demands was considered premature in that the original hydraulic model of the KCWA water system was completed in June 2004. Therefore, the 2006 model update did not include an update of consumer demands. Due to the fact that the an update of the consumer demands has not occurred in the last 10 years since the hydraulic model was first developed, this 2014 model update includes an update of consumer demands.

In order to establish and allocate the consumer water demands in the KCWA system the demand allocation zone method was utilized whereby the KCWA service territory was divided into smaller sections referred to as demand allocation zones. The KCWA distribution system includes seven (7) Cities and Towns. When the hydraulic model was originally developed in 2004, the service territory was divided into seven (7) demand allocation zones representing each City and Town serviced by the KCWA water system. There have been no updates to or additions of demand allocation zones in this model update and the demand allocation zones that were identified during the original development of the hydraulic model were also utilized in this 2014 model update. Following is a table depicting the designated demand allocation zones in the model.

DEMAND ALLOCATION ZONES

DEMAND ALLOCATION ZONE	TOWN
1	West Warwick
2	Warwick
3	West Greenwich
4	East Greenwich
5	Cranston
6	Scituate
7	Coventry

(Note: The KCWA water distribution system extends into a small area of North Kingstown however, there are no customer services in this portion of the system. As a result, North Kingstown was not included in the demand allocation for the model.)

KCWA personnel provided consumer demand information for all of the customer accounts in the water system in the form of consumption data totaling the metered use by each street in each City or Town for four (4) years from 2010 to 2013. For the purposes of this model update, the consumption data from the year 2012 was utilized. The year 2012 was selected as the model base demand year for this model update because of the completeness of the data and due to the fact that this year's consumer demands best represent the distribution system's water consumption for the demand periods evaluated. Demand totals were submitted to KCWA staff for concurrence prior to selecting 2012 as the model update demand year. The total consumption per street per City or Town was utilized to develop the water consumption per demand allocation zone. The following table depicts a breakdown of the consumption totals for the water demand zone allocation of the KCWA distribution system.

2012 WATER USAGE

DEMAND ALLOCATION ZONE	TOWN/CITY	TOTAL ANNUAL USAGE (GAL)	AVG. DAY + UNMETERED (GPM)
1	West Warwick	728,401,929	1,470
2	Warwick	619,603,249	1,250
3	West Greenwich	132,897,646	268
4	East Greenwich	547,520,472	1,105
5	Cranston	51,219,749	103
6	Scituate	36,245,568	73
7	Coventry	635,956,684	1,283
TOTALS		**2,751,845,297**	**5,552**

The total annual usage from the table above corresponds to an average day rate of 7.54 million gallons per day (MGD). The percentage of unmetered water in the distribution system was determined to be 6.04% and was added to the consumption demand data in order to account for water that is not billed (i.e. leaks, meter slippage, etc.). (It should be noted that the percentage of unmetered water of 6.04% is lower than the percentage of unmetered water from the February 2006 model update which was calculated as 9.53%). Adding the percentage of unmetered water to the total annual usage results in a total average day demand of 7.99 MGD. This total average day demand is the base average day system demand that was utilized in this 2014 model update. It should be noted that the demands in the table above also include the large users of the water system.

In order to develop the system maximum day and peak hour demand allocations, consumption data was correlated with the actual flow record data from all of the system sources. All of the water for the KCWA water system is produced from three (3) well fields (East Greenwich, Coventry/Spring Lake and Mishnock) and received directly from interconnections with Providence Water and the City of Warwick (indirectly through Providence Water). These facilities are metered on a continual basis. The production and source water data was reviewed for the base year of 2012 which is the year of the consumer demand data that was utilized. The maximum day and peak hour multipliers were updated as part of this model update to represent the fluctuation in water usage within the water system on a day where demands vary significantly from average day demands. These multipliers were updated by reviewing daily recordings and charts for sources of supply, storage facilities, booster pump stations and PRV stations for the base demand year of 2012.

After reviewing the data for 2012, it was determined that a maximum day demand for the water system is in the range of 14.99 MGD and this demand would most accurately represent a maximum day demand for the water system. Based on this maximum day demand, the updated maximum day multiplier for the water system was determined to be 2.05 and was included in this model update. It should be noted that this multiplier considers the fact that large users were assigned varying multipliers based on the type of use of the large user and the remaining water usage was assigned to the consumers in the water system.

In order to update the peak hour multiplier, the records for the 2012 maximum day demand were reviewed. A review of the flow data for pump stations, tank charts, well stations and other available data related to system operation during the maximum day period was conducted. The review of this data indicated that the peak demand of the water system occurred during a period on July 17, 2012 between the hours of 3:25 AM and 6:51 AM. During this timeframe, the total system production from all sources of supply was approximately 12.51 MGD with a volume of water from storage to the system of approximately 5.19 MGD on an average hourly basis. The peak hour demand rate was determined to be 18.16 MGD (12.51 MGD supply rate plus 5.19 MGD tank volume plus 0.455 unmetered volume). This translates to a peak hour multiplier of 2.53 which was included in this model update.

In the original development of the model, unaccounted for water, which was calculated as 6.04%, was assigned a multiplier of 1.0 as it is not considered to vary significantly with customer demands during maximum day and peak hour demands. This unaccounted for water multiplier was also utilized in this model update.

3.2 Large User Demand Updates

The demand database in the model for the previously identified large users was reviewed and updated as appropriate based on the 2012 consumer demand data information. This list was reviewed and any large users which were no longer within the water system were removed from the model and any new large users were included in the model update. There were five (5) new large users added to the list and there were nine (9) previous large users which had been removed from the latest list. The following table details each of the large users with their previous total annual usage (if they were included previously in the model) and their current total annual usage. The model was updated with the 2012 demand data information which represents the base year demand data utilized in the 2014 model update.

WATER SYSTEM LARGE USERS

WATER SYSTEM LARGE USERS	2006 TOTAL ANNUAL USAGE (GAL)	2012 TOTAL ANNUAL USAGE (GAL)	% CHANGE +/-
Bradford Soap Works	14,335,719	6,013,995	-58.0%
Greenwich Place Apartments*	N/A	5,236,000	N/A
Quaker Valley Condos	7,240,640	5,380,364	-25.7%
Royal Mills*	N/A	7,405,200	N/A
Tanglewood Village	10,068,080	8,736,640	-13.2%
AIMCO Warwick LLC	14,601,708	17,952,000	+22.9%
Briarwood Meadows	23,404,920	25,659,183	+9.6%
Cowesett Hills	18,288,600	12,573,880	-31.2%
Kent Hospital	36,056,629	37,730,444	+4.6%
Vishay Electro Films	9,555,700	8,094,108	-15.3%
Amgen	177,261,040	97,739,679	-44.9%
G-Tech	13,538,800	5,848,380	-56.8%
Amtrol	29,014,920	18,602,760	-35.9%
Edens & Advent	11,893,200	9,447,240	-20.6%
Shoreside Apartments*	N/A	6,148,560	N/A
Clariant	131,449,032	8,723,819	-93.4%
Commerce Park/Center of New England*	N/A	26,532,084	N/A
Haven Eldercare of New England	12,606,044	6,951,164	-44.9%
Mapleroot Corporation*	N/A	6,067,125	N/A
Westwood Trailer Park	26,494,160	17,687,268	-33.2%
TOTALS		**338,529,893**	

*This large user was not included previously in the model and was added to the model as part of the 2014 update.

The total annual usage of the large users from the 2006 model update totaled 748,655,150 gallons. The total annual usage of the large users from this 2014 update totals 338,529,893 gallons. The total cumulative demand from the large users has decreased 54.8% or 410.13 million gallons per year. The most significant increase in water use occurred for AIMCO Warwick LLC which was approximately 3.35 million gallons per year. The most significant decrease in water use occurred for Clariant which was approximately 122.73 million gallons per year, or approximately 336,000 gallons per day.

KCWA's wholesale interconnection to the City of Warwick is represented in the hydraulic model as a wholesale large user and is not identified in the largest consumer users in the table above. The KCWA wholesales water to the City of Warwick at the Potowomut interconnection on Post Road. This wholesale volume of water has increased 26.1% or 18.86 million gallons per year since the 2006 model update and was modified in this model update.

As previously indicated, large users were assigned varying multipliers based on the type of use of the large user. The updated large user multipliers were based upon the 2012 base year demand data and the multipliers developed as part of the original hydraulic model development. The large users were classified into groups based upon their type of water usage. Residential users were assigned similar multipliers because these users typically have a large number of water-using appliances and irrigation needs and their demand peaks are usually higher in the early morning hours, evening hours and the summer months. Commercial and industrial users were assigned similar multipliers because these users utilize water on a more consistent basis throughout the day and year. The following table identifies the updated multipliers included in this model update for the large users for both the maximum day and peak hour.

LARGE WATER USERS MULTIPLIERS

LARGE WATER USERS	TOTAL ANNUAL USAGE (GAL)	MAP ID LOCATION*	MAXIMUM DAY MULTIPLIER	PEAK HOUR MULTIPLIER
Bradford Soap Works	6,013,995	1A	1.5	1.5
Greenwich Place	5,236,000	1B	2.0	2.5
Quaker Valley Condos	5,380,364	1C	2.0	2.5
Royal Mills	7,405,200	1D	2.0	2.5
Tanglewood Village	8,736,640	1E	2.0	2.5
AIMCO Warwick LLC	17,952,000	2A	2.0	2.5
Briarwood Meadows	25,659,183	2B	2.0	2.5
Cowesett Hills	12,573,880	2C	2.0	2.5
Kent Hospital	37,730,444	2D	1.5	1.5
Vishay Electro Films	8,094,108	2E	1.5	1.5
Amgen	97,739,679	3A	1.2	1.2
G-Tech	5,848,380	3B	1.2	1.2
Amtrol	18,602,760	4A	1.2	1.2
Edens & Advent	9,447,240	4B	1.5	1.5
Shoreside Apartments	6,148,560	4C	2.0	2.5
Clariant	8,723,819	7A	1.2	1.2
Commerce Park	26,532,084	7B	1.5	1.5
Haven Eldercare	6,951,164	7C	2.0	2.5
Mapleroot Corporation	6,067,125	7D	2.0	2.5
Westwood Trailer Park	17,687,268	7E	2.0	2.5

*Identifies the location in the particular demand allocation zone on the node and pipeline plan.

3.3 Approved Developments

The model update included incorporating all significant KCWA Board approved developments within the service territory since completion of the February 2006 model update. This included all new water piping infrastructure, interconnection(s) to the water system and consumer demands for average day, maximum day and peak hour simulations. The following table depicts the specific developments that have been approved by the KCWA, their location in the system, descriptive use (i.e. residential, commercial, etc.), pressure zone location and anticipated demand.

The KCWA Regulations require that specific hydraulic model assessments be performed for all proposed residential developments containing ten (10) or more residences or condominium units, all industrial facilities and all commercial facilities, or the equivalent thereof. The assessments are performed to ensure that the KCWA water system has adequate supply and water utility infrastructure in order to provide these developments with sufficient domestic and fire flow at adequate pressure. Hydraulic model assessments have been performed for the developments listed in the table.

APPROVED DEVELOPMENTS

DEVELOPMENT	LOCATION	DESCRIPTION	PRESSURE ZONE	AVG. DAY DEMAND (GPM)	MAX. DAY DEMAND (GPM)
Royal Hatheway Heights	East Greenwich Ave., WW	Residential	High Service South	6.25	14.38
Riverwalk Commons	Howard Ave., COV	Residential	Low Service	12.78	29.39
Centerville Gardens	Centerville Rd., WAR	Residential	Low Service	2.92	6.71
Phenix Mills	Main St., WW	Residential	Low Service	1.81	4.16
Wildberry Senior Housing	Archambault Ave., WW	Residential	Low Service	6.53	15.02
ENT & Allergy Medical Office	Post Rd., WAR	Commercial	Reduced Low Service	1.06	1.59
Medical Office Building	South County Tr., EG	Commercial	Low Service	4.58	6.87
Coventry Crossing	New London Tpk., COV	Commercial	High Service South	1.69	2.55
West Warwick Senior Center	Washington St., WW	Commercial	Low Service	1.33	2.00
Royal Mills Cotton Shed	Providence St., WW	Restaurant	Low Service	32.50	48.75
Glenwood Subdivision	Red Barn Ct., COV	Residential	High Service North	8.33	19.17
The Oaks	Watercress Ct., COV	Residential	High Service North	31.25	71.88
Anthony Mill	Washington St., COV	Residential	Low Service	31.25	71.88
Harris Mill	Main St., COV	Residential	Low Service	33.19	76.35
Cottages on Greene	Greene St., EG	Residential	Reduced Low Service	4.17	9.58
Royal Woods	Providence St., WW	Residential	Oaklawn	4.44	10.22
Golden Ridge	Washington St., COV	Residential	High Service North	18.47	42.49
Coventry Meadows	Edith St., COV	Residential	Low Service	13.47	30.99
Kent Hospital	Health Ln., WAR	Commercial	Low Service	75.00	112.50

DEVELOPMENT	LOCATION	DESCRIPTION	PRESSURE ZONE	AVG. DAY DEMAND (GPM)	MAX. DAY DEMAND (GPM)
Centrex	Hopkins Hill Rd., WG	Commercial	High Service	76.50	114.75
Greenwich Center	South County Tr., EG	Commercial	Low Service	6.50	9.75
Balise Subaru	Quaker Ln., WAR	Commercial	High Service	85.44	128.16
RIANG Camp Fogarty	South County Tr., EG	Commercial	Low Service	104.00	156.00
		TOTAL APPROVED DEMAND (GPM)		**563.46**	**985.14**

4.0 Hydraulic Model Simulation Updates

4.1 Simulations Overview

Hydraulic model simulations were performed for average day, maximum day and peak hour demand scenarios with the latest modifications to the system geometry and updates in system operations included in the hydraulic model. The following sections describe the simulations for each demand scenario and the results of the simulations.

4.2 Average Day Simulation

A complete summary of this simulation is provided in Appendix A.

Average Day Initial Modeling Conditions:

The following is a summary of the initial model conditions (i.e. tank levels, pumps on / off, etc.) categorized by the various pressure gradients. The "status" provides indication if the facility is either on or off for this simulation. A designation of "off" implies that it is not active during the simulation but is available for service. A designation of "off line" or "out of service" implies that this facility cannot be used for service.

Facility	*Status*
Low Service (334') Gradient	
- Setian Lane Tank	327.00 feet
- Frenchtown Road Tank	330.25 feet
- Mishnock Water Treatment Plant	On
- East Greenwich Well	On
- Coventry (Spring Lake) Well	Off
- Clinton Avenue Pump Station	On – Two Pumps Active (2 VFD's)
- Quaker Lane Pump Station	On – One Pump Active
Tiogue (425') Gradient	
- Tiogue PRV Station	Active – Open
High Service North (500') Gradient	
- Read School House Road Tank	497.08 feet
- Clinton Avenue Pump Station	Off
High Service South (500') Gradient	
- Technology Park Tank	497.50 feet
- Carr Pond Tank	495.82 feet

- Johnson Boulevard Pump Station	Off
- West Warwick Business Park Pump Station	On – One Pump Active
- Setian Lane Booster Pump Station	On – One Pump Active
- Mishnock Water Treatment Plant	Off – Not Active (pending transmission main installation)
Low Service Reduced (280') Gradient	
- Centerville Road PRV Station	Active – Open
- Division Street PRV Station	Active – Open
- Middle Road PRV Station	Active – Open
- Cowesett Road PRV Station	Active – Open
- Love Lane PRV Station	Active – Open
- Post Road PRV Station	Active – Open
High Service South Reduced (430') Gradient	
- Mishnock Road PRV Station	Active – Open
- Helen Avenue PRV Station	Active – Open
Warwick Wholesale Interconnection (231') Gradient	
- Wholesale Connection to Warwick	Active – Open
Oaklawn (231') Gradient	
- Wholesale Connection to Providence Water	Active - Open

Average Day Results Summary:

This scenario was premised on a total consumer system demand of 5,552.13 gpm (7.99 MGD), which is the total system demand including unmetered water volume. The scenario indicates that the total volume of flow being stored in the tanks (aggregate volume going to storage tanks) is equal to 1,866.93 gpm (2.69 MGD). Overall, the hydraulic gradients for the various pressure zones were calculated to be in the range in which these pressure zones are normally operated.

Facility	*Output Results Summary*
Low Service (334') Gradient	
- Setian Lane Tank	Filling 1,347.74 gpm
- Frenchtown Road Tank	Filling 208.08 gpm
- Mishnock Water Treatment Plant	800.00 gpm output
- East Greenwich Well	1,144.59 gpm output
- Coventry (Spring Lake) Well	Off
- Clinton Avenue Pump Station	3,141.48 gpm output
- Quaker Lane Pump Station	2,186.69 gpm output

Tiogue (425') Gradient	
- Tiogue PRV Station	Open 46.79 gpm
High Service North (500') Gradient	
- Read School House Road Tank	Draining 269.59 gpm
- Clinton Avenue Pump Station	Off
High Service South (500') Gradient	
- Technology Park Tank	Draining 259.28 gpm
- Carr Pond Tank	Filling 859.96 gpm
- Johnson Boulevard Pump Station	Off
- West Warwick Business Park Pump Station	867.26 gpm output
- Setian Lane Booster Pump Station	799.46 gpm output
- Mishnock Water Treatment Plant	Off – Not Active
Low Service Reduced (280') Gradient	
- Centerville Road PRV Station	Active – Closed
- Division Street PRV Station	Active – Closed
- Middle Road PRV Station	Open 207.15 gpm
- Cowesett Road PRV Station	Open 980.88 gpm
- Love Lane PRV Station	Active – Closed
- Post Road PRV Station	Active – Closed
High Service South Reduced (430') Gradient	
- Mishnock Road PRV Station	Open 230.12 gpm
- Helen Avenue PRV Station	Active – Closed
Warwick Wholesale Interconnection (231') Gradient	
- Wholesale Connection to Warwick	2,190.96 gpm
Oaklawn (231') Gradient	
- Wholesale Connection to Providence Water	161.92 gpm

4.3 Maximum Day Simulation

A complete summary of this simulation is provided in Appendix B.

Maximum Day Initial Modeling Conditions:

The following is a summary of the initial model conditions (i.e. tank levels, pumps on / off, etc.) categorized by the various pressure gradients:

Facility	*Status*
Low Service (334') Gradient	
- Setian Lane Tank	328.70 feet
- Frenchtown Road Tank	331.10 feet
- Mishnock Water Treatment Plant	On
- East Greenwich Well	On
- Coventry (Spring Lake) Well	Off
- Clinton Avenue Pump Station	On – Two Pumps Active (1 VFD)
- Quaker Lane Pump Station	On – Two Pumps Active
Tiogue (425') Gradient	
- Tiogue PRV Station	Active – Open
High Service North (500') Gradient	
- Read School House Road Tank	498.20 feet
- Clinton Avenue Pump Station	On – One Pump Active
High Service South (500') Gradient	
- Technology Park Tank	496.40 feet
- Carr Pond Tank	494.50 feet
- Johnson Boulevard Pump Station	Off
- West Warwick Business Park Pump Station	On – One Pump Active
- Setian Lane Booster Pump Station	On – One Pump Active
- Mishnock Water Treatment Plant	Off – Not Active (pending transmission main installation)
Low Service Reduced (280') Gradient	
- Centerville Road PRV Station	Active – Open
- Division Street PRV Station	Active – Open
- Middle Road PRV Station	Active – Open
- Cowesett Road PRV Station	Active – Open
- Love Lane PRV Station	Active – Open
- Post Road PRV Station	Active – Open
High Service South Reduced (430') Gradient	
- Mishnock Road PRV Station	Active – Open
- Helen Avenue PRV Station	Active – Open
Warwick Wholesale Interconnection (231') Gradient	
- Wholesale Connection to Warwick	Active - Open
Oaklawn (231') Gradient	
- Wholesale Connection to Providence Water	Active - Open

Maximum Day Results Summary:

This scenario was premised on a total consumer system demand of 10,724.06 gpm (15.44 MGD), which is the system demand including "unaccounted" water volume. The scenario indicates that the total volume of flow being stored in the tanks (aggregate volume going to storage tanks) is equal to 2,812.06 gpm (4.05 MGD). Overall, the hydraulic gradients for the various pressure zones were calculated to be in the range in which these pressure zones are normally operated.

Facility	*Output Results Summary*
Low Service (334') Gradient	
- Setian Lane Tank	Filling 1,650.65 gpm
- Frenchtown Road Tank	Draining 149.89 gpm
- Mishnock Water Treatment Plant	800.00 gpm output
- East Greenwich Well	1,148.81 gpm output
- Coventry (Spring Lake) Well	Off
- Clinton Avenue Pump Station	5,203.89 gpm output
- Quaker Lane Pump Station	4,000.88 gpm output
Tiogue (425') Gradient	
- Tiogue PRV Station	Open 93.04 gpm
High Service North (500') Gradient	
- Read School House Road Tank	Filling 1,515.71 gpm
- Clinton Avenue Pump Station	2,051.84 gpm output
High Service South (500') Gradient	
- Technology Park Tank	Draining 865.15 gpm
- Carr Pond Tank	Filling 660.74 gpm
- Johnson Boulevard Pump Station	Off
- West Warwick Business Park Pump Station	900.12 gpm output
- Setian Lane Booster Pump Station	818.73 gpm output
- Mishnock Water Treatment Plant	Off – Not Active
Low Service Reduced (280') Gradient	
- Centerville Road PRV Station	Open 352.77 gpm
- Division Street PRV Station	Open 431.65 gpm
- Middle Road PRV Station	Open 302.27 gpm
- Cowesett Road PRV Station	Open 304.58 gpm
- Love Lane PRV Station	Open 424.61 gpm
- Post Road PRV Station	Open 528.06 gpm
High Service South Reduced (430') Gradient	
- Mishnock Road PRV Station	Open 185.20 gpm

- Helen Avenue PRV Station	Open 270.85 gpm
Warwick Wholesale Interconnection (231') Gradient	
- Wholesale Connection to Warwick	4,009.37 gpm
Oaklawn (231') Gradient	
- Wholesale Connection to Providence Water	322.30 gpm

4.4 Peak Hour Simulation

A complete summary of this simulation is provided in Appendix C.

Peak Hour Initial Modeling Conditions:

The following is a summary of the initial model conditions (i.e. tank levels, pumps on / off, etc.) categorized by the various pressure gradients:

Facility	*Status*
Low Service (334') Gradient	
- Setian Lane Tank	328.70 feet
- Frenchtown Road Tank	331.10 feet
- Mishnock Water Treatment Plant	On
- East Greenwich Well	On
- Coventry (Spring Lake) Well	Off
- Clinton Avenue Pump Station	On – Two Pumps Active (1 VFD)
- Quaker Lane Pump Station	On – Two Pumps Active
Tiogue (425') Gradient	
- Tiogue PRV Station	Active – Open
High Service North (500') Gradient	
- Read School House Road Tank	498.20 feet
- Clinton Avenue Pump Station	On – One Pump Active
High Service South (500') Gradient	
- Technology Park Tank	496.40 feet
- Carr Pond Tank	494.50 feet
- Johnson Boulevard Pump Station	Off
- West Warwick Business Park Pump Station	On – One Pump Active
- Setian Lane Booster Pump Station	On – One Pump Active
- Mishnock Water Treatment Plant	Off – Not Active (pending transmission main installation)

Low Service Reduced (280') Gradient

- Centerville Road PRV Station	Active – Open
- Division Street PRV Station	Active – Open
- Middle Road PRV Station	Active – Open
- Cowesett Road PRV Station	Active – Open
- Love Lane PRV Station	Active – Open
- Post Road PRV Station	Active – Open

High Service South Reduced (430') Gradient

- Mishnock Road PRV Station	Active – Open
- Helen Avenue PRV Station	Active – Open

Warwick Wholesale Interconnection (231') Gradient

- Wholesale Connection to Warwick	Active - Open

Oaklawn (231') Gradient

- Wholesale Connection to Providence Water	Active - Open

Peak Hour Results Summary:

This scenario was premised on a total system demand of 13,046.72 gpm (18.79 MGD), which is the system demand including "unaccounted" water volume. The scenario indicates that the total volume of flow being stored in the tanks (aggregate volume going to storage tanks) is equal to 1,053.58 gpm (1.52 MGD). Overall, the hydraulic gradients for the various pressure zones were calculated to be in the range in which these pressure zones are normally operated.

Facility	*Output Results Summary*
Low Service (334') Gradient	
- Setian Lane Tank	Filling 1,108.17 gpm
- Frenchtown Road Tank	Draining 895.79 gpm
- Mishnock Water Treatment Plant	800.00 gpm output
- East Greenwich Well	1,161.21 gpm output
- Coventry (Spring Lake) Well	Off
- Clinton Avenue Pump Station	5,606.25 gpm output
- Quaker Lane Pump Station	4,054.56 gpm output
Tiogue (425') Gradient	
- Tiogue PRV Station	Open 114.23 gpm
High Service North (500') Gradient	
- Read School House Road Tank	Filling 1,414.56 gpm
- Clinton Avenue Pump Station	2,072.74 gpm output

High Service South (500') Gradient

- Technology Park Tank	Draining 1,038.17 gpm
- Carr Pond Tank	Filling 464.80 gpm
- Johnson Boulevard Pump Station	Off
- West Warwick Business Park Pump Station	893.70 gpm output
- Setian Lane Booster Pump Station	821.31 gpm output
- Mishnock Water Treatment Plant	Off – Not Active

Low Service Reduced (280') Gradient

- Centerville Road PRV Station	Open 452.19 gpm
- Division Street PRV Station	Open 491.16 gpm
- Middle Road PRV Station	Open 355.12 gpm
- Cowesett Road PRV Station	Open 404.31 gpm
- Love Lane PRV Station	Open 604.66 gpm
- Post Road PRV Station	Open 570.08 gpm

High Service South Reduced (430') Gradient

- Mishnock Road PRV Station	Open 228.07 gpm
- Helen Avenue PRV Station	Open 332.85 gpm

Warwick Wholesale Interconnection (231') Gradient

- Wholesale Connection to Warwick	4,064.98 gpm

Oaklawn (231') Gradient

- Wholesale Connection to Providence Water	395.74 gpm

4.5 Model Simulations Summary and Conclusions

This 2014 hydraulic model update consisted of modifying the model geometry to represent changes in the water system infrastructure and changes in operation of the water system, updating the consumer and large water users demand data and including the consumer demands of all the developments that were approved by the KCWA Board. Once these updates were completed, average day, maximum day and peak hour model simulations were performed with the latest modifications to the system geometry and system operational changes. The following table summarizes the water system demand for the 2014 updated hydraulic model compared to the water system demands contained in the 2006 updated hydraulic model.

COMPARISON OF WATER SYSTEM DEMANDS

MODELING SCENARIO	2006 MODEL UPDATE	2014 MODEL UPDATE	% CHANGE +/-
Average Day System Demand	8,074.15 gpm (11.63 MGD)	5,552.13 gpm (7.99 MGD)	-31.3%
Maximum Day System Demand	15,464.75 gpm (22.27 MGD)	10,724.06 gpm (15.44 MGD)	-30.7%
Peak Hour System Demand	17,962.26 gpm (25.87 MGD)	13,046.72 gpm (18.79 MGD)	-27.4%

The results of the updated model simulations indicate that the KCWA water system demand has decreased under all of the demand scenarios (average day, maximum day, peak hour). On average the decrease is 30%.

The following table summarizes the consumer demand for each pressure zone under the various demand scenarios based on the model simulation summaries presented in Appendices A, B and C.

CONSUMER DEMANDS

PRESSURE ZONE	DEMAND SCENARIO	DEMAND (GPM)
Low Service (334') Gradient	Average Day Maximum Day Peak Hour	2,834.27 5,533.95 6,712.11
Tiogue (425') Gradient	Average Day Maximum Day Peak Hour	46.79 93.04 114.22
High Service North (500') Gradient	Average Day Maximum Day Peak Hour	250.82 499.09 612.33
High Service South (500') Gradient	Average Day Maximum Day Peak Hour	835.91 1,467.20 1,727.45
Low Service Reduced (280') Gradient	Average Day Maximum Day Peak Hour	1,188.03 2,343.93 2,913.52
High Service (430') Reduced Gradient	Average Day Maximum Day Peak Hour	230.12 456.05 560.92
Warwick Wholesale Interconnection (231') Gradient	Average Day Maximum Day Peak Hour	4.27 8.50 10.43
Oaklawn (231') Gradient	Average Day Maximum Day Peak Hour	161.92 322.30 395.74

5.0 Model Calibration

5.1 General

The completed updated hydraulic model described herein accurately represents the physical infrastructure of the water system facilities allowing the ability to perform simulations that realistically simulate the existing operation practices of the KCWA water supply and distribution system. Achieving accuracy of the model was accomplished by reviewing all readily available system operation data (i.e. flow records, consumption data, drawings of infrastructure, mapping, etc.) and applying the data to each scenario in the model to represent actual operating conditions. This 2014 model update was enhanced by the fact that the majority of the KCWA facilities are now on the system wide SCADA system which allows for 24/7 monitoring and data gathering that provided data for use in model calibration and verification. The system operation data was supplemented by data provided by KCWA operations personnel which was applied to an average day, maximum day and peak hour scenario in the updated model.

Calibration of the updated model was achieved by comparing results of various scenarios in the model with the performance of the physical system. Actual recorded system conditions (i.e. flow records, tank charts, pressure readings, etc.) were compared to calculated values in the model during a time when the system most closely experienced a particular demand scenario. When it is concluded that the actual physical conditions in the model as evidenced through historic and current records are within an acceptable tolerance to the model output results, then the model is considered calibrated. In accordance with the American Water Works Association (AWWA) Manual M32 *Distribution Network Analysis for Water Utilities*, a model is acceptably calibrated if "...it predicts performance within 5 to 10 percent of observed performance". For purposes of completing the model update and calibrating the updated model for the KCWA water system, it is expected that the updated model is able to predict observed performance in the system to 5 percent or better, therefore achieving a relative accuracy of upwards of 95 percent.

An inherent problem when calibrating a computerized hydraulic model is with the vast number of system infrastructure changes that occur routinely through ongoing Capital Improvement and Infrastructure Replacement Projects. For example, when reviewing historical system data and comparing it with computed model results, it is critical to consider that various system improvements have occurred since the recording of the data. This may impact the model simulation results in that the system improvements have been included in the model but the historical data was collected when these system improvements were not yet in place. The most critical projects are pipeline improvement projects that involve large water transmission mains. These improvements can dramatically alter the flow patterns throughout the water system. Nevertheless, an attempt was made to correlate the historical data with the actual model results in order to achieve a relative accuracy of the model that is consistent with standard hydraulic modeling practices.

For the purposes of calibration, it is ideal to collect system operational data during the periods that the maximum day and peak hour demands occur. The water system experiences the greatest head losses when the maximum demand conditions occur and are most measurable by the model. The hydraulic model calculates head losses at specific demand conditions and field measurements of system operational conditions are more accurate when there are more head losses during periods when flows are the highest. In order to establish data in the base scenario of the model, physical data was collected when demands were low to ensure that interference with system operations was minimized.

As part of the model verification and calibration process, C&E conducted a series of hydrant tests with the assistance of KCWA personnel from October 29 through November 5, 2014 in Scituate, Cranston, West Warwick and Coventry. The results of the hydrant flow tests are included in Appendix D. The hydrant tests were correlated by street location and were completed on various fire hydrants throughout the water system. In order to compare the model results with the hydrant test results and to obtain a level of verification, a comparison of the recorded static pressure obtained from the field test results and the static pressures calculated by the model under an average day simulation was made. Due to the fact that records of the tank levels, pumps operating, etc. at the time of the hydrant tests were not available, it was considered impractical to correlate the actual flow test data to the calculated model results. For example, if a pump station was off or on there would be a dramatic impact on the amount of flow and the pressure drop (residual) at the flow location.

Following is a table that illustrates a comparison of data from the flow tests of a selection of fourteen (14) hydrants and the calculated model results for an average day simulation. For the purposes of comparison, the nearest junction node in the model to the test hydrant was utilized. Generally, the percentage of accuracy was in the range of 91.7 percent to 100.0 percent with an average relative accuracy of 97.3 percent.

SUMMARY OF HYDRANT FLOW TESTS

STREET	CITY / TOWN	STATIC PRESSURE* (PSI)	CALCULATED MODEL PRESSURE (PSI)	JUNCTION NODE**	% ACCURACY
Cranberry Dr.	SCIT	98	99.7	J-6026	98.3
Seven Mile Rd.	SCIT	70	72.0	J-5176	97.2
Main St.	CRA	53	51.1	J-6033	96.4
Harris Ave.	WW	68	72.1	J-646	94.3
Homestead Dr.	COV	44	41.8	J-8101	95.0
Bank St.	COV	42	42.0	J-7439	100.0
Gail Ct.	COV	103	103.7	J-7201	99.3
Ironwood Dr.	COV	74	74.3	J-7247	99.7
Eleanor Dr.	COV	62	61.8	J-7946	99.7
Donna's Way	COV	88	87.2	J-8060	99.9
Daniel Dr.	COV	92	92.1	J-7168	99.9
Burlingame Rd.	WW	38	35.1	J-734	92.4
West View Dr.	COV	52	56.7	J-7051	91.7
Larch Dr.	COV	46	45.4	J-7576	98.7
				Average	97.3

*Hydrant flow tests were conducted by C&E and KCWA personnel from October 29 through November 5, 2014.

**The location of the hydrant was correlated to the nearest junction node in the model.

Further verification relative to the accuracy of the model was achieved through a review of the historical pump flow, pump head and tank chart data which was supplied by KCWA personnel. The comparison of the model outputs from the major pumping stations, such as the Clinton Avenue Pump Station, were found to be near accurate to the historical data when comparing station output and total system head with various combinations of pumps running. The accuracy of the updated model was further affirmed through comparison of the model output results and the booster pump station historical data as well as the historical data for the rates of filling and draining of the tanks.