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Kent County Water Authority
Distribution Storage Tank Hydraulic Evaluation

Technical Memorandum No. 4A
Existing Storage Facility Analysis
April 2007 (Revised June & July 2007)

1.0 Purpose and Scope

This project relates to utilizing the updated computerized hydraulic model of the Kent County Water Authority (Authority) water system to complete a detailed hydraulic study and evaluation of the entire supply and distribution system in regards to distribution storage for the next twenty (20) year planning period. This evaluation is intended to consider system demand for both the existing and the projected planning period and an evaluation of the ability of the water system infrastructure distribution storage components to effectively meet these demands.

The project has been divided into various sub tasks and each of which will be further detailed in a specific technical memorandum. The purpose of this technical memorandum is to evaluate the existing water storage facilities within the distribution system including their ability to meet system demands, provide adequate system pressure, provide fire flow reserve, etc. The criteria previously presented in Technical Memorandum No. 2A along with the consumer demands (current and future) developed in Technical Memorandum 1 and 3 will be utilized to evaluate the facilities. The following are the specific efforts associated with this task.

1. The water system shall be evaluated using the existing hydraulic model to determine its capability to deliver water under average and peak demand (maximum day) conditions as well as fire flow conditions. The following model scenarios will be evaluated.

    - Average Day Demand
    - Peak Hour Demands (during Maximum Day)
    - Maximum Day Demand Plus Fire Flow

    Storage and supply capacities will also be reviewed to ensure that they meet operational and regulatory requirements. Other critical factors will be identification of potential surplus water supply capacity and potential for future growth.

2. Perform hydraulic model simulations for both steady state and extended period for the water system with critical attention for each of the varied pressure zones in the system. Based on the aforementioned model scenarios, specific water system improvements for the immediate planning horizon shall be identified. Any recommended improvements will also be included in various modeling scenarios to demonstrate their effectiveness in meeting deficiencies and to assist in sizing of components.

3. An operational assessment of the eight (8) existing storage tanks in order to determine their effectiveness in meeting the various system demands shall be conducted. Such determination would

include specific analysis of each tank including fill and draw rates, system influences on tank operation including pump station set points and operation, etc.

a. An assessment will be provided for potential solutions and alternatives for cycling those tanks, which are problematic. This may include retrofitting tanks with mixing systems, operation modifications such as off-hour pumping systems, control valve sequencing or reconfiguration of underground infrastructure. This would all be performed in consideration of the critical nature of these tanks in providing fire protection in the general area of the tanks.

b. A discussion will be provided on the overall effect on system operation for the removal of "locked up" or low turn over tanks and what affect they may have on fire flow capacity in the surrounding areas.

c. For each existing storage tank, a determination shall be performed for the volumes of fire flow storage, emergency storage, equalization storage, as well as active and dead storage by service zone. These volumes shall be compared to the standards that were previously developed as part of this study and appropriate recommendations shall be made.

4. Available fire flow rates shall be determined on a system wide basis. See Technical Memorandum No. 4B. The available fire flow rates shall be categorized by range and are color-coded on a system map for graphic presentation.

2.0 Current (2006) Water Demands

Analysis of the various storage components was performed for each of the pressure zones that incorporate the water system. For purpose of this analysis, it was required to analyze the various pressure zones collectively when they are directly interconnected (i.e. by pressure reducing valve) or when the sources are dedicated to providing supply to a particular number of pressure zones (Hope Road Gradient). For example, when analyzing the Low Service Pressure Gradient (334'), it was necessary to include those consumer demands that comprised the Low Pressure Reduced Gradient and the Hope Road Gradient. The analysis comprised the three gradients identified as follows: Low Service Pressure Gradient (334'), Read School House Gradient (500') and the High Service Pressure Gradient. The following is a summary of existing (2006) demands for each of these gradients.

LOW SERVICE GRADIENT (334') CONSUMER DEMANDS

PRESSURE ZONE	AVERAGE DAY DEMAND (MGD)	MAXIMUM DAY DEMAND (MGD)	PEAK HOUR DEMAND (MGD)
Low Service (334') Gradient	5.393	10.237	11.844
Low Service Reduced (334') Gradient	1.871	3.727	4.320
Hope Road (510') Gradient	0.006	0.013	0.014
TOTALS	**7.27 MGD**	**13.98 MGD**	**16.18 MGD**

READ SCHOOL HOUSE GRADIENT (500') CONSUMER DEMANDS

PRESSURE ZONE	AVERAGE DAY DEMAND (MGD)	MAXIMUM DAY DEMAND (MGD)	PEAK HOUR DEMAND (MGD)
Read School House Road (500') Gradient	0.397	0.811	0.924
TOTALS	**0.40 MGD**	**0.81 MGD**	**0.92 MGD**

Note: For purposes of this analysis, it is assumed that the new Read School House Road Tank would be in service by 2008, which will increase the hydraulic grade line in this portion of the system from 430 feet to 500 feet.

HIGH SERVICE GRADIENT (500') CONSUMER DEMANDS

PRESSURE ZONE	AVERAGE DAY DEMAND (MGD)	MAXIMUM DAY DEMAND (MGD)	PEAK HOUR DEMAND (MGD)
High Service (500') Gradient	2.323	4.379	5.828
High Service (500') Reduced Gradient	0.528	1.035	1.274
Tiogue Tank (350') Gradient	0.086	0.176	0.200
TOTALS	**2.94 MGD**	**5.59 MGD**	**7.30 MGD**

For purposes of this analysis of this evaluation, the Oaklawn Pressure Gradient (232') was not included in the tank capacity analysis as this Gradient is supplied directly through a wholesale interconnection with Providence Water. This service area contains no storage facilities nor does any portion of the Authority's distribution system serve it. This service zone is currently isolated from the Authority's Low Service Gradient by a closed valve. Consideration should be given to providing a backup or emergency connection from the Authority system to service this area. This would include the addition of a PRV station in order to reduce the hydraulic grade from 334 to 232 feet.

The following water system changes / modifications to both the water system infrastructure or operations and all of which are either in the construction or design phase were incorporated into this analysis. This also included updating the computerized hydraulic model to incorporate these changes / modifications.

- The existing Tiogue Tank Pressure (350') Gradient will become a permanent part of the High Service Pressure (500') Gradient. A PRV station is installed on the new supply line to supply the Tiogue Tank Service area. The existing Tiogue Tank and booster pump station are removed from service.

- The Bald Hill Booster Pump Station is upgraded in capacity to 10.0 MGD. This includes installation of significant water main infrastructure such that the pump station will have the ability to pump directly to the High Service Pressure Gradient. The breakdown of the pumping capacity is as follows: 2.0 MGD to High Service Pressure Gradient and 8.0 MGD to Low Service Pressure Gradient.

- The new Read School House Road Tank is in service and the pressure zone increased from a hydraulic grade of 430 feet to 500 feet. This includes activation of the 3.0 MGD High Service Pumps at Clinton Avenue Pump Station that are designed to supply this pressure zone.

- The existing Knotty Oak Pump Station that currently supplies the Read School House Pressure Gradient (430 feet) is removed from service (replaced by pumps at Clinton Avenue Pump Station).

- East Greenwich and Spring Lake Wells are rehabilitated (i.e. cleaned) to restore original supply capacity.

- Installation of a new interconnection to Providence Water in vicinity to Wakefield Street with the ability to pump up to 6 MGD into the Low Service Pressure Gradient and 2 MGD into the High Service Pressure Gradient. The Authority and Providence Water have entered into an agreement to supply an average day capacity of 5.0 MGD. *This emergency interconnection was not active during any of the simulations performed for this evaluation.*

- Installation of new water main infrastructure along Harding Street, Main Street, Pleasant Street, etc. in West Warwick which will serve in combination with the emergency interconnection to increase flow capacity in this area.

3.0 Existing Water Storage Facility Assessment

3.1 General

The existing water supply and distribution system for the Authority as previously indicated has been divided into three distinct pressure gradients for purposes of analysis, which include the Low Service, Read School House Road, and High Service Pressure Gradients. The criteria for evaluation was provided and discussed in Technical Memorandum 2A and is summarized below.

The Authority's water system currently functions in varied modes of operation for the each of the pressure gradients. The mode of operation in a particular pressure zone and the location of the tank in the pressure zone have a direct influence as to how each of the water storage tanks operates. The types of operating modes can generally be classified as follows.

Continuous Pumping

The Low Service Gradient operates principally on a mode of continuous pumping whereby at any given time of the day or year there is at minimum one pump operating at the Clinton Avenue Pump Station. This is required to meet consumer demands (this facility supplies approximately 70% of the entire system demand), replenish storage tank(s) in the distribution system and most importantly to maintain adequate pressures to service customers at higher elevations. Although the Low Service Pressure Gradient operates at a maximum overflow elevation of 334 feet (the overflow elevation of the water storage tanks), the Clinton Avenue Pump Station will supply a pump head in vicinity to the station that varies from 350 – 380 feet depending upon system demand conditions.

This pump head is required to ensure that distant tanks (i.e. Setian Lane and Frenchtown Road) within the distribution system are supplied with adequate water volumes for refill. Also, areas of high elevations (i.e. customer service elevations in range of 275 feet) rely on this pump head to maintain adequate pressure. In the event the Clinton Avenue Pump Station is turned off, the system pressures in proximity to the station will immediately be reduced to the Low Service system hydraulic grade, which is 334 feet or lower depending upon the water level in the storage tanks. This can result in an immediate drop of pressure to customers in proximity to the Clinton Avenue Pump Station of anywhere between 10 and 20 psi. This has an immediate and noticeable impact on service customers that maintain a pressure of 20 – 30 psi when the Clinton Avenue

Pump Station is in operation and in the most severe demand conditions can result in service customers with resulting pressures in the range of 0 – 10 psi.

The Authority is cognizant of these locations and is exploring alternatives to resolve these pressure problems at higher elevations. The most obvious solution, if deemed feasible, is to re-service these areas from pressure gradients with higher hydraulic grade lines. Another inherent problem with continuous pumping is the effect on distribution system storage tanks. While tanks located away from the supply source are drained by customer demands and subsequently refilled from the supply source, those tanks located in proximity to the supply source are adversely impacted. Due to the fact that the supply sources imparts a hydraulic grade that is above the overflow elevation of tanks in close proximity, these tanks have a tendency to not drain when the supply source is in operation. This results in tanks that are essentially "locked up" with no ability to cycle on a routine basis. The West Street Tank and Fiskeville Reservoirs have historically been subject to this "locked up" condition.

The location of these identified "low pressure" areas is as follows. These include areas that have marginal pressure (20 psi and less) and areas that have pressures below the 35 psi regulatory standard of the Authority Regulations when the Clinton Avenue Pump Station is in operation. It should be noted that all the identified locations may not directly impact service customers as these locations could occur at high points along transmission mains with no services, areas around storage reservoirs and suction side of booster pump stations. These locations are depicted on a system map in Enclosure No. 1.

LOCATIONS IN SYSTEM WITH PRESSURES BELOW 20 PSI

SERVICE PRESSURE ZONE	STREET	LOCATION/APPROXIMATE INTERSECTION	ELEVATION RANGE (FEET)	CALCULATED PRESSURE	CUSTOMER SERVICE (Y/N)
Low	Cowesett Road	Fairgreen Drive to Kulas Road	206 - 280	19 psi – 20 psi	Y
Low	East Greenwich Avenue*	Juniper Drive to Setian Lane	259 - 295	15 psi – 32 psi	N
Low	South County Trail*	EG Medical Center to Pine Glen Drive	249 - 303	11 psi – 34 psi	Y
Low	Signal Ridge Way	Boulder Way to Division Street	270 - 290	17 psi – 27 psi	Y
Low	Arnold Road*	Larch Drive to Acorn Street	228 - 280	18 psi – 34 psi	Y
Low	Lane A	Morningside Drive to Lane E	250 - 294	16 psi – 29 psi	Y
Low	Tiogue Avenue*	Jennifer Lane to Holloway Avenue	264 - 301	12 psi – 28 psi	Y
Low	Knotty Oak Road	Maple Street to Long Pond Road	273 - 302	14 psi – 34 psi	N
Low	Knotty Oak Road	White Rock Drive to Highwood Drive	279 - 315	9 psi – 24 psi	N
Low	Knotty Oak Road	Gervais Street to Oak Way	300	12 psi – 16 psi	N

LOCATIONS IN SYSTEM WITH PRESSURES BELOW 35 PSI

SERVICE PRESSURE ZONE	STREET	LOCATION/APPROXIMATE INTERSECTION	ELEVATION RANGE (FEET)	CALCULATED PRESSURE	CUSTOMER SERVICE (Y/N)
Low	New London Avenue	Factory Street to Iron Drive	231 - 261	28 psi – 34 psi	Y
Low	Macarthur Boulevard	Yates Avenue to Knight Street	245 - 273	25 psi – 31 psi	Y
Low	Beauchene Street	East Street to West Street	170 - 270	25 psi	Y
Low	Laurel Avenue	Pilgrim Avenue to Princeton Avenue	228 - 267	28 psi – 34 psi	Y
Low	Cowesett Road	Church Street to Narragansett Avenue	235 - 260	29 psi – 34 psi	Y
Low	Major Potter Road*	Quaker Lane to Eagle Run	265	29 psi	N
Reduced Low	Windermere Way	Love Lane to Lantern Lane	180 - 205	30 psi – 34 psi	Y
Reduced Low	Love Lane*	Overhill Road to Cedar Street	204 - 205	27 psi – 29 psi	Y
Low	Division Street	Brooks Pharmacy Headquarters to Old Quaker Lane	243 - 275	25 psi	Y
Low	Mayflower Drive	Crest Ridge Drive to Bunker Hill Lane	170 - 201	29 psi – 34 psi	Y
Low	Frenchtown Road*	Cardinal Lane to High Hawk Road	266 - 276	24 psi – 29 psi	N
Low	Lynn Circle	Darl Court to Fernwood Drive	230 - 280	22 psi – 34 psi	Y
High	Carr Pond Road*	Carr Pond Tank to Deer Run Drive	410 - 430	28 psi – 30 psi	Y
Low	Greenbush Road	New London Turnpike to Bratt Lane	255 - 280	22 psi – 33 psi	N
Low	Nooseneck Hill Road	Reservoir Road to Comfort Way	256 - 282	23 psi – 34 psi	Y
Low	Main Street (COV)	Battey Avenue to Sandy Bottom Road	234 - 255	34 psi	Y
Low	Hope Furnace Road	Howard Avenue to Colvintown Road	249 - 270	31 psi	Y
Low	Blackrock Road*	Gervais Street to Country View Drive	250 - 270	29 psi	N
Low	North Road	White Lane to Blossom Lane	240 - 271	31 psi – 32 psi	Y
Low	Cranberry Drive	Mitchell Way to Kerri Court	240 - 276	29 psi	Y
Low	Fairview Avenue	Spencer Street to Marshall Circle	235 - 272	24 psi – 34 psi	Y

Low	Phenix Avenue	Harding Street to Garnet Street	245 - 273	26 psi – 33 psi	Y
Low	River Run	Rosewood Court to Quail Court	249 - 260	31 psi – 32 psi	Y
Reduced High	Nooseneck Hill Road	Brant Trail to End of KCWA System	300 - 354	34 psi	Y
Low	Hornbeam Road	Mountain Laurel Drive to Hawthorne Road	250 - 260	34 psi	Y
Low	Hornbeam Road	Mountain Laurel Drive to Hawthorne Road	232 - 265	31 psi	Y

* Denotes area of low pressure that consists of a transmission main, area near storage reservoir, suction side of booster pump station.

Call on Demand
The Read School House Road and High Service Pressure Gradients operate predominately in a call on demand mode whereby supply sources (booster pumps) are turned on and off in response to water levels in the storage tanks. During periods when the supply sources are off, the water level in the storage tank(s) provides adequate pressure and supply to all areas of the service gradient. Upon a predetermined lowering of the water level in the tank(s), a signal is relayed to turn on the necessary number of supply sources (booster pumps). Generally, the greater the rate of depletion in a tank will result in additional pumps or supply sources coming on line to keep pace with demand as well as to refill the storage tank. This mode of operation is advantageous in that it permits tanks to routinely cycle and maintain adequate system pressures when the supply sources are off line.

The Read School House Road and High Service Pressure Gradients can operate in this mode due to the fact that the customer service elevations can be supplied by the water level in the tanks and do not rely on the pump head of the supply sources to increase the system head to maintain adequate pressure.

3.2 Storage Tank(s) Component Assessment

This section provides evaluation with regard to the various components of the total storage volume that comprises each of the distribution storage tanks. It was necessary during this evaluation to consider the existing tank overflow elevations in a particular service gradient in order to determine the water elevation in the tank which equates to providing a minimum pressure of 35 psi for domestic and 20 psi for fire flow at a particular ground service elevation. This is necessary as the various volumes of components of storage in the tank relate to providing a minimum pressure in the service gradient.

This process is relatively straightforward within the pressure gradients that operate on a "call on demand" mode of operation which include the Read School House Road and High Service Pressure Gradients. These gradients can maintain adequate pressure throughout the service area when the supply sources are off and the water level in the storage tanks are required to maintain the system hydraulic grade. The Low Service Gradient which predominately operates on a "continuous pumping" basis differs in that the Clinton Avenue Pump Station must be operated on a continuous basis to ensure adequate pressure at higher service elevations in vicinity to the station.

For purposes of this evaluation, it is assumed that a long-term goal of the Authority is to eliminate through re-servicing, etc. those areas at higher elevations such that the Clinton Avenue Pump Station would not require continuous operation simply for maintaining adequate pressure. It is likely however that given the critical nature of this facility for supplying water system supply that this station will be relied upon to provide a majority of the water supply to the system.

Multiple tanks in the same pressure zone should be placed roughly at equal distances from a source or sources of supply. If one tank is very close to the source while other tanks are at a greater distance, it may be difficult to effectively fill the remote tanks without "shutting off" or "locking up" the nearer tank(s). This is most common in water systems that have evolved and expanded over the years. As the water system expands, newer tanks are located at further points from the supply source and existing tanks are located between the supply source and new tanks. A tank that was on the "fringe of the system" years ago is now close to the supply source relative to the new remote tanks within the growing service area.

This is indicative of what has occurred in the Authority's Low Service Gradient, the oldest portion of the distribution system, as it has slowly expanded to the south, east and west away from the primary supply source, the Clinton Avenue Pump Station, in the north. In most cases, the use of control valves or booster pump stations can enable multiple tank systems with problematic tanks to be used effectively. Alternatively, to simplify system operations, it may be desirable in a particular instance to abandon a tank in an undesirable location when it needs maintenance and, if required, replace it at a more suitable location within the distribution system. Each water system must consider and evaluate each storage facility on an individual basis as there are no set criteria on which to base this decision as it usually considers many factors (i.e. age and size of tank, required maintenance and cost, need for additional storage at other locations, ability to cycle tank, complexity of operations, etc.).

3.2.1 Storage Tank(s) Assessment Criteria

The various components of storage were previously detailed in Technical Memorandum 2A and are briefly summarized below.

The water levels in a storage tank above which a minimum distribution system pressure of 35 psi can be maintained are comprised of two distinct components. These include the *operational* and *equalization storage*. *Operational storage* is defined by the upper portion of the tank volume below the overflow and above the water level where the supply / booster pumps are set to turn on. This is the volume in the tanks that is set to routinely cycle on a daily basis.

Directly below the *operational storage* is the *equalization storage*, which is that volume of tank storage that meets the water system demands that are in excess of the pumping or supply capacity of the water system. This storage component is located below the *operational storage* and above the *emergency and fire storage*. The bottom of the *operational storage* volume is also defined by the water level in the tank at which 35 psi would be available at the highest service elevation. It is imperative that water levels in the tank do not drop below the *equalization storage* as this could result in pressures below 35 psi within areas of the distribution system and the volume of *emergency and fire storage* would be eroded. Typically, additional supply / booster pumps are called on to run when the water level in the tank reaches the top of the *equalization storage*. The water volume dedicated to *equalization storage* is utilized during peak demand periods of the day.

Storage located below the *equalization storage* zone is referred to as *emergency and fire storage* and provides at minimum a pressure of 20 psi at the highest service elevation within the distribution system. The water volume that is dedicated to *emergency and fire storage* should always be available in the tank and is only utilized during emergency purposes as would occur during a fire.

Any water in the tank below the *emergency and fire storage* zone is considered ineffective or *dead storage*. Water in this zone cannot effectively supply the entire distribution system with a minimum pressure of 20 psi.

The *effective storage* in a storage tank is that water volume below the *operational storage* zone and above the *dead storage* zone. Theoretically, this volume of water is always available to the water system to meet peak hour, fire and emergency needs. Therefore, the total *nominal storage* volume of a tank does not provide a true indication of the available *effective storage* volume that would be readily available for use in the water system under all demand conditions.

Refer to Figure 1 for a graphical presentation of the various water storage components of a tank.

3.2.2 Service Gradient – Customer Service Elevations

As previously indicated it was necessary to determine customer service elevations within each of the pressure zones such that a minimum pressure of 35 psi can be maintained at the highest service elevation. This 35-psi requirement is also in concurrence with the Authority's Regulations, which require that all new service connections conform to this minimum pressure requirement. As previously indicated, all locations in the distribution system currently serviced by the Low Service Pressure Gradient do not meet this minimum pressure requirement. Additionally, in an attempt to maintain pressures, the Authority is required to maintain operation of the Clinton Avenue Pump Station at all times in order that the pump head provide additional pressure to service these areas with low pressures. The Authority has a long-term goal to eliminate these previously identified "low-pressure" areas.

As the Low Service Pressure Gradient is set to operate at a hydraulic grade line of 334 feet, which is the existing overflow elevation of the system storage tanks, the maximum service elevation in the system was premised on this overflow elevation. All customer services above the maximum elevation to achieve 35 psi should further be examined for alternative methods of supply or means to increase pressure.

Low Service Pressure Gradient
The Low Service Pressure Gradient is controlled by the overflow elevation in the six water storage tanks (i.e. Fiskeville 1 and 2, West Street, Wakefield Street, Setian Lane and Frenchtown Road storage tanks), which is at approximately 334 feet (survey conducted as part of this study has determined that the majority of these storage tanks are within one foot of this 334 foot overflow elevation). C&E conducted a review of the historical tank chart records for the Low Service Gradient that indicates that the Authority is capable of maintaining the water level in the tanks within the top ten feet of the overflow. This includes the period of peak hour system demand.

The water level set points for control of the operation of booster pumps and supply sources are maintained within a span of five feet within the control tanks (i.e. Frenchtown Road and Setian Lane tanks). Therefore, for purposes of defining the range and volumes of *operational storage* within the Low Service Gradient tanks, the top five feet in each of the storage tanks was utilized.

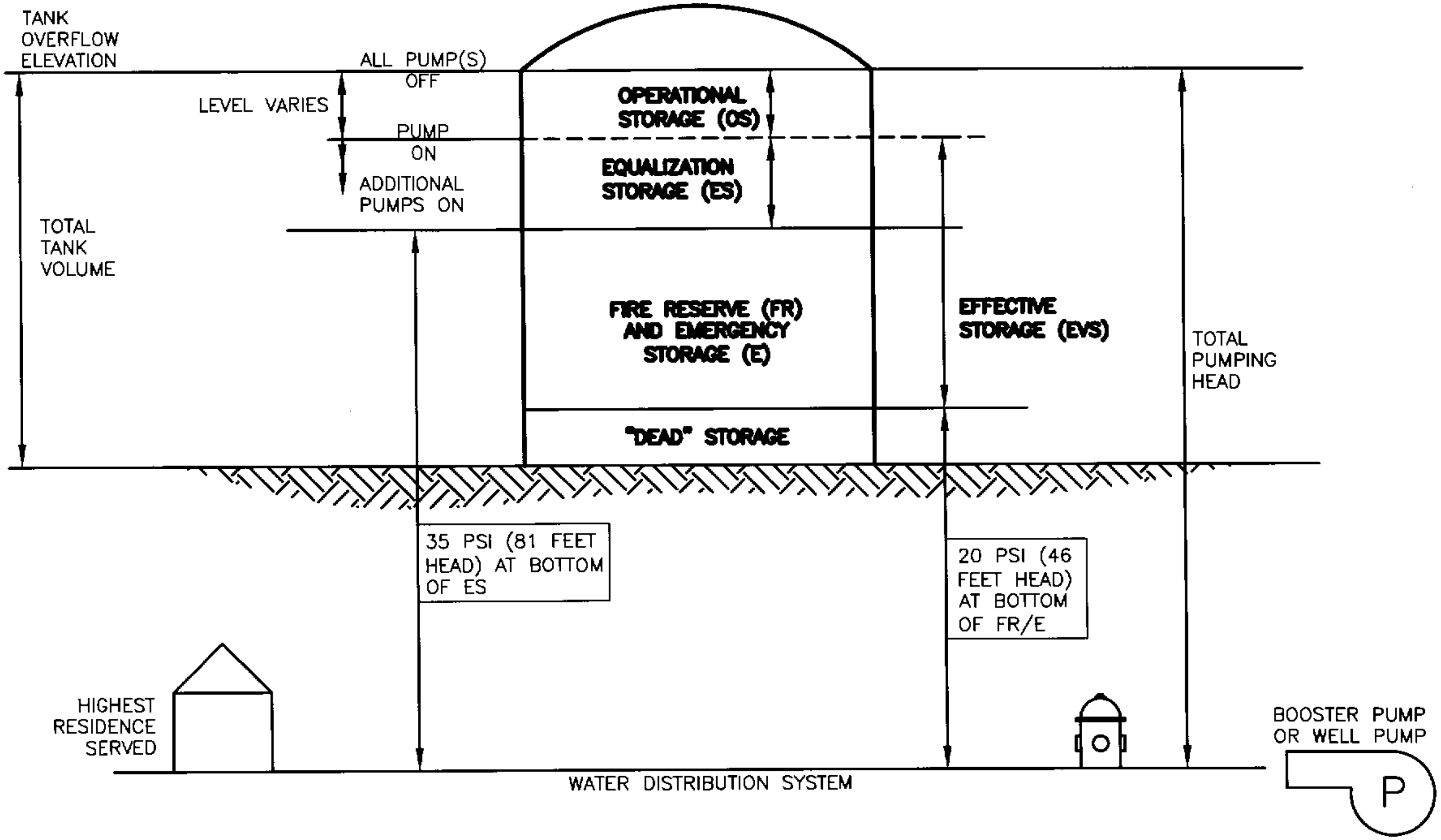
The range for *equalization storage* was defined to be the water volume below the *operational storage* (5 feet down in the tank) to a water level within the tank that the historic tank charts indicate that the system is capable of maintaining. As previously indicated, historic tank charts indicate that the Low Service Gradient tanks are maintained at minimum within the top ten feet from the overflow elevation.

Based on this ten-foot potential drawdown for *operational* and *equalization storage* a maximum ground elevation within the service territory that can be provided with a minimum pressure of 35 psi (i.e. bottom of *equalization storage*) was calculated as follows.

334 feet (overflow) – 10 feet (bottom of *operational* and *equalization storage*) = 324 feet (water level)

35 psi (minimum pressure) X 2.31 feet/psi = 80 feet (35 psi converted to feet of water)

FIGURE 1



TYPICAL WATER STORAGE FACILITY— WATER STORAGE COMPONENTS

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324 feet (tank level) – 80 feet (feet of water for 35 psi) = 244 feet (ground elevation)

This corresponds to a water elevation in the storage tanks of 324 feet at which a minimum pressure of 35 psi would be maintained at a ground elevation of 244 feet. Similarly, the water elevation that corresponds to servicing a ground elevation of 244 feet while maintaining a minimum pressure of 20 psi (i.e. bottom of *effective storage* and *fire/emergency reserve storage*) equates to a water level of 290 feet in the tanks. All water in any Low Service Gradient tank below a water elevation of 290 feet is therefore considered *dead storage,* as it cannot provide a minimum pressure of 20 psi at a ground elevation of 244 feet. Also, if a tank has a bottom elevation above 290 feet then there is no *dead storage* in the tank, as all the water in the tank can be considered available to supply a minimum pressure of 20 psi at a ground elevation of 244 feet.

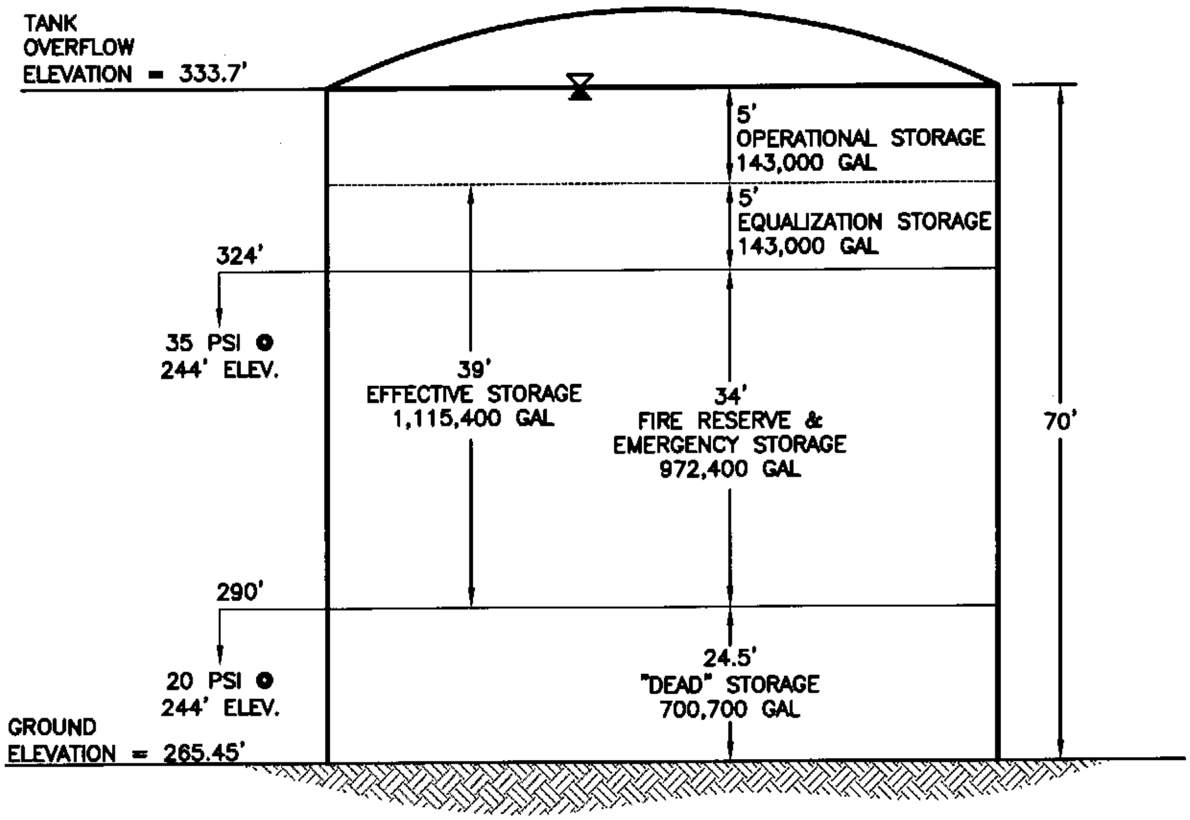
With these elevations established, each of the various components of storage volume was calculated for each of the storage tanks in the Low Service Pressure Gradient. The various elevations and volumes for the storage components for the Low Service storage tanks are depicted graphically on Figures 2 through 6 and the related storage volume components are listed in Table 1.

TABLE 1
LOW SERVICE GRADIENT (334') STORAGE VOLUMES

FACILITY	EFFECTIVE STORAGE (MG)	OPERATIONAL STORAGE (MG)	EQUALIZATION STORAGE (MG)	FIRE RESERVE & EMERGENCY STORAGE (MG)	"DEAD" STORAGE (MG)
Wakefield Street Tank	1.115	0.143	0.143	0.972	0.701
Frenchtown Road Tank	1.170	0.150	0.150	1.020	0.165
Setian Lane Tank	2.250	0.750	0.750	1.500	0
West Street Tank	0.760	0.080	0.080	0.680	0.180
Fiskeville Reservoirs	0.898	0.680	0.680	0.218	0
TOTALS	**6.193**	**1.803**	**1.803**	**4.390**	**1.046**

The total nominal storage capacity of all storage tanks in the Low Service Pressure Gradient is equal to 9,000,000 gallons.

LOW SERVICE GRADIENT (334')



TOTAL VOLUME = 2,000,000 GALLONS; 28,600 GAL/FT
HEIGHT = 70 FEET
DIAMETER = 70 FEET
MATERIAL = CONCRETE
CONSTRUCTED = 1990

WAKEFIELD STREET TANK
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FIGURE 2

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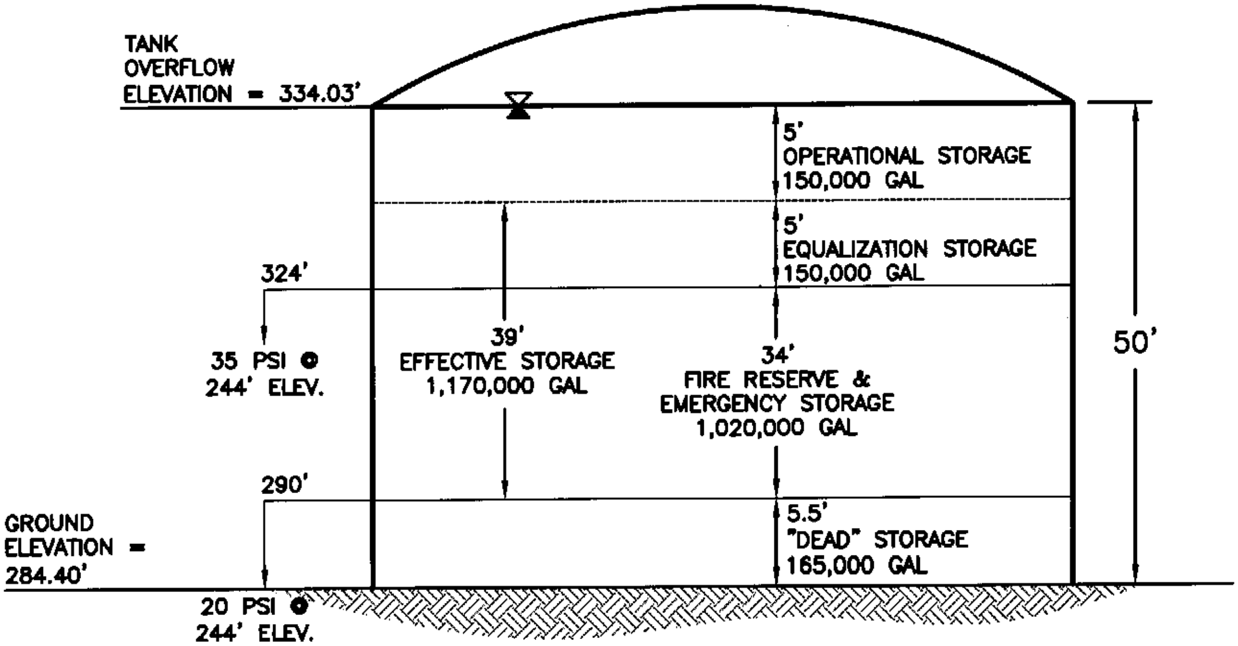
LOW SERVICE GRADIENT (334')



TOTAL VOLUME = 1,500,000 GALLONS; 30,000 GAL/FT
HEIGHT = 50 FEET
DIAMETER = 73 FEET
MATERIAL = CONCRETE
CONSTRUCTED = 1977

FRENCHTOWN ROAD TANK
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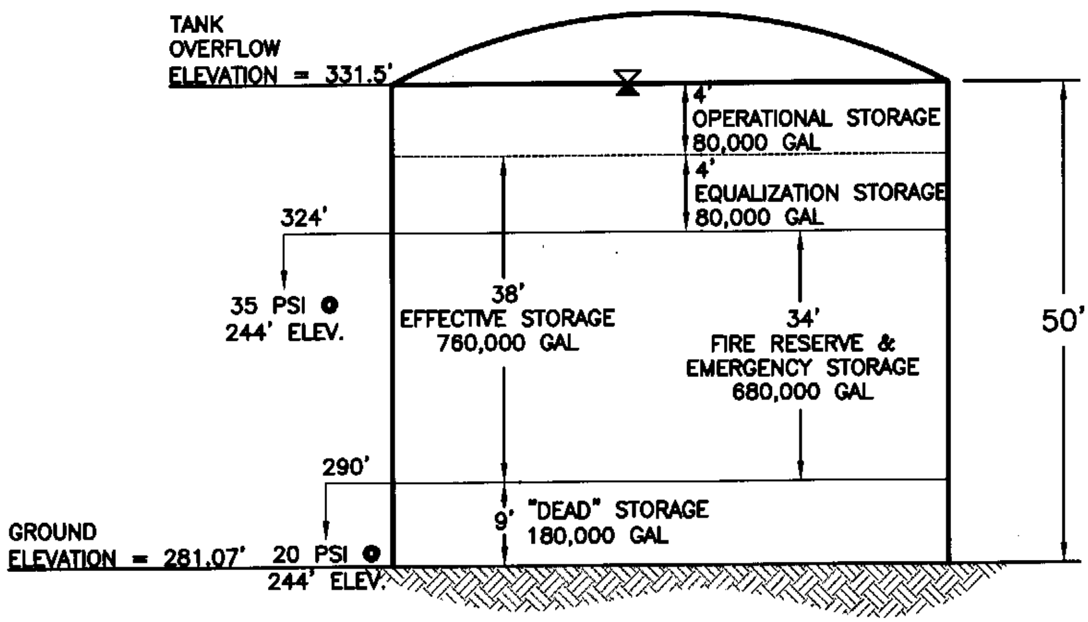
FIGURE 3

LOW SERVICE GRADIENT (334')



TOTAL VOLUME = 1,000,000 GALLONS; 20,000 GAL/FT
HEIGHT = 50 FEET
DIAMETER = 58 FEET
MATERIAL = STEEL
CONSTRUCTED = 1956

WEST STREET TANK

N.T.S.

FIGURE 4

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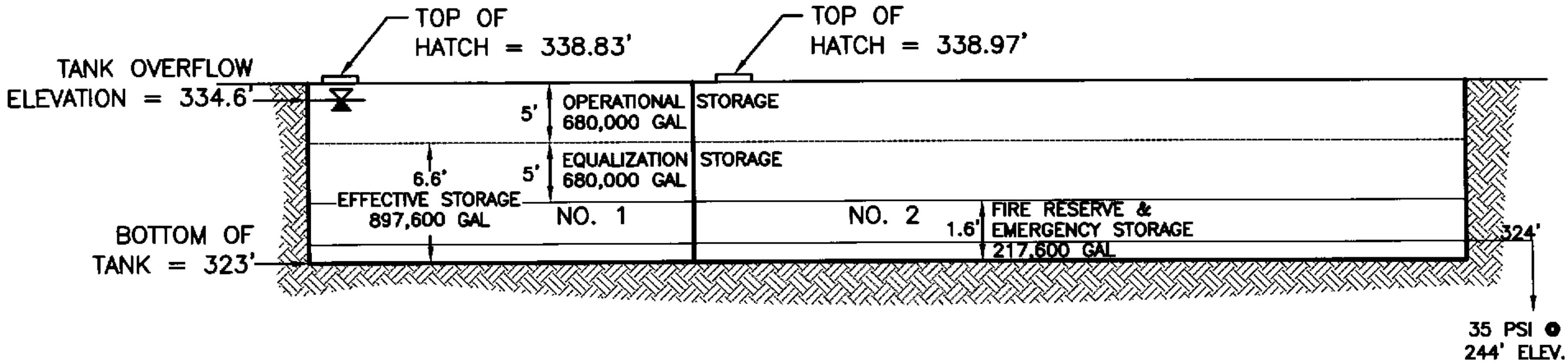
LOW SERVICE GRADIENT (334')



TOTAL VOLUME = 1,500,000 GALLONS (COMBINED); 136,000 GAL/FT
HEIGHT = 11 FEET
MATERIAL = REINFORCED CONCRETE
CONSTRUCTED = 1944 & 1960

FISKEVILLE UNDERGROUND RESERVOIRS (NO. 1&2)

N.T.S.

NOTE: NO "DEAD" STORAGE AS ABLE TO ACHIEVE 20 PSI @ HIGHEST SERVICE ELEVATION OF 244 FEET

FIGURE 5

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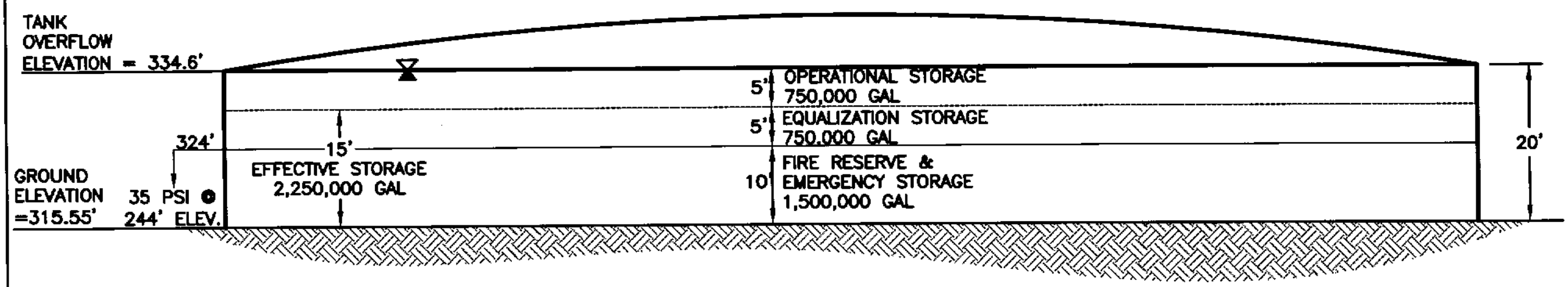
LOW SERVICE GRADIENT (334')



TOTAL VOLUME = 3,000,000 GALLONS; 150,000 GAL/FT
HEIGHT = 20 FEET
DIAMETER = 160 FEET
MATERIAL = STEEL
CONSTRUCTED = 1968

CROMPTON (SETIAN LANE) TANK
N.T.S.

NOTE: NO "DEAD" STORAGE AS ABLE TO ACHIEVE A MINIMUM 20 PSI @ HIGHEST SERVICE ELEVATION OF 244 FEET

FIGURE 6

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For the near term, it is considered necessary to maintain the current mode of operation for the Clinton Avenue Pump Station in order to provide adequate pressure above those customer service elevations that exceed 244 feet until such time that these elevations can be evaluated and potentially re-serviced by alternate means. This operational mode for the Clinton Avenue Pump Station also results in "locking up" the Fiskeville and West Street storage tanks (consideration will be given to utilizing the West Street tank through off peak pumping) as model simulations and historical observed field conditions confirm that the hydraulic grade at these tanks does not drop below 334 feet when Clinton Avenue Pump Station is in operation. It was not considered practical in this evaluation to perform model simulations without Clinton Avenue Pump Station in operation as this would result in extreme low pressures throughout the system (possible negative pressures under certain demand scenarios) and result in difficulty in performing and interpreting model results. The following Table 1-A was therefore developed to totalize storage volumes without the Fiskeville tanks.

TABLE 1-A
LOW SERVICE GRADIENT (334') STORAGE VOLUMES WITHOUT FISKEVILLE TANKS

FACILITY	EFFECTIVE STORAGE (MG)	OPERATIONAL STORAGE (MG)	EQUALIZATION STORAGE (MG)	FIRE RESERVE & EMERGENCY STORAGE (MG)	"DEAD" STORAGE (MG)
Wakefield Street Tank	1.115	0.143	0.143	0.972	0.701
Frenchtown Road Tank	1.170	0.150	0.150	1.020	0.165
Setian Lane Tank	2.250	0.750	0.750	1.500	0
West Street Tank	0.760	0.080	0.080	0.680	0.180
TOTALS	**5.295**	**1.123**	**1.123**	**4.172**	**1.046**

The total nominal storage capacity of all storage tanks in the Low Service Pressure Gradient without the Fiskeville tanks is equal to 7,500,000 gallons.

Read School House Road Pressure Gradient
The existing Read School House Road Pressure Gradient is controlled by the overflow elevation of the Read School House Road storage tank, which is at an elevation of 500 feet. C&E conducted a review of the historical tank chart record for this tank, which indicated that the Authority is capable of maintaining the water level within the top fifteen feet of the overflow. This includes the period of peak hour system demand. Note, this includes tank charts for the existing tank (overflow of 430 feet), which will be replaced within the next year with a tank of higher overflow elevation (500 feet). It is assumed that the consumer demands will not be affected and that the existing tank charts will be representative of operation of the new tank.

The water level set point for control of the operation of the booster pumps (Knotty Oak Road Station) is maintained within a span of five feet for the tank. Therefore, for purposes of defining the range and volumes of *operational storage* within this gradient, the top five feet in the storage tank was utilized.

The range for *equalization storage* was defined to be the water volume below the *operational storage* (5 feet down in the tank) to a water level within the tank that the historic tank charts indicate that the system is capable of maintaining. Historic tank charts indicate that the Read School House Road tank is maintained at minimum within the top fifteen feet from the overflow elevation.

Based on this fifteen-foot potential drawdown for *operational* and *equalization storage* a maximum ground elevation within the service territory that can be provided with a minimum pressure of 35 psi (i.e. bottom of *equalization storage*) was calculated as follows.

500 feet (overflow) – 15 feet (bottom of *operational* and *equalization storage*) = 485 feet (water level)

35 psi (minimum pressure) X 2.31 feet/psi = 80 feet (35 psi converted to feet of water)

485 feet (tank level) – 80 feet (feet of water for 35 psi) = 405 feet (ground elevation)

This corresponds to a water elevation in the storage tanks of 485 feet at which a minimum pressure of 35 psi would be maintained at a ground elevation of 405 feet. Similarly, the water elevation that corresponds to servicing a ground elevation of 405 feet while maintaining a minimum pressure of 20 psi (i.e. bottom of *effective storage* and *fire/emergency reserve storage*) would equate to a water level of 451 feet in the tank, which is below the bottom elevation of the tank. Therefore all the water in this tank is considered to be *effective storage* and there is no *dead storage*. At a ground elevation of 405 feet and a water elevation of 475 feet (bottom of tank), the resulting pressure would be 30 psi.

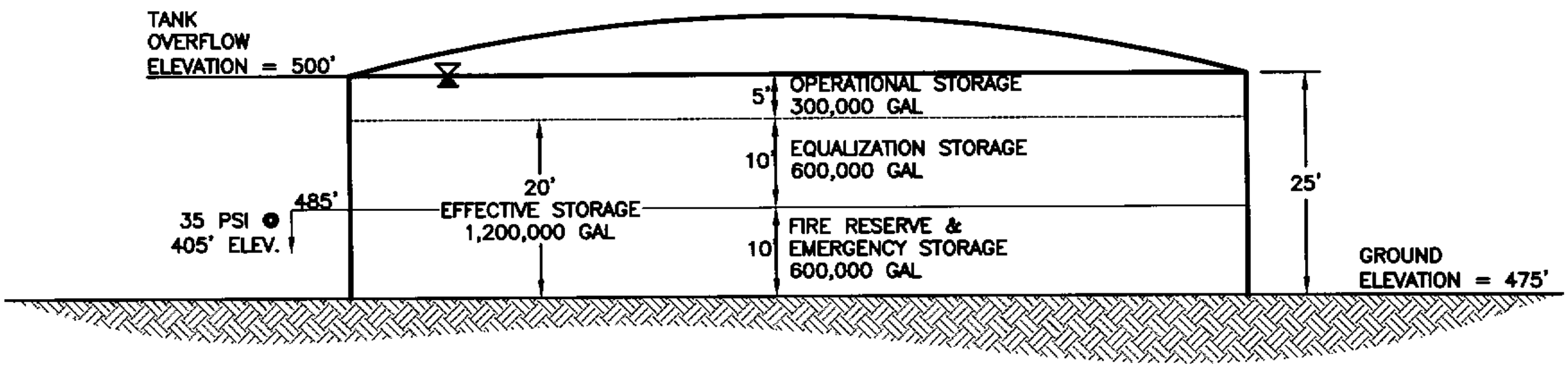
With these elevations established, each of the various components of storage volume was calculated for the Read School House Road Pressure Gradient. The various elevations and volumes for the storage components for the Read School House Road Storage Tank is depicted graphically on Figure 7 and the related storage volume components are listed in Table 2.

TABLE 2
READ SCHOOL HOUSE ROAD GRADIENT (500') STORAGE VOLUMES

FACILITY	EFFECTIVE STORAGE (MG)	OPERATIONAL STORAGE (MG)	EQUALIZATION STORAGE (MG)	FIRE RESERVE & EMERGENCY STORAGE (MG)	"DEAD" STORAGE (MG)
Read School House Road Tank	1.200	0.300	0.600	0.600	0
TOTALS	**1.200**	**0.300**	**0.600**	**0.600**	**0**

The total nominal storage capacity of all storage tanks in the Read School House Road Pressure Gradient is equal to 1,500,000 gallons.

READ SCHOOL HOUSE ROAD GRADIENT (500')



TOTAL VOLUME = 1,500,000 GALLONS; 60,000 GAL/FT
HEIGHT = 25 FEET
DIAMETER = 105 FEET
MATERIAL = CONCRETE
CONSTRUCTED = 2007/2008

READ SCHOOL HOUSE ROAD TANK

N.T.S.

NOTES:

1. TANK ANTICIPATED TO BE PLACED IN SERVICE IN 2008
2. NO "DEAD" STORAGE AS ABLE TO ACHIEVE A MINIMUM OF 20 PSI @ HIGHEST SERVICE ELEVATION OF 410 FEET

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FIGURE 7

High Service Pressure Gradient

The High Service Pressure Gradient is controlled by the overflow elevation in the Technology Park and Carr Pond water storage tanks, which are at an elevation of 500 feet. C&E conducted a review of the historical tank chart records for these two storage tanks, which indicates that the Authority is routinely capable of maintaining the water level in the tanks within the top fifteen feet of the overflow. This includes the period of peak hour system demand most notably during the summer months.

The water level set points for control of the operation of booster pump stations that supply this pressure zone are maintained within a span of five feet within each of the two tanks. Therefore, for purposes of defining the range and volumes of *operational storage* within the High Service Gradient tanks, the top five feet in each of the storage tanks was utilized.

The range for *equalization storage* was defined to be the water volume below the *operational storage* (5 feet down in the tank) to a water level within the tank that the historic tank charts indicate that the system is capable of maintaining. As previously indicated, historic tank charts indicate that the High Service Gradient tanks are maintained at minimum within the top fifteen feet from the overflow elevation.

Based on this fifteen-foot potential drawdown for *operational* and *equalization storage* a maximum ground elevation within the service territory that can be provided with a minimum pressure of 35 psi (i.e. bottom of *equalization storage*) was calculated as follows.

500 feet (overflow) – 15 feet (bottom of *operational* and *equalization storage*) = 485 feet (water level)

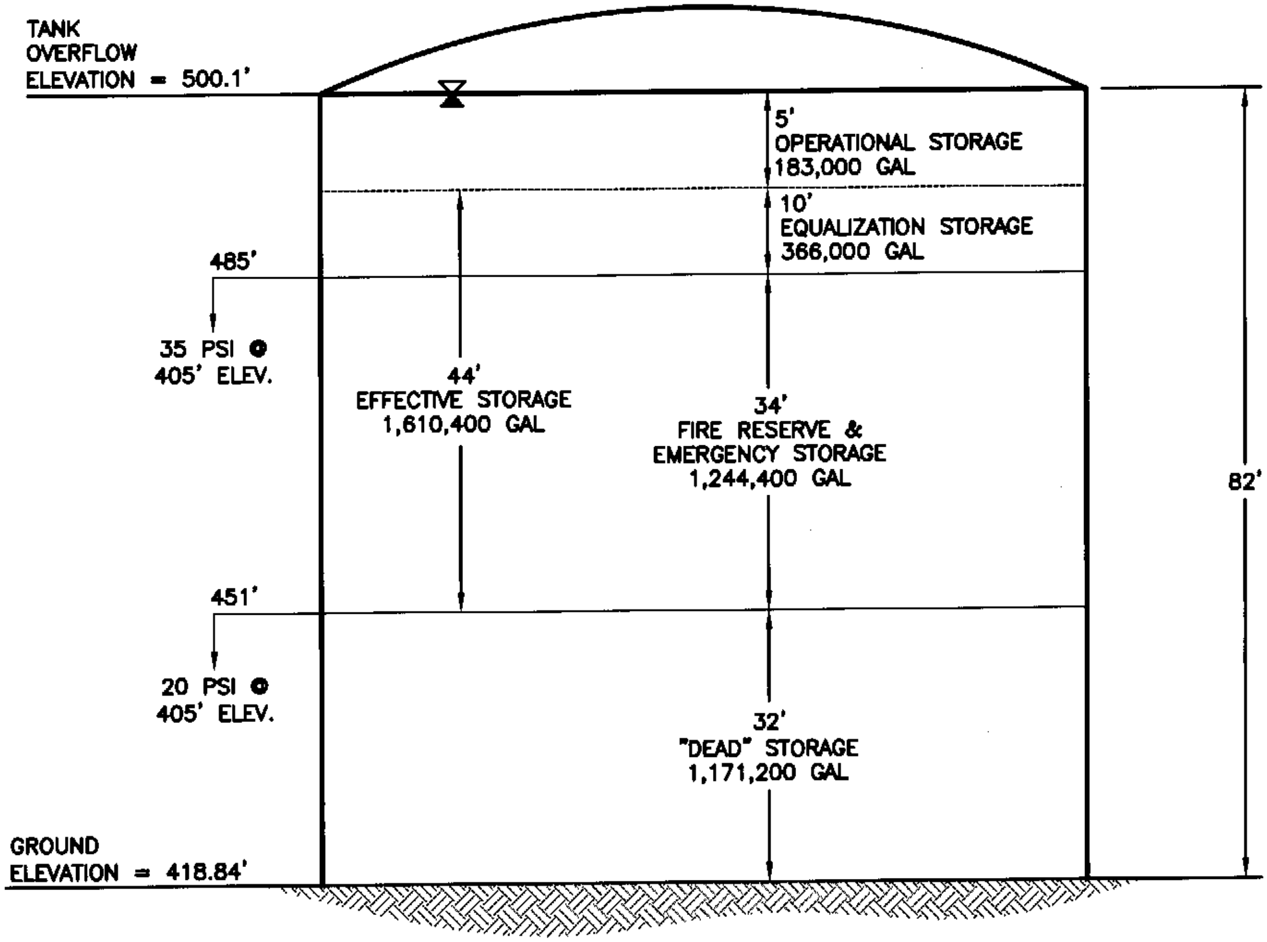
35 psi (minimum pressure) X 2.31 feet/psi = 80 feet (35 psi converted to feet of water)

485 feet (tank level) – 80 feet (feet of water for 35 psi) = 405 feet (ground elevation)

This corresponds to a water elevation in the storage tanks of 485 feet at which a minimum pressure of 35 psi would be maintained at a ground elevation of 405 feet. Similarly, the water elevation that corresponds to servicing a ground elevation of 405 feet while maintaining a minimum pressure of 20 psi (i.e. bottom of *effective storage* and *fire/emergency reserve storage*) equates to a water level of 451 feet in the tanks. All water in any High Service Gradient tank below a water elevation of 451 feet is therefore considered *dead storage,* as it cannot provide a minimum pressure of 20 psi at a ground elevation of 405 feet. The Technology Park Tank has a bottom bowl elevation of 455 feet, which is above the 451-foot elevation, and therefore all water in this tank is considered to be *effective storage* and as a result there is no *dead storage.* The Carr Pond Tank that has a bottom tank elevation of 419 feet has a volume of associated *dead storage.*

With these elevations established, each of the various components of storage volume was calculated for each of the storage tanks in the High Service Pressure Gradient. The various elevations and volumes for the storage components for the High Service storage tanks are depicted graphically on Figures 8 and 9 and the related storage volume components are listed in Table 3.

HIGH SERVICE GRADIENT (500')



TOTAL VOLUME = 3,000,000 GALLONS; 36,600 GAL/FT
HEIGHT = 82 FEET
DIAMETER = 80 FEET
MATERIAL = CONCRETE
CONSTRUCTED = SEPTEMBER 2001

CARR POND ROAD TANK
N.T.S.

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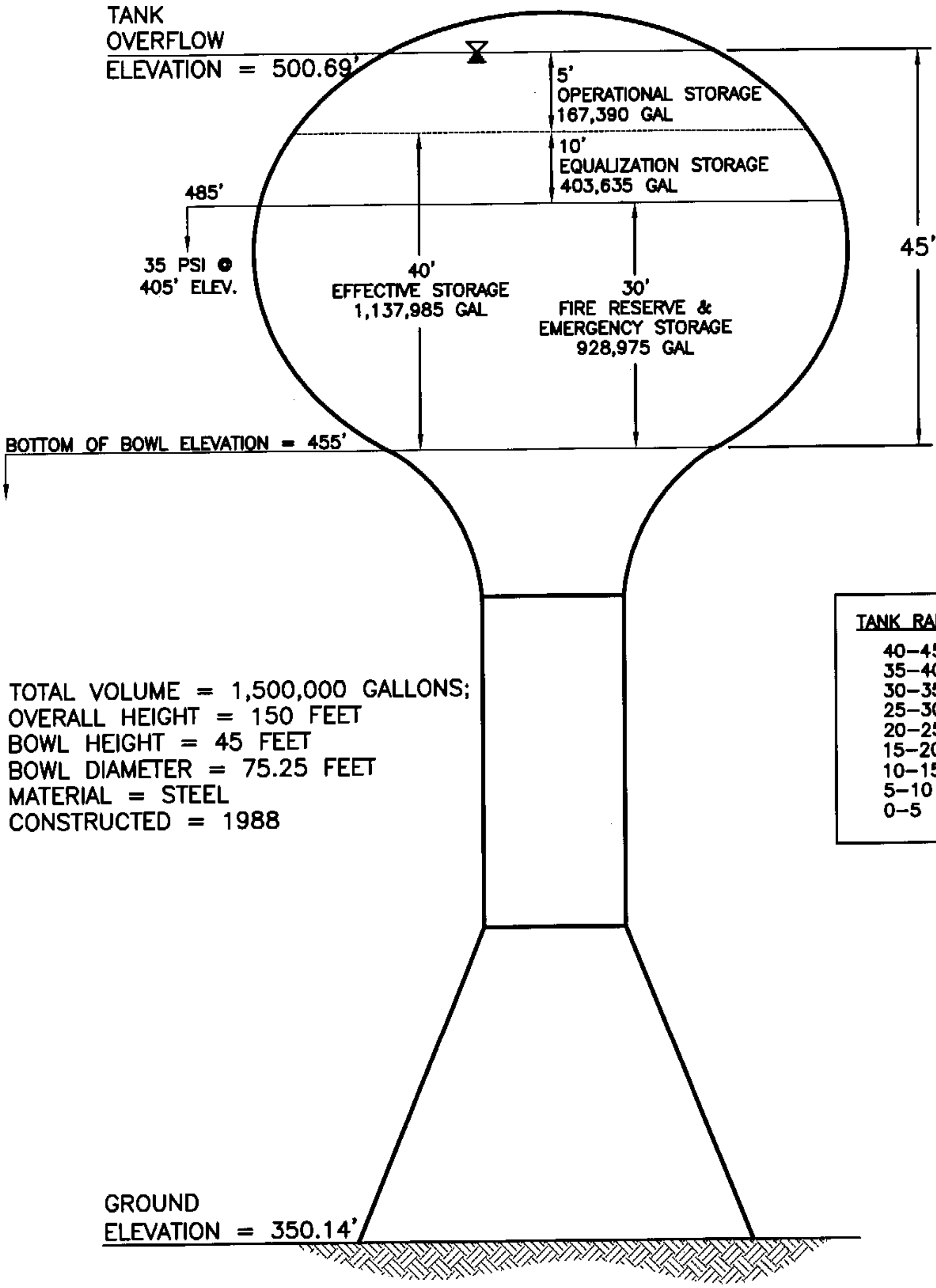
FIGURE 8

HIGH SERVICE GRADIENT (500')



TANK RANGE	GAL/FT
40–45	33,478
35–40	38,925
30–35	41,802
25–30	42,406
20–25	40,745
15–20	36,375
10–15	29,864
5–10	21,035
0–5	15,410

TOTAL VOLUME = 1,500,000 GALLONS;
OVERALL HEIGHT = 150 FEET
BOWL HEIGHT = 45 FEET
BOWL DIAMETER = 75.25 FEET
MATERIAL = STEEL
CONSTRUCTED = 1988

TECHNOLOGY PARK ELEVATED TANK

N.T.S.

NOTE: NO "DEAD" STORAGE AS ABLE TO ACHIEVE A MINIMUM OF 20 PSI @ HIGHEST SERVICE ELEVATION OF 405 FEET

FIGURE 9

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TABLE 3
HIGH SERVICE GRADIENT (500') STORAGE VOLUMES

FACILITY	EFFECTIVE STORAGE (MG)	OPERATIONAL STORAGE (MG)	EQUALIZATION STORAGE (MG)	FIRE RESERVE & EMERGENCY STORAGE (MG)	"DEAD" STORAGE (MG)
Carr Pond Road Tank	1.610	0.183	0.366	1.244	1.171
Technology Park Tank	1.138	0.167	0.404	0.929	0
TOTALS	**2.748**	**0.350**	**0.770**	**2.173**	**1.171**

The total nominal storage capacity of all storage tanks in the High Service Pressure Gradient is equal to 4,500,000 gallons.

3.3 Existing Storage Tank(s) Volume Assessment

The following includes an analysis of each of the primary pressure gradients in the water distribution system with regard to the various aforementioned components of storage as related to consumer water system demands, fire flow requirements and emergency storage requirements. As previously indicated, there is not a set procedure or formula to employ when evaluating the size and location of storage tanks as each system is unique with regard to its mode of operation, consumer demand, available supply and location, volume and number of storage facilities. There is however general water works standards and practice, typically referred to regulatory based sizing criteria, which can be utilized to evaluate the storage facilities including various components of storage (i.e. operational, equalization, fire, etc.). This evaluation would be further supported through extended period simulations of hydraulic modeling. The results from the modeling evaluation would lend support to the regulatory-based sizing criteria. Significant difference or variation between the two methods would need to be further examined.

3.3.1 Evaluation Criteria

The criteria that was previously discussed in Technical Memorandum No. 2A and summarized in Section 3.2.1 Storage Tank(s) Assessment Criteria of this Memorandum was utilized to assess the various storage tanks and their components of storage.

Effective Storage volume is equal to the total nominal volume less the volume of *operational* and *dead storage*. It is this volume in the tank that is always available to meet peak consumer demands or during fire and emergency conditions. The *operational storage* is that volume in the tank that is routinely cycled on a daily basis. The area of *dead storage* is defined as the water elevation in the tank below which a satisfactory pressure (i.e. 20 psi) cannot be supplied for purposes of emergency or fire flow storage. Only the volume of *effective storage* will be used to determine the actual available, or design, storage volume. Again, it is noted that there exist isolated areas within the service territory within particular pressure zones that do not meet this 20-psi criteria. These must be examined on an individual basis.

The *equalization storage* is that volume of tank storage, which lies below the *operational storage* volume that meets water system demands that are in excess of the pumping or supply capacity of the water system. The bottom of the *equalization storage* volume is also defined by the water level in the tank at which 35 psi would be available at the highest serviceable ground elevation. These serviceable ground elevations were previously defined for each pressure service zone. The water volume dedicated to *equalization storage* is utilized during peak demand periods of the day.

The measure of the adequacy of *equalization storage* will be evaluated based upon achieving 25 percent of the system average day demand. This is a general water works guideline and will provide an indication of the overall ability of the water system to meet anticipated peak demands that are in excess of the supply capability of the water system. As the water system is segregated into three distinct pressure zones, the assessment of the volume of the tanks will include the aggregate storage capacity of all tanks in a particular pressure zone.

This will however only provide a general interpretation of the adequacy of the storage tank volumes. The modeling evaluations, most notably extended period simulations, will provide a more definitive indication as to how each of the individual tanks operates with regard to meeting varied system demand conditions. It is critical for example that during modeling evaluations that no one storage tank (exclusive of fire flow conditions) remains in a constant locked up condition, drains or fills at excessive rates with respect to other tanks and that there is no erosion of the storage volume below the level of established *equalization storage*.

Storage located below the *equalization storage* zone is referred to as *emergency and fire storage* and must provide a minimum pressure of 20 psi throughout the water distribution system. The Authority's distribution system including each of the three primary pressure zones consists of a variety of mixed uses including suburban and urban residential, commercial and office and varied intensity industrial development. The residential and commercial development will in general require fire flows in the range of 1,000 – 1,500 gpm. High intensity use areas and industrial facilities may require fire flows up to (and at times in excess of) 3,500 gpm.

Technical Memorandum 4B provided an assessment with regard to available fire flow throughout the service territory. This included identification for each model junction node as to the available fire flow. The results were represented on a system map, which was color-coded by pipe section based on available fire flow ranges. It is intended that this map provide an indication of the available fire flow rates in a particular location within the system. This TM 4B should be consulted for specifics with regard to the assessment of available fire flow rates.

As always, it is recommended that fire flows for specific developments or facilities be evaluated on an individual basis. This is due to the fact that there may be adequate reserve for fire flow in a particular tank however the infrastructure (water mains, hydrants, etc.) may be limited in their ability to transmit this flow rate from the tank to the point of required fire flow.

For purposes of this evaluation, each storage tank was evaluated for its ability to supply a required fire flow of 3,500 gpm for a duration of 3 hours as required by NFPA (National Fire Protection Association) for a fire flow requirement of this rate. This fire flow rate equates to a total fire flow volume of 630,000 gallons, which would necessarily need to be available in a storage tank. This is considered a conservative approach for the evaluation in that during an actual fire flow event the water system will have the ability to supply the required fire flow from multiple tanks, as they are available in the pressure gradient, and from redundant supply sources.

The volume of water, if any, in excess of the required fire flow is considered to be *emergency storage*. Below this water level, storage is ineffective or considered to be *dead storage* that cannot effectively supply the distribution system with an adequate pressure of 20 psi.

The following tables provide an indication of the ratio of the total tank equalization storage to the average day demand and an assessment of the available fire flow capacity on a tank-by-tank basis for each of the three pressure zones.

LOW SERVICE (334') GRADIENT WITH ALL TANKS

EQUALIZATION STORAGE ASSESSMENT

DEMAND SCENARIO	SYSTEM DEMAND (GAL)	TOTAL EQUALIZATION VOLUME (GAL)	% STORAGE OF AVERAGE DAY DEMAND
Average Day	7,270,000	1,803,000	25%

The total of the *equalization storage* in all the Low Service tanks provides 25 percent of the average day demand, which is in line with the water works 25% guideline. It is also critical to evaluate these storage tanks under an extended period modeling scenario. It should also be noted that the Low Service Gradient is operated under a continuous pumping mode. The continual operation of the Clinton Avenue Pump Station and its ability to effectively meet a large portion of the overall system demand may in part serve to reduce the reliance on the tanks in meeting peak demands. This is represented in the historic tank charts, which indicate that overall the Low Service storage tanks are not excessively taxed during periods of peak demands.

FIRE & EMERGENCY STORAGE ASSESSMENT

STORAGE TANK	TOTAL FIRE & EMERGENCY STORAGE (GAL)	REQUIRED FIRE STORAGE IN TANK (GAL)	AVAILABLE EMERGENCY STORAGE IN TANK (GAL)
Wakefield Street Tank	972,000	630,000	342,000
Frenchtown Road Tank	1,020,000	630,000	390,000
West Street Tank	680,000	630,000	50,000
Fiskeville Reservoirs	217,600	630,000	0
Setian Lane Tank	1,500,000	630,000	870,000
TOTALS	**4,389,600**		**1,652,000**

All of the Low Service Gradient storage tanks, with exception of the Fiskeville Reservoirs, provide a fire flow volume of 630,000 gallons, which is equivalent to a 3,500 gpm fire flow rate at a three hour duration. Additionally, all the tanks, exclusive of Fiskeville Reservoirs, provide a varied source of emergency volume that cumulatively equals 1,652,000 gallons. This emergency storage volume is approximately 23% of the Low Service average day demand. The storage volumes associated with the fire and emergency reserve are considered to be adequate and will be further assessed during the modeling portion of the evaluation.

Due to the fact that the Fiskeville Reservoirs No. 1 and No. 2 are continually maintained in a "locked up" condition due to their proximity to the Clinton Avenue Pump Station (approximately 1.5 miles), and likely have been since construction of the Clinton Avenue Pump Station in 1968, the Low Service tanks were also evaluated without consideration of the storage volume from these reservoirs. It is probable that these reservoirs will be removed from future service. The following tables were prepared without the storage capacity from the Fiskeville Reservoirs.

LOW SERVICE (334') GRADIENT WITHOUT FISKEVILLE TANKS

EQUALIZATION STORAGE ASSESSMENT

DEMAND SCENARIO	SYSTEM DEMAND (GAL)	TOTAL EQUALIZATION VOLUME (GAL)	% STORAGE OF AVERAGE DAY DEMAND
Average Day	7,270,000	1,123,000	15%

The total of the *equalization storage* in all the Low Service tanks with the Fiskeville Reservoirs removed provides 15% percent of the average day demand, which is below the water works 25% guideline. The effect of removing these reservoirs may not be as dramatic as would first appear. Due to the fact that these tanks are routinely maintained in a "locked up" condition, the benefit of these tanks in terms of meeting peak system demands is inconsequential. During periods of peak demands, the supply volume is provided through the remaining storage tanks in combination with the supply capacity from the Clinton Avenue Pump Station.

FIRE & EMERGENCY STORAGE ASSESSMENT

STORAGE TANK	TOTAL FIRE & EMERGENCY STORAGE (GAL)	REQUIRED FIRE STORAGE IN TANK (GAL)	AVAILABLE EMERGENCY STORAGE IN TANK (GAL)
Wakefield Street Tank	972,000	630,000	342,000
Frenchtown Road Tank	1,020,000	630,000	390,000

West Street Tank	680,000	630,000	50,000
Setian Lane Tank	1,500,000	630,000	870,000
TOTALS	**4,172,000**		**1,652,000**

Each of the Low Service Gradient storage tanks provide a fire flow volume of 630,000 gallons, which is equivalent to a 3,500 gpm fire flow rate at a three hour duration. Additionally, each tank provides a varied source of emergency volume that cumulatively equals 1,652,000 gallons. This emergency storage is approximately 23% of the Low Service average day demand. The storage volumes associated with the fire and emergency reserve are considered to be adequate and will be further assessed during the modeling portion of the evaluation. On this basis, the storage tanks even without the Fiskeville Reservoirs are of adequate individual and combined capacity to provide for the various components of storage for this pressure gradient.

READ SCHOOL HOUSE ROAD (500') GRADIENT

EQUALIZATION STORAGE ASSESSMENT

DEMAND SCENARIO	SYSTEM DEMAND (GAL)	TOTAL EQUALIZATION VOLUME (GAL)	% STORAGE OF AVERAGE DAY DEMAND
Average Day	400,000	600,000	150%

The total of the *equalization storage* in the Read School House Road tank provides 150% percent of the average day demand, which is well in excess of the water works 25% guideline. It is also important to evaluate this storage tank under an extended period modeling scenario.

FIRE & EMERGENCY STORAGE ASSESSMENT

STORAGE TANK	TOTAL FIRE & EMERGENCY STORAGE (GAL)	REQUIRED FIRE STORAGE IN TANK (GAL)	AVAILABLE EMERGENCY STORAGE IN TANK (GAL)
Read School House Road Tank	600,000	630,000	0
TOTALS	**600,000**		**0**

The Read School House Road Tank provides a fire flow storage volume of 600,000 gallons, which is near equivalent to a 3,500 gpm fire flow rate at a three hour duration. There is no emergency storage offered by this tank. This storage tank is of adequate capacity to provide for the various components of storage for this pressure gradient. Given the nature of the service territory of the Read School House Road Pressure Zone that is predominately rural residential and commercial, it is unlikely that a fire flow rate of this magnitude would be required. A reduced fire flow rate in the range of 1,000 – 1,500 gpm would afford this zone with an available volume of emergency storage.

HIGH SERVICE (500') GRADIENT

EQUALIZATION STORAGE ASSESSMENT

DEMAND SCENARIO	SYSTEM DEMAND (GAL)	TOTAL EQUALIZATION VOLUME (GAL)	% STORAGE OF AVERAGE DAY DEMAND
Average Day	2,940,000	770,000	26%

The total of the *equalization storage* in the two High Service tanks provides 26% of the average day demand, which is near equal to the water works 25% guideline. It is also important to evaluate these storage tanks under an extended period modeling scenario to ensure proper operation. Additionally, the Authority has in the past effectively maintained water levels in these storage tanks within the range for equalization storage volumes under peak demand scenarios.

FIRE & EMERGENCY STORAGE ASSESSMENT

STORAGE TANK	TOTAL FIRE & EMERGENCY STORAGE (GAL)	REQUIRED FIRE STORAGE IN TANK (GAL)	AVAILABLE EMERGENCY STORAGE IN TANK (GAL)
Carr Pond Road Tank	1,244,400	630,000	614,400
Technology Park Tank	929,000	630,000	299,000
TOTALS	**2,173,400**		**913,400**

Each of the High Service Gradient storage tanks provide a fire flow volume of 630,000 gallons, which is equivalent to a 3,500 gpm fire flow rate at a three hour duration. Additionally, each tank provides a varied source of emergency volume that cumulatively equals 913,400 gallons. This emergency storage is approximately 31% of the High Service average day demand. The storage volumes associated with the fire and emergency reserve are considered to be adequate and will be further assessed during the modeling portion of the evaluation.

4.0 Extended Period Simulations Without Fire Flow

Extended period simulations (EPS) were completed for a 96 hour (4 day period) during which existing (2006) average day and maximum day demands were utilized with the diurnal flow curves that were previously developed for each of the various pressure zones. The supply sources (wells and interconnections) and booster pump stations were set on level control with the corresponding tank that currently controls operation of these facilities. For the EPS, one pump at Clinton Avenue Pump Station was in continuous operation while a second and third pump were set on operational control with Frenchtown Road tank. The intent of these EPS was to determine the adequacy of the distribution system storage tanks during an EPS of average day and maximum day demand conditions to determine how the storage tanks operate.

The critical indicators that were examined for each storage facility were the rate of fill and draw, time of recovery, extent of drawdown in the tank (i.e. eroding of fire and emergency storage volume), ability to cycle and overall effectiveness in meeting system demands. A time step graph for each of the storage tanks is provided as Attachment No. 1 (EPS Average Day) and No. 2 (EPS Maximum Day). A description of the tank(s) effectiveness in meeting these demands is also provided. Additionally, due to the fact that the Clinton Avenue Pump Station facility is critical with regard to supply and pressure for the Low Service Gradient, time step graphs of the operation of these pumps are also provided in the Attachments. For purposes of this analysis, it is assumed that adequate backup is provided at each interconnection or booster pump station in the form of redundant pumps at the facility. It should be noted that this simulation did not include evaluation of fire flows, which were performed in subsequent EPS evaluations.

4.1 Extended Period Simulation (96 Hour) – Average Day Demand

An extended period simulation (EPS) was completed for a 96 hour (4 day period) during which existing (2006) average day demands were utilized with the diurnal flow curves that were previously developed for each of the various pressure zones. The intent of this EPS was to determine the adequacy of the distribution system storage tanks during an EPS of average day demand conditions to determine how the storage tanks operate.

4.1.1 Read School House Road Pressure (500') Gradient Evaluation

The EPS for this pressure gradient depicts the Read School House Road Tank fluctuating within a range of approximately 3.5 feet from its overflow elevation of 500 feet. Reference the time step graph for this tank in Attachment No. 1. This cycle range is coincident with the set points for the 3.0 MGD pump(s) at the Clinton Avenue Pump Station, which are designed to supply this tank. Over the span of the EPS, the tank cycles within its set point range on average of two to three times daily which is within the prescribed "operational" storage range for this facility. The EPS demonstrates that this tank is of sufficient capacity to meet the current average day demands and consideration could be given to expanding the operational range of the set points of the pump to expand the drawdown in the tank by several feet (especially during non peak demand periods) in order to promote greater cycling and tank turn over. This may not be necessary if the new tank is equipped with an internal mixing system or with independent fill and draw lines.

4.1.2 High Service Pressure (500') Gradient Evaluation

This pressure gradient contains two storage tanks, the Technology Park Tank and Carr Pond Tank that are both at an overflow elevation of 500 feet. Reference the time step graph for these tanks in Attachment No. 1. For this simulation the West Warwick Business Park Pump Station (level control with Technology Park Tank) and Johnson Boulevard Booster Pump Station (level control with Technology Park and Carr Pond Tanks) were on during this simulation. Quaker Lane and Setian Lane Booster Pump Stations were off during this simulation.

Carr Pond Tank
The EPS for this pressure gradient depicts the Carr Pond Tank as fluctuating within a range of approximately 4 feet (from 488 to 492 feet) below its overflow elevation of 500 feet. This cycle range is coincident with the set points for the Johnson Boulevard Pump Station. Over the span of the EPS, the tank cycles within its set point range on average of one time daily and within the prescribed "operational" and equalization storage ranges (i.e. 15 feet) for this facility. The cycle range of the tank is such that it never refills to the pump off elevation of 499 feet, however it does fill sufficiently to avoid depletion below an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current average day demands.

Technology Park Tank
The EPS for this pressure gradient depicts the Technology Park Tank as fluctuating within a range of approximately 6 feet (from 490 to 496 feet) below its overflow elevation of 500 feet. This cycle range is coincident with the set points for Johnson Boulevard and West Warwick Business Park Booster Pump Stations. Over the span of the EPS, the tank cycles within its set point range on average of one time daily and is within the prescribed "operational" and "equalization" storage range (i.e. 15 feet) for this facility. The cycle range of the tank is such that it never refills to the pump off elevation of 499 feet however depletion in the tank is within an acceptable low water point on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current average day demands.

4.1.3 Low Service Pressure (334') Gradient Evaluation

This pressure gradient contains six storage tanks, Frenchtown Road, Setian Lane, Wakefield Street, West Street and Fiskeville Reservoirs No. 1 and 2 and all are at an overflow elevation of 334 feet. Reference the time step graphs for these tanks in Attachment No. 1. For this simulation the Clinton Avenue Pump Station (level control with Frenchtown Road Tank), Quaker Lane Pump Station (level control with Setian Lane Tank) and East Greenwich Well (level control with Frenchtown Road Tank) were on during this simulation. Spring Lake and Mishnock Wells were off during this simulation.

Frenchtown Road Tank
The EPS for this pressure gradient depicts the Frenchtown Road Tank as fluctuating within a range of approximately 2 feet (from 329 to 331 feet) below its overflow elevation of 334 feet. This cycle range is coincident with the set points for Clinton Avenue Pump Station and East Greenwich Well. Over the span of the EPS, the tank cycles within its set point range on average of three times daily and within the prescribed "operational" storage range (i.e. 5 feet) for this facility. The cycle range of the tank is such that it never refills to the pump off elevation of 333 feet however depletion in the tank is within an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current average day demands.

Setian Lane Tank
The EPS for this pressure gradient depicts the Setian Lane Tank as fluctuating within a range of approximately 1.5 feet (from 332.5 to 334 feet) below its overflow elevation of 334 feet. This cycle range is coincident with the set points for Quaker Lane Pump Station. This tank is also provided with significant refill volume from the Clinton Avenue Pump Station, which is on level control with Frenchtown Road Tank. Over the span of the EPS, the tank cycles within its set point range on average of one time daily and within the prescribed "operational" storage range (i.e. 5 feet) for this facility. The cycle range of the tank is such that it refills to 334 feet, which is above the pump off elevation of 333 feet, and depletion in the tank is within an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current maximum day demands.

Wakefield Street Tank
The EPS for this pressure gradient depicts the Wakefield Street Tank as being in a "locked up" condition throughout the EPS. Several factors can be attributed to this condition. The operation of the Clinton Avenue Pump Station, which during this simulation has at minimum one pump operating at all times, creates a system hydraulic grade in proximity to this tank that is above the overflow elevation of 334 feet. Additionally, the new distribution water mains from Main Street to Wakefield Street (i.e. Harding, Phenix, Harris, Potter, etc.) along with the new transmission mains on Main, Ames and across the Pawtuxet River allow for increased flow capacity to this storage tank. Previously, the older cast iron mains in these areas allowed for greater friction losses and decreased flow capacity, which permitted this tank to cycle.

It is likely that this tank will continue to operate in a near "locked up" mode during off peak demand periods (i.e. non summer periods) due to the new water infrastructure and the influence of the Clinton Avenue Pump Station. In order to promote cycling of this tank, it is recommended that options be examined during the update of the CIP (Capital Improvement Plan) that would include isolating this tank to the west on Wakefield Street with a valving station. This would create a condition whereby the tank would be supplied from the east on Wakefield Street and at a lower system hydraulic grade that would promote tank cycling. In addition, the valving station should include a provision to open and allow flow to the west along Wakefield Street in the event the hydraulic grade drops below the overflow elevation in the tank (i.e. fire flow condition). Recent model simulations for the proposed emergency interconnection with Providence Water off of Wakefield Street have also shown that the Wakefield Street Tank will remain in a "locked up" condition during operation.

West Street Tank
The EPS for this pressure gradient depicts the West Street Tank as being in a "locked up" condition throughout the EPS. The primary factor related to this condition is the influence of the Clinton Avenue Pump Station and the corresponding increase in the system hydraulic grade in proximity to this tank that is above the tank overflow elevation of 334 feet (survey revealed actual overflow at elevation 331.5 feet). Normal system operations require that the Clinton Avenue Pump Station run at minimum one pump on a continuous basis in order to meet system demand and maintain adequate distribution system pressure at areas of higher elevation. It should be noted that the slightly lower overflow elevation does not affect the "locked up" condition of this tank as the hydraulic grade is consistently above the 334-foot gradient.

System operations over the past several years have included isolating this tank from the system due to this tendency to remain in a "locked up" condition under all demand scenarios. It is reported by system operations personnel that the hydraulic grade at the tank never drops below the overflow elevation of this tank. Given that the probability of shutting down the Clinton Avenue Pump Station for any time span during any given 24 hour period is not likely for the immediate future due to its critical nature to the system as a whole, other options need to be considered for this tank. It is considered that this tank provides a measure of fire reserve storage for the general surrounding area in which it is located. Further, this tank was recently rehabilitated which included interior and exterior coating replacement and structural repair.

It is recommended to maintain this tank for purposes of reserve storage for fire protection. In order to avoid conditions of stagnant water and poor tank turnover, it is recommended that a booster pump be installed at the tank to periodically pump water back into the distribution system. In this manner, it may be possible to turn off Clinton Avenue Pump Station for a period of time (i.e. 1 – 2 hours) during the early morning hours when the pump station at the tank is in operation. The pump station would be sized to replicate the head conditions produced by Clinton Avenue Pump Station in order that the customers at higher elevations would still maintain adequate pressure. The control for operation of this station would need to be coordinated through the Authority's SCADA system.

Once the long-term goal of re-servicing customers at higher elevations is achieved and the pumps at Clinton Avenue can be periodically turned off then this tank will fluctuate on a routine basis.

Fiskeville Reservoirs No. 1 & 2
These underground reservoirs were considered jointly as they are located at the same site and adjacent to one another and are of similar dimension (overflow and base). The EPS for this pressure gradient depicts the Fiskeville Reservoirs as being in a "locked up" condition throughout the EPS. The primary factor related to this condition, as is similar to the West Street Tank, is the influence of the Clinton Avenue Pump Station and the corresponding increase in the system hydraulic grade in proximity to these reservoirs that is above the overflow elevation of 334 feet. These reservoirs are also located within one mile of the Clinton Avenue Pump Station, which further worsens the condition. Normal system operations require that the Clinton Avenue Pump Station run at minimum one pump on a continuous basis in order to meet system demand and maintain adequate distribution system pressure at areas of higher elevation.

These reservoirs were constructed in 1944 and 1960 respectively, which predated the construction of the Clinton Avenue Pump Station in 1968 – 1969. It is reported by system operations personnel that these reservoirs have historically been maintained in a "locked up" condition when the Clinton Avenue Pump Station is in operation. As the water system continued to grow and expand over the years the Clinton Avenue Pump Station became ever more critical in meeting system demand and maintaining pressure at higher service elevations in proximity to the pump station. Further, development has occurred in the area surrounding these underground reservoirs on Seven Mile Road at elevations in the range of 250 to over 300 feet. These reservoirs are not designed to provide adequate pressures at these service elevations and these customers currently rely on the system head from the Clinton Avenue Pump Station for adequate pressure.

It is likely that customers at these higher service elevations will be re-serviced in the near future (2008) from the new Read School House Road Pressure Gradient or other alternative means. This gradient will be supplied from new pumps at the Clinton Avenue Pump Station and the Knotty Oak Pump Station will be decommissioned. At that point, the Fiskeville Reservoirs would be isolated from the Low Service Pressure Gradient. It is not considered practical to maintain these reservoirs in operation due to their proximity to the Clinton Avenue Pump Station, their location at the extreme northern "end" of the system and due to the inherent problems associated with maintaining sanitary conditions for below grade structures. It is recommended that these underground storage facilities be permanently removed from service on the Low Service Pressure Gradient.

4.2 Extended Period Simulation (96 Hour) – Maximum Day Demand

An extended period simulation (EPS) was completed for a 96 hour (4 day period) during which existing (2006) maximum day demands were utilized with the diurnal flow curves that were previously developed for each of the various pressure zones. The intent of this EPS was to determine the adequacy of the distribution system storage tanks during an EPS of maximum day demand conditions and under a scenario when the tanks would most likely be strained.

4.2.1 Read School House Road Pressure (500') Gradient Evaluation

The EPS for this pressure gradient depicts the Read School House Road Tank fluctuating within a range of approximately 3.5 feet from its overflow elevation of 500 feet. Reference the time step graph for this tank in Attachment No. 2. This cycle range is coincident with the set points for the 3.0 MGD pump(s) at the Clinton Avenue Pump Station, which are designed to supply this tank. Over the span of the EPS, the tank cycles within its set point range on average of three to four times daily which is within the prescribed "operational" storage range for this facility. The EPS demonstrates that this tank is of sufficient capacity to meet the current maximum day demands and as recommended previously, consideration could be given to expanding the operational range of the set points of the pump to expand the drawdown in the tank by several feet (especially during non peak demand periods as depicted in the average day EPS) in order to promote greater cycling and tank turn over. This may not be necessary if the new tank is equipped with an internal mixing system or with independent fill and draw lines.

4.2.2 High Service Pressure (500') Gradient Evaluation

This pressure gradient contains two storage tanks, the Technology Park Tank and Carr Pond Tank that are both at an overflow elevation of 500 feet. Reference the time step graph for these tanks in Attachment No. 2. The West Warwick Business Park Pump Station (level control with Technology Park Tank) and Johnson Boulevard Booster Pump Station (level control with Technology Park and Carr Pond Tanks) were on during this simulation. The Quaker Lane and Setian Lane Booster Pump Stations were off during this simulation.

Carr Pond Tank
The EPS for this pressure gradient depicts the Carr Pond Tank as fluctuating within a range of approximately 5 feet (from 491 to 496 feet) below its overflow elevation of 500 feet. This cycle range is coincident with the set points for Johnson Boulevard Pump Station. Over the span of the EPS, the tank cycles within its set point range on average of one time daily and within the prescribed "operational" and "equalization" storage range (i.e. 15 feet) for this facility. The cycle range of the tank is such that it never refills to the pump off elevation of 499 feet, however it does fill sufficiently to avoid depletion below an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current maximum day demands.

Technology Park Tank
The EPS for this pressure gradient depicts the Technology Park Tank as fluctuating within a range of approximately 8 feet (from 491 to 499 feet) below its overflow elevation of 500 feet. This cycle range is coincident with the set points for Johnson Boulevard and West Warwick Business Park Booster Pump Stations. Over the span of the EPS, the tank cycles within its set point range on average of one time daily and is within the prescribed "operational" and "equalization" storage range (i.e. 15 feet) for this facility. The cycle range of the tank is such that it refills to the pump off elevation of 499 feet and depletion in the tank is within an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current maximum day demands.

4.2.3 Low Service Pressure (334') Gradient Evaluation

This pressure gradient contains six storage tanks, Frenchtown Road, Setian Lane, Wakefield Street, West Street and Fiskeville Reservoirs No. 1 and 2 and all are at an overflow elevation of 334 feet. Reference the time step graphs for these tanks in Attachment No. 2. For this simulation the Clinton Avenue Pump Station (level control with Frenchtown Road Tank), Quaker Lane Pump Station (level control with Setian Lane Tank) and East Greenwich Well (level control with Frenchtown Road Tank) were on during this simulation. Spring Lake and Mishnock Wells were off during this simulation.

Frenchtown Road Tank
The EPS for this pressure gradient depicts the Frenchtown Road Tank as fluctuating within a range of approximately 7 feet (from 326 to 333 feet) below its overflow elevation of 334 feet. This cycle range is coincident with the set points for Clinton Avenue Pump Station and East Greenwich Well. Over the span of the EPS, the tank cycles within its set point range on average of two times daily and within the prescribed "operational" and "equalization" storage range (i.e. 10 feet) for this facility. The cycle range of the tank is such that it fills to the pump off elevation of 333 feet and depletion in the tank is within an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current maximum day demands.

Setian Lane Tank
The EPS for this pressure gradient depicts the Setian Lane Tank as fluctuating within a range of approximately 4 feet (from 329 to 333 feet) below its overflow elevation of 334 feet. This cycle range is coincident with the set points for Quaker Lane Pump Station. This tank is also provided with significant refill volume from the Clinton Avenue Pump Station, which is on level control with Frenchtown Road Tank. Over the span of the EPS, the tank cycles within its set point range on average of one time daily and within the prescribed "operational" storage range (i.e. 5 feet) for this facility. The cycle range of the tank is such that it fills to the pump off elevation of 333 feet and depletion in the tank is within an acceptable low water point in the tank on subsequent drawdowns. The EPS demonstrates that this tank is of sufficient capacity to meet the current maximum day demands.

Wakefield Street Tank
The EPS for this pressure gradient depicts the Wakefield Street Tank as fluctuating within a range of approximately 0.5 feet (from 333.5 to 334 feet) below its overflow elevation of 334 feet and remains in a near "locked up" condition throughout the EPS. As with the Average Day EPS, several factors are attributed to this condition. The operation of the Clinton Avenue Pump Station, which during this simulation has at minimum two pumps operating at all times, creates a system hydraulic grade in proximity to this tank that is above the overflow elevation of 334 feet. Additionally, the new distribution water mains from Main Street to Wakefield Street (i.e. Harding, Phenix, Harris, Potter, etc.) along with the new transmission mains on Main, Ames and across the Pawtuxet River allow for increased flow capacity to this storage tank. Previously, the older cast iron mains in these areas allowed for greater friction losses and decreased flow capacity, which permitted this tank to cycle.

As previously indicated, it is recommended that consideration be given to isolating this tank to the west on Wakefield Street with a valving station.

West Street Tank
The EPS for this pressure gradient depicts the West Street Tank as being in a "locked up" condition throughout the EPS. Similar to the EPS Average Day, the primary factor related to this condition is the influence of the Clinton Avenue Pump Station and the corresponding increase in the system hydraulic grade in proximity to this tank that is above the tank overflow elevation of 334 feet (survey revealed actual overflow at elevation at 331.5 feet). As recommended above, this tank should be maintained for purposes of reserve storage for fire protection. This would include installation of a booster pump at the tank to periodically pump water back into the distribution system.

Fiskeville Reservoirs No. 1 & 2
These underground reservoirs were considered jointly as they are located at the same site and adjacent to one another. The EPS for this pressure gradient depicts the Fiskeville Reservoirs as being in a "locked up" condition throughout the EPS. The primary factor related to this condition, as is similar to the West Street Tank, is the influence of the Clinton Avenue Pump Station and the corresponding increase in the system hydraulic grade in proximity to these reservoirs that is above the overflow elevation of 334 feet. These reservoirs are also located within one mile of the Clinton Avenue Pump Station that further worsens the situation. Normal system operations require that the Clinton Avenue Pump Station run at minimum one pump on a continuous basis in order to meet system demand and maintain adequate distribution system pressure at areas of higher elevation.

As discussed previously, it is recommended that these underground storage facilities be permanently removed from service on the Low Service Pressure Gradient.

5.0 Extended Period Simulations With Fire Flow

Extended period simulations (EPS) were completed for a 24 hour (1 day period) during which existing (2006) average day and maximum day demands were utilized with the diurnal flow curves that were previously developed for each of the various pressure zones. This also included simulating a 2,000 gpm fire flow at two (2) specific junction nodes in proximity to each of the distribution system storage tanks. This fire flow rate was applied for a two-hour duration beginning at 12:00 PM and ending at 2:00 PM under each EPS. The 2,000-gpm fire flow rate was selected as a conservative fire flow requirement in that the majority of locations within the service territory are not anticipated to require fire flows in excess of this rate.

The primary intent was to determine to what extent the water system and storage tanks were impacted by these fire flows. Of critical nature was the extent of drawdowns in tanks during the fire flow period and the recovery period following the two-hour fire flow duration. The evaluation was also critical in that it examined tanks that typically do not cycle (i.e. West Street and Fiskeville) during normal system operations. The fire flow analysis was not performed at all the junction nodes simultaneously as this was considered an unlikely event of occurrence.

The critical indicators that were examined for each storage facility were the rate of fill and draw, time of recovery, extent of drawdown in the tank and overall effectiveness in meeting fire flow demands. A time step graph for each of the storage tanks is provided as Attachment No. 3 (EPS Average Day with Fire Flow) and No. 4 (EPS Maximum Day with Fire Flow). A description of the tank(s) effectiveness in meeting these fire flow demands is also provided.

The supply sources (wells and interconnections) and booster pump stations were set on level control with the corresponding tank that currently controls operation of these facilities. For the EPS, one pump at Clinton Avenue was placed in continuous operation while a second and third pumps were set on operational control with Frenchtown Road tank.

5.1 Average Day - Extended Period Simulations With Fire Flow
5.1.1 Read School House Road Gradient

The Read School House Gradient contains one (1) storage facility. A total of two (2) junction nodes were evaluated for fire flow within this pressure zone as follows.

Read School House Road Tank:

J-7154 – located on Flat River Road along a 12" AC water main, elevation of 254 feet. The EPS model results indicate that at the start of the fire flow the tank is in refill mode. The fire flow has the effect of dropping the tank level a total of approximately 1 foot during the two-hour period. At the end of the fire flow the tank recovers to a complete refill within 2 hours. This tank has adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the low end of the normal pump cycle elevation.

J-7258 – located on Hunters Crossing Drive along a 16" DI water main, elevation of 343 feet. The EPS model results indicate that at the start of the fire flow the tank is in refill mode. The fire flow has the effect of dropping the tank level a total of approximately 0.5 foot during the two-hour period. At the end of the fire flow the tank recovers to a complete refill within 1 hour. This tank has adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the low end of the normal pump cycle elevation.

5.1.2 High Service Gradient

The High Service Gradient contains two (2) storage tanks. A total of four (4) junction nodes were evaluated within this pressure zone as follows.

Carr Pond Road Tank:

J-4117 – located on Middle Road along a 16" DI water main, elevation of 300 feet. The EPS model results indicate that at the start of the fire flow the tank is in refill mode. The fire flow has the effect of dropping the tank level a total of approximately 5 feet during the two-hour period. At the end of the fire flow the tank begins to recover and stabilizes at an elevation of approximately 485 feet (15 feet below overflow). The Technology Park Tank is draining during the start of the fire flow and continues to drain approximately 2 feet during the two hour period. This tank continues to drain for an additional 8 hours to an elevation of approximately 487 feet (13 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

J-4056 – located on Frenchtown Road along a 12" DI water main, elevation of 246 feet. The EPS model results indicate that at the start of the fire flow the tank is in refill mode. The fire flow has the effect of dropping the tank level a total of approximately 5 feet during the two-hour period. At the end of the fire flow the tank begins to recover and stabilizes at an elevation of approximately 486 feet (14 feet below overflow). The Technology Park Tank is draining during the start of the fire flow and continues to drain approximately 1 foot during the two-hour period. This tank continues to drain for an additional 8 hours to an elevation of approximately 487 feet (13 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

Technology Park Tank:

J-8145 – located on Hopkins Hill Road along a 12" DI water main, elevation of 316 feet. The EPS model results indicate that at the start of the fire flow the tank is draining. The fire flow has the effect of dropping the tank level a total of approximately 7 feet during the two-hour period. At the end of the fire flow the tank begins to recover and stabilizes at an elevation of approximately 486 feet (14 feet below overflow). The Carr Pond Tank is refilling at the start of the fire flow and continues to drain approximately 2 feet during the two-hour period. This tank continues to drain for an additional 8 hours to an elevation of approximately 485 feet (15 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

J-951 – located on Lonsdale Street along a 12" AC water main, elevation of 298 feet. The EPS model results indicate that at the start of the fire flow the tank is draining. The fire flow has the effect of dropping the tank level a total of approximately 4 feet during the two-hour period. At the end of the fire flow the tank continues to drain for the next 8 hours and stabilizes at elevation 487 feet (13 feet below overflow) and then begins to recover. The Carr Pond Tank is refilling at the start of the fire flow and then drains approximately 4 feet during the two-hour fire flow period. This tank then stabilizes over the next 8 hours at elevation 486 feet (14 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

5.1.3 Low Service Gradient

The Low Service Gradient includes six (6) storage tanks. A total of ten (10) junctions nodes were evaluated including 2 junction nodes in proximity to each storage tank. For purposes of this evaluation Fiskeville Reservoirs No. 1 and No. 2 were treated as one storage facility.

Wakefield Street Tank:

J-727 – located on River Farms Drive along a 12" PVC water main, elevation of 190 feet. The model results indicated that the Wakefield Street Tank is "locked up" during the 24-hour span of the EPS. The only tanks that are apparently affected by the fire flow are Setian Lane and Frenchtown Road. Setian Lane is refilling at the start of the fire flow and then drops approximately 0.5 feet to elevation 333 feet during the two-hour fire flow period. At the end of the fire flow, the tank continues to refill and stabilize at elevation 333.5 feet at which point it fluctuates within a range of approximately 1 foot for the remainder of the EPS. The Frenchtown Road Tank is filling at the start of the fire flow but immediately drops 2 feet during the course of the 2-hour fire flow period. At the end of the fire flow the tank continues to fluctuate within a range of 2 feet throughout the EPS. The West Street Tank and Fiskeville Reservoirs No. 1 and No. 2 remain "locked up" throughout the span of the fire flow EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-769 – located on Main Street along a 20" DI water main, elevation of 92 feet. The model results indicated that the Wakefield Street Tank is "locked up" during the 24-hour span of the EPS. The only tanks that are apparently affected by the fire flow are Setian Lane and Frenchtown Road. Setian Lane is refilling at the start of the fire flow and then drops approximately 0.25 feet to elevation 333 feet during the two-hour fire flow period. At the end of the fire flow, the tank continues to refill and stabilize at elevation 333.5 feet at which point it fluctuates within a range of approximately 1 foot for the remainder of the EPS. The Frenchtown Road Tank is filling at the start of the fire flow but immediately drops 2 feet during the course of the 2-hour fire flow period. At the end of the fire flow the tank continues to fluctuate within a range of 2 feet throughout the EPS. The West Street Tank and Fiskeville Reservoirs No. 1 and No. 2 remain "locked up" throughout the span of the fire flow EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

Frenchtown Road Tank:

J-4091 – located on Frenchtown Road along a 20" AC water main, elevation of 247 feet. The model results indicate that the Frenchtown Road Tank is refilling at the start of the fire flow and then drops a total of 5 feet from 331 to 326 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 331 feet and then stabilizes and continues to refill and cycle throughout the EPS. The Setian Lane Tank is refilling at the start of the fire flow scenario and drains at a slight rate (i.e. range of 0.1 feet) during the 2-hour fire flow period. It continues to refill to its overflow elevation at the end of the fire flow period and then cycles within an acceptable range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-4175 – located on South County Trail along a 12" AC water main, elevation of 109 feet. The model results indicate that the Frenchtown Road Tank is refilling at the start of the fire flow and then drops a total of 4 feet from 331 to 327 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 331 feet and then stabilizes and continues to refill and cycle throughout the EPS. The Setian Lane Tank is refilling at the start of the fire flow scenario and drains at a slight rate (i.e. range of 0.1 feet) during the 2-hour fire flow period. It continues to refill to its overflow elevation at the end of the fire flow period and then cycles within an acceptable range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield

Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

Setian Lane Tank:

J-390 – located on Cowesett Road along a 12" AC water main, elevation of 205 feet. The model results indicate that the Setian Lane Tank is slowly refilling at the start of the fire flow and then drops a total of 1 foot from 333.5 to 332.5 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 333 feet and then stabilizes and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow and at the start of the fire flow drops 2 feet from 331 to 329 feet. At the end of the fire flow it continues to refill to cycle within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-2005 – located on Centerville Road along a 12" AC water main, elevation of 100 feet. The model results indicate that the Setian Lane Tank is slowly refilling at the start of the fire flow and then drops a total of 1 foot from 333.5 to 332.5 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 333.25 feet and then stabilizes and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow and at the start of the fire flow drops 2 feet from 331 to 329 feet. At the end of the fire flow it continues to refill to cycle within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

West Street Tank:

J-626 – located on West Street along a 16" AC water main, elevation of 245 feet. This tank is "locked up" during the span of the EPS and does not provide fire flow to this junction node. Upon reviewing the model results, it would appear that Setian Lane and Frenchtown Road tanks are affected by this fire flow. Setian Lane is slightly filling at the start of the fire flow however it then continues to drop approximately 0.4 feet during the 2 hour fire flow period from elevation 333.4 to 333 feet. At the end of the fire flow the tank refills to elevation 333.5 feet and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario however at the start of the fire flow it starts to drop and during the course of the 2 hour period drops a total of 2 feet from 331 to 329 feet. At the end of the fire flow the tank cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-7879 – located on Fairview Avenue along a 16" AC water main, elevation of 255 feet. This tank is "locked up" during the span of the EPS and does not provide fire flow to this junction node. Upon reviewing the model results, it would appear that Setian Lane and Frenchtown Road tanks are affected by this fire flow. Setian Lane is slightly filling at the start of the fire flow however it then continues to drop approximately 0.3 feet during the 2 hour fire flow period from elevation 333.4 to 333.1 feet. At the end of the fire flow the tank refills to elevation 333.5 feet and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario however at the start of the fire flow it starts to drop and during the course of the 2 hour period drops a total of 2 feet from 331 to 329 feet. At the end of the fire flow the tank cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The Wakefield Street

Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

Fiskeville Reservoirs No. 1 and No. 2:

J-5112 – located on Seven Mile Road along a 16" DI water main, elevation of 240 feet. The model results indicate that these tanks are "locked up" throughout the entire span of the EPS and do not provide the fire flow to this junction node. Upon reviewing the model results, it would appear that Setian Lane and Frenchtown Road tanks are affected by this fire flow. Setian Lane is slightly filling at the start of the fire flow however it then continues to drop approximately 0.2 feet during the 2 hour fire flow period from elevation 333.4 to 333.2 feet. At the end of the fire flow the tank refills to elevation 333.5 feet and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario however at the start of the fire flow it starts to drop and during the course of the 2 hour period drops a total of 2 feet from 331 to 329 feet. At the end of the fire flow the tank cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The Wakefield Street Tank and West Street Tank are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-6027 – located on Hope Avenue along a 16" AC water main, elevation of 222 feet. The model results indicate that these tanks are "locked up" throughout the entire span of the EPS and do not provide the fire flow to this junction node. Upon reviewing the model results, it would appear that Setian Lane and Frenchtown Road tanks are affected by this fire flow. Setian Lane is slightly filling at the start of the fire flow however it then continues to drop approximately 0.1 feet during the 2 hour fire flow period from elevation 333.3 to 333.2 feet. At the end of the fire flow the tank refills to elevation 333.6 feet and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario however at the start of the fire flow it starts to drop and during the course of the 2 hour period drops a total of 2 feet from 331 to 329 feet. At the end of the fire flow the tank cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The Wakefield Street Tank and West Street Tank are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

5.2 Maximum Day - Extended Period Simulations With Fire Flow

5.2.1 Read School House Road Gradient

The Read School House Gradient contains one (1) storage facility. A total of two (2) junction nodes were evaluated for fire flow within this pressure zone as follows.

Read School House Road Tank:

J-7154 – located on Flat River Road along a 12" AC water main, elevation of 254 feet. The EPS model results indicate that at the start of the fire flow the tank is within the outflow cycle mode. The fire flow increases the rate of outflow from the tank and as a result the water level drops approximately 0.8 feet below its normal water elevation. At the end of the fire flow the tank completely recovers within its normal pump cycle time. This tank has adequate fire reserve capacity to accommodate a fire flow rate of this magnitude during a maximum day demand scenario including if it begins at the low end of the normal pump cycle elevation.

J-7258 – located on Hunters Crossing Drive along a 16" DI water main, elevation of 343 feet. The EPS model results indicate that at the start of the fire flow the tank is within the outflow cycle mode. The fire flow increases the rate of outflow from the tank and as a result the water level drops approximately 0.3

feet below its normal water elevation. At the end of the fire flow the tank completely recovers within its normal pump cycle time. This tank has adequate fire reserve capacity to accommodate a fire flow rate of this magnitude during a maximum day demand scenario including if it begins at the low end of the normal pump cycle elevation.

5.2.2 High Service Gradient

The High Service Gradient contains two (2) storage tanks. A total of four (4) junction nodes were evaluated within this pressure zone as follows.

Carr Pond Road Tank:

J-4117 – located on Middle Road along a 16" DI water main, elevation of 300 feet. The EPS model results indicate that at the start of the fire flow the tank is in refill mode. The fire flow has the effect of dropping the tank level a total of approximately 5 feet during the two-hour period. At the end of the fire flow the tank begins to recover and stabilizes at an elevation of approximately 490 feet (10 feet below overflow). The Technology Park Tank is draining during the start of the fire flow and continues to drain at an accelerated rate of approximately 2 feet during the two-hour period. This tank continues to drain for an additional 8 hours to an elevation of approximately 489 feet (11 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

J-4056 – located on Frenchtown Road along a 12" DI water main, elevation of 246 feet. The EPS model results indicate that at the start of the fire flow the tank is in refill mode. The fire flow has the effect of dropping the tank level a total of approximately 5 feet during the two-hour period. At the end of the fire flow the tank begins to recover and stabilizes at an elevation of approximately 489 feet (11 feet below overflow). The Technology Park Tank is draining during the start of the fire flow and continues to drain at an accelerated rate of approximately 2 feet during the two-hour period. This tank continues to drain for an additional 8 hours to an elevation of approximately 490 feet (10 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

Technology Park Tank:

J-8145 – located on Hopkins Hill Road along a 12" DI water main, elevation of 316 feet. The EPS model results indicate that at the start of the fire flow the tank is draining. The fire flow has the effect of dropping the tank level a total of approximately 6 feet during the two-hour period. At the end of the fire flow the tank begins to recover and stabilizes at an elevation of approximately 490 feet (10 feet below overflow). The Carr Pond Tank is refilling at the start of the fire flow and continues to drain approximately 0.5 feet during the two-hour period. This tank continues to drain for an additional 8 hours to an elevation of approximately 489 feet (11 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

J-951 – located on Lonsdale Street along a 12" AC water main, elevation of 298 feet. The EPS model results indicate that at the start of the fire flow the tank is moderately draining. The fire flow has the effect of dropping the tank level a total of approximately 2 feet during the two-hour period. At the end of the fire flow the tank continues to drain moderately for the next 8 hours and stabilizes at elevation 489 feet (11 feet below overflow) and then begins to recover. The Carr Pond Tank is refilling at the start of the fire flow and then continues to drain approximately 4 feet during the two-hour fire flow period. This tank then stabilizes over the next 8 hours at elevation 490 (10 feet below overflow) and then begins to refill. Both tanks have adequate fire reserve capacity to accommodate a fire flow rate of this magnitude including if it were to begin at the bottom of the "equalization" storage zone (i.e. 15 feet below overflow).

5.2.3 Low Service Gradient

The Low Service Gradient includes six (6) storage tanks. A total of ten (10) junctions nodes were evaluated including 2 junction nodes in proximity to each storage tank. For purposes of this evaluation Fiskeville Reservoirs No. 1 and No. 2 were treated as one storage facility.

Wakefield Street Tank:

J-727 – located on River Farms Drive along a 12" PVC water main, elevation of 190 feet. The model results indicated that the Wakefield Street Tank is "locked up" during the 24-hour span of the EPS. The only tanks that are apparently affected by the fire flow are Setian Lane and Frenchtown Road. Setian Lane is refilling at the start of the fire flow and then drops approximately 0.5 feet to elevation 329.5 feet during the two-hour fire flow period. At the end of the fire flow, the tank continues to refill and stabilize at elevation 329 feet. The Frenchtown Road Tank is filling during the fire flow. The effect of the fire flow is to decrease the rate of refill during the two-hour period. At the end of the fire flow the tank resumes its normal refill rate. The West Street Tank and Fiskeville Reservoirs No. 1 and No. 2 remain "locked up" throughout the span of the fire flow EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-769 – located on Main Street along a 20" DI water main, elevation of 92 feet. The model results indicated that the Wakefield Street Tank is "locked up" during the 24-hour span of the EPS. The only tanks that are apparently affected by the fire flow are Setian Lane and Frenchtown Road. Setian Lane is refilling at the start of the fire flow and then drops approximately 0.25 feet to elevation 329.5 feet during the two-hour fire flow period. At the end of the fire flow, the tank continues to refill and stabilize at elevation 330 feet. The Frenchtown Road Tank is filling during the fire flow. The effect of the fire flow is to decrease the rate of refill during the two-hour period. At the end of the fire flow the tank resumes its normal refill rate. The West Street Tank and Fiskeville Reservoirs No. 1 and No. 2 remain "locked up" throughout the span of the fire flow EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

Frenchtown Road Tank:

J-4091 – located on Frenchtown Road along a 20" AC water main, elevation of 247 feet. The model results indicate that the Frenchtown Road Tank is refilling at the start of the fire flow and then drops a total of 4 feet from 326 to 322 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 326 feet and then stabilizes and continues to refill throughout the EPS. The Setian Lane Tank is refilling during the course of the fire flow scenario although at a decreased rate during the 2-hour fire flow period. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-4175 – located on South County Trail along a 12" AC water main, elevation of 109 feet. The model results indicate that the Frenchtown Road Tank is refilling at the start of the fire flow and then drops a total of 5 feet from 327 to 322 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 326.5 feet and then stabilizes and continues to refill throughout the EPS. The Setian Lane Tank is refilling during the course of the fire flow scenario although at a decreased rate during the 2-hour fire flow period. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

Setian Lane Tank:

J-390 – located on Cowesett Road along a 12" AC water main, elevation of 205 feet. The model results indicate that the Setian Lane Tank is slowly refilling at the start of the fire flow and then drops a total of 0.5 feet from 329.5 to 329 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 330.5 feet and then stabilizes and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario although at a decreased rate during the 2-hour fire flow period. At the end of the fire flow it continues to refill to elevation 331 feet and cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-2005 – located on Centerville Road along a 12" AC water main, elevation of 100 feet. The model results indicate that the Setian Lane Tank is slowly refilling at the start of the fire flow and then drops a total of 0.5 feet from 329.5 to 329 feet during the span of the fire flow. The tank recovers over the next 2-hour period after the fire flow to elevation 330.5 feet and then stabilizes and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario although at a decreased rate during the 2-hour fire flow period. At the end of the fire flow it continues to refill to elevation 331 feet and cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The West Street Tank, Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

West Street Tank:

J-626 – located on West Street along a 16" AC water main, elevation of 245 feet. This tank is "locked up" during the span of the EPS and does not provide fire flow to this junction node. Upon reviewing the model results, it would appear that Setian Lane and Frenchtown Road tanks are affected by this fire flow. Setian Lane is slightly filling at the start of the fire flow however it then continues to drop approximately 0.2 feet during the 2 hour fire flow period from elevation 329.5 to 329.3 feet. At the end of the fire flow the tank refills and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario although at a decreased rate during the 2-hour fire flow period. At the end of the fire flow it continues to refill to elevation 331 feet and cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

J-7879 – located on Fairview Avenue along a 16" AC water main, elevation of 255 feet. This tank is "locked up" during the span of the EPS and does not provide fire flow to this junction node. Upon reviewing the model results, it would appear that Setian Lane and Frenchtown Road tanks are affected by this fire flow. Setian Lane is slightly filling at the start of the fire flow however it then continues to drop approximately 0.1 feet during the 2 hour fire flow period from elevation 329.5 to 329.4 feet. At the end of the fire flow the tank refills and continues to cycle within a normal range throughout the EPS. The Frenchtown Road Tank is refilling during the course of the fire flow scenario although at a decreased rate during the 2-hour fire flow period. At the end of the fire flow it continues to refill to elevation 331 feet and cycles within a normal range throughout the EPS. Both tanks operate at sufficient levels throughout the EPS. The Wakefield Street Tank and Fiskeville Reservoirs No. 1 and No. 2 are "locked up" throughout the span of the EPS. The Low Service tanks possess adequate fire reserve capacity to accommodate a fire flow rate of this magnitude.

Fiskeville Reservoirs No. 1 and No. 2:

J-5112 – located on Seven Mile Road along a 16" DI water main, elevation of 240 feet. The model results indicate that these tanks are "locked up" throughout the entire span of the EPS and do not provide the fire flow to this junction node. It is surmised that the Clinton Avenue Pump Station largely supplies the required fire flow at this location. The Setian Lane and Frenchtown Road tanks are somewhat affected by this fire flow. Frenchtown Road Tank is refilling at the beginning of the fire flow however the rate of refill is slowed during the course of the 2-hour fire flow period. At the end of the fire flow the tank continues to refill to elevation 331 feet and continues to operate within a normal range throughout the EPS. The model results show that the level of the Setian Lane Tank remains at a near constant elevation of 329.5 feet throughout the duration of the fire flow and at the end of the fire flow begins to refill to elevation 330 feet. The tank continues to cycle within a normal range throughout the EPS. The Wakefield Street Tank and the West Street Tank remain "locked up" throughout the span of the EPS.

J-6027 – located on Hope Avenue along a 16" AC water main, elevation of 222 feet. The model results indicate that these tanks are "locked up" throughout the entire span of the EPS and do not provide the fire flow to this junction node. It is surmised that the Clinton Avenue Pump Station largely supplies the required fire flow at this location. The Setian Lane and Frenchtown Road tanks are somewhat affected by this fire flow. Frenchtown Road Tank is refilling at the beginning of the fire flow however the rate of refill is slowed during the course of the 2-hour fire flow period. At the end of the fire flow the tank continues to refill to elevation 331 feet and continues to operate within a normal range throughout the EPS. The model results show that the level of the Setian Lane Tank remains at a near constant elevation of 329.5 feet throughout the duration of the fire flow and at the end of the fire flow begins to refill to elevation 330 feet. The tank continues to cycle within a normal range throughout the EPS. The Wakefield Street Tank and the West Street Tank remain "locked up" throughout the span of the EPS.

6.0 Summary

- Current consumer demands for the Authority's service territory have been categorized for each of the major pressure zones as depicted in the following table.

CURRENT CONSUMER DEMANDS BY PRESSURE GRADIENT

PRESSURE ZONE	AVERAGE DAY DEMAND (MGD)	MAXIMUM DAY DEMAND (MGD)	PEAK HOUR DEMAND (MGD)
Low Service (334') Gradient	7.27	13.98	16.18
High Service (500') Gradient	2.94	5.59	7.30
Read School House Road (500') Gradient	0.40	0.81	0.92
TOTALS	**10.61 MGD**	**20.38 MGD**	**24.40 MGD**

- For purposes of this analysis of this evaluation, the Oaklawn Pressure Gradient (232') was not included in the tank capacity analysis as this Gradient is supplied directly through a wholesale interconnection with Providence Water. Consideration should be given to providing a backup or emergency connection from the Authority system to service this area in the event of emergency. This would include the addition of a PRV station in order to reduce the hydraulic grade from 334 to 232 feet.

- The storage tank facilities in each of the major pressure zones were evaluated with regard to components of storage and associated volume totals were developed for each tank facility. The storage volume component assessment was based on maintaining a water elevation in the storage tank that would supply a minimum pressure of 35 psi (Authority Standard) at the highest customer service elevation and a minimum pressure of 20 psi (AWWA and NFPA standard) for fire flow and emergency storage. This was also premised on maintaining adequate storage volumes in the storage tank(s) that would ensure sufficient capacity to meet normal daily (operational storage) and peak system demands (equalization storage). The maximum customer serviceable elevations were determined as the following.

MAXIMUM CUSTOMER SERVICEABLE ELEVATION BY PRESSURE GRADIENT

PRESSURE ZONE	35 PSI SERVICE ELEVATION	TANK(S) OVERFLOW ELEVATION
Low Service (334') Gradient[1]	244 feet	334 feet
High Service (500') Gradient[2]	405 feet	500 feet
Read School House Road (500') Gradient	405 feet	500 feet

[1]Includes Low Service Reduced Gradient and Hope Road Gradient
[2]Includes High Service Reduced Gradient and Tiogue Tank Service Area

There do exist customer services within the pressure gradients, which are above these elevations and have pressures below 35 psi. These include areas that have marginal pressure (20 psi and less) and areas that have pressures below the 35 psi regulatory standard of the Authority Regulations when Clinton Avenue Pump Station is in operation. It should be noted that all the identified locations may not directly impact service customers as these locations could occur at high points along transmission mains with no services, areas around storage reservoirs, suction side of booster pump stations and upstream side of PRV stations. These locations are depicted on a system map in Enclosure No. 1

LOCATIONS IN SYSTEM WITH PRESSURES BELOW 20 PSI

SERVICE PRESSURE ZONE	STREET	LOCATION/APPROXIMATE INTERSECTION	ELEVATION RANGE (FEET)	CALCULATED PRESSURE	CUSTOMER SERVICE (Y/N)
Low	Cowesett Road	Fairgreen Drive to Kulas Road	206 - 280	19 psi – 20 psi	Y
Low	East Greenwich Avenue*	Juniper Drive to Setian Lane	259 - 295	15 psi – 32 psi	N
Low	South County Trail*	EG Medical Center to Pine Glen Drive	249 - 303	11 psi – 34 psi	Y

Low	Signal Ridge Way	Boulder Way to Division Street	270 - 290	17 psi – 27 psi	Y
Low	Arnold Road*	Larch Drive to Acorn Street	228 - 280	18 psi – 34 psi	Y
Low	Lane A	Morningside Drive to Lane E	250 - 294	16 psi – 29 psi	Y
Low	Tiogue Avenue*	Jennifer Lane to Holloway Avenue	264 - 301	12 psi – 28 psi	Y
Low	Knotty Oak Road	Maple Street to Long Pond Road	273 - 302	14 psi – 34 psi	N
Low	Knotty Oak Road	White Rock Drive to Highwood Drive	279 - 315	9 psi – 24 psi	N
Low	Knotty Oak Road	Gervais Street to Oak Way	300	12 psi – 16 psi	N

LOCATIONS IN SYSTEM WITH PRESSURES BELOW 35 PSI

SERVICE PRESSURE ZONE	STREET	LOCATION/APPROXIMATE INTERSECTION	ELEVATION RANGE (FEET)	CALCULATED PRESSURE	CUSTOMER SERVICE (Y/N)
Low	New London Avenue	Factory Street to Iron Drive	231 - 261	28 psi – 34 psi	Y
Low	Macarthur Boulevard	Yates Avenue to Knight Street	245 - 273	25 psi – 31 psi	Y
Low	Beauchene Street	East Street to West Street	170 - 270	25 psi	Y
Low	Laurel Avenue	Pilgrim Avenue to Princeton Avenue	228 - 267	28 psi – 34 psi	Y
Low	Cowesett Road	Church Street to Narragansett Avenue	235 - 260	29 psi – 34 psi	Y
Low	Major Potter Road*	Quaker Lane to Eagle Run	265	29 psi	N
Reduced Low	Windermere Way	Love Lane to Lantern Lane	180 - 205	30 psi – 34 psi	Y
Reduced Low	Love Lane*	Overhill Road to Cedar Street	204 - 205	27 psi – 29 psi	Y
Low	Division Street	Brooks Pharmacy Headquarters to Old Quaker Lane	243 - 275	25 psi	Y
Low	Mayflower Drive	Crest Ridge Drive to Bunker Hill Lane	170 - 201	29 psi – 34 psi	Y
Low	Frenchtown Road*	Cardinal Lane to High Hawk Road	266 - 276	24 psi – 29 psi	N
Low	Lynn Circle	Darl Court to Fernwood Drive	230 - 280	22 psi – 34 psi	Y
High	Carr Pond Road*	Carr Pond Tank to Deer Run Drive	410 - 430	28 psi – 30 psi	Y

Low	Greenbush Road	New London Turnpike to Bratt Lane	255 - 280	22 psi – 33 psi	N
Low	Nooseneck Hill Road	Reservoir Road to Comfort Way	256 - 282	23 psi – 34 psi	Y
Low	Main Street (COV)	Battey Avenue to Sandy Bottom Road	234 - 255	34 psi	Y
Low	Hope Furnace Road	Howard Avenue to Colvintown Road	249 - 270	31 psi	Y
Low	Blackrock Road*	Gervais Street to Country View Drive	250 - 270	29 psi	N
Low	North Road	White Lane to Blossom Lane	240 - 271	31 psi – 32 psi	Y
Low	Cranberry Drive	Mitchell Way to Kerri Court	240 - 276	29 psi	Y
Low	Fairview Avenue	Spencer Street to Marshall Circle	235 - 272	24 psi – 34 psi	Y
Low	Phenix Avenue	Harding Street to Garnet Street	245 - 273	26 psi – 33 psi	Y
Low	River Run	Rosewood Court to Quail Court	249 - 260	31 psi – 32 psi	Y
Reduced High	Nooseneck Hill Road	Brant Trail to End of KCWA System	300 - 354	34 psi	Y
Low	Hornbeam Road	Mountain Laurel Drive to Hawthorne Road	250 - 260	34 psi	Y
Low	Hornbeam Road	Mountain Laurel Drive to Hawthorne Road	232 - 265	31 psi	Y

* Denotes area of low pressure that consists of a transmission main, area near storage reservoir, suction side of booster pump station.

- The operation of the Clinton Avenue Pump Station on a near continual basis creates difficulties with operation of several storage tank facilities in the Low Service Gradient. This predominately relates to the inability of these storage tank facilities to turn over and they routinely remain in a "locked up" condition due to the pump head from the pump station, which is above the overflow of these tanks. It is also recognized that there is an inherent need to operate Clinton Avenue in this mode primarily due to the necessity to maintain adequate pressures at higher customer service elevations, to provide upwards of 70% of water supply to the entire system, the need to replenish distant water storage tanks in the Low Service Gradient and to provide supply to booster pump stations and PRV stations that supply other pressure gradients that rely on the Low Service Gradient as the primary source of supply.

- It is recommended that the Fiskeville Reservoirs in the Low Service Gradient be permanently removed from service as these storage facilities are maintained in a continued "locked up" condition due to their proximity to the Clinton Avenue Pump Station. Due to their location at the extreme northern end of the system and the inherent problems associated with maintaining sanitary conditions for below grade structures, it is not considered practical to maintain these facilities in operational service. Additionally, these facilities predated the construction of the Clinton Avenue Pump Station and have become "obsolete" over the years as the distribution system and customer has grown and expanded. It is likely that the general service area surrounding these reservoirs will be re-serviced from the High Service Gradient, which will assist in alleviating low pressures in this portion of the system.

- The West Street and Wakefield Street Tanks are also routinely maintained in a "locked up" condition due to their proximity to the Clinton Avenue Pump Station.
  - The West Street Tank was constructed in 1956 and was completely rehabilitated in 2002. As it remains in a constant "locked up" condition, it is not considered significant to the daily operation of the water system. It is however considered significant in terms of available fire and emergency storage due largely in part to its location in the system which includes proximity to densely populated urban areas and mill complexes.
  - The Wakefield Street Tank was constructed in 1990 and is in good condition. This tank is beneficial in supplying daily peak system demands and fire and emergency storage. With the addition of new pipeline infrastructure associated with the new Providence Water emergency connection, it is anticipated that this tank may remain in a "locked up" condition on a frequent basis. The new pipelines will increase the flow of water from Clinton Avenue Pump Station to the general area and the pump head will influence the tank.

Due to the importance of these tank facilities, it is recommended that alternatives be evaluated to maintain these facilities in operation while promoting tank cycling or turnover. Potential methods include booster pump stations (West Street Tank) and valve stations to isolate the tank (Wakefield Street Tank). These methods will be further evaluated in the CIP.

- Based on these established customer service elevations, the volumes for the various storage components for each of the storage tanks were calculated. The various components of storage are summarized for each pressure zone as follows. This includes removing the Fiskeville Reservoirs from service.

SYSTEM STORAGE TANKS – TOTAL COMPONENT VOLUMES

PRESSURE GRADIENT	EFFECTIVE STORAGE (MG)	OPERATIONAL STORAGE (MG)	EQUALIZATION STORAGE (MG)	FIRE RESERVE & EMERGENCY STORAGE (MG)	"DEAD" STORAGE (MG)
Low Service (334') Gradient	5.295	1.123	1.123	4.172	1.046
High Service (500') Gradient	2.748	0.350	0.770	2.173	1.171
Read School House Road (500') Gradient	0.900	0.300	0.600	0.600	0

- Historical tank charts indicate that the Authority is capable of maintaining a water level in each of the storage tanks within the ranges as indicated for maintaining an adequate consumer system pressure of 35 psi and a fire flow pressure of 20 psi for the serviceable elevations in each pressure zone. Reference Figures 2 – 9 that graphically portray the various components of storage for each tank facility.

- The measure of the sufficiency of the equalization storage component (i.e. volume in tank dedicated to meeting peak demands that are in excess of the supply capacity) was premised on maintaining 25 percent of the average day demand. This is a general water works standard and needs to be combined with additional evaluation such as extended period hydraulic modeling and review of tank charts to ensure that the storage tanks fill and drain at acceptable rates and maintain adequate water elevation under all demand conditions. In other words, having the 25 percent volume of average day demand in equalization storage does not in of itself ensure that a particular storage facility is sufficient in size or capacity. Similarly, not having 25 percent volume of average day demand in equalization storage does not necessarily indicate that a particular tank is insufficient in size or capacity.

- An assessment of the total equalization storage from each of the storage facilities in the major pressure zones was performed. The Low Service Gradient tanks in total (without Fiskeville Reservoirs) provide 15 percent of the average day demand while the High Service Gradient tanks provide 26 percent and the Read School House Road Gradient provides 150 percent. In terms of the water works standard, the Read School House Road and High Service Gradients have in excess of the 25 percent storage capacity of equalization storage with the Read School House Road gradient having well in excess. The Low Service Gradient in terms of this standard is considered deficient in that the storage tanks supply only 15 of the recommended 25 percent standard.

- Extended period model simulations for average and maximum day (with peak hour demand) indicate that the system's storage tanks operate within a range defined for operational and equalization storage. Equalization storage is primarily drawn upon when the demands exceed the supply capacity of the system. For all scenarios there were no instances under which the dedicated volume for fire and emergency storage protection was depleted. It is concluded that the Low Service Gradient storage tanks while only providing 15 of the recommended 25 percent volume average day demand in equalization storage are not adversely affected in this regard.

- Each of the system's storage tanks (excluding Fiskeville Reservoirs) has adequate fire reserve at an elevation such that 20 psi minimum is maintained for a fire flow rate of 3,500 gpm for a duration of three hours which equates to a total volume of 630,000 gallons.

- Although there is no standard or regulation that indicates that water storage facilities should "turn over" the water volume on a periodic basis, it is generally recognized by the water works industry that this must occur at regular intervals. This practice, which is enhanced by internal tank mixing, will assist in maintaining water quality and avoid potential water quality issues such as chlorine decay, color, odor, and taste. At a minimum, it recommended that each storage tank turn over its volume every 5 – 7 days. This will also depend on seasonal factors during which periods of increased demand will create a greater drawdown in the tanks to meet peak demand periods. Factors such as stratification, common inlet / outlet, "dead" zones, poor circulation and low demand periods will all contribute to poor efficiency in tank turn over.

- The combination of all storage tanks in the system provides a total emergency storage volume of 2.57 MGD, which is approximately 24% of the overall average day system demand of 10.61 MGD. This is premised on maintaining the fire flow volume of 630,000 gallons within each tank and does not include "dead" storage, which is not available to the system at a minimum of 20 psi. The volume of emergency storage that a particular water system maintains is usually a function of the perceived "emergency". A general rule is that a water system without sufficient redundant source of supply should maintain at minimum one day's volume of average day demand. Water systems with backup or redundant sources of supply often rely on a considerable less volume for emergency storage.

  In this case, the Authority relies upon the connection with Providence Water at Clinton Avenue Pump Station to supply the majority (upwards of 70 percent) of water supply to the system. Disruption of this supply connection would severely hamper the supply capability of the water system. There is however alternate existing sources of supply available to the District, which could be relied upon to provide water to the system in an emergency situation and assuming that water use restrictions would be put in place. These include the well facilities (East Greenwich, Spring Lake and Mishnock) and the Quaker Lane Pump Station (wholesale supply from Warwick Water) and which collectively would have the ability to meet system average day demand.

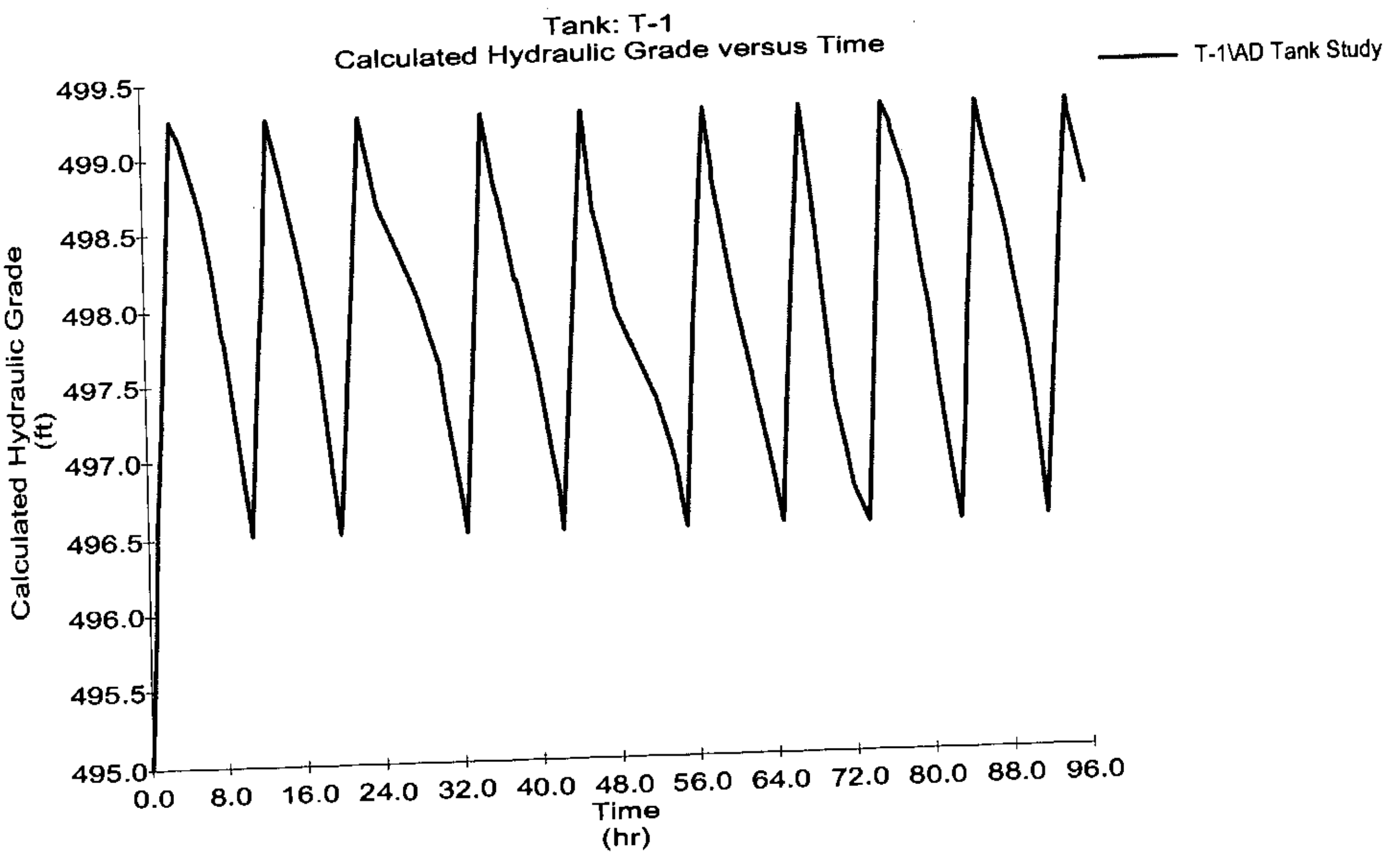
It is therefore considered that the Authority has emergency supply source capability, which has a greater value on a day-to-day basis in the case of emergency than a distinct volume of water in storage tanks, which would be readily depleted in an emergency. It is therefore considered that Authority has a greater benefit in redundant supply sources than any available emergency storage in the tanks and that the 24 percent volume of emergency storage to average day demand is sufficient.

ATTACHMENT NO.1

EXTENDED PERIOD SIMULATION
AVERAGE DAY DEMAND
STORAGE TANK GRAPHS

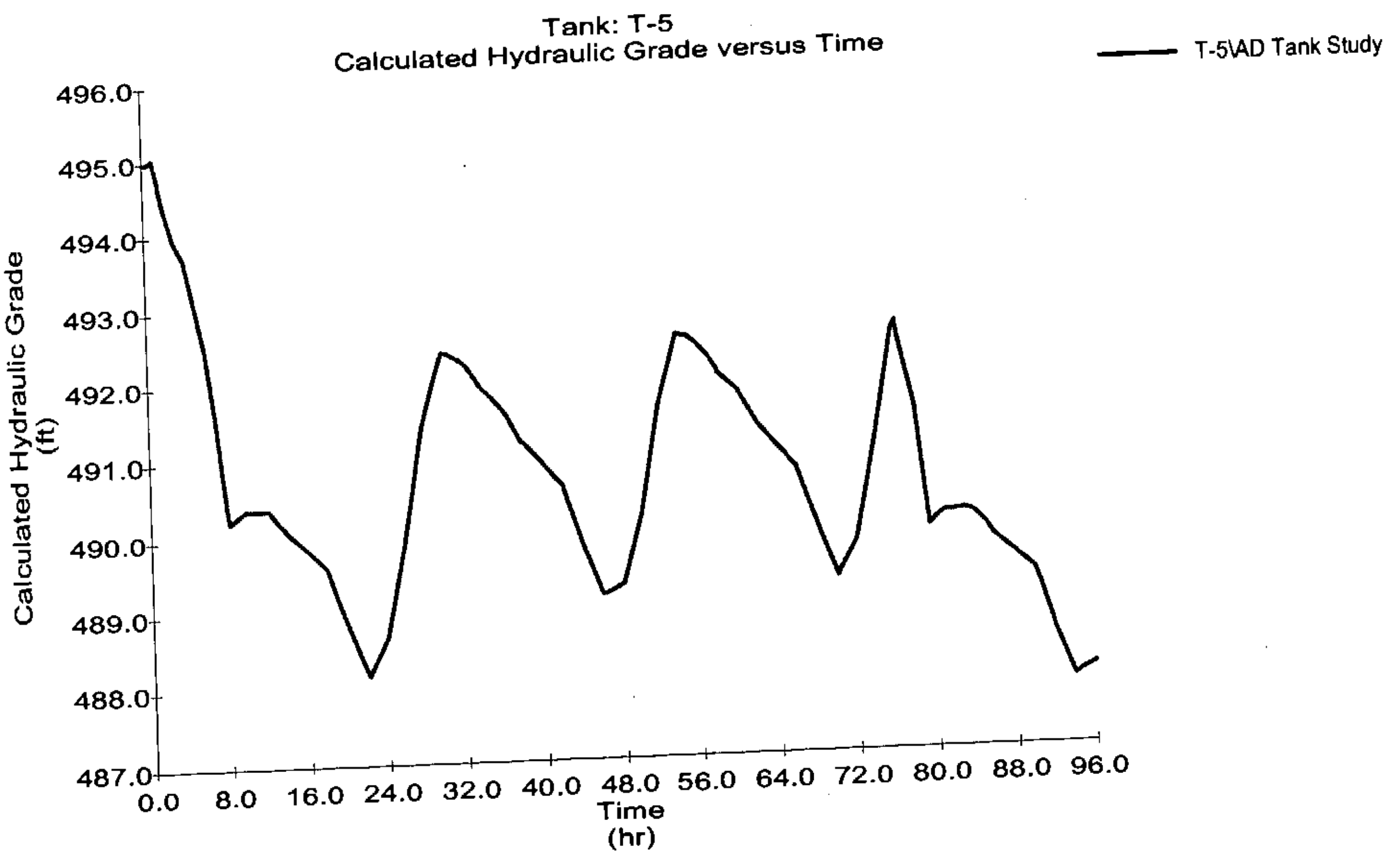
Graph

Read School House Road Tank



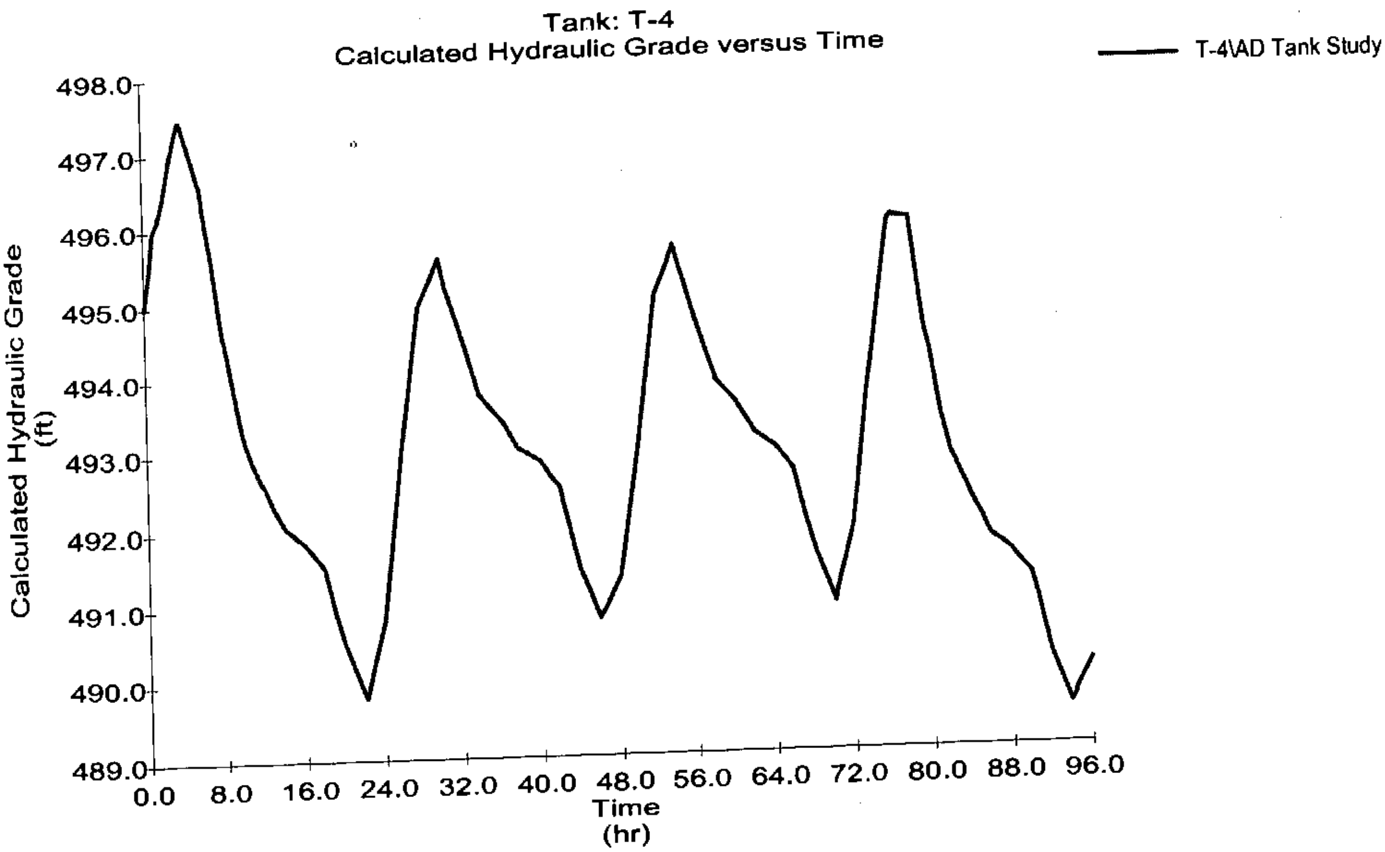
Graph

Carrs Pond Road Tank



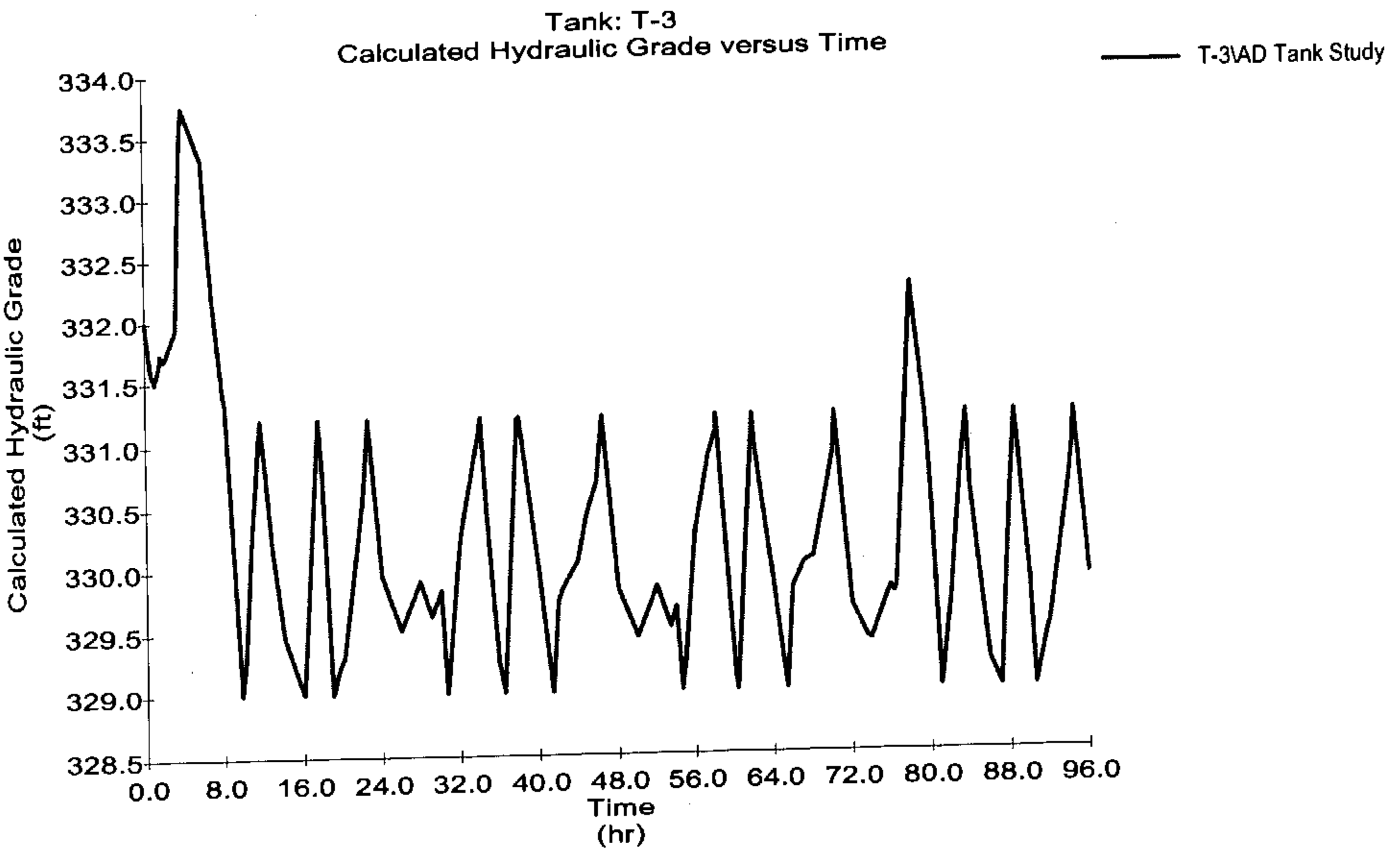
Graph

Technology Park Tank



Graph

Frenchtown Road Tank



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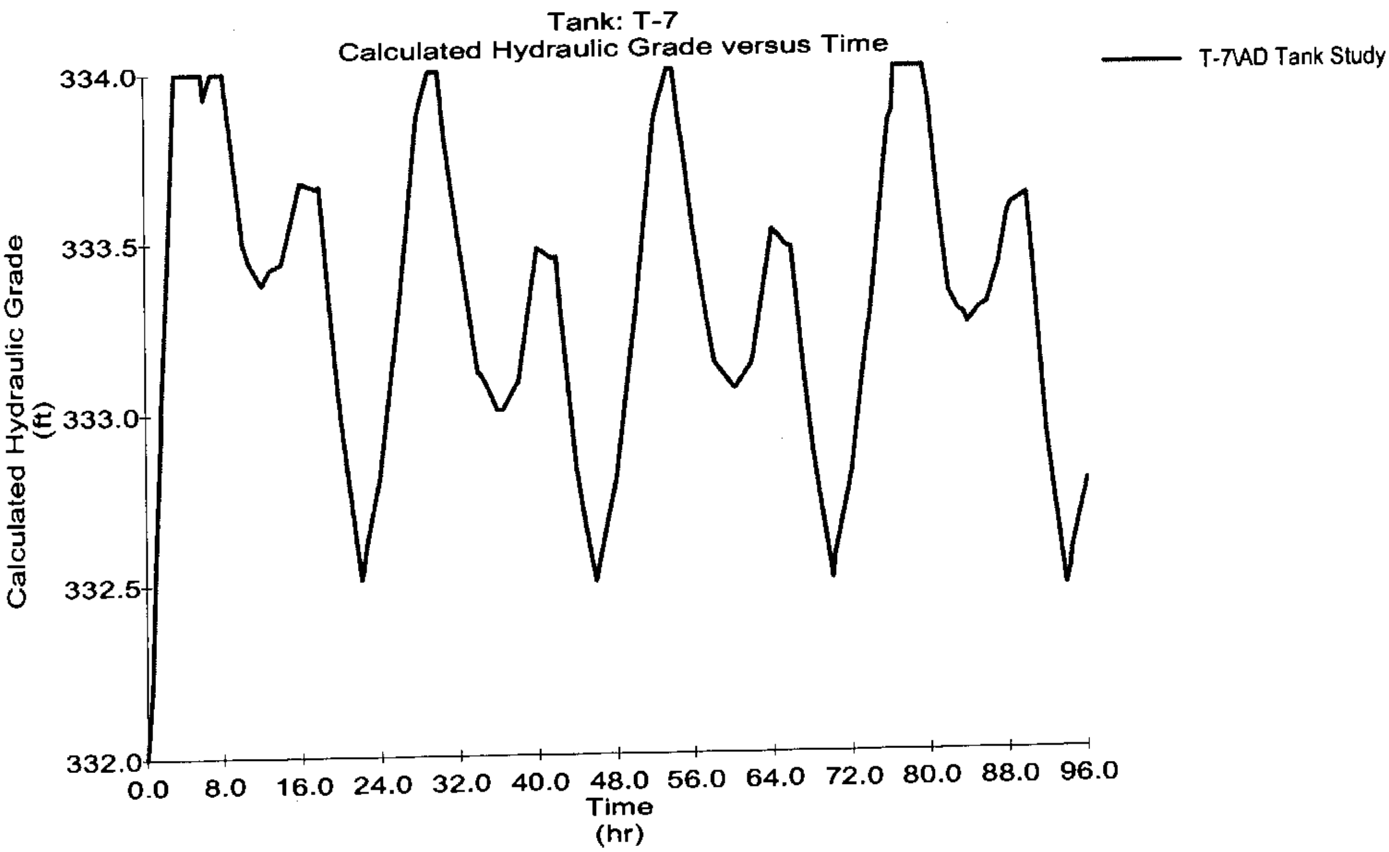
Setian Lane Tank



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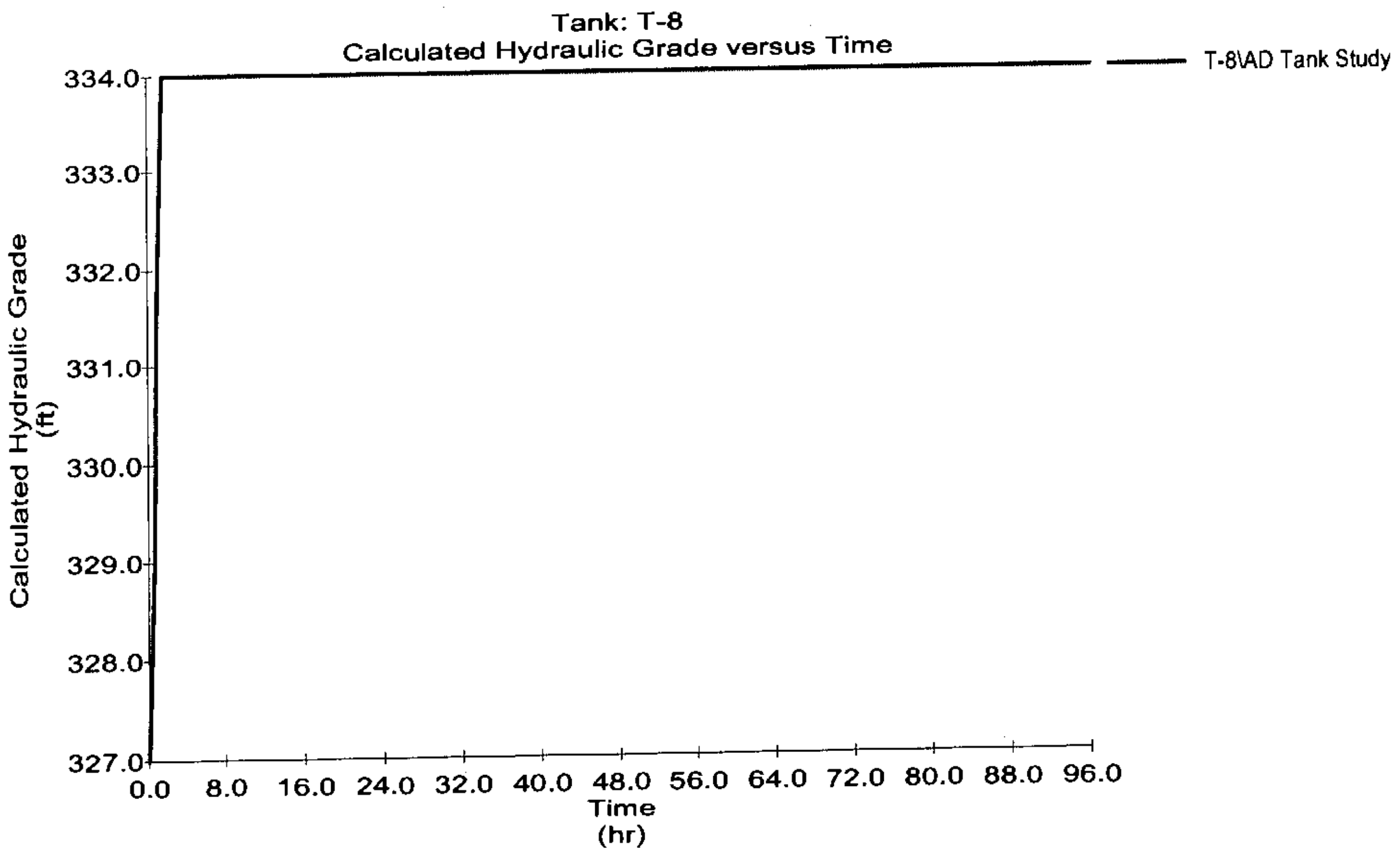
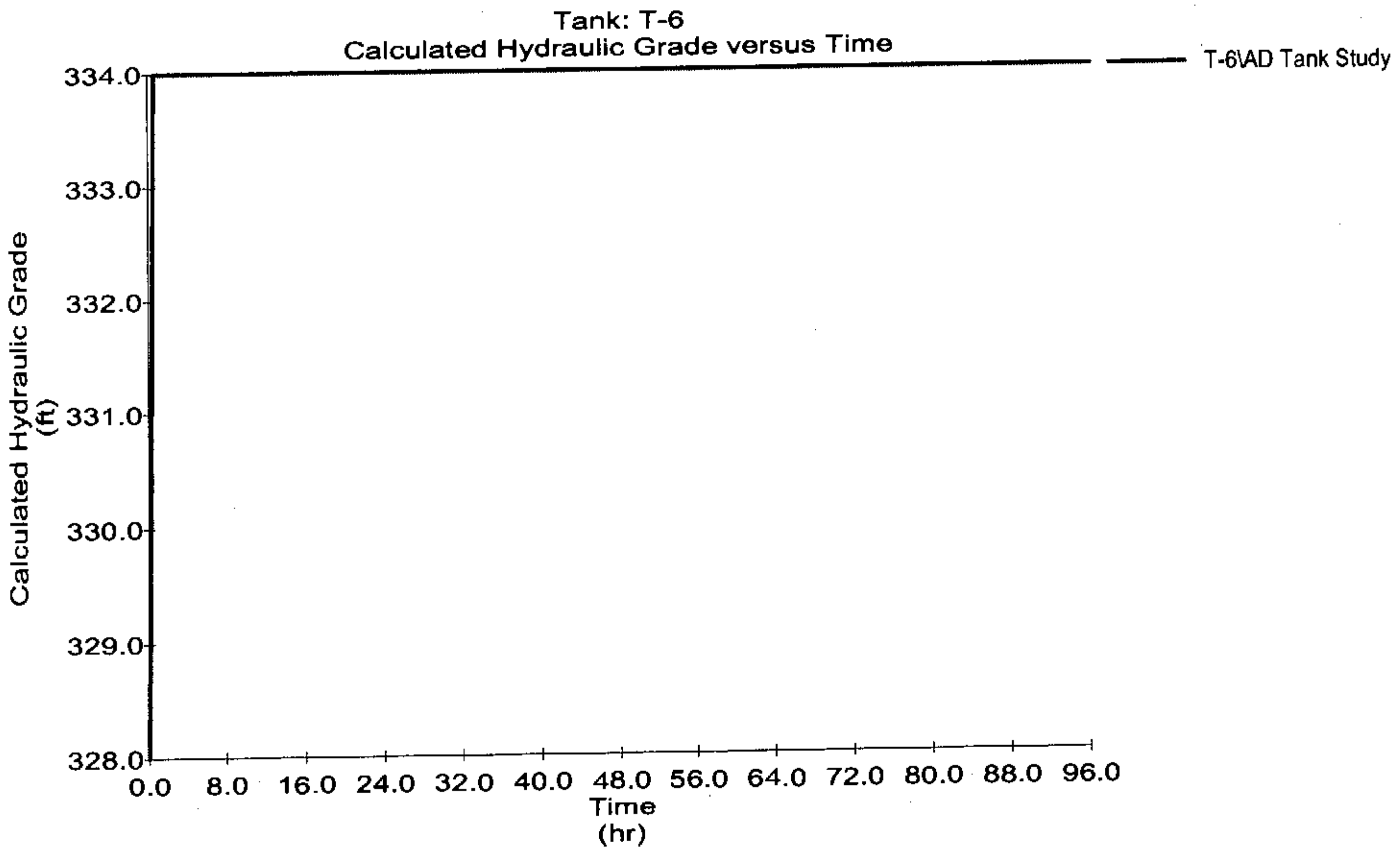
Wakefield Street Tank



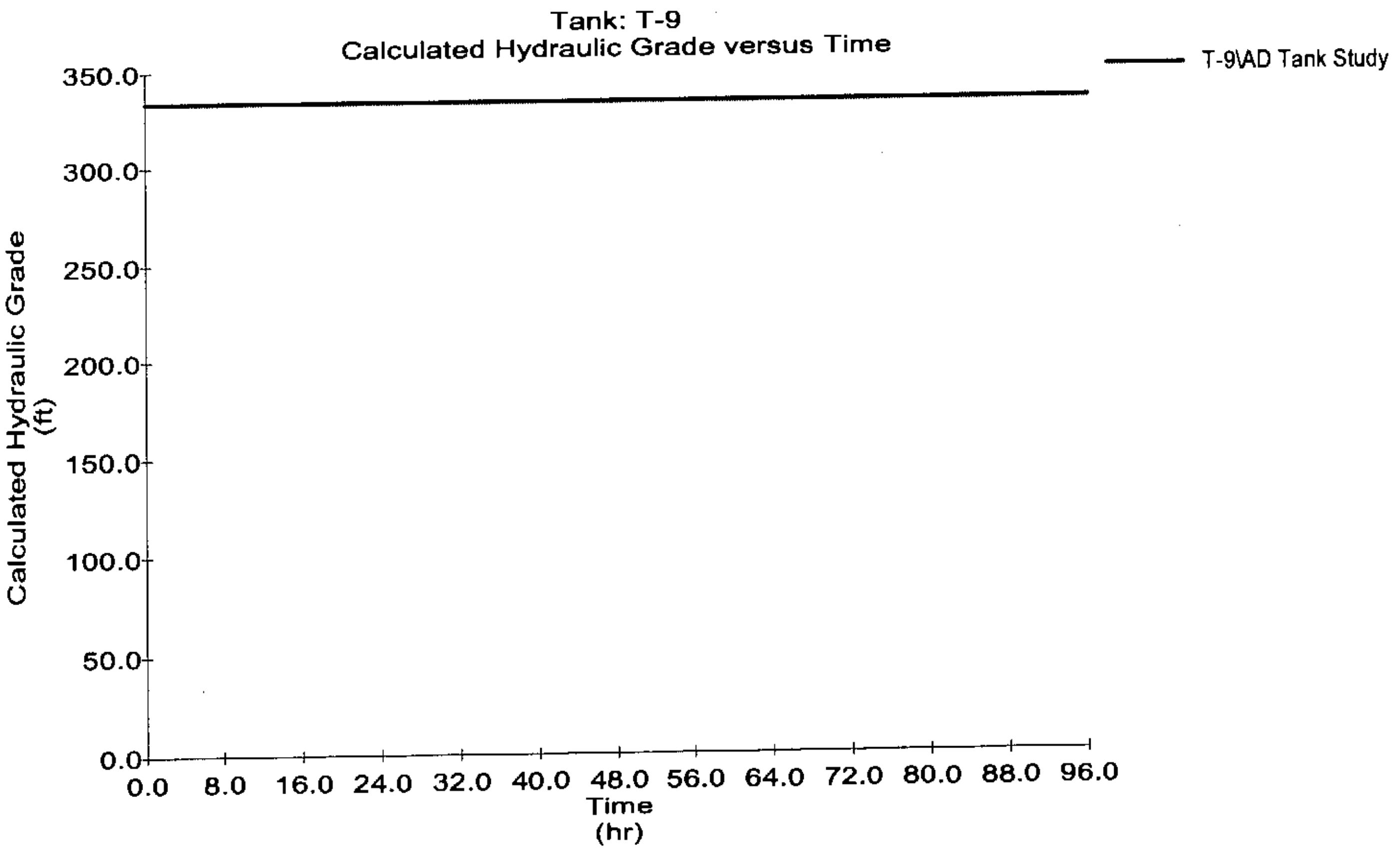
Graph

West Street Tank



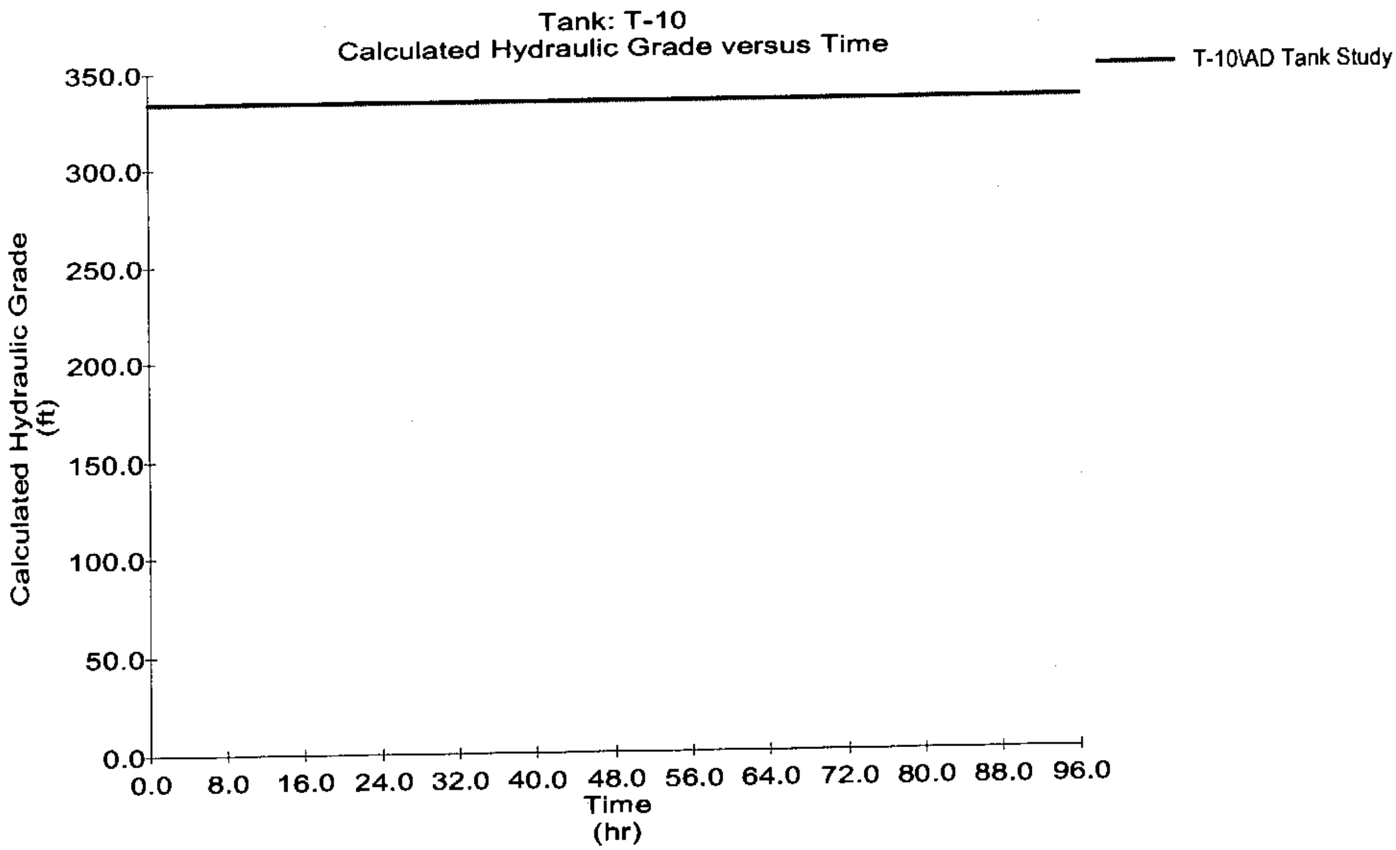
Graph

Fiskeville Reservoir #1



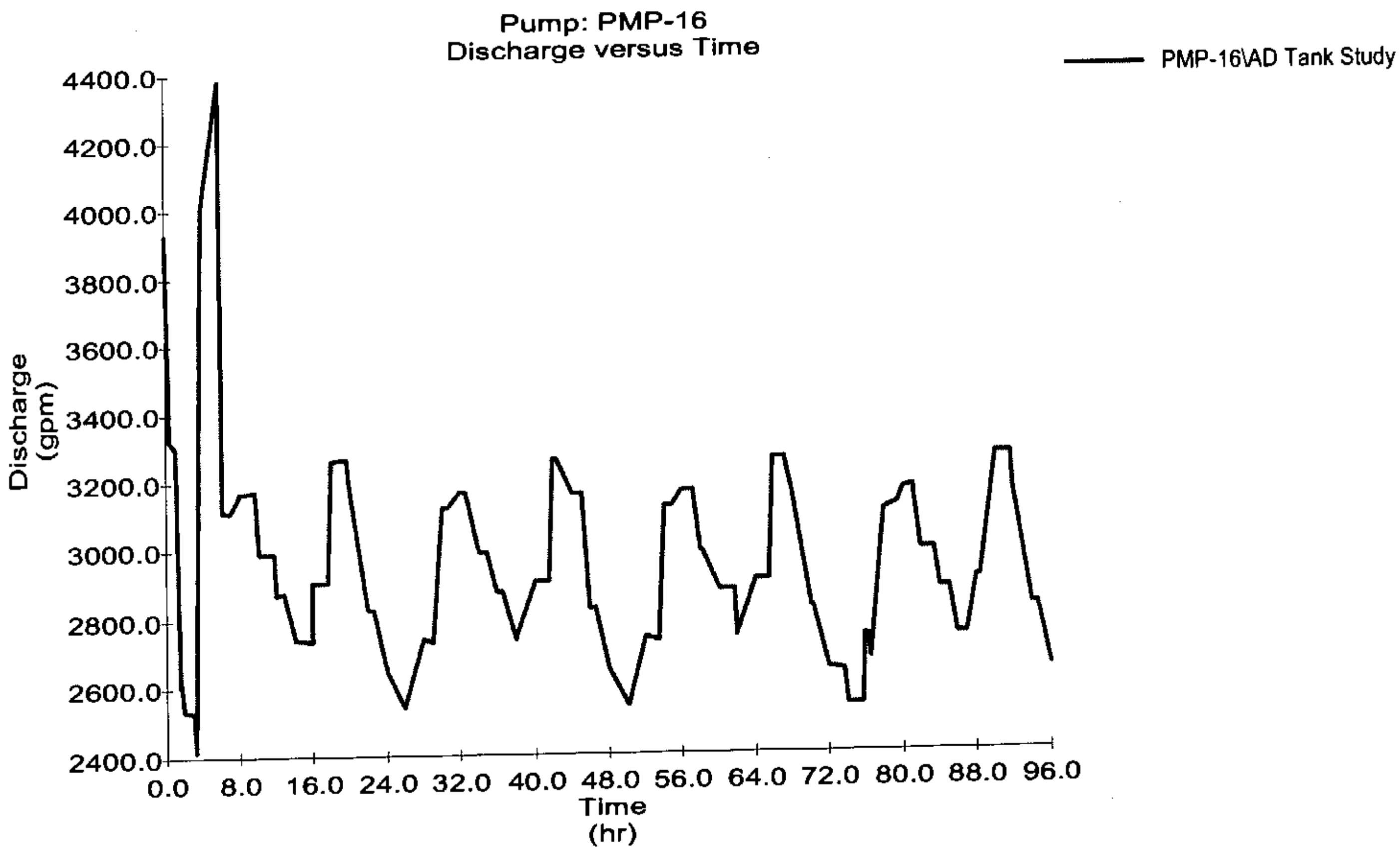
Graph

Fiskeville Reservoir #2



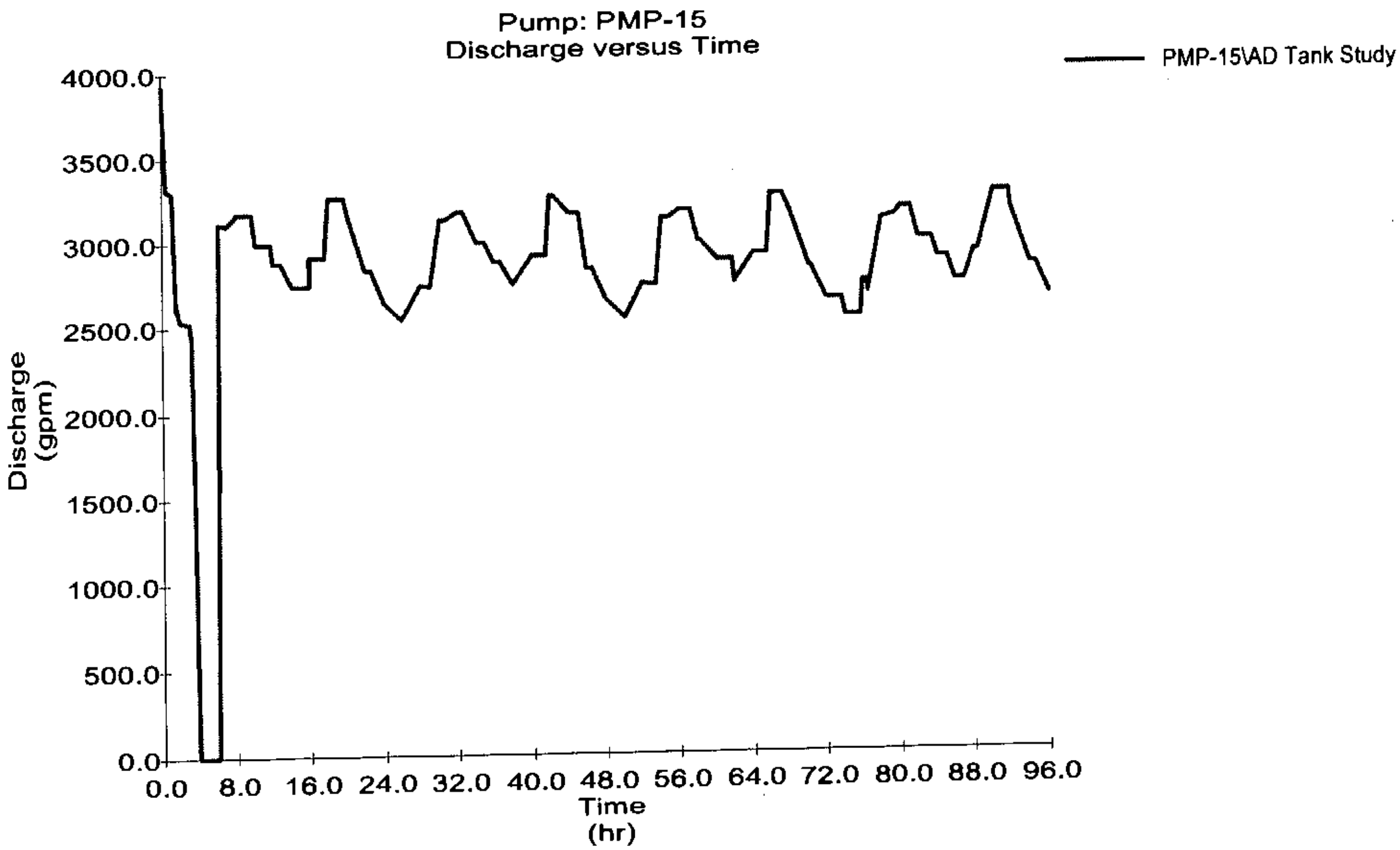
Graph

Clinton Avenue Pump#1



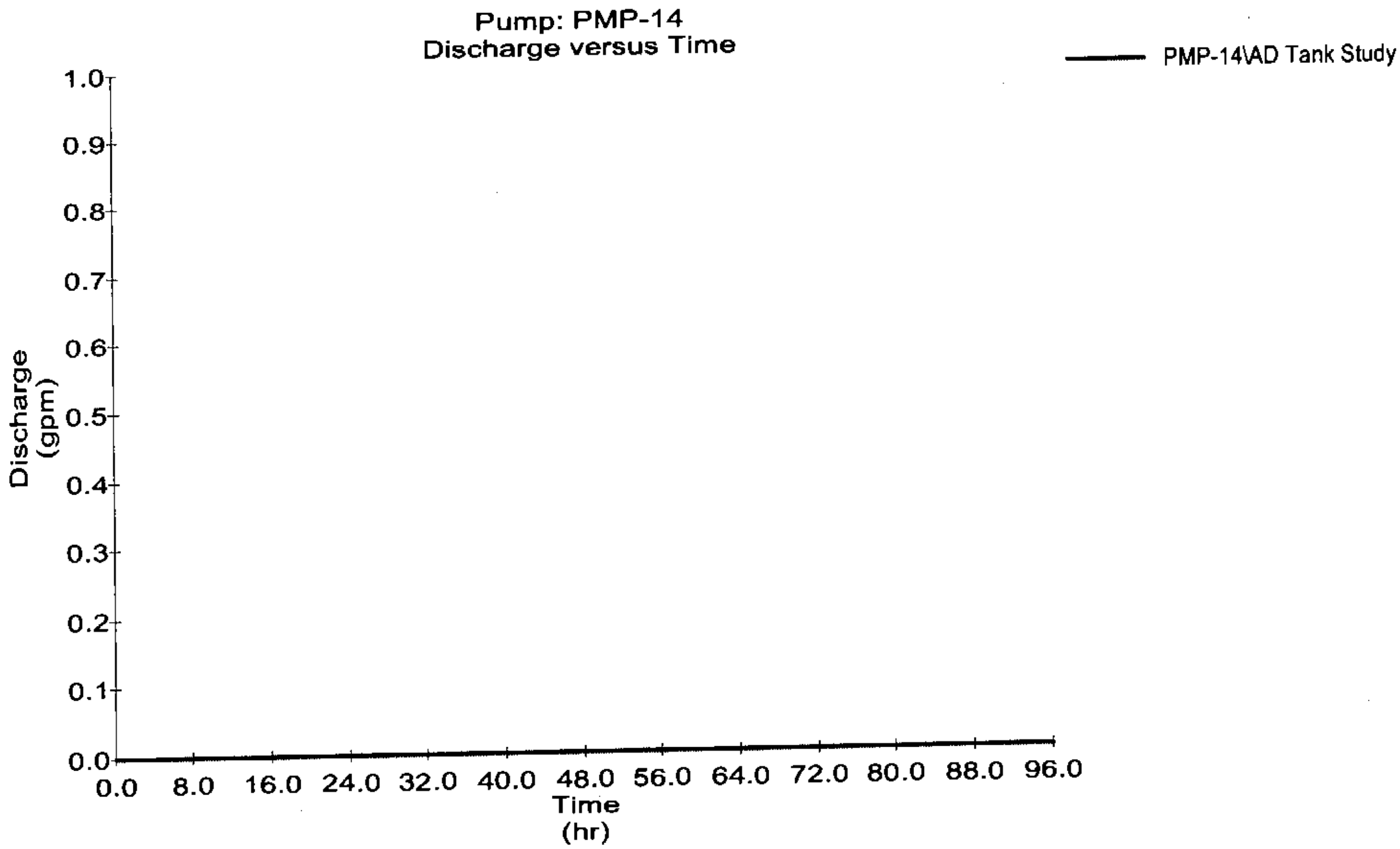
Graph

Clinton Avenue Pump #2



Graph

Clinton Avenue Pump #3

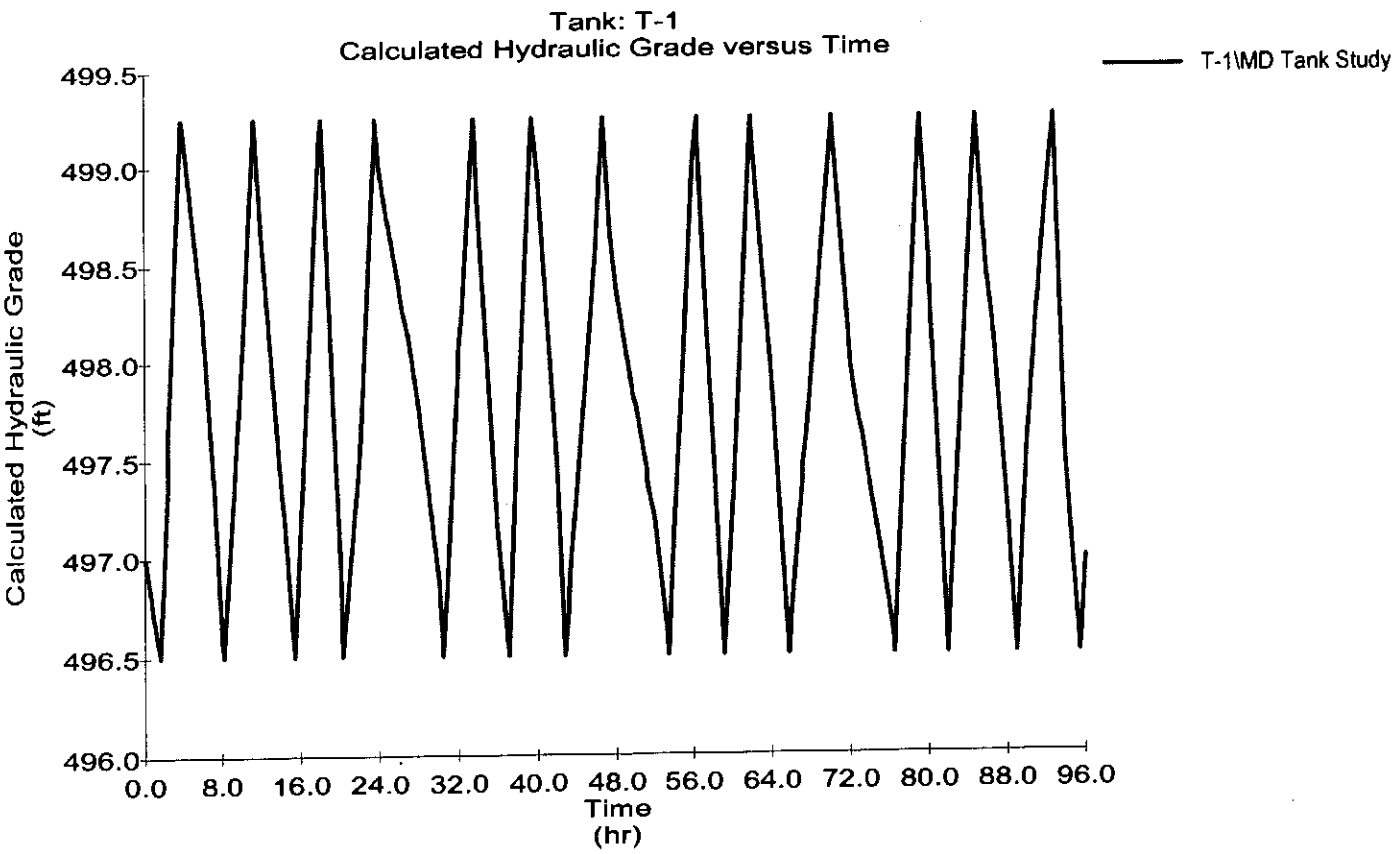


ATTACHMENT NO.2

EXTENDED PERIOD SIMULATION
MAXIMUM DAY DEMAND
STORAGE TANK GRAPHS

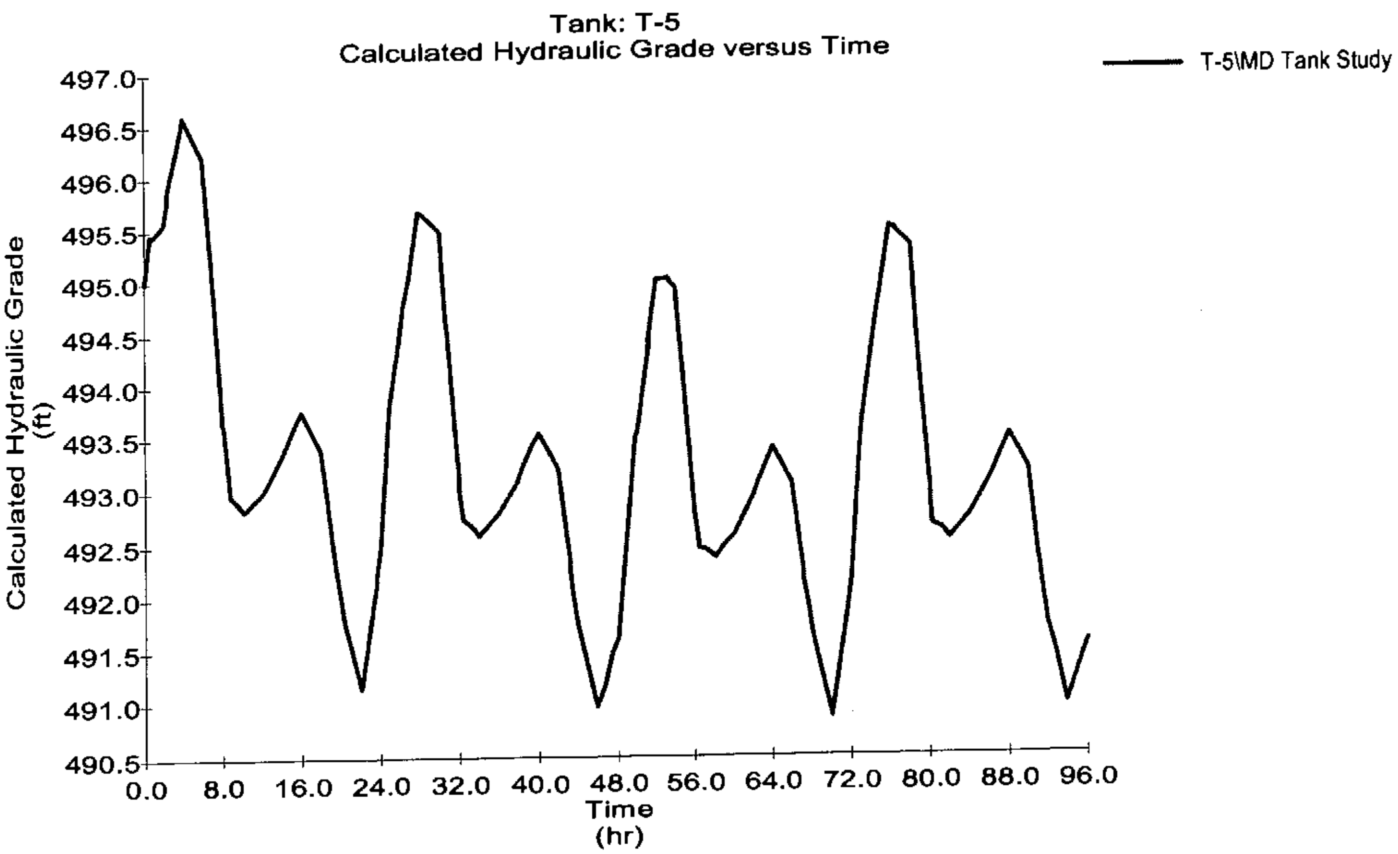
Graph

Read School House Road Tank



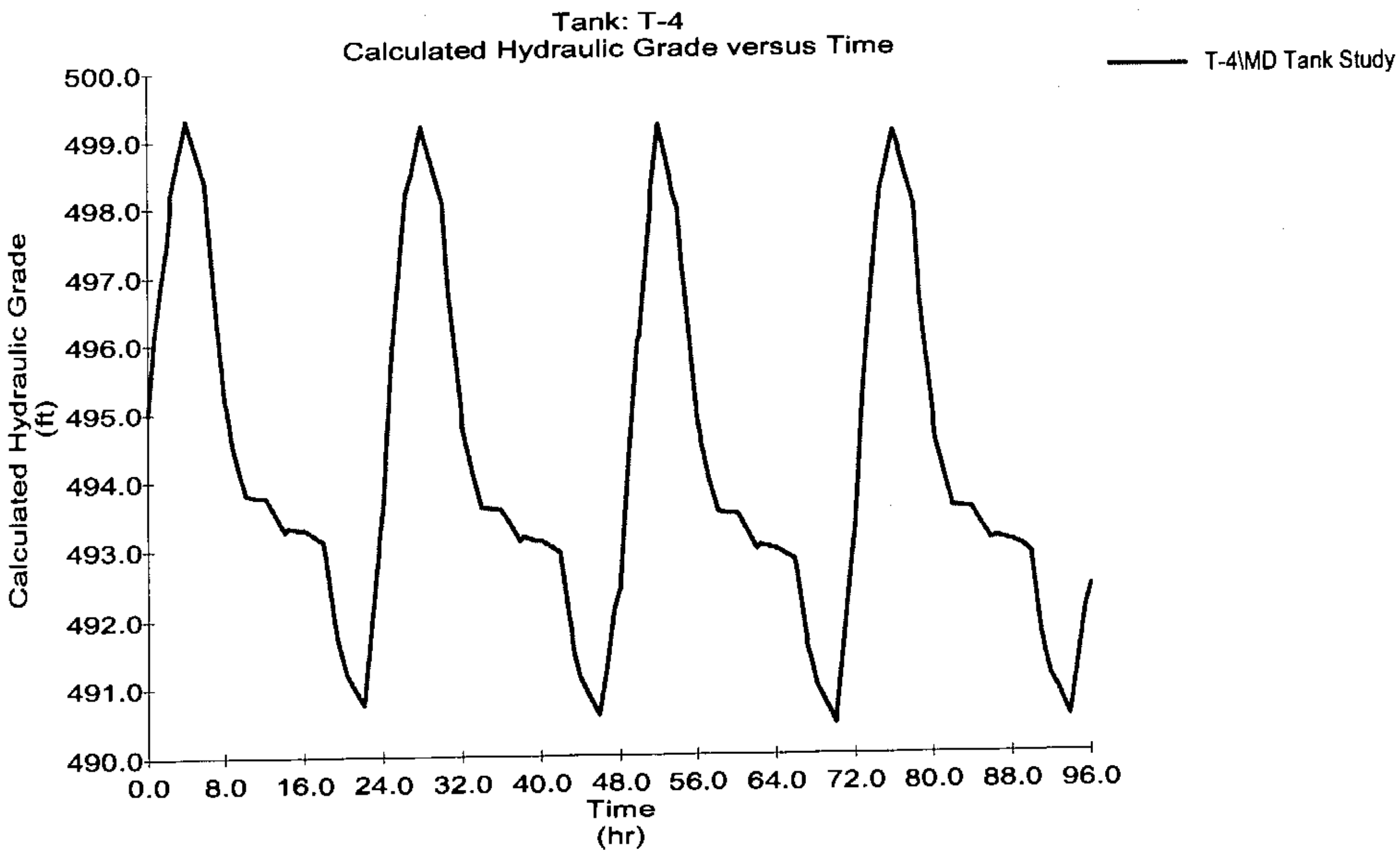
Graph

Carrs Pond Road Tank



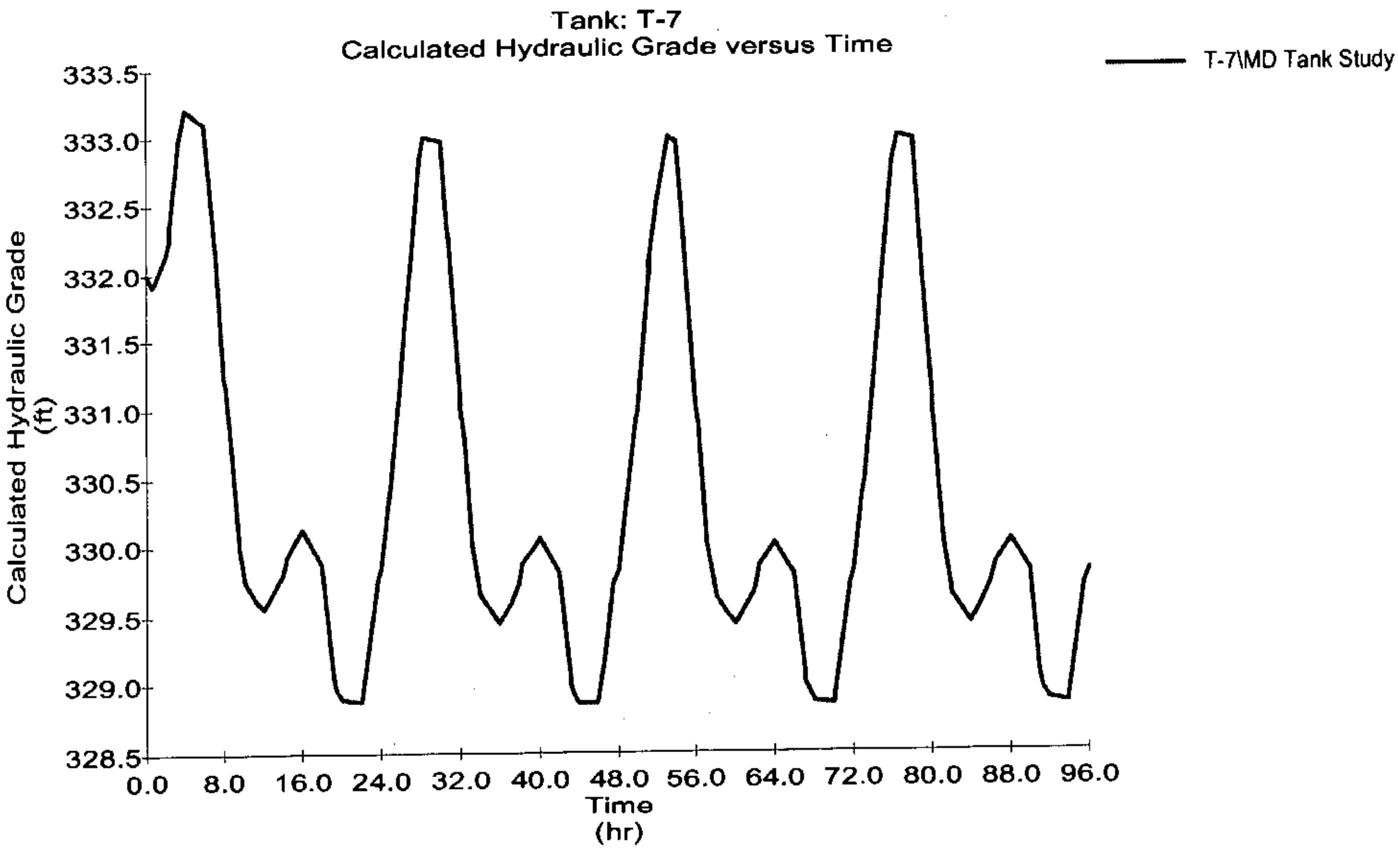
Graph

Technology Park Tank



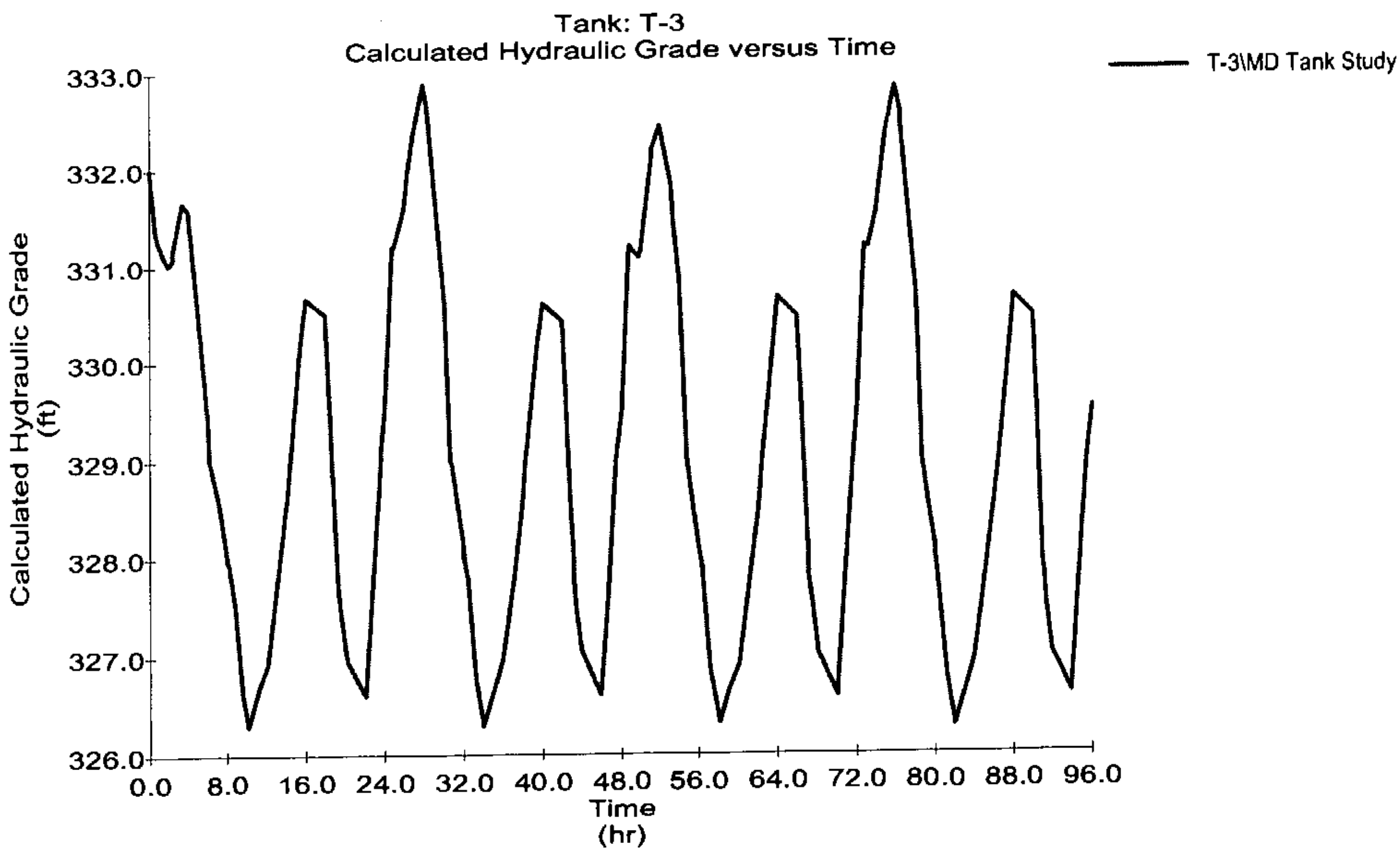
Graph

Setian Lane Tank



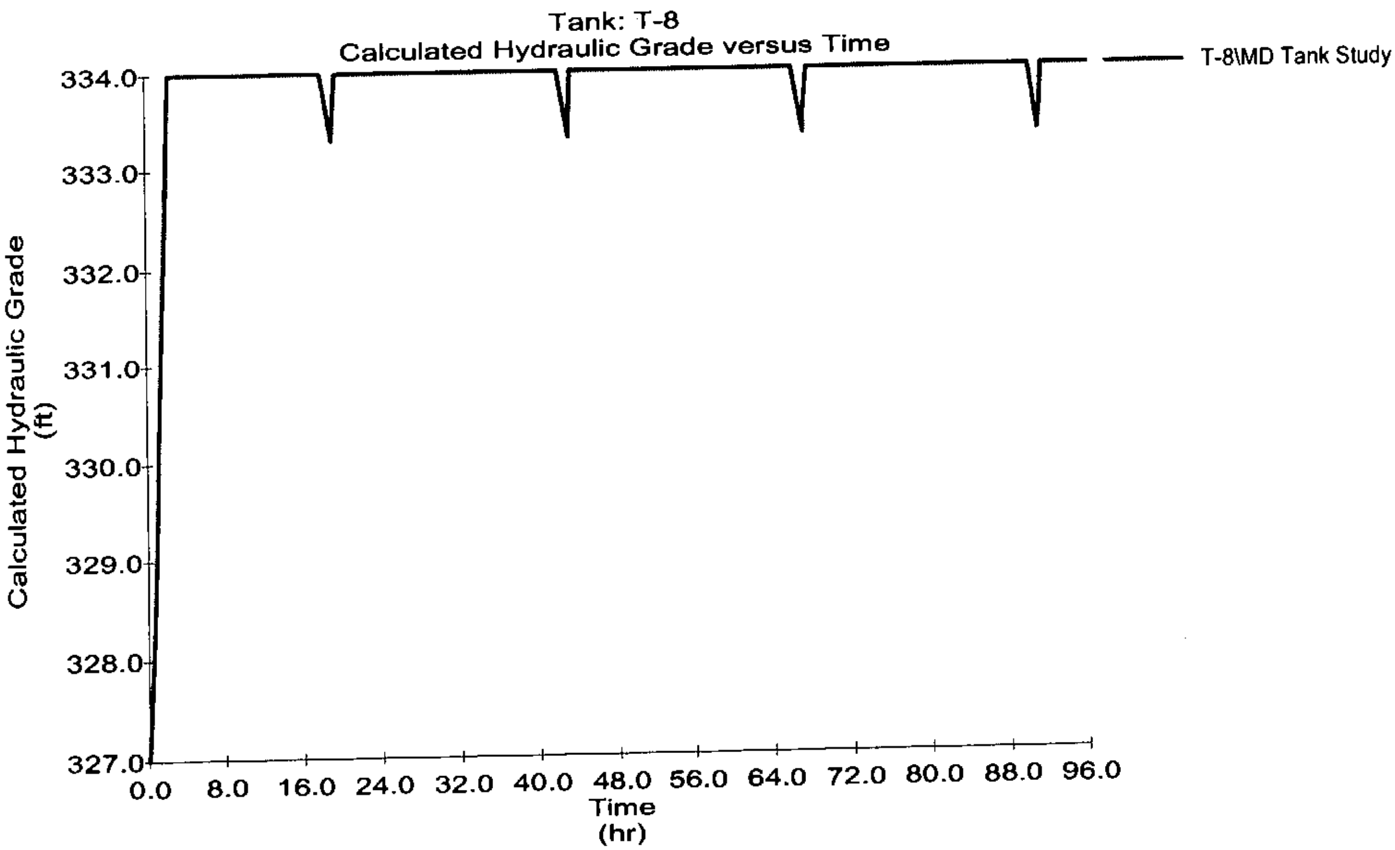
Graph

Frenchtown Road Tank



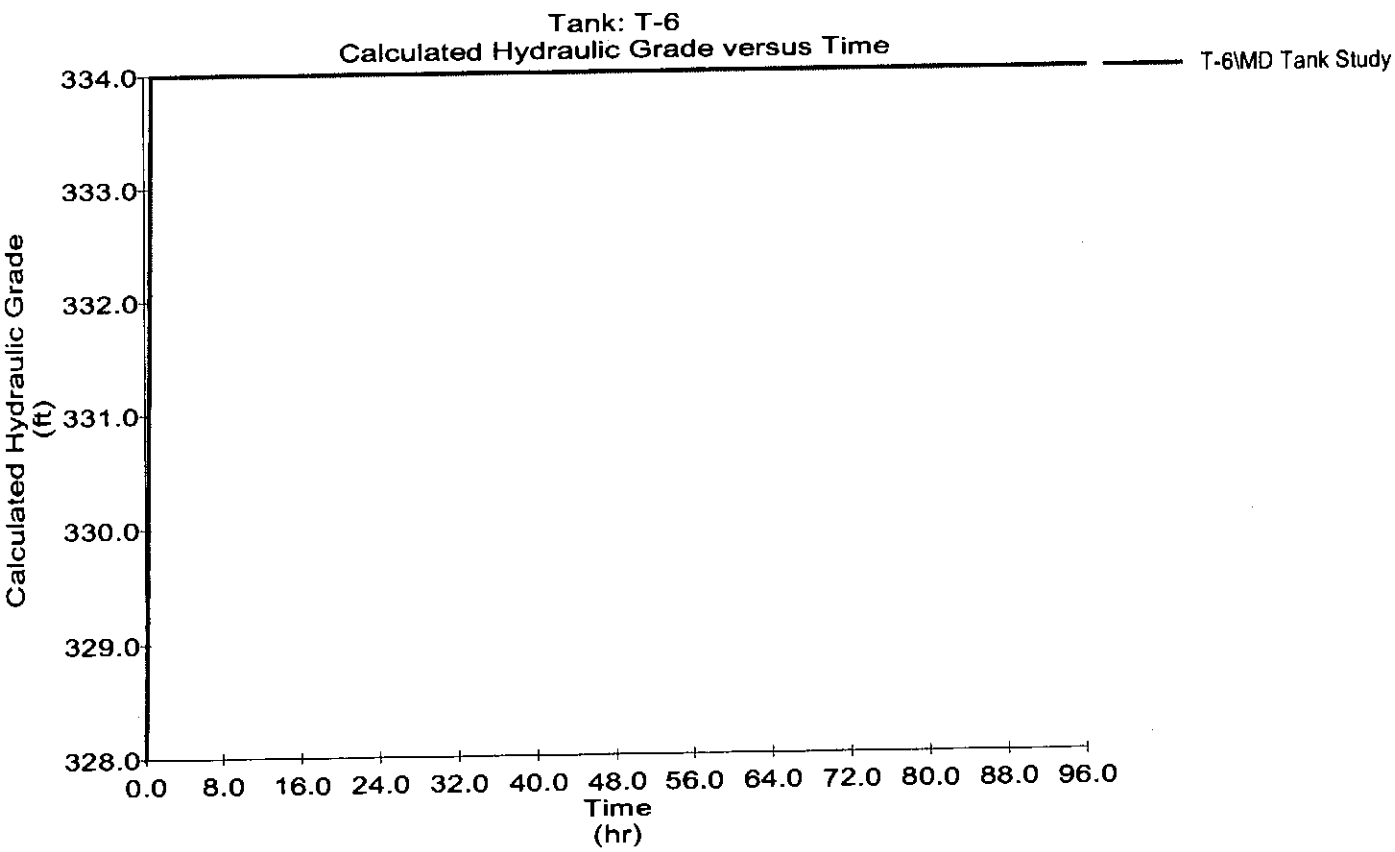
Graph

Wakefield Street Tank



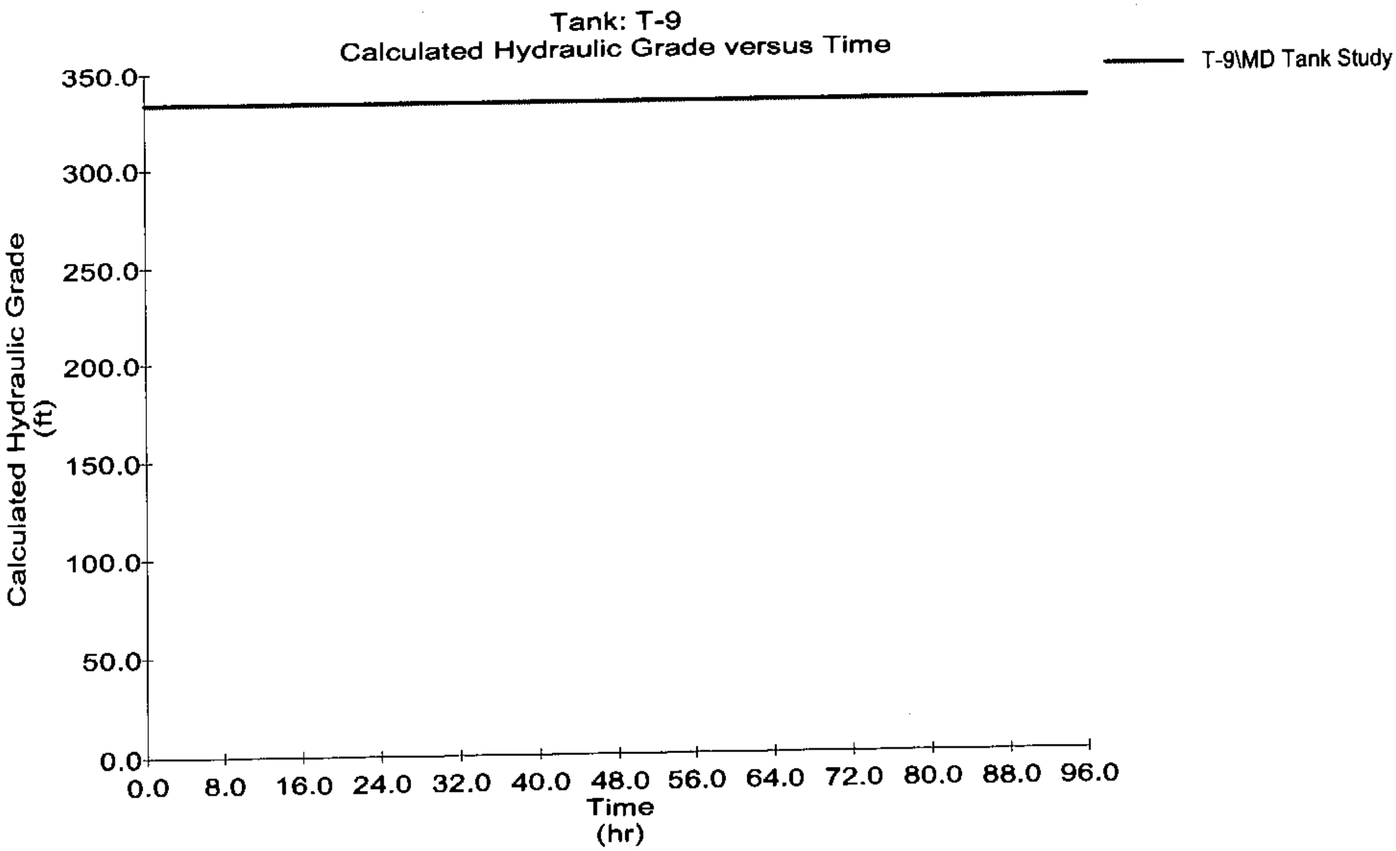
Graph

West Street Tank



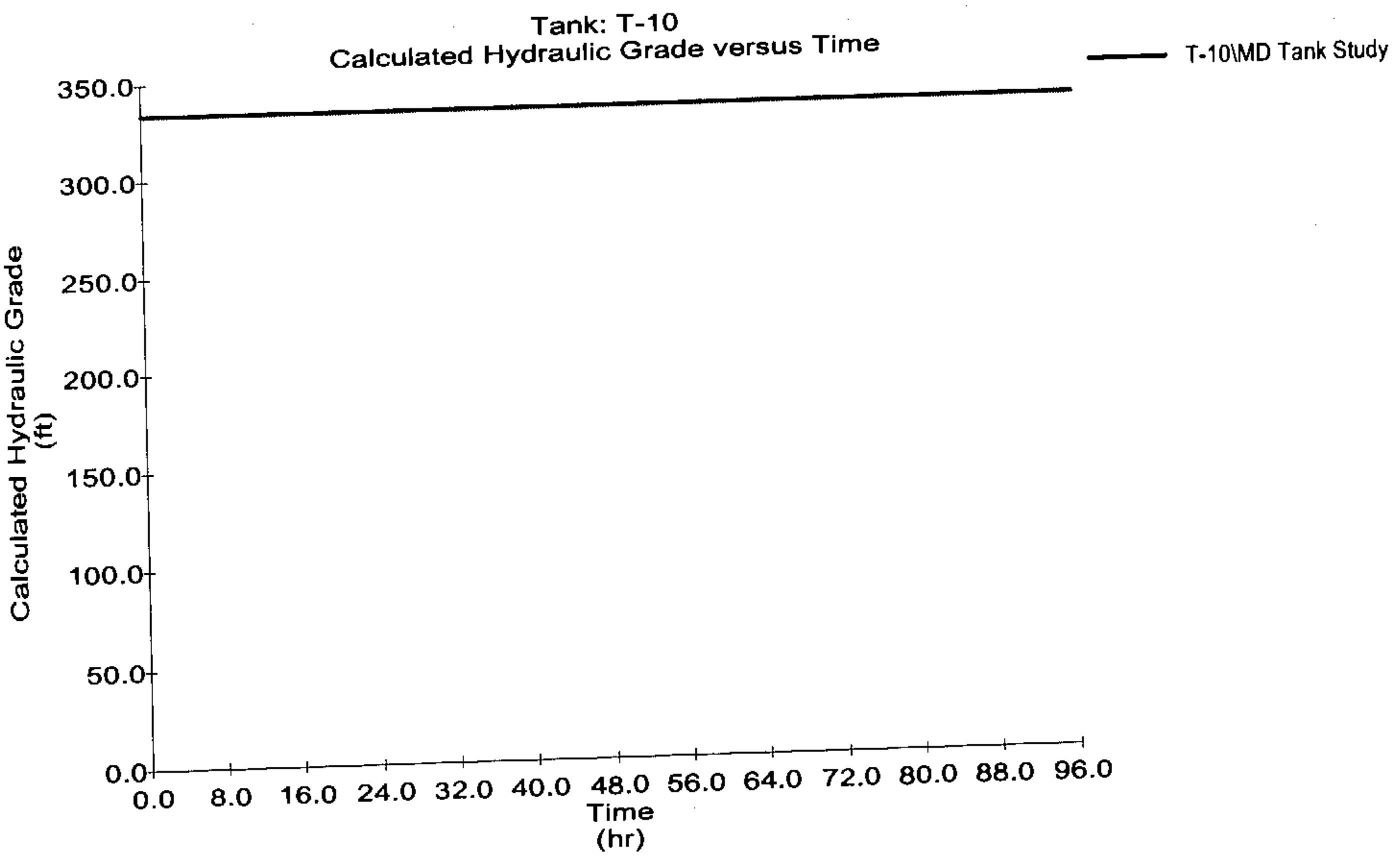
Graph

Fiskeville Reservoir #1



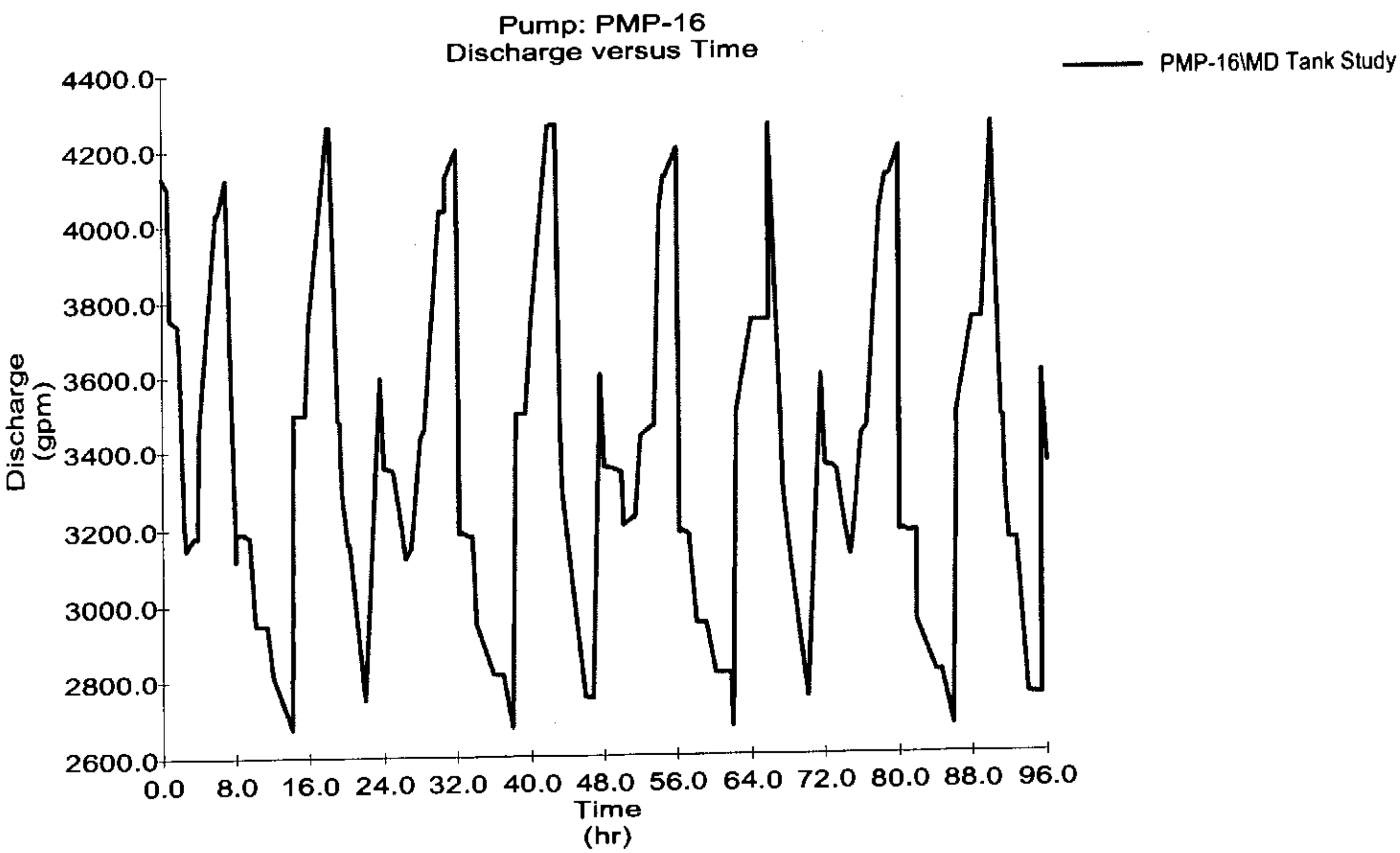
Graph

Fiskeville Reservoir #2



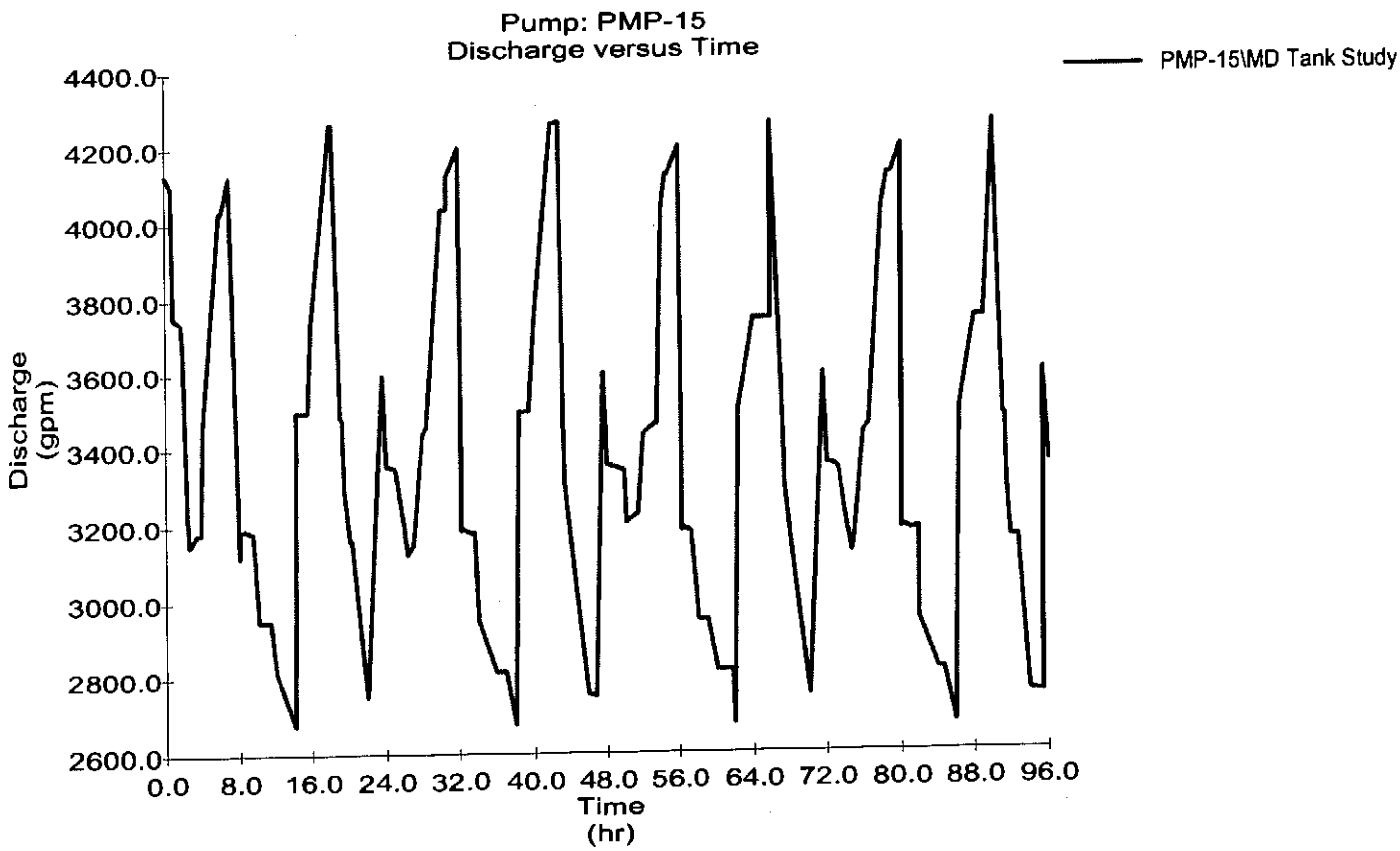
Graph

Clinton Avenue Pump #1



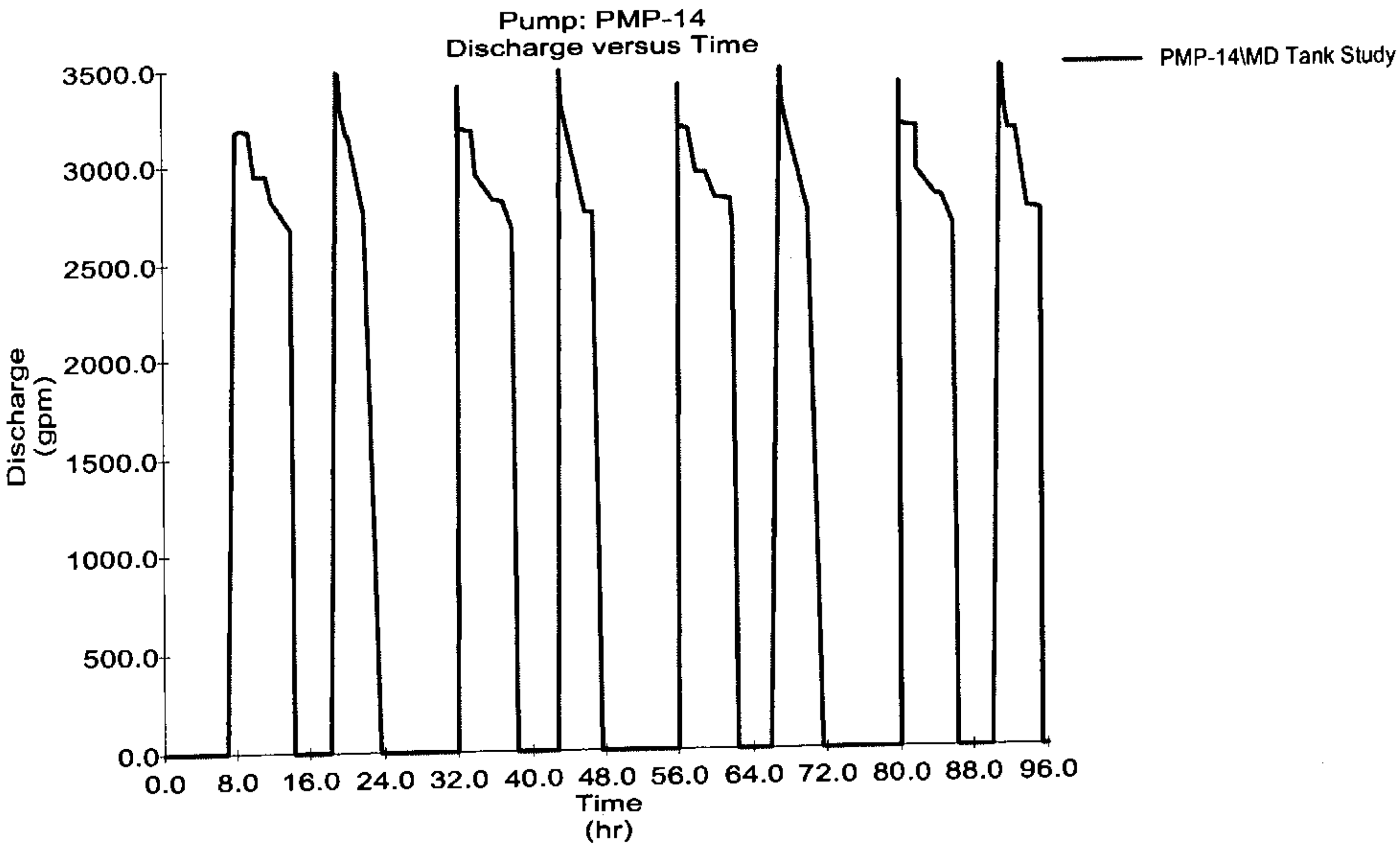
Graph

Clinton Avenue Pump #2



Graph

Clinton Avenue Pump #3

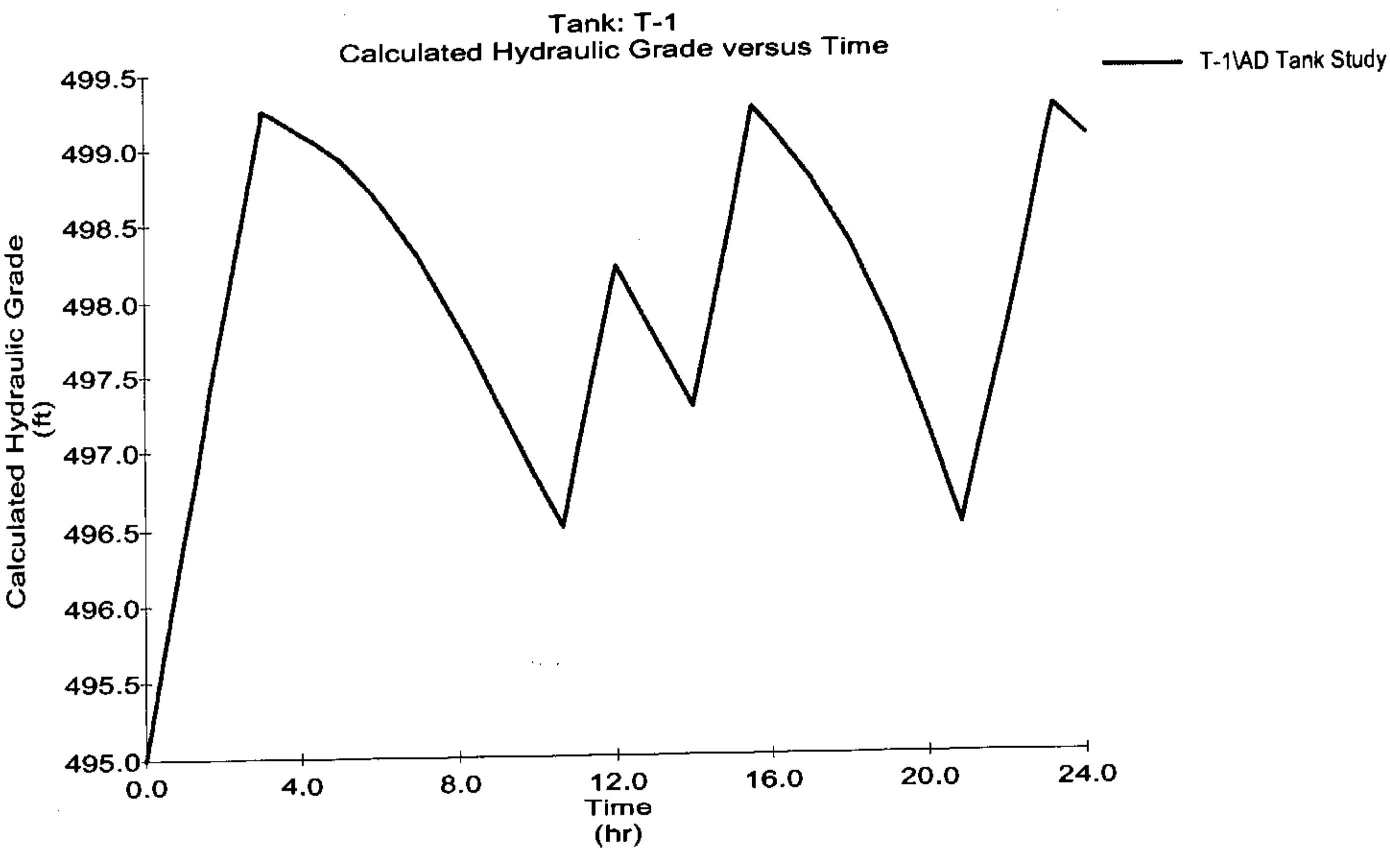


ATTACHMENT NO. 3

EXTENDED PERIOD SIMULATION
AVERAGE DAY DEMAND WITH FIRE FLOW
STORAGE TANK GRAPHS

Graph

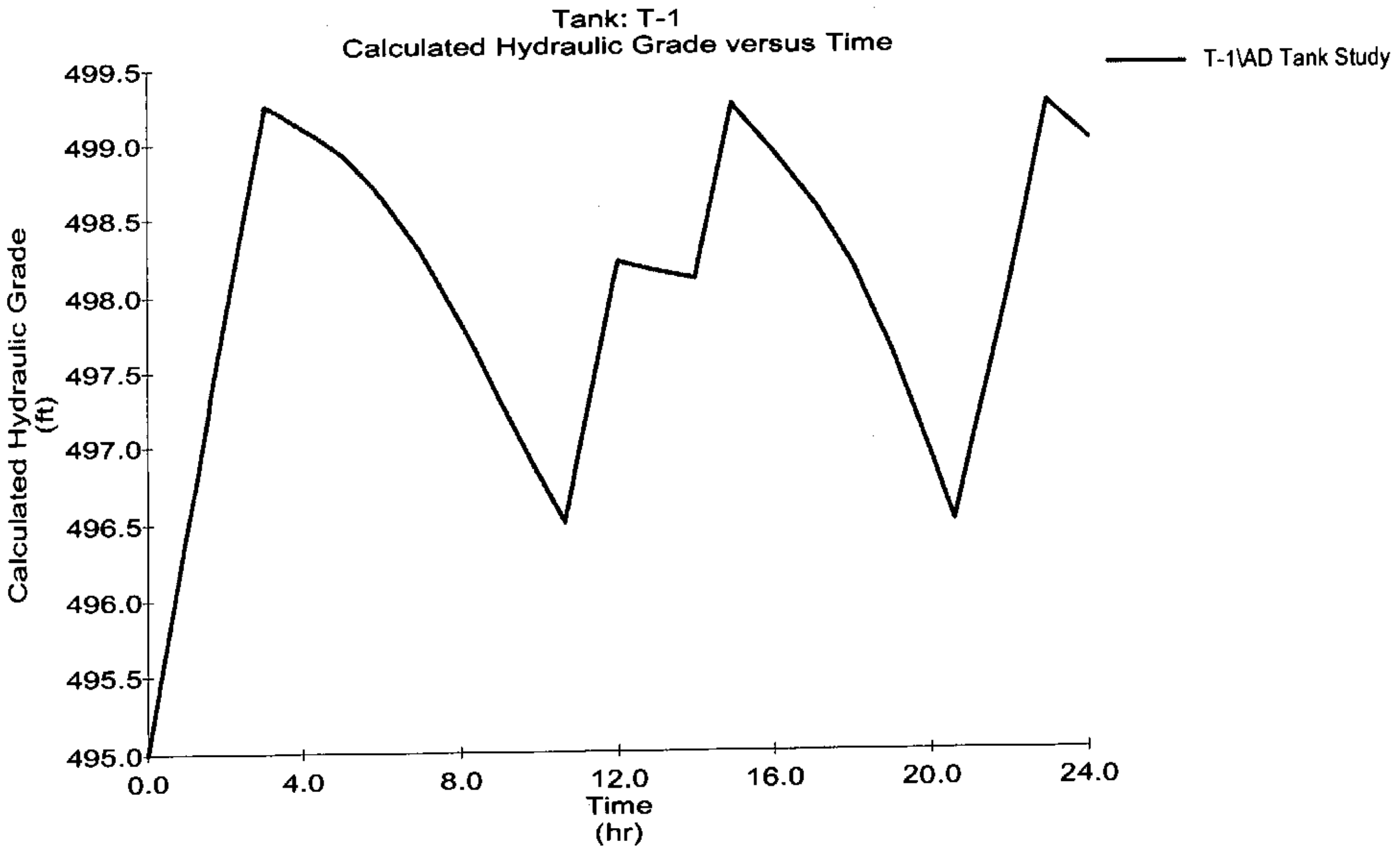
Read School House Road Tank



- 2000 gpm fire flow at node J-7154
- Flat River Rd.
- 12" AC main
- Elevation = 254 ft

Graph

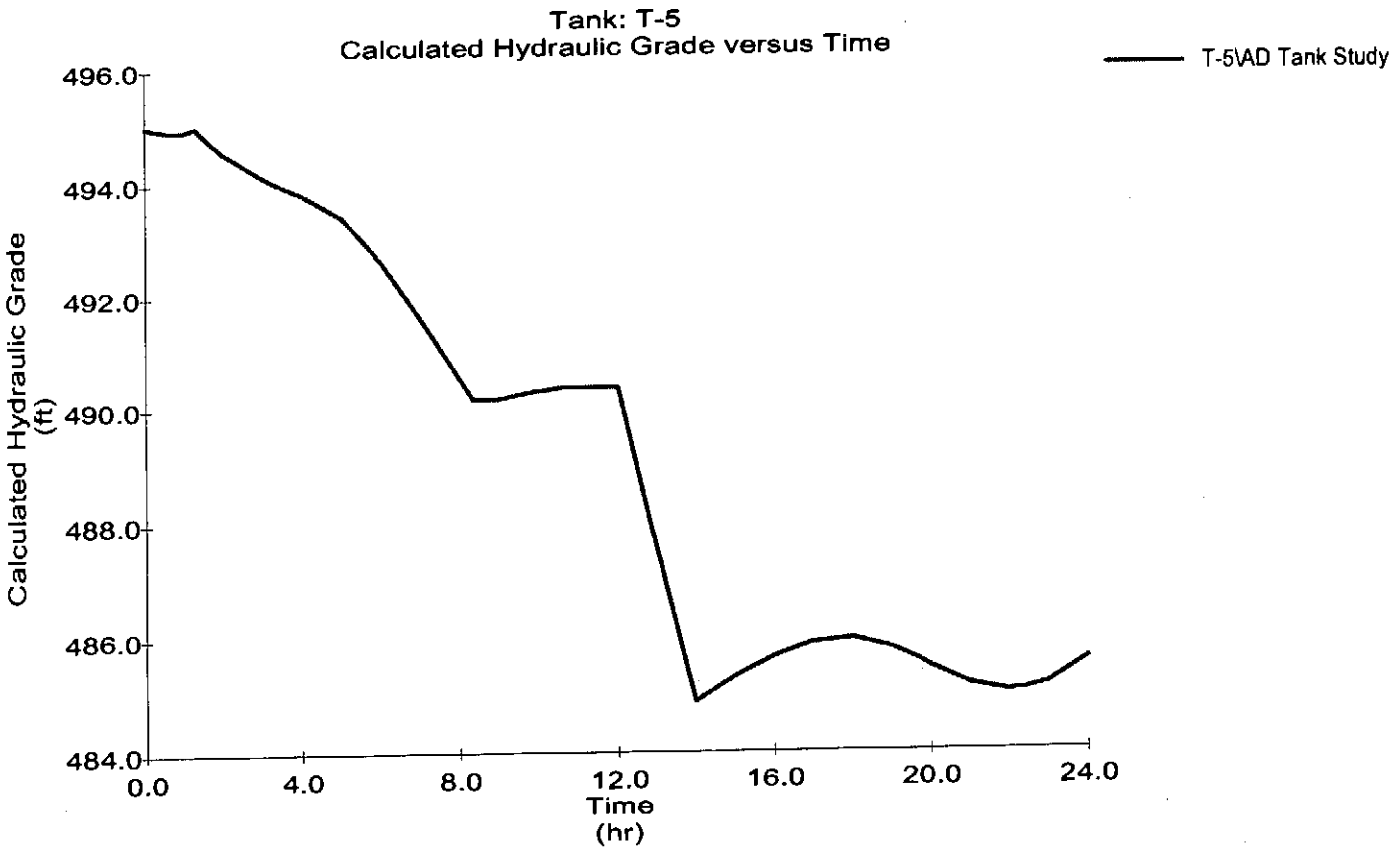
Read School House Road Tank



- 2000 gpm fire flow at node J-7258
- Hunters Crossing Dr.
- 16" DI main
- Elevation = 343 ft

Graph

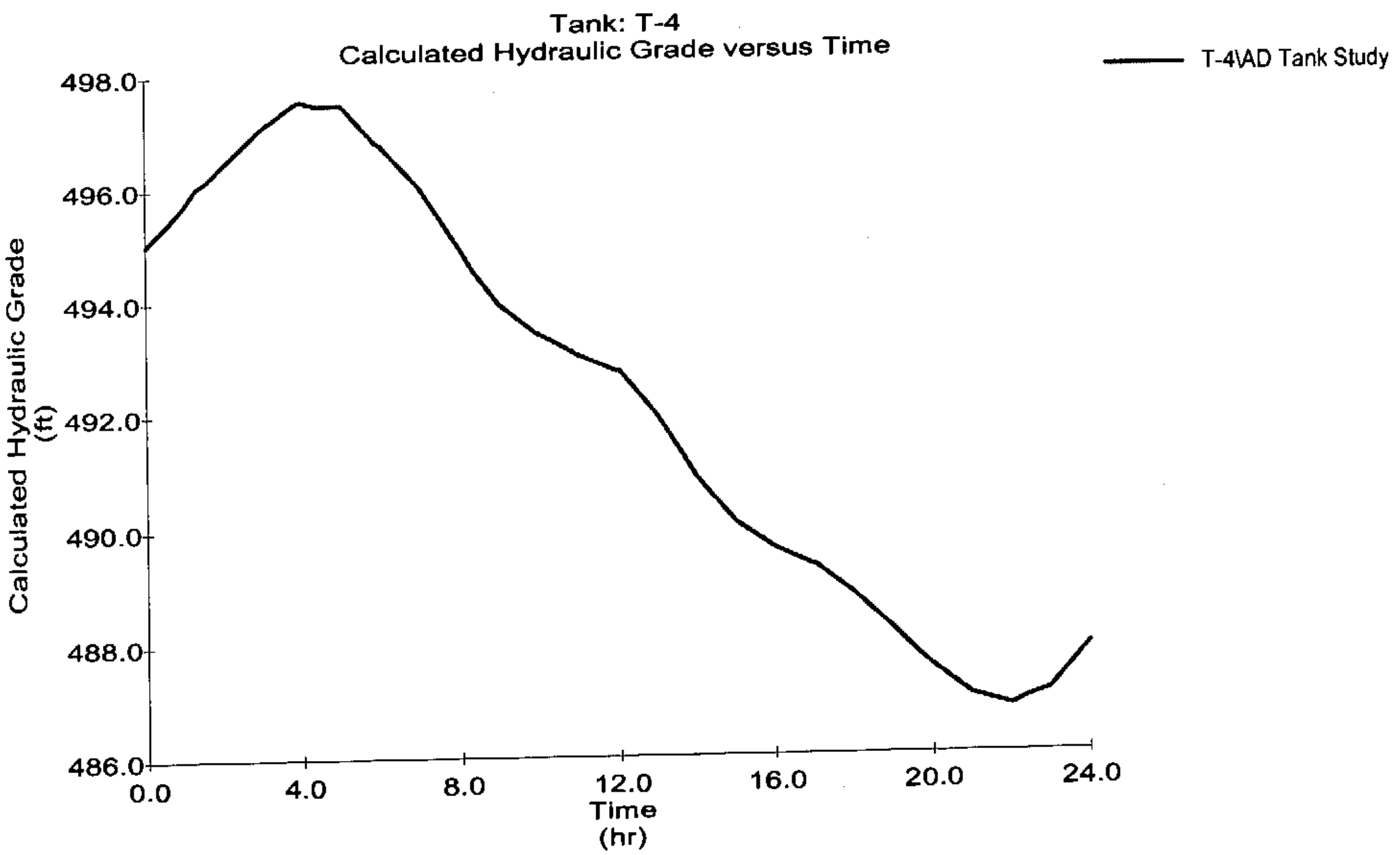
Carrs Pond Road Tank



- 2000 gpm fire flow at node J-4117
- Middle Rd.
- 16" DI main
- Elevation = 300 ft

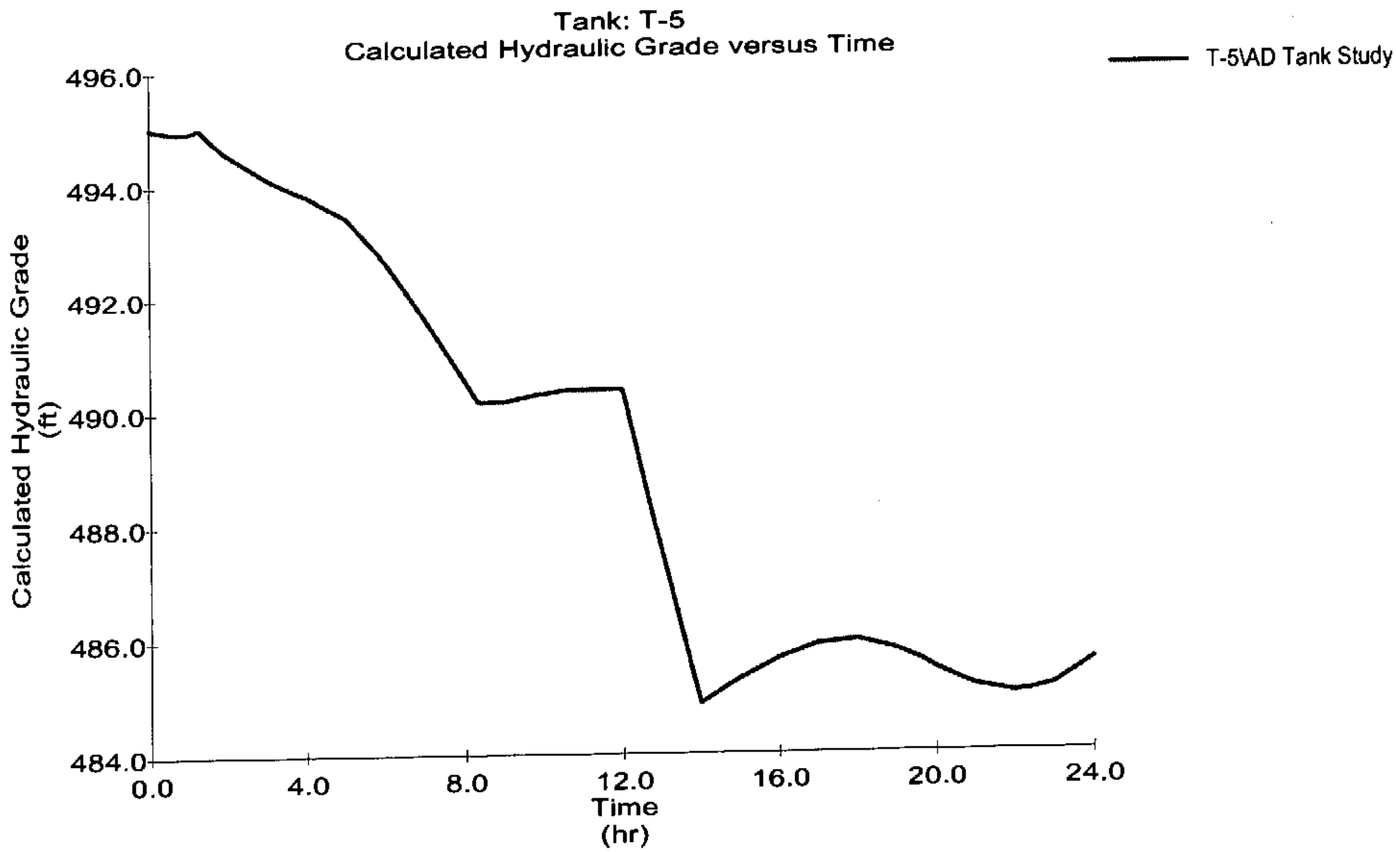
Graph

Technology Park Tank



Graph

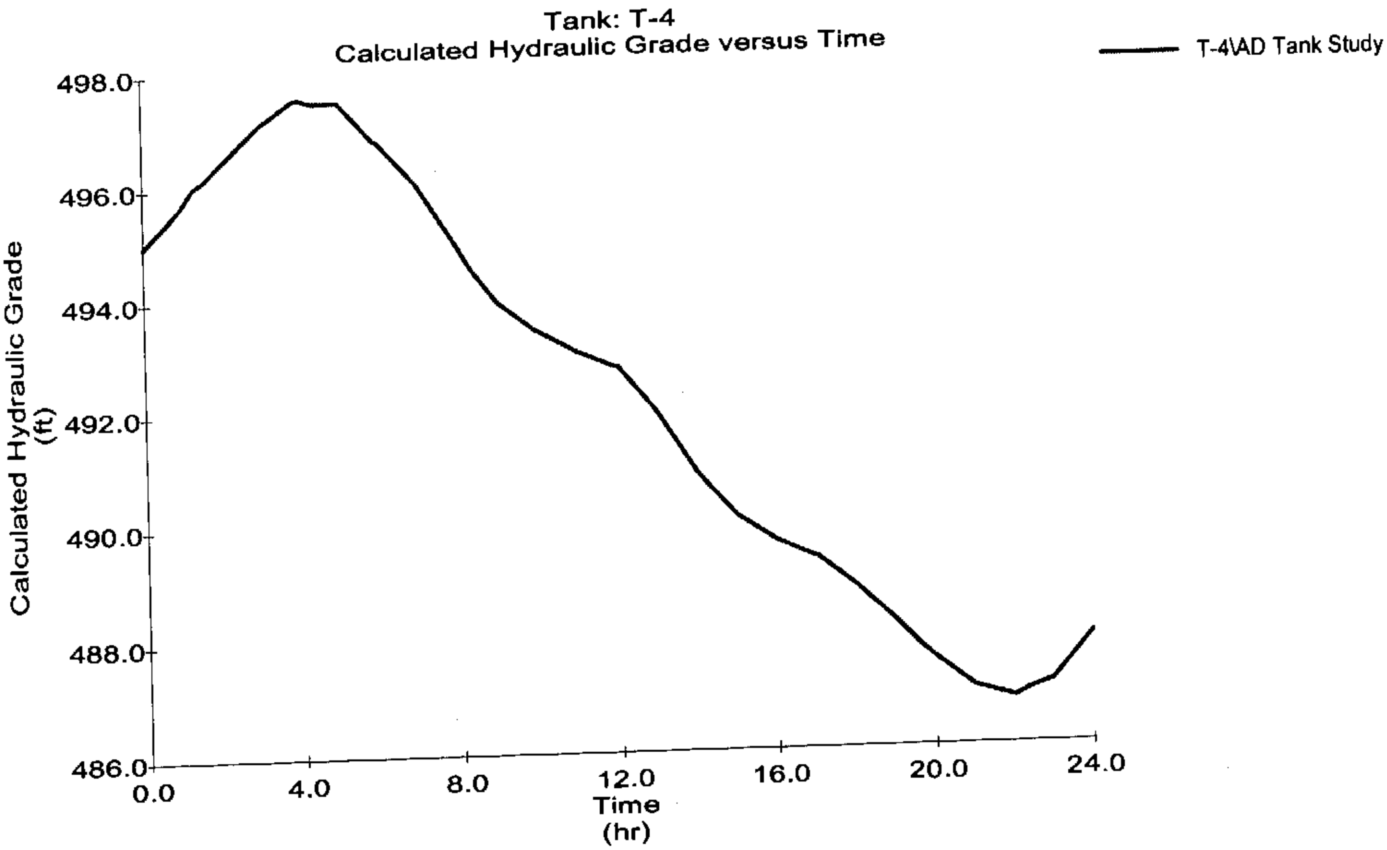
Carrs Pond Road Tank



- 2000 gpm fire flow at node J-4056
- Frenchtown Rd.
- 12" DI main
- Elevation = 246 ft

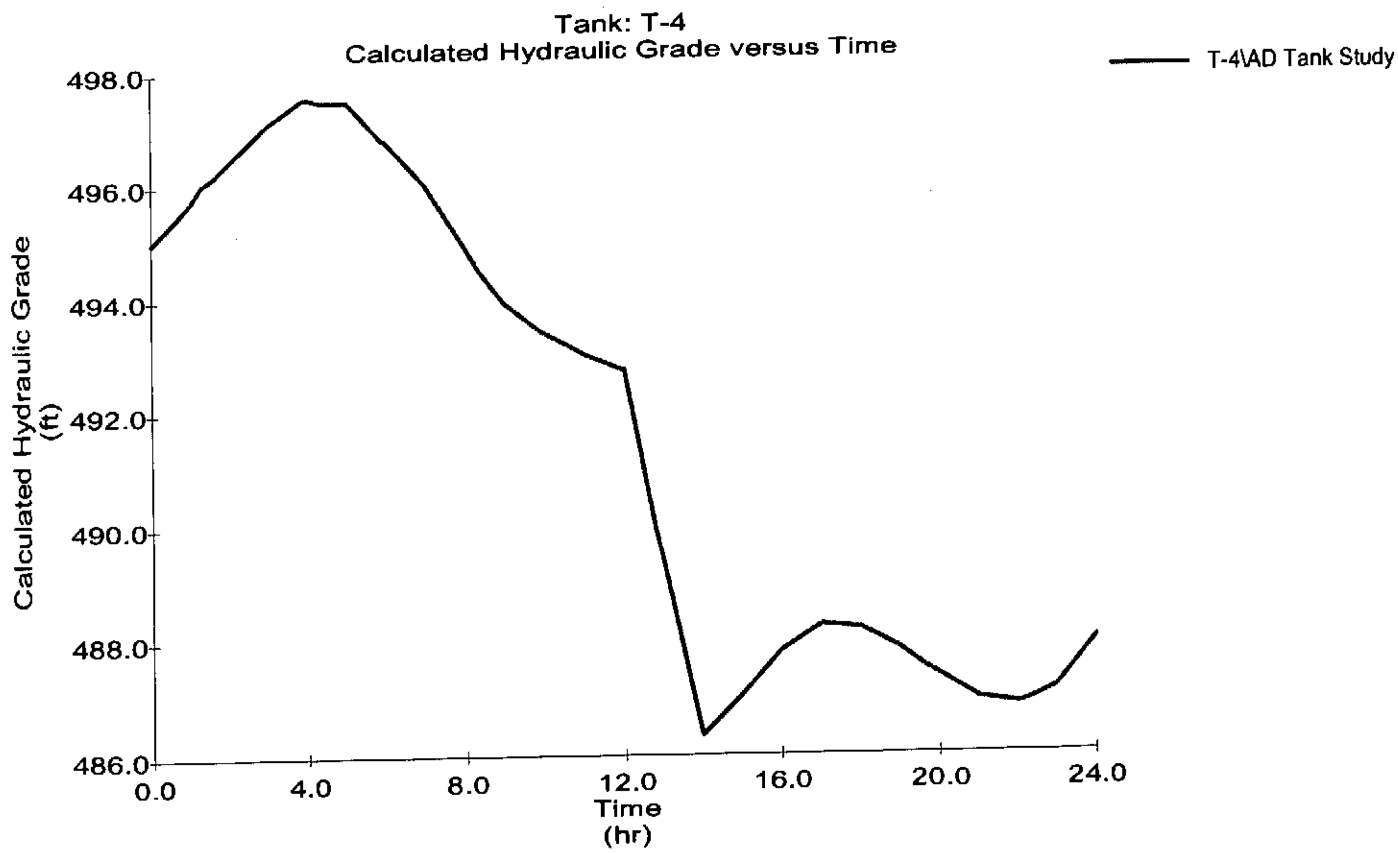
Graph

Technology Park Tank



Graph

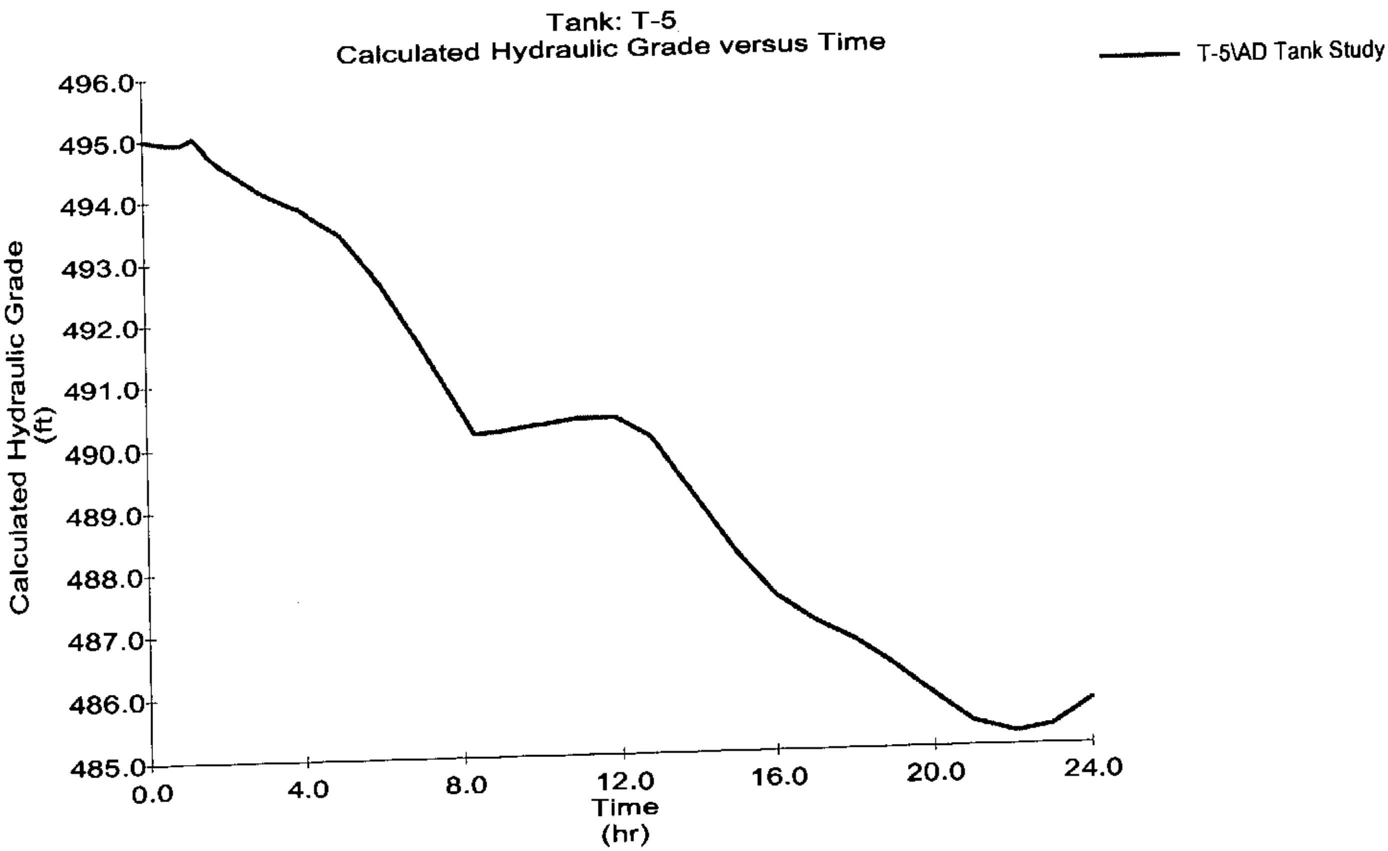
Technology Park Tank



- 2000 gpm fire flow at node J-8145
- Hopkins Hill Rd.
- 12" DI main
- Elevation = 316 ft

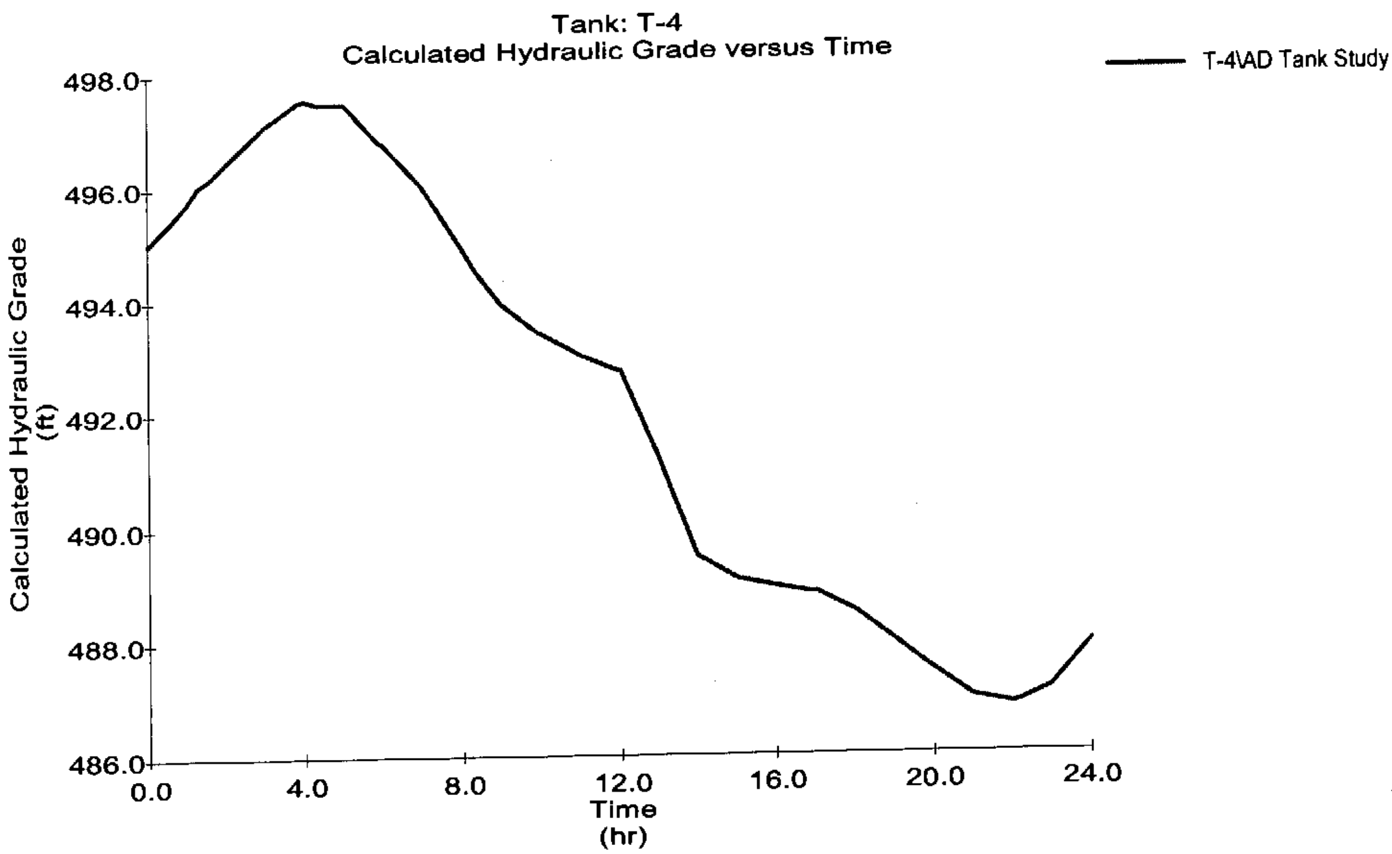
Graph

Carrs Pond Road Tank



Graph

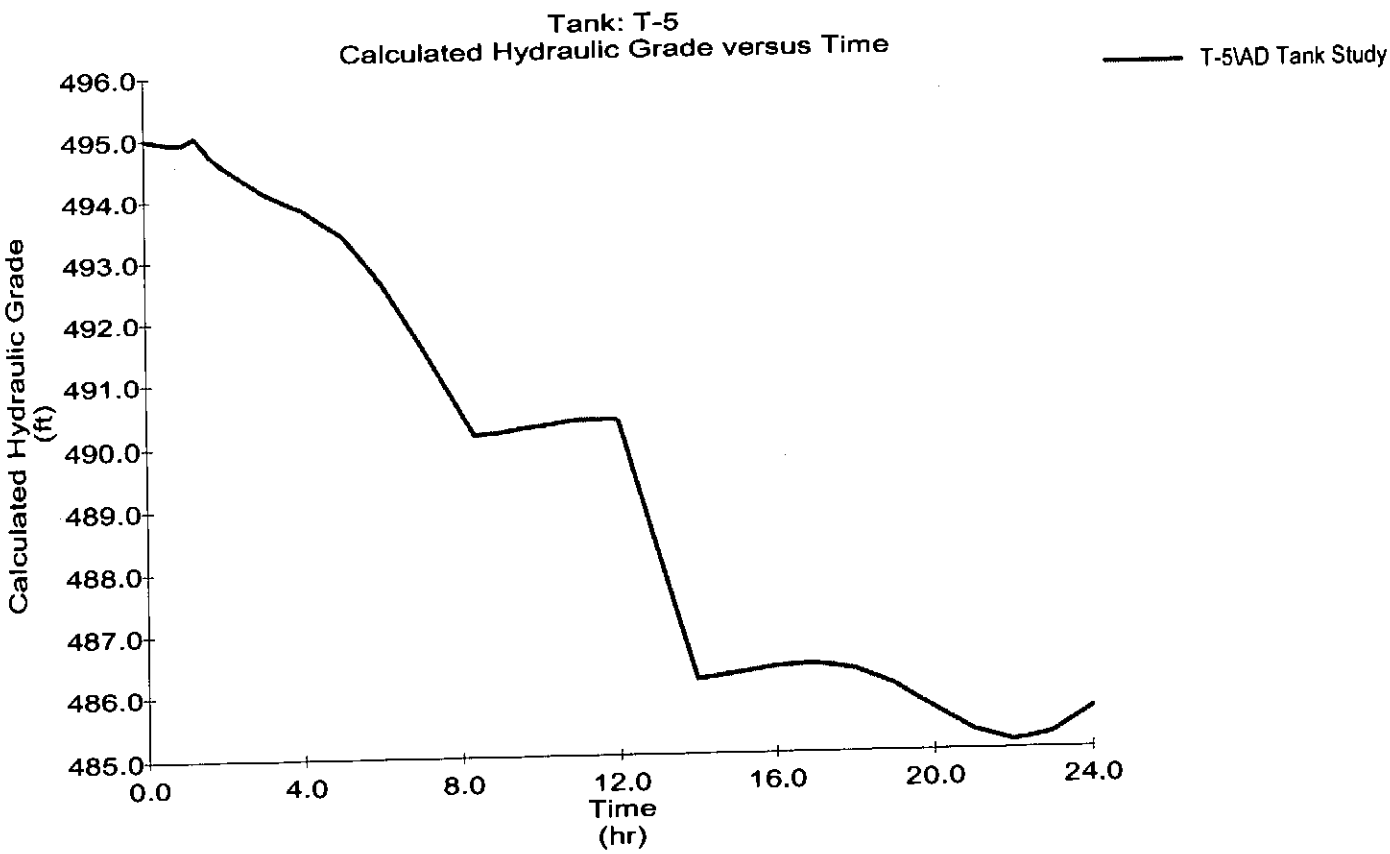
Technology Park Tank



- 2000 gpm fire flow at node J-951
- Lonsdale St.
- 12" AC main
- Elevation = 298 ft

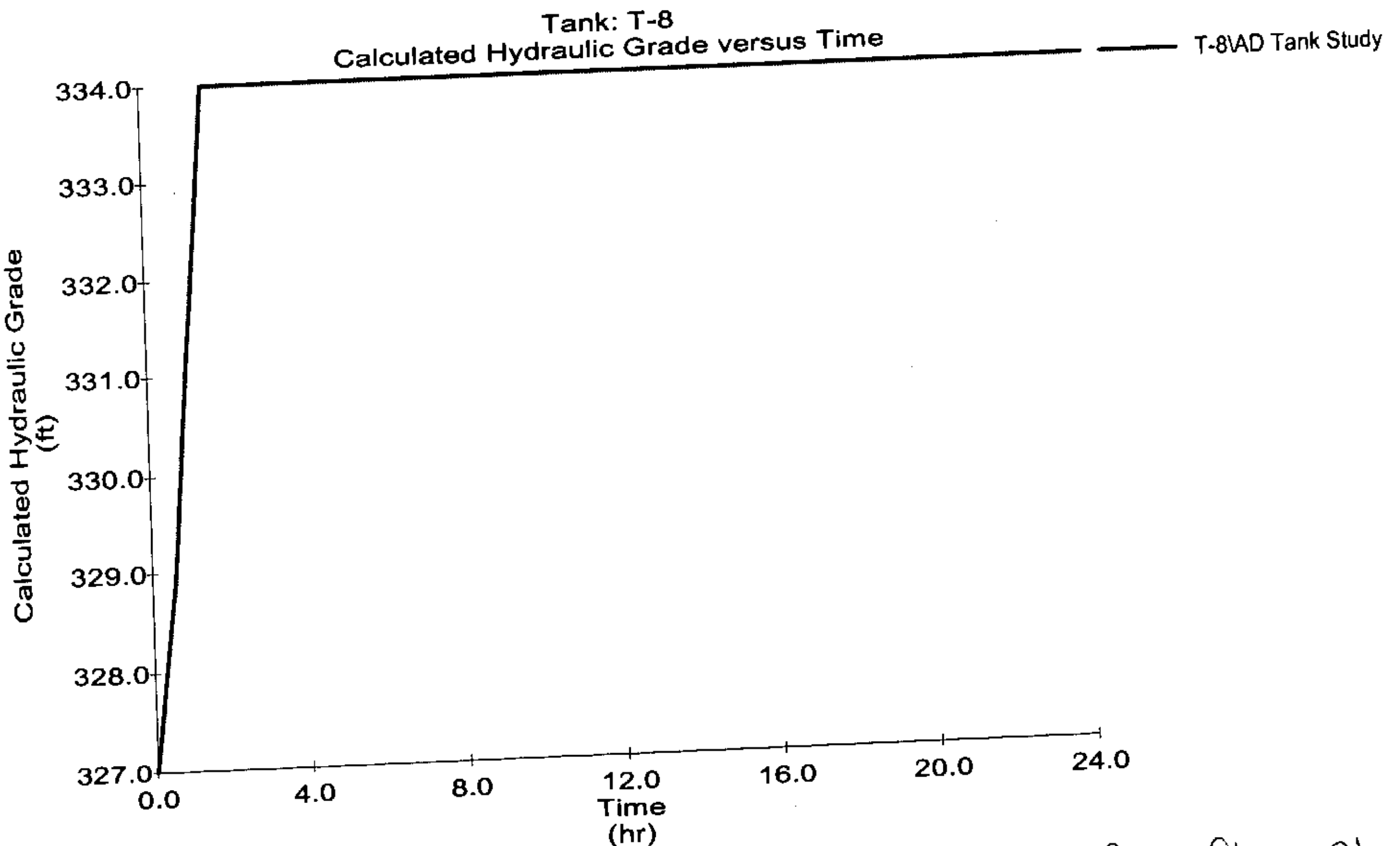
Graph

Carrs Pond Road Tank



Graph

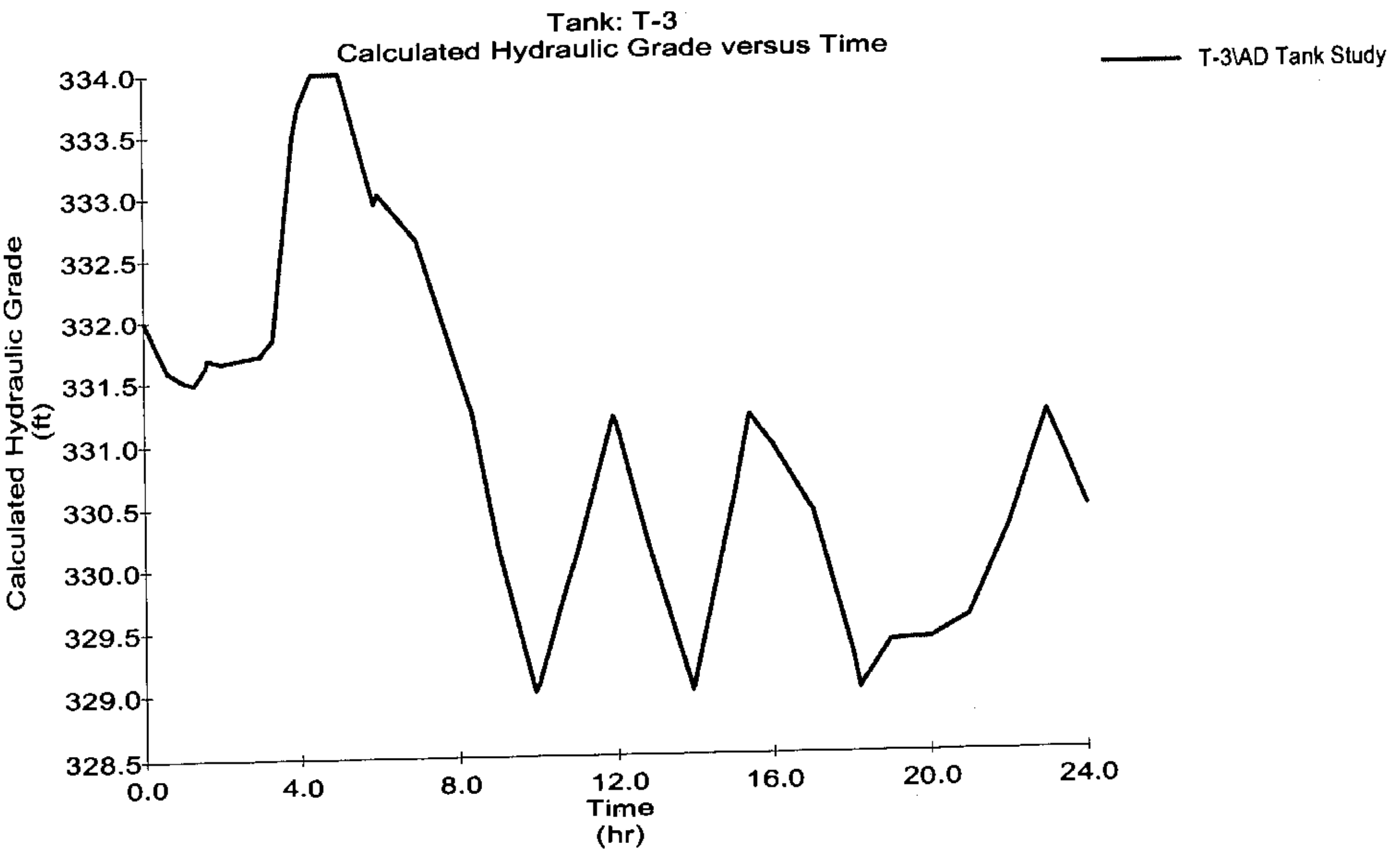
Wakefield Street Tank



- 2000 gpm fire flow at node J-727
- River Farms Dr.
- 12" PVC main
- Elevation = 190 ft

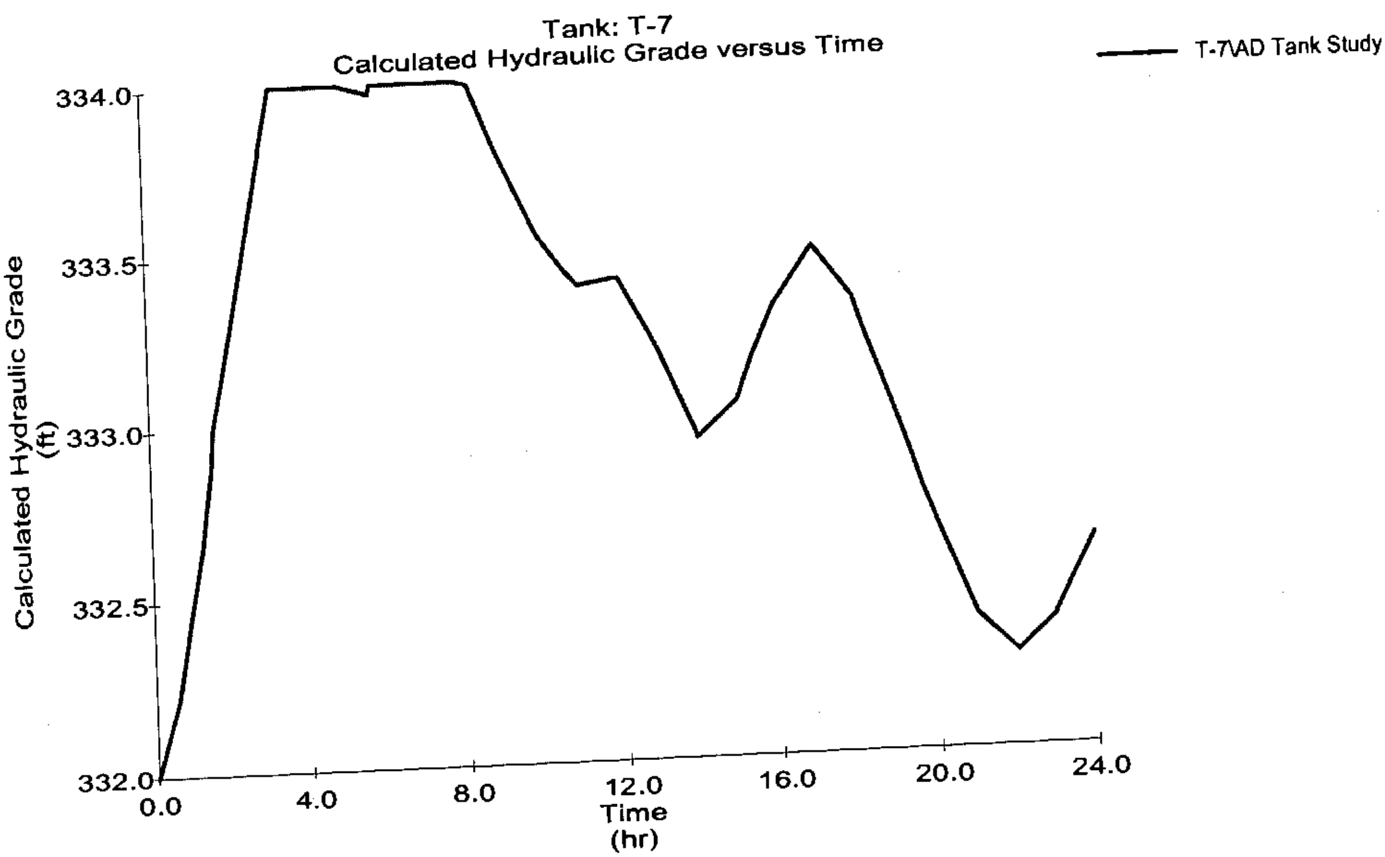
Graph

Frenchtown Road Tank



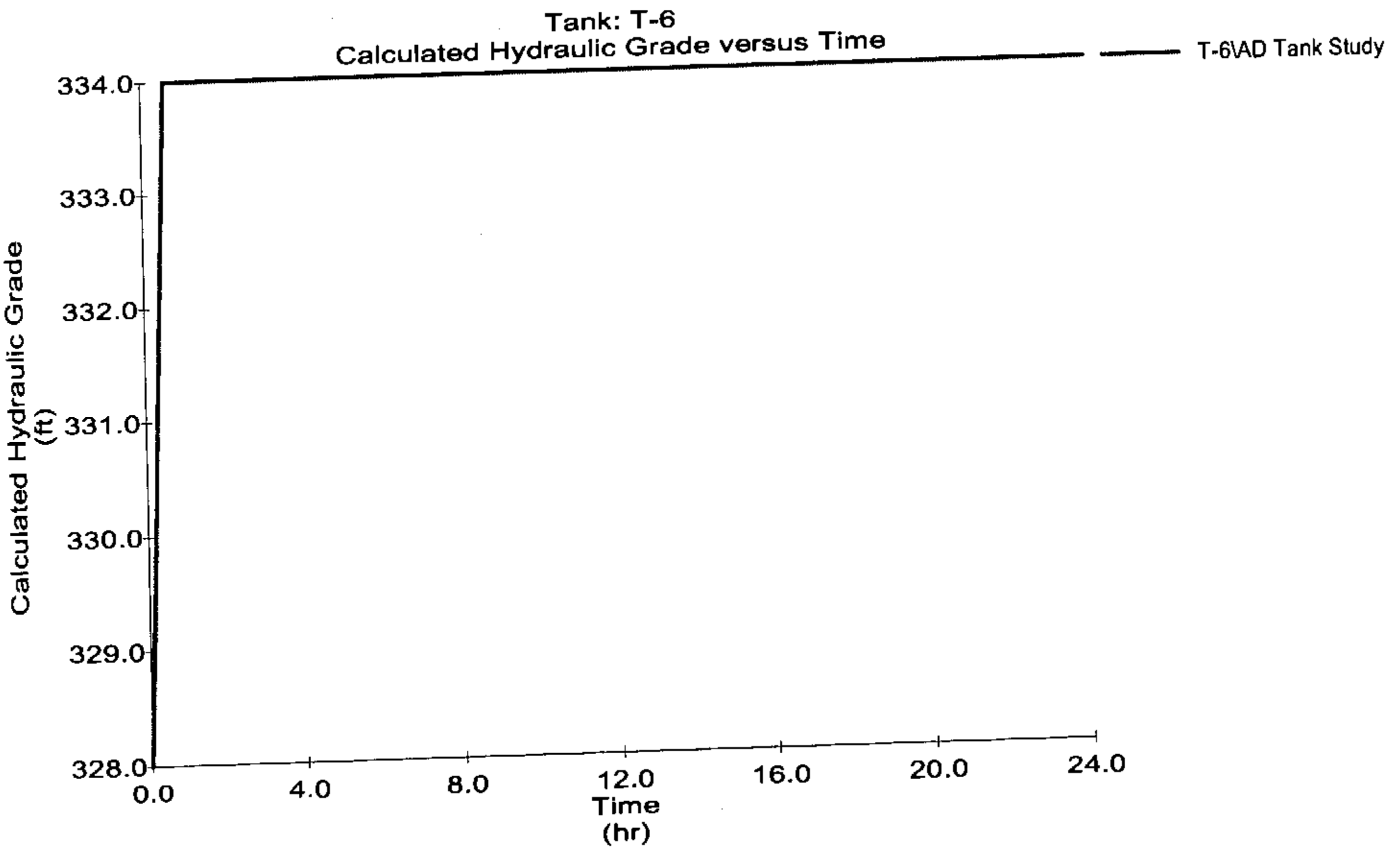
Graph

Setian Lane Tank



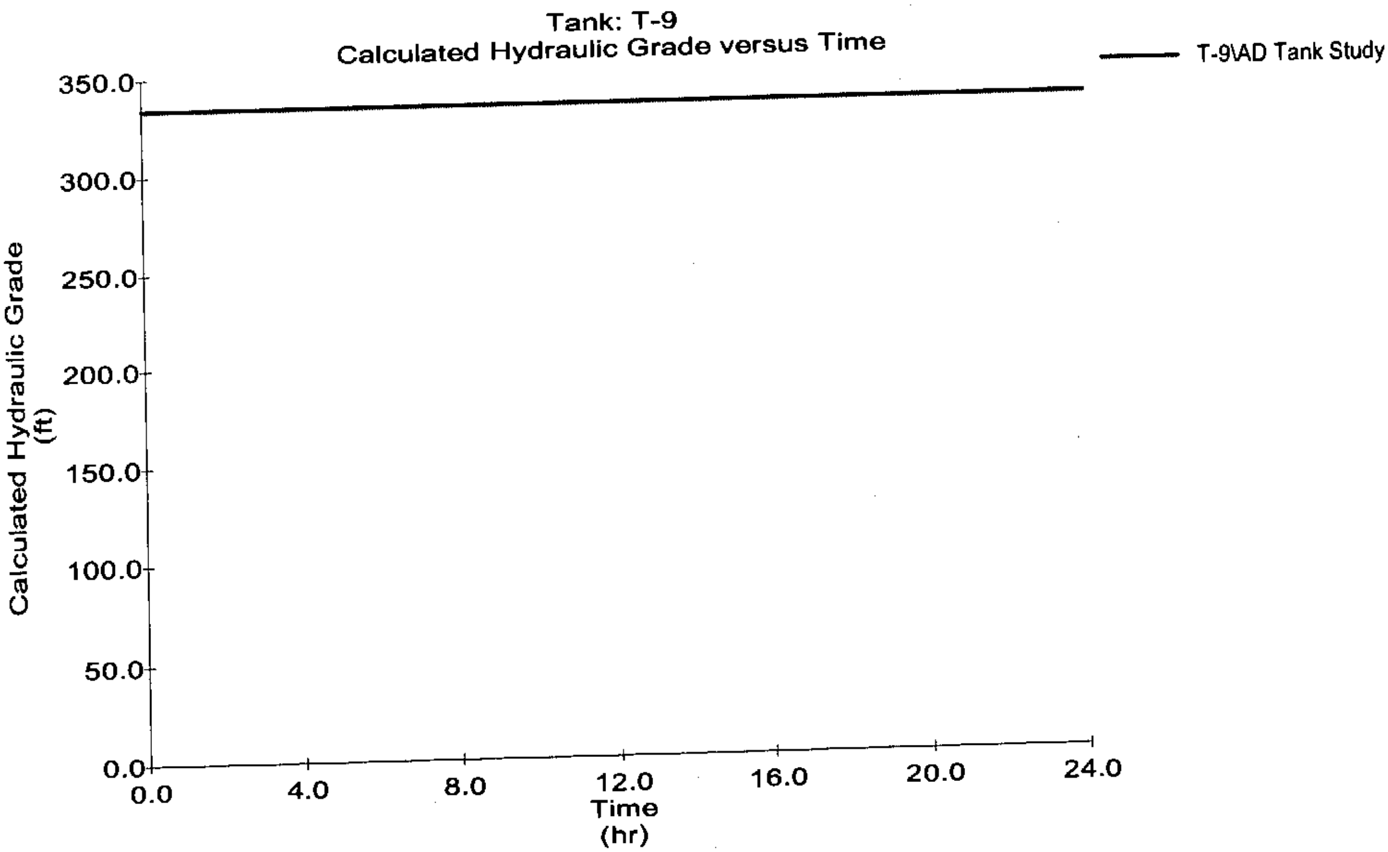
Graph

West Street Tank



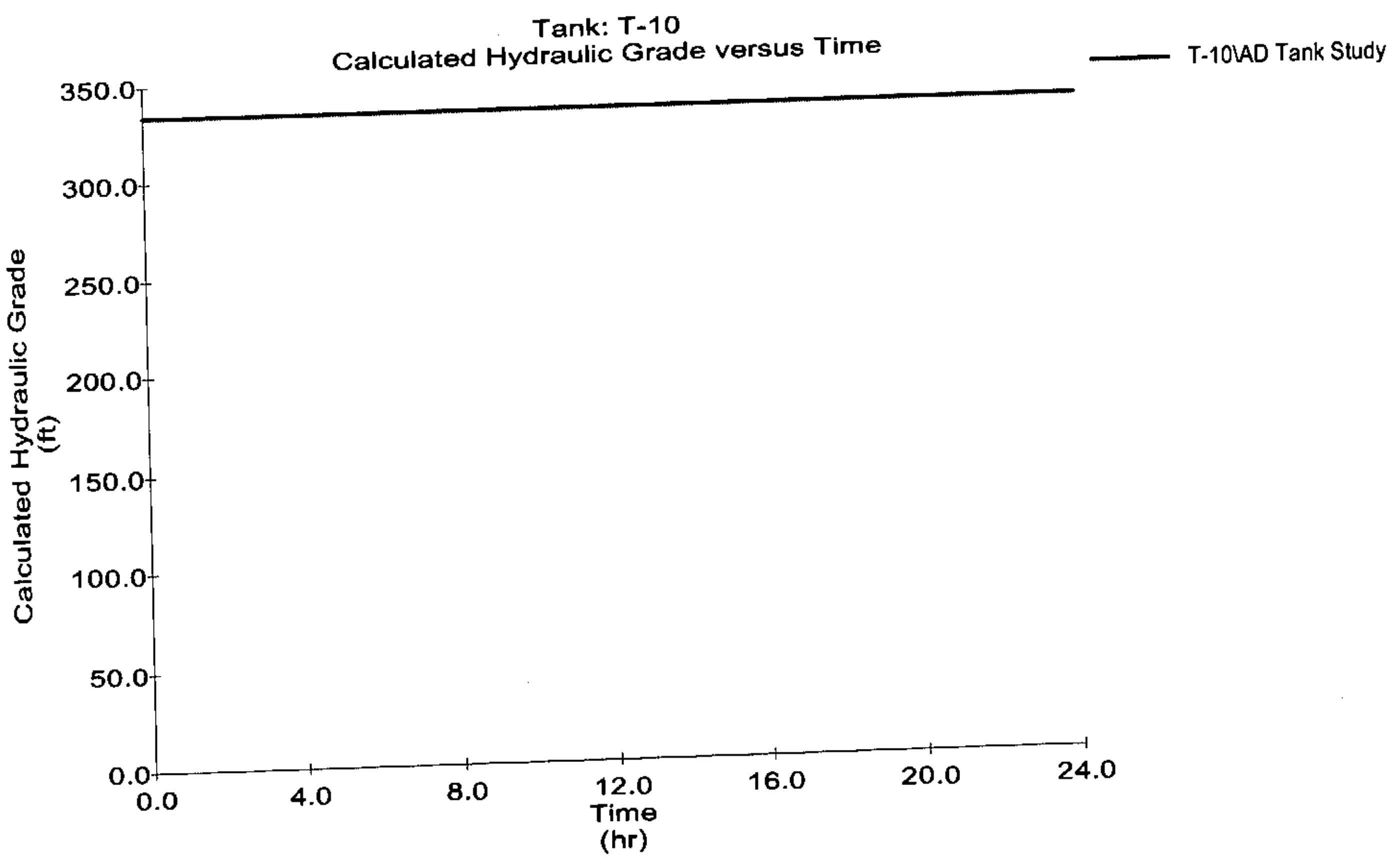
Graph

Fiskeville Reservoir #1



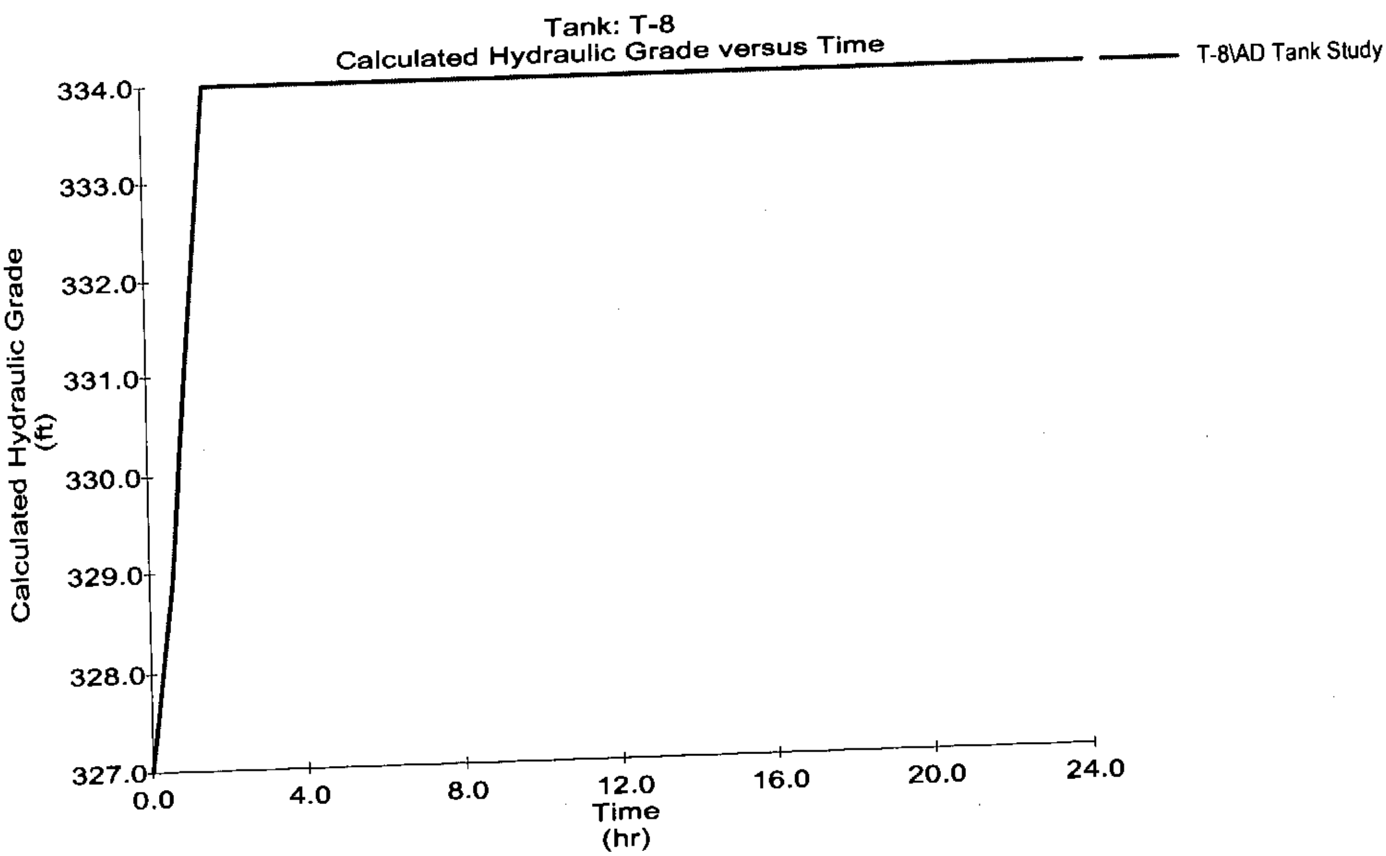
Graph

Fiskeville Reservoir #2



Graph

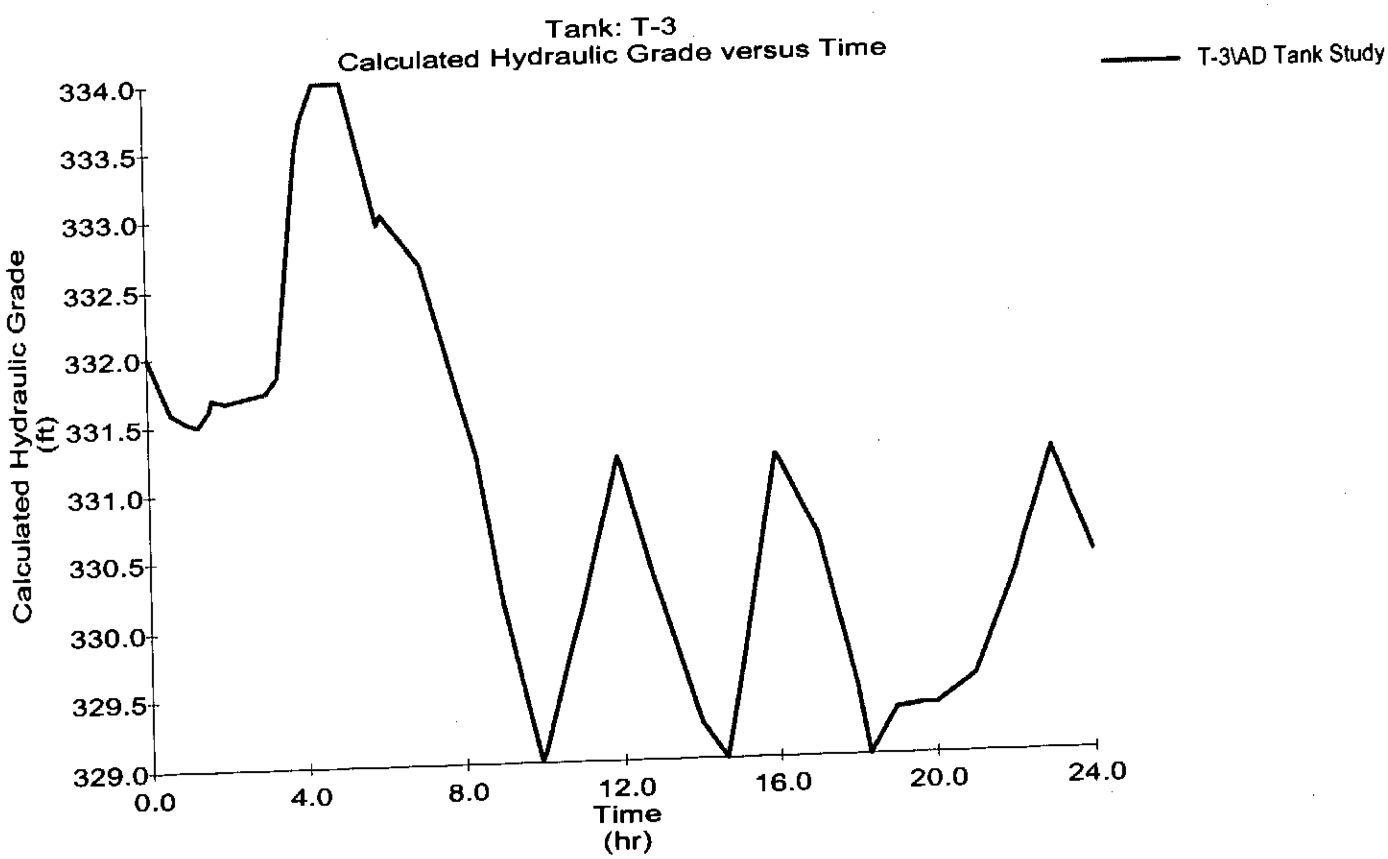
Wakefield Street Tank



- 2000 gpm fire flow at node J-769
- Main St.
- 20" DI main
- Elevation = 92 ft

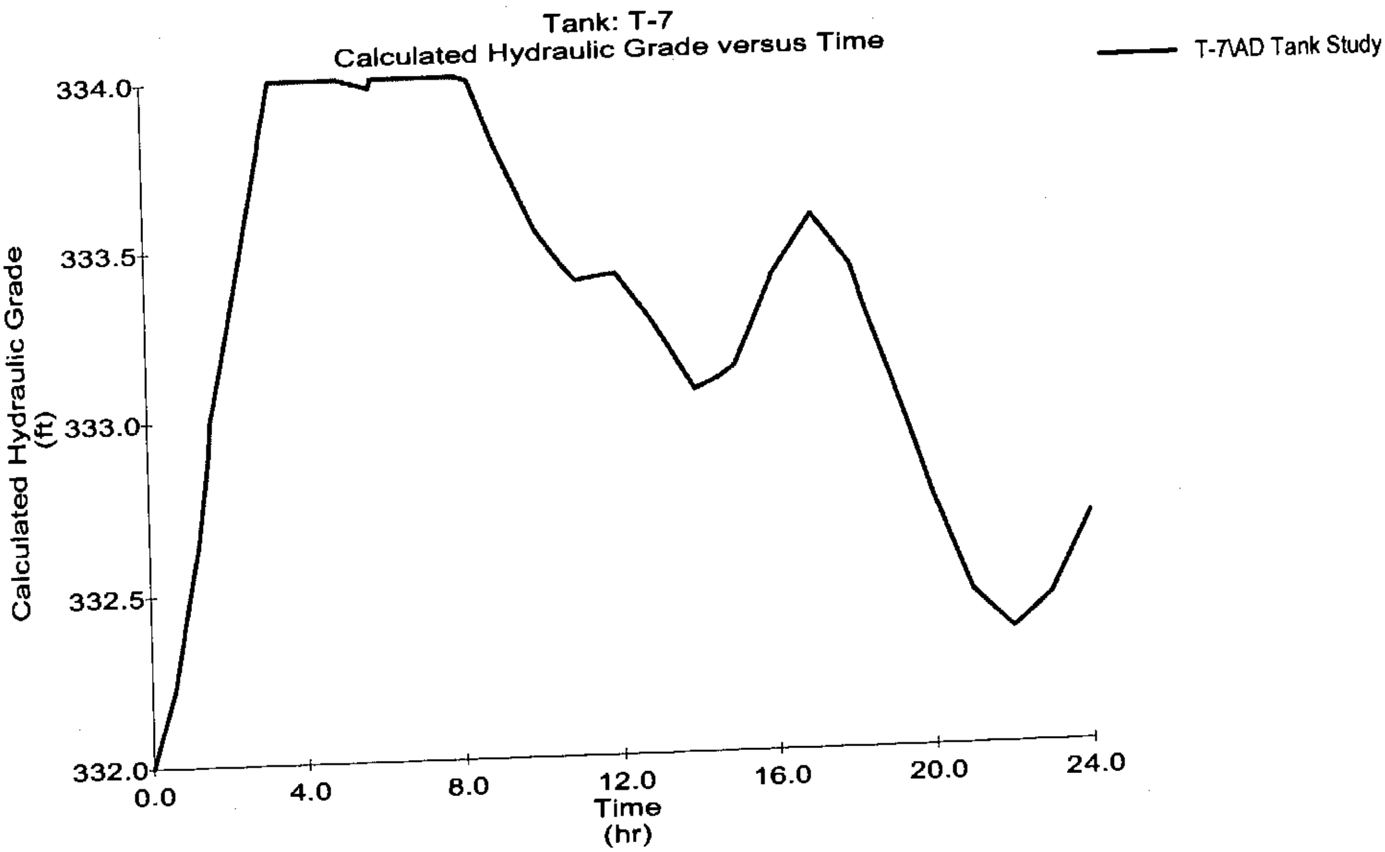
Graph

Frenchtown Road Tank



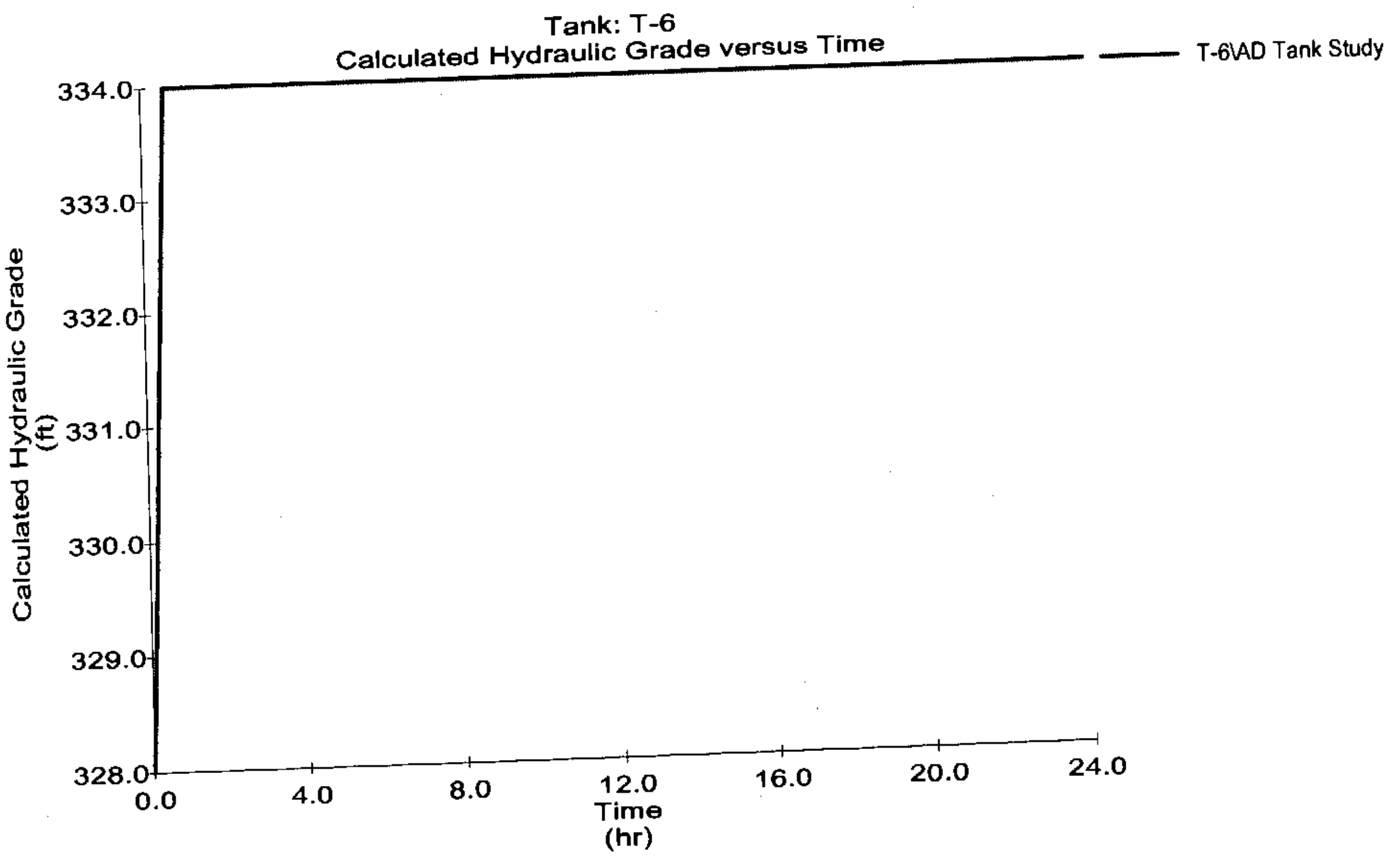
Graph

Setian Lane Tank



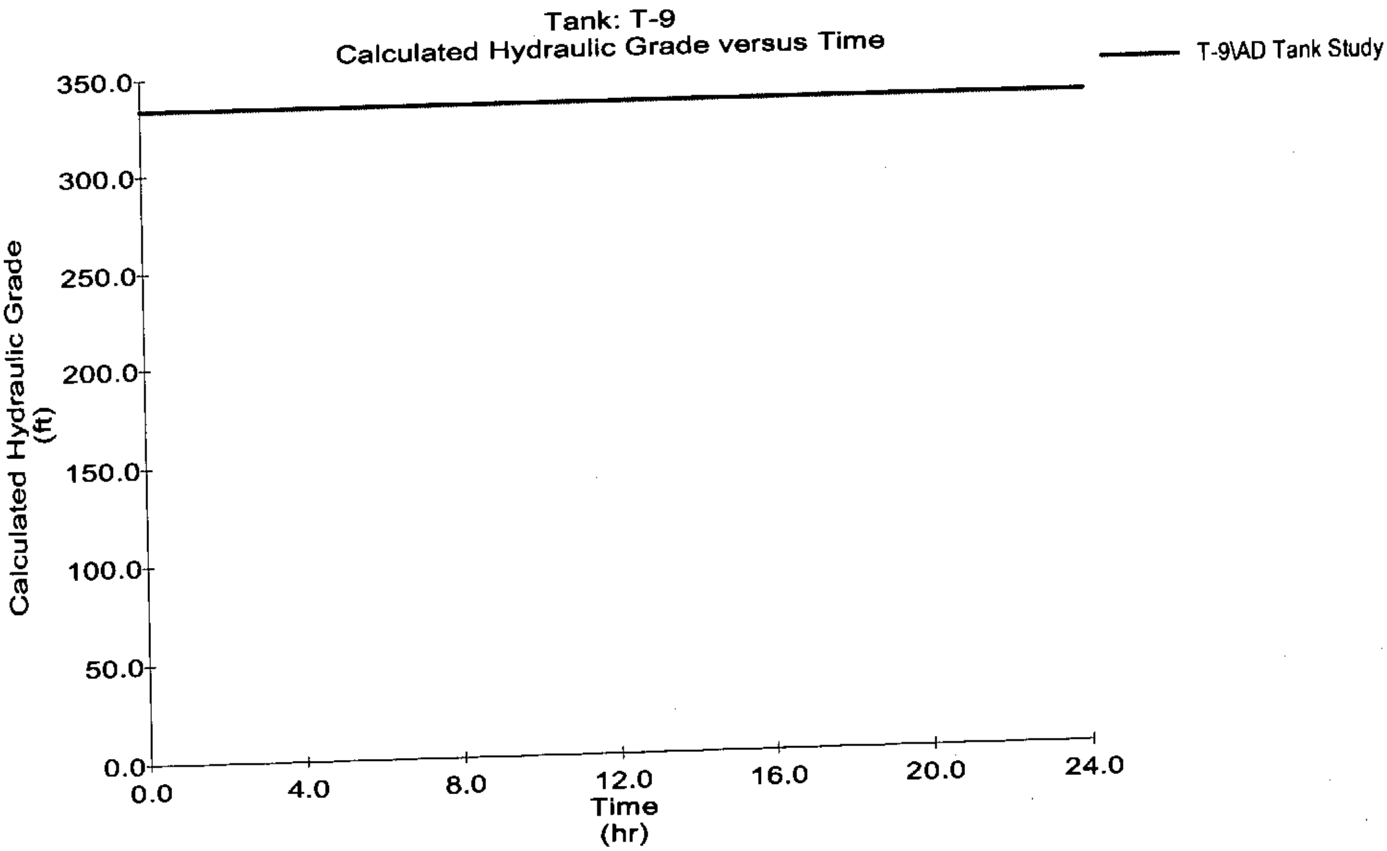
Graph

West Street Tank



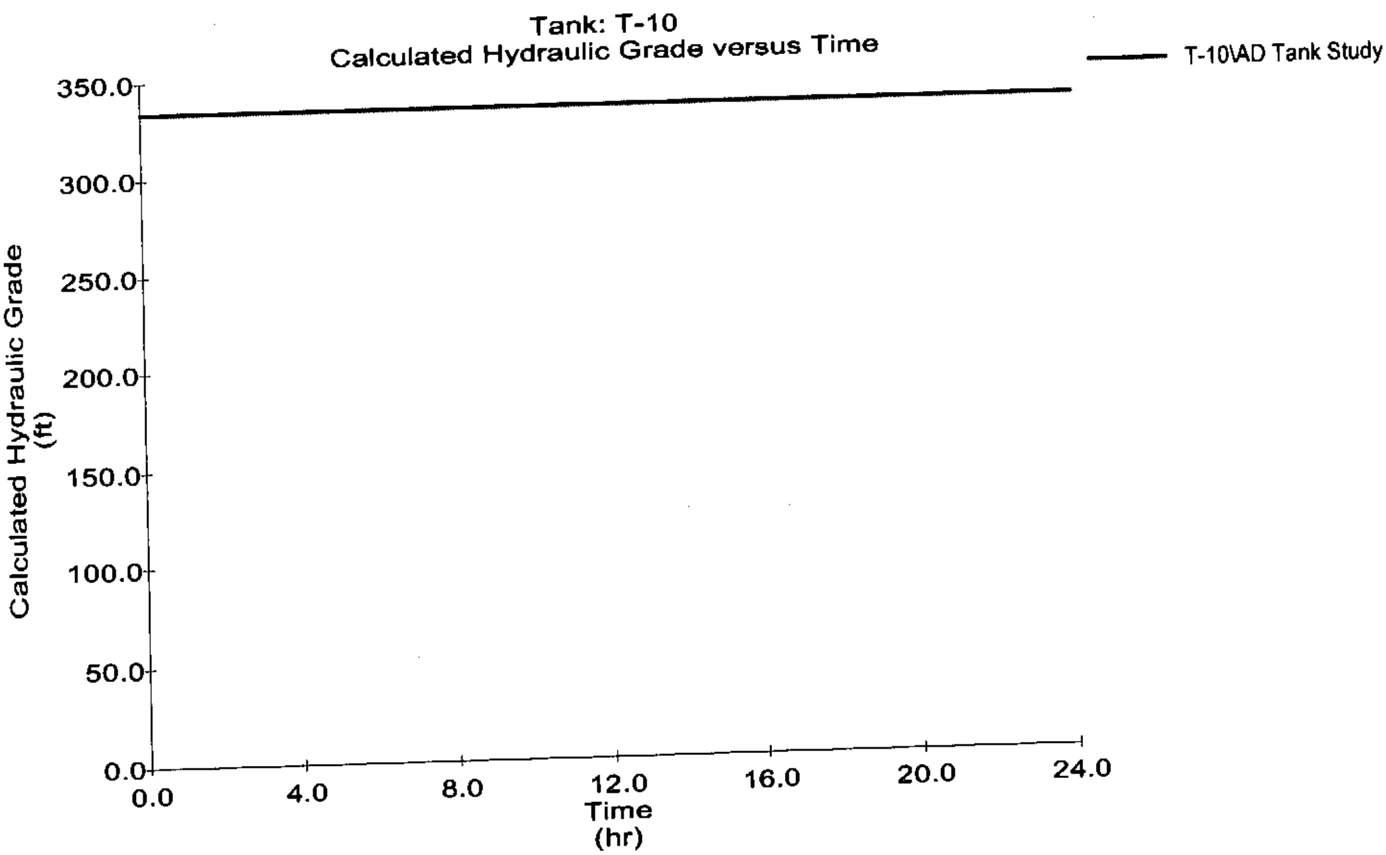
Graph

Fiskeville Reservoir #1



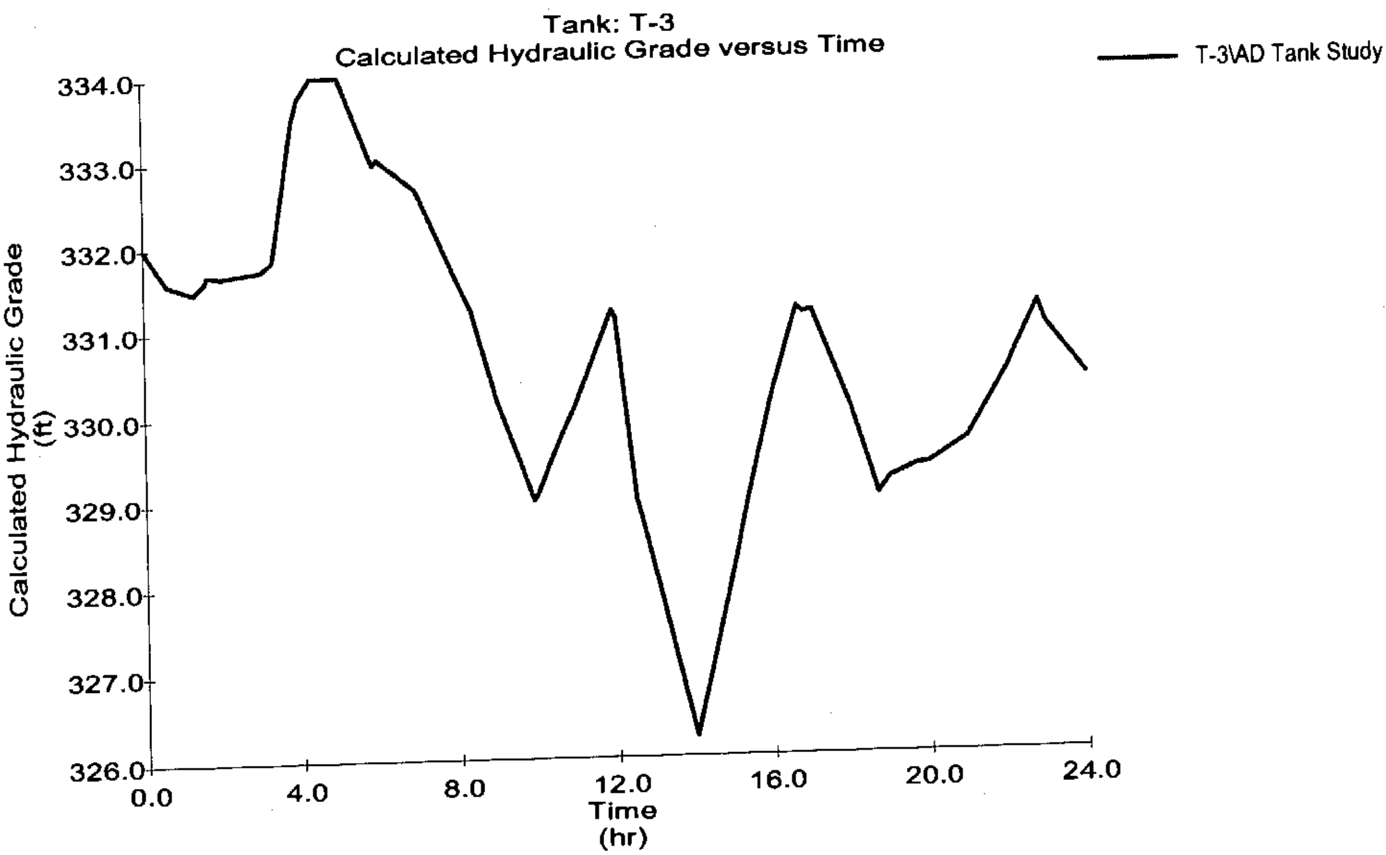
Graph

Fiskeville Reservoir #2



Graph

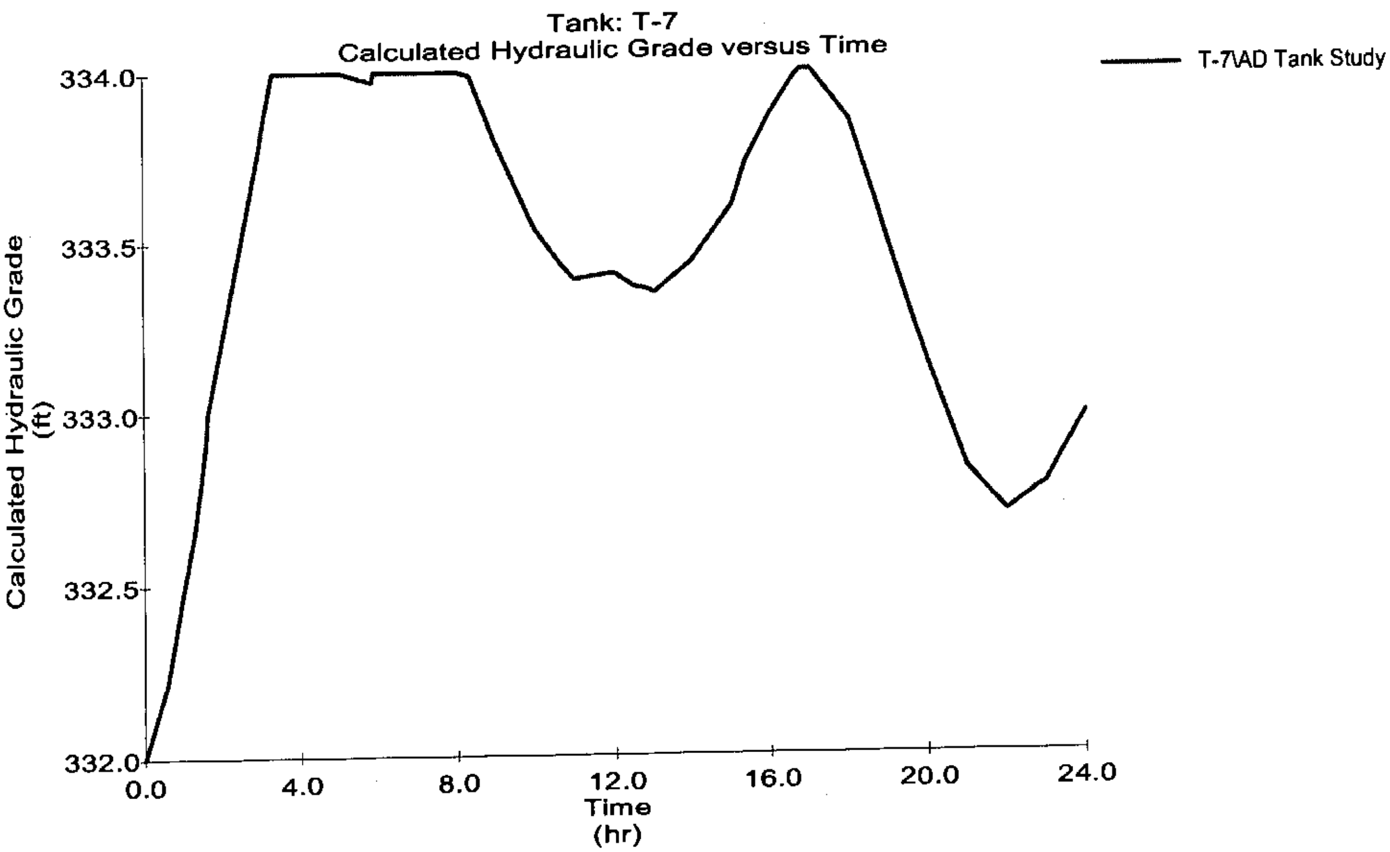
Frenchtown Road Tank



- 2000 gpm fire flow at node J-4091
- Frenchtown Rd.
- 20" AC main
- Elevation = 247 ft

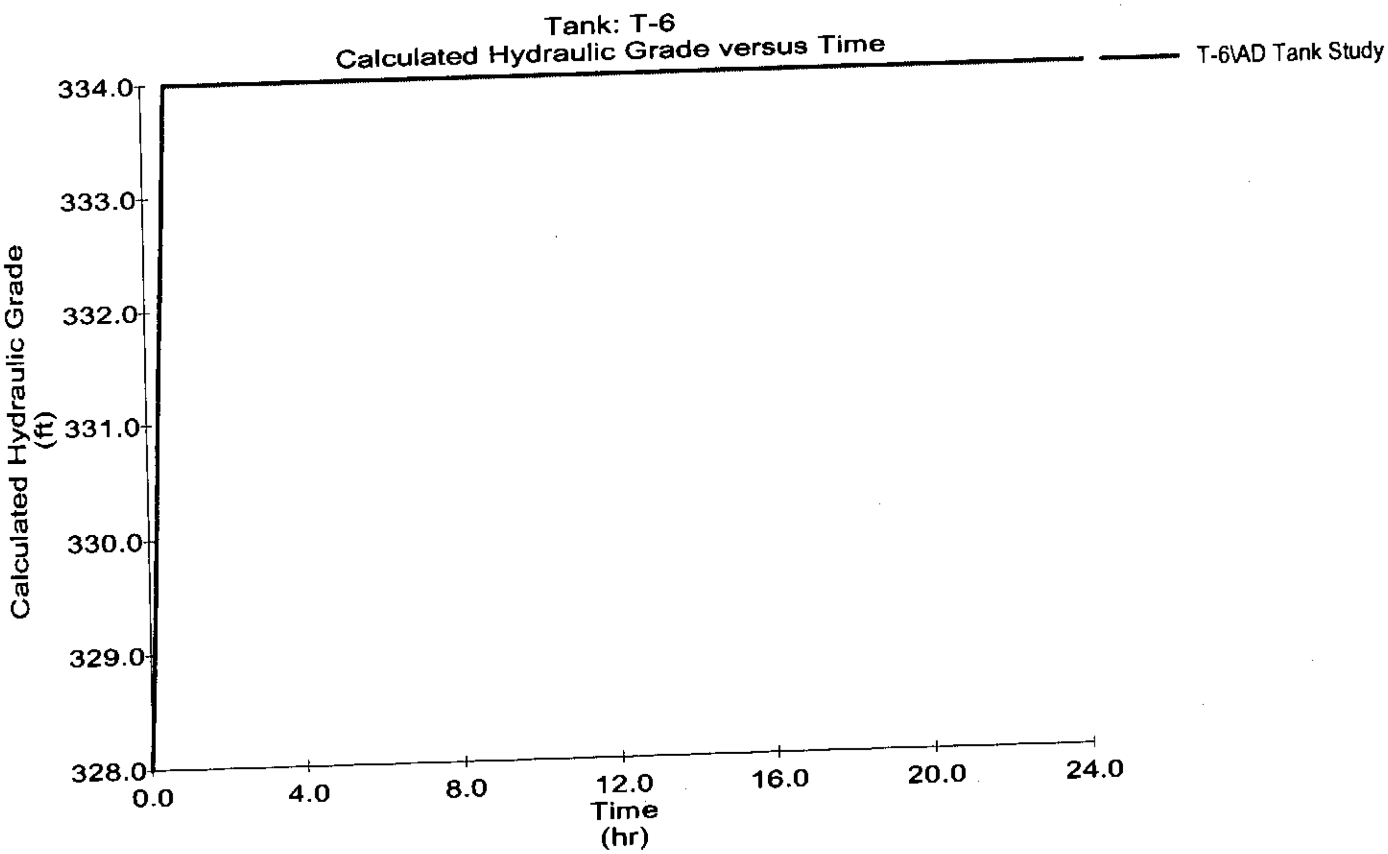
Graph

Setian Lane Tank



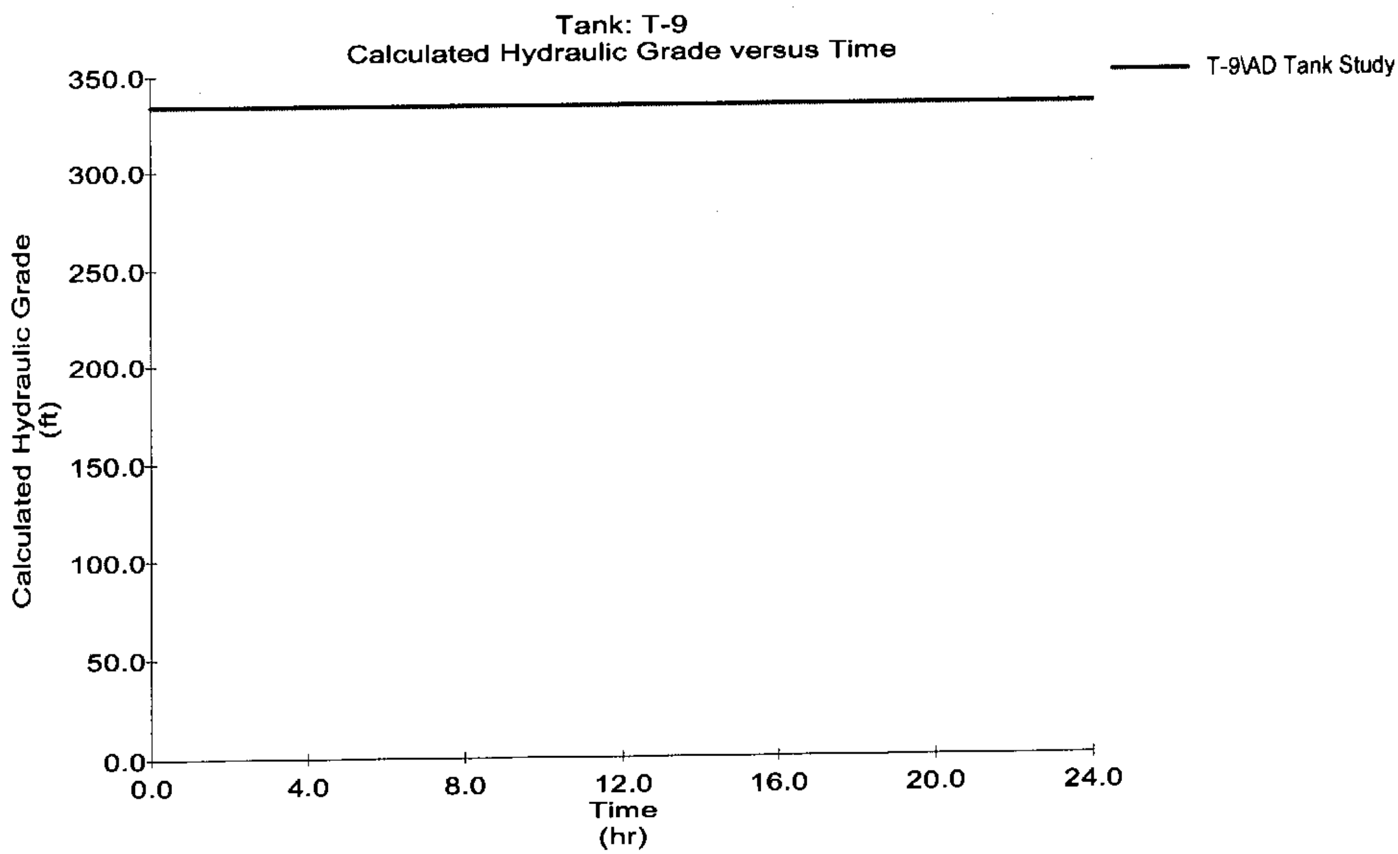
Graph

West Street Tank



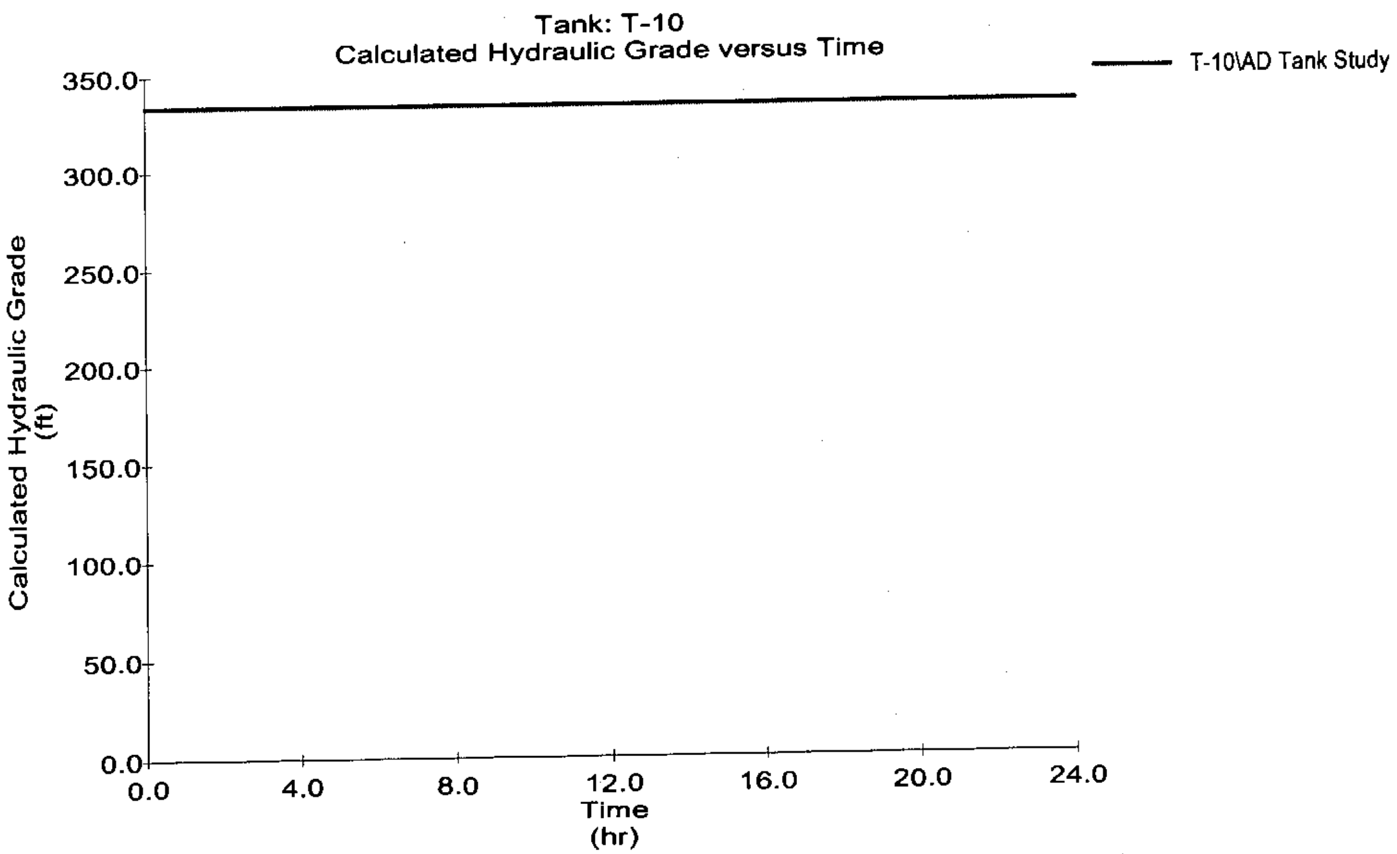
Graph

Fiskeville Reservoir #1



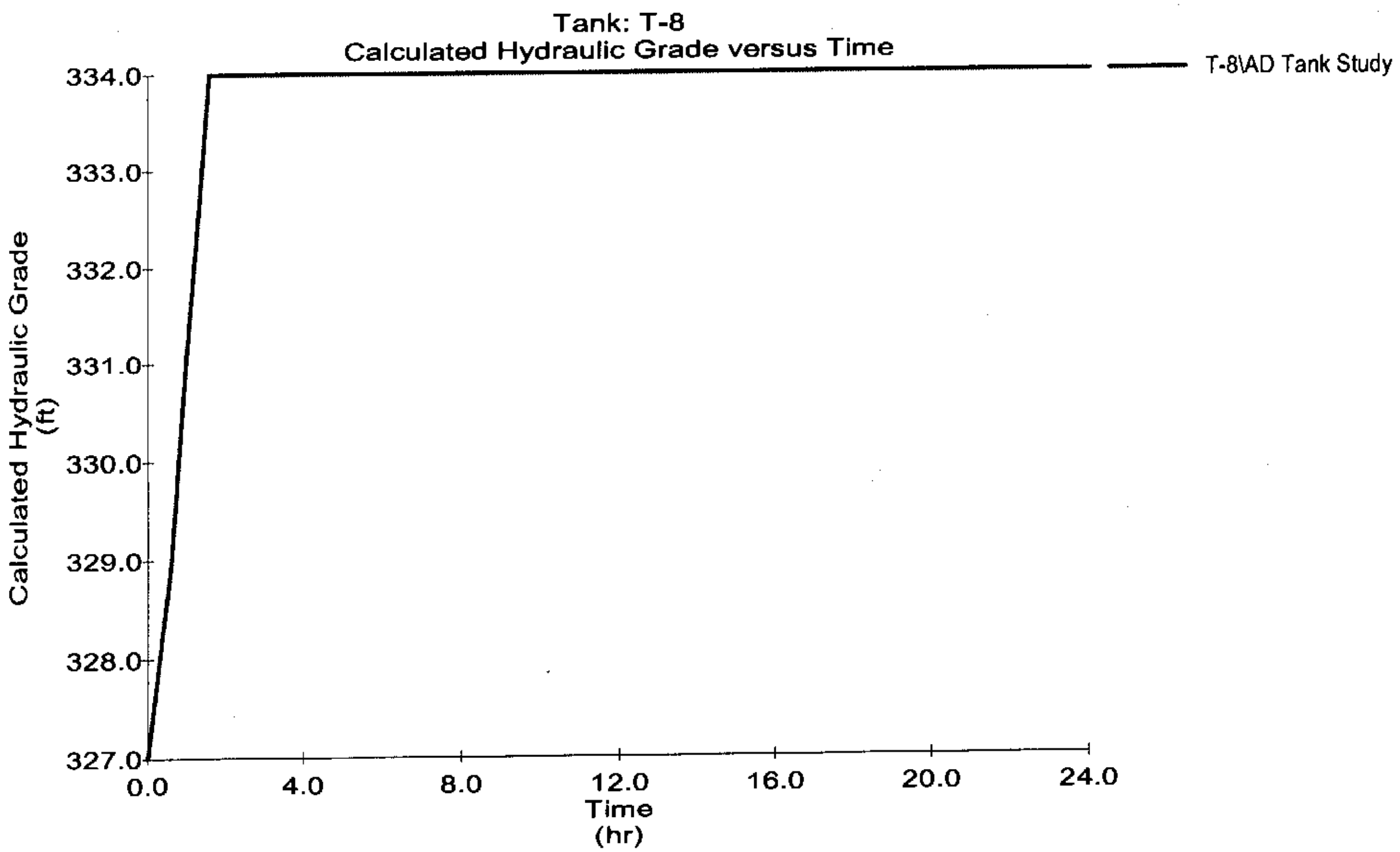
Graph

Fiskeville Reservoir #2



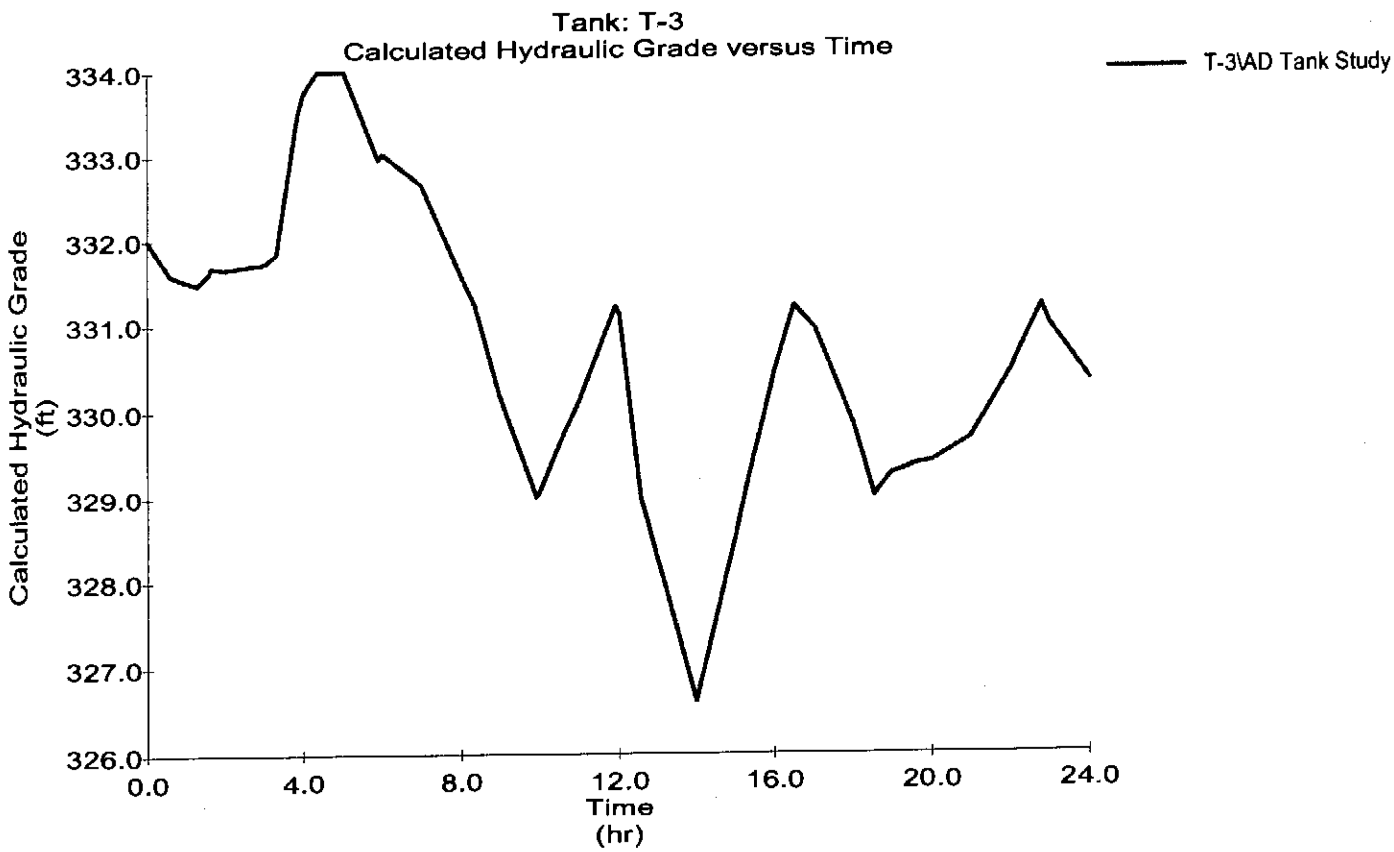
Graph

Wakefield Street Tank



Graph

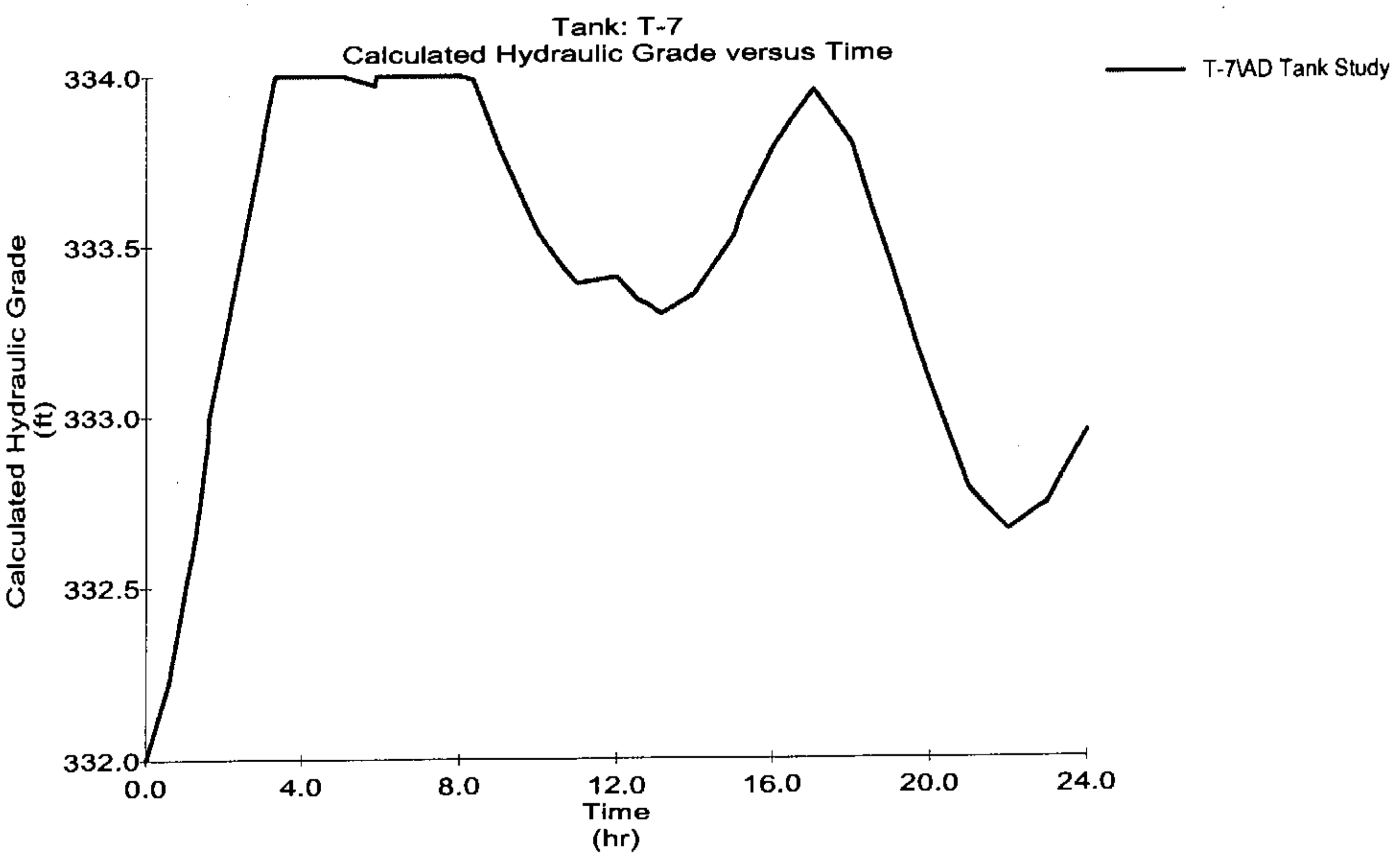
Frenchtown Road Tank



- 2000 gpm fire flow at node J-4175
- South County Tr.
- 12" AC main
- Elevation = 109 ft

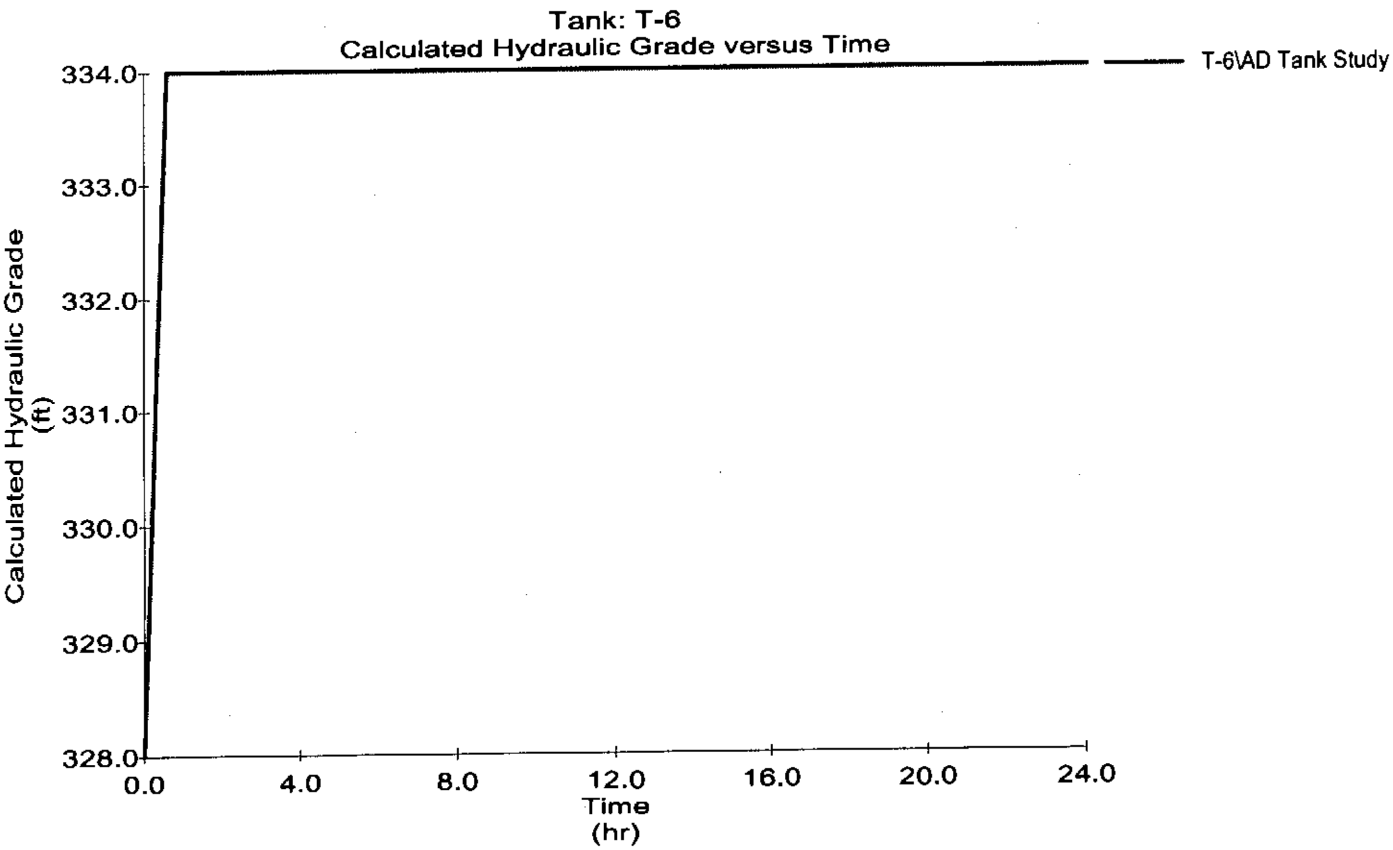
Graph

Setian Lane Tank



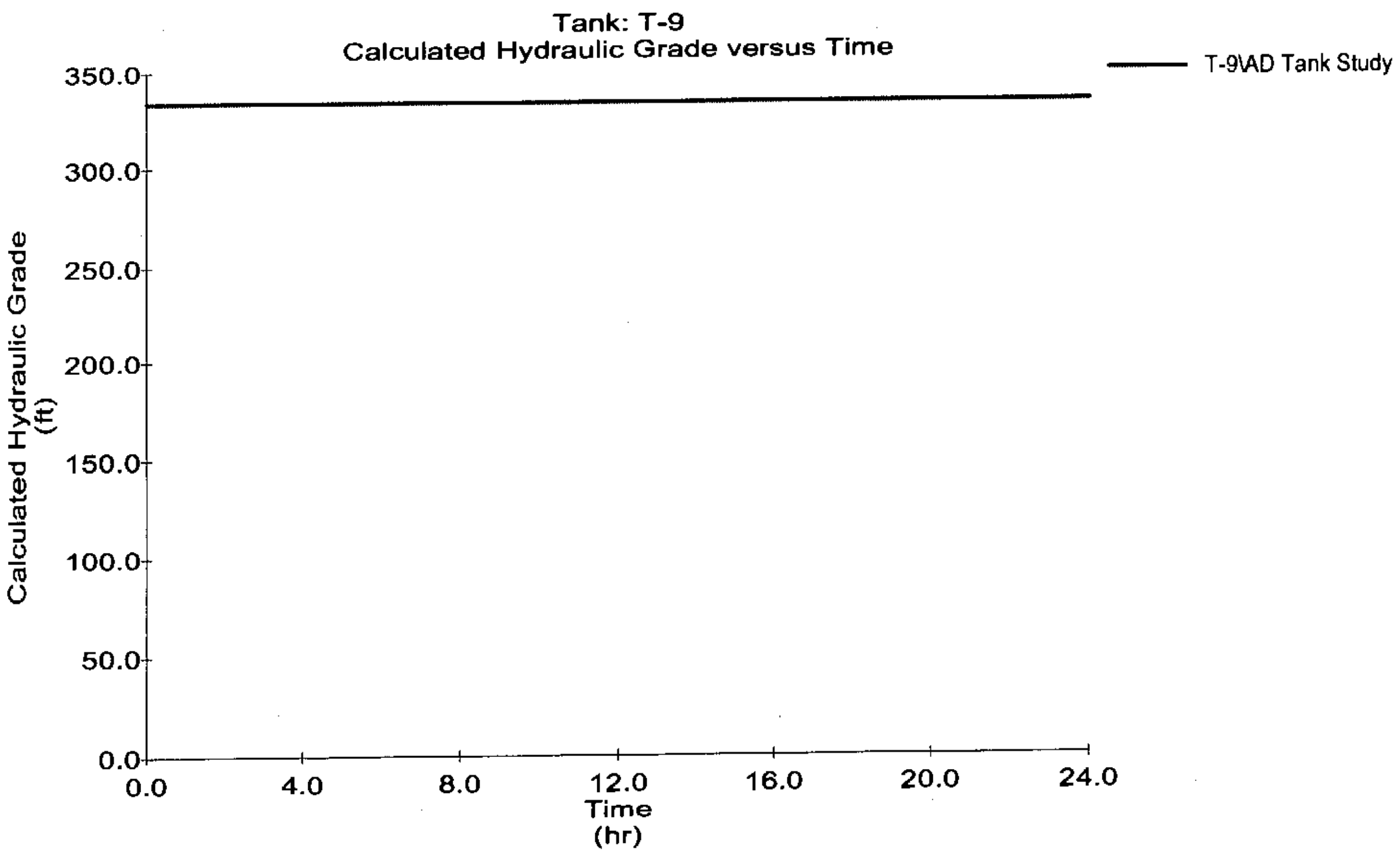
Graph

West Street Tank



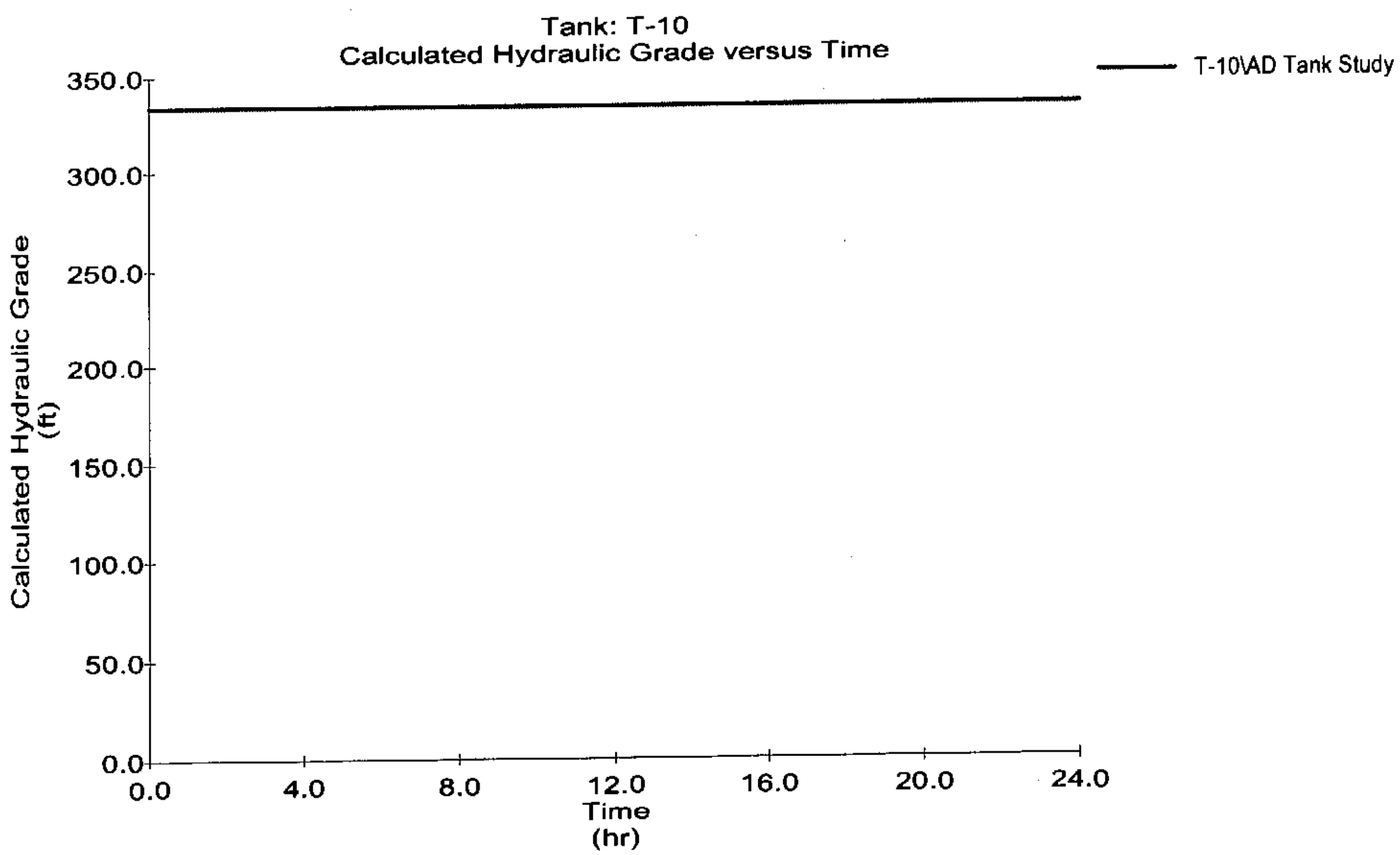
Graph

Fiskeville Reservoir #1



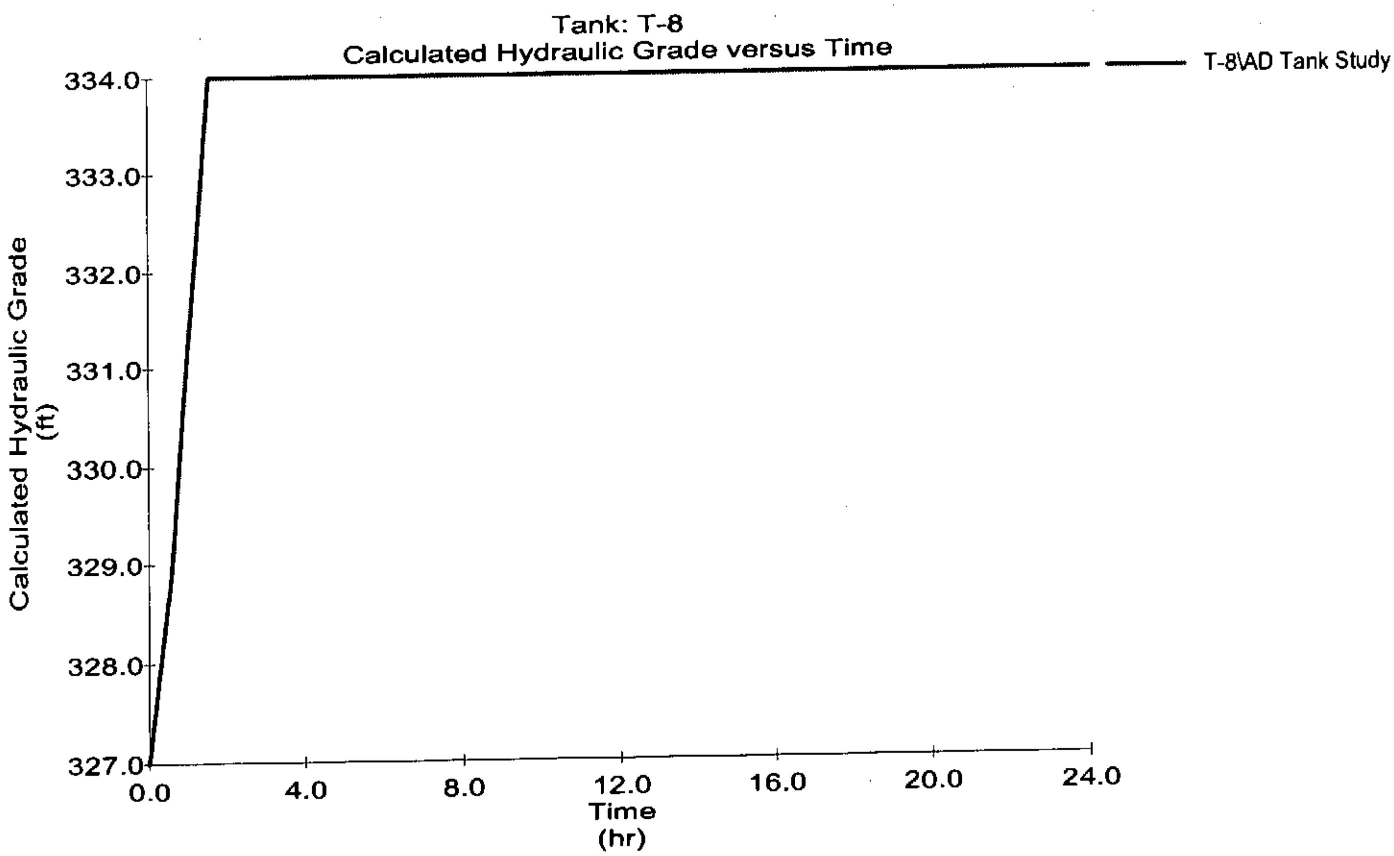
Graph

Fiskeville Reservoir #2



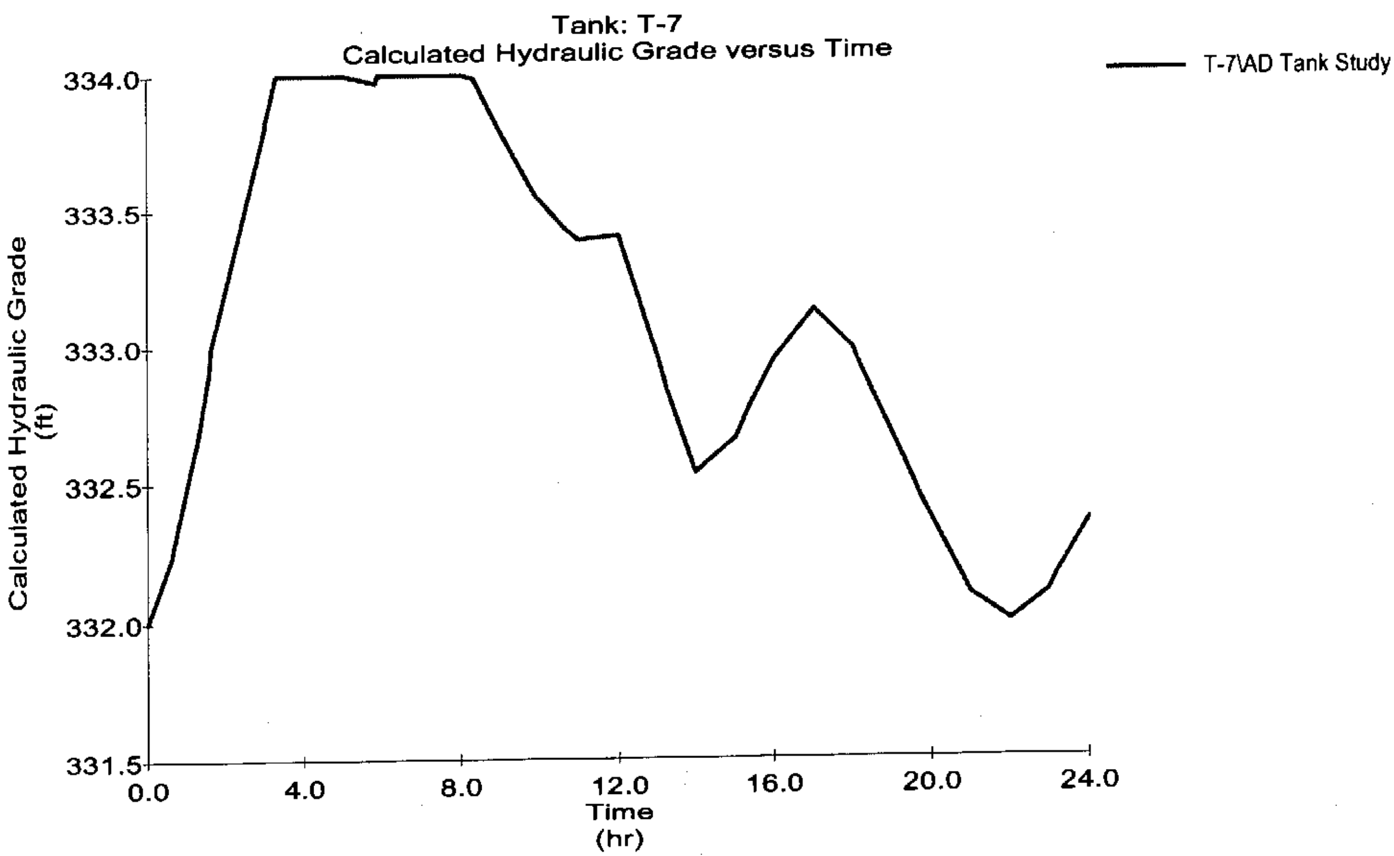
Graph

Wakefield Street Tank



Graph

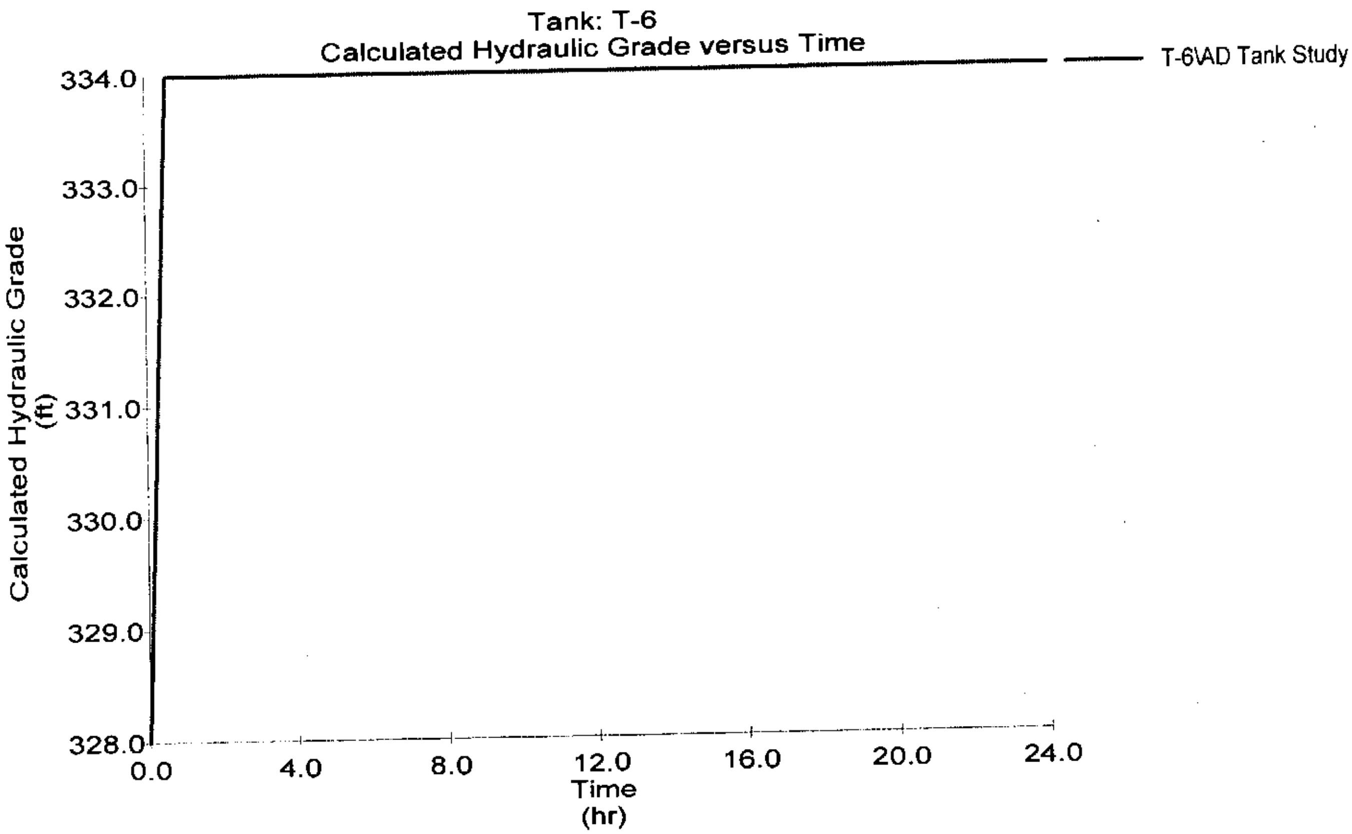
Setian Lane Tank



- 2000 gpm fire flow at node J-390
- Cowesett Rd.
- 12" AC main
- Elevation = 205 ft

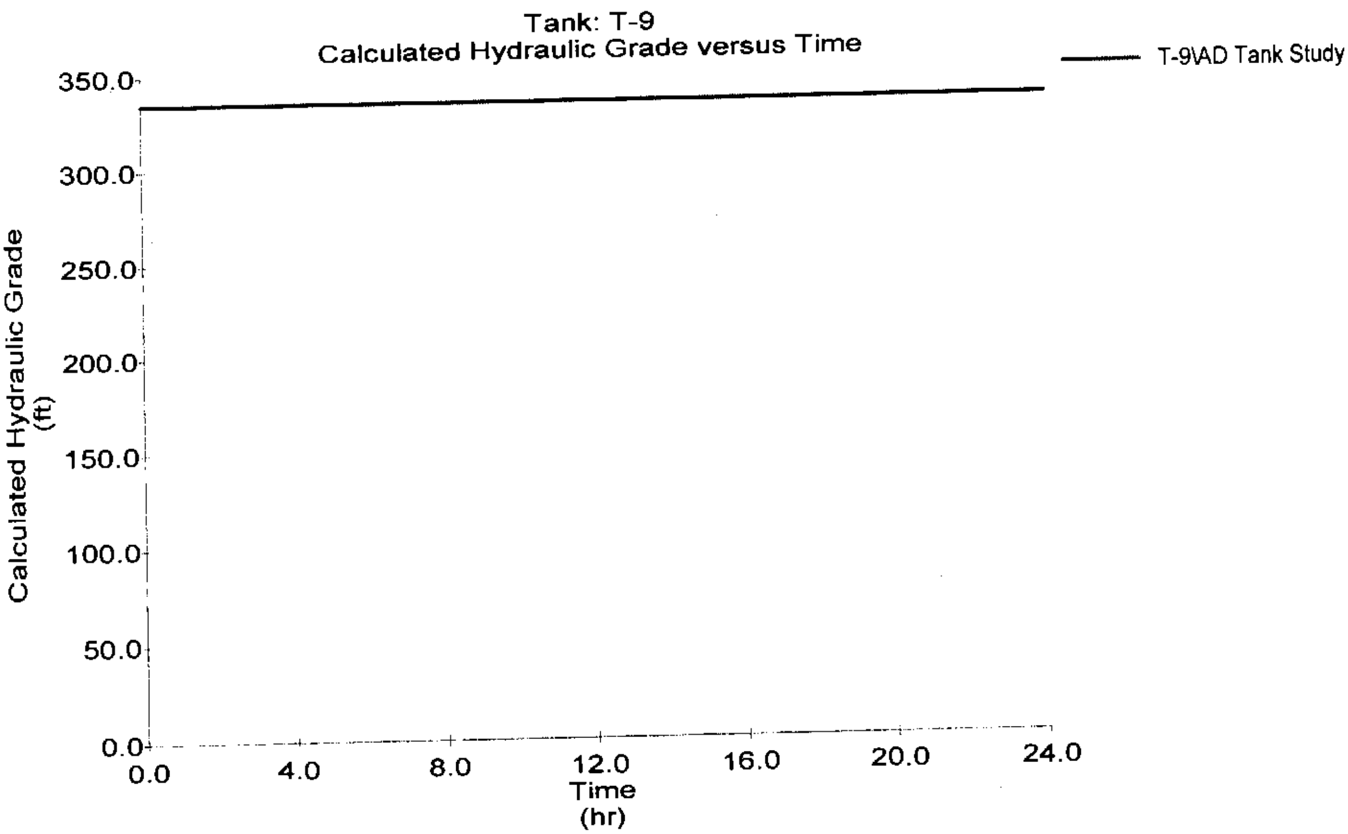
Graph

West Street Tank



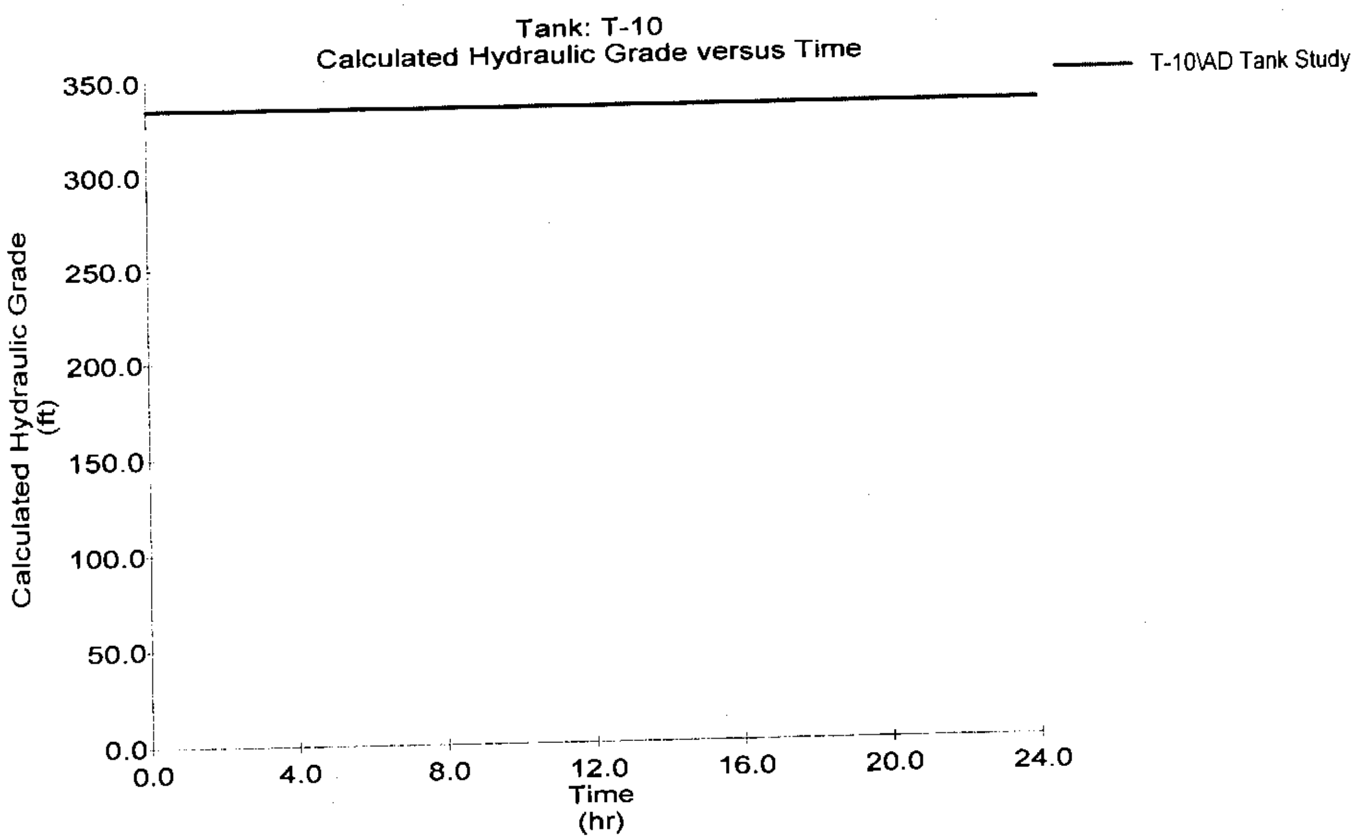
Graph

Fiskeville Reservoir #1



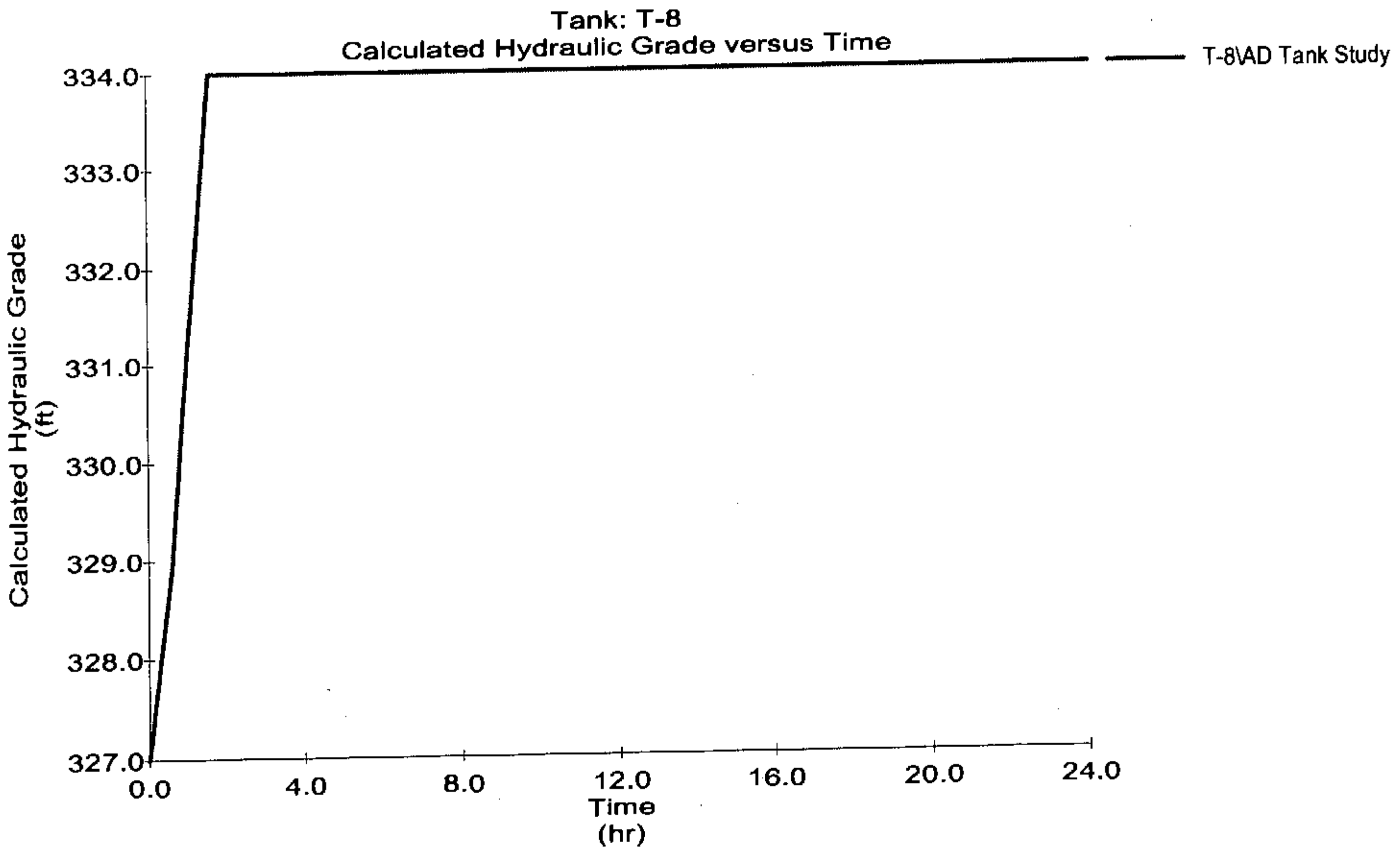
Graph

Fiskeville Reservoir #2



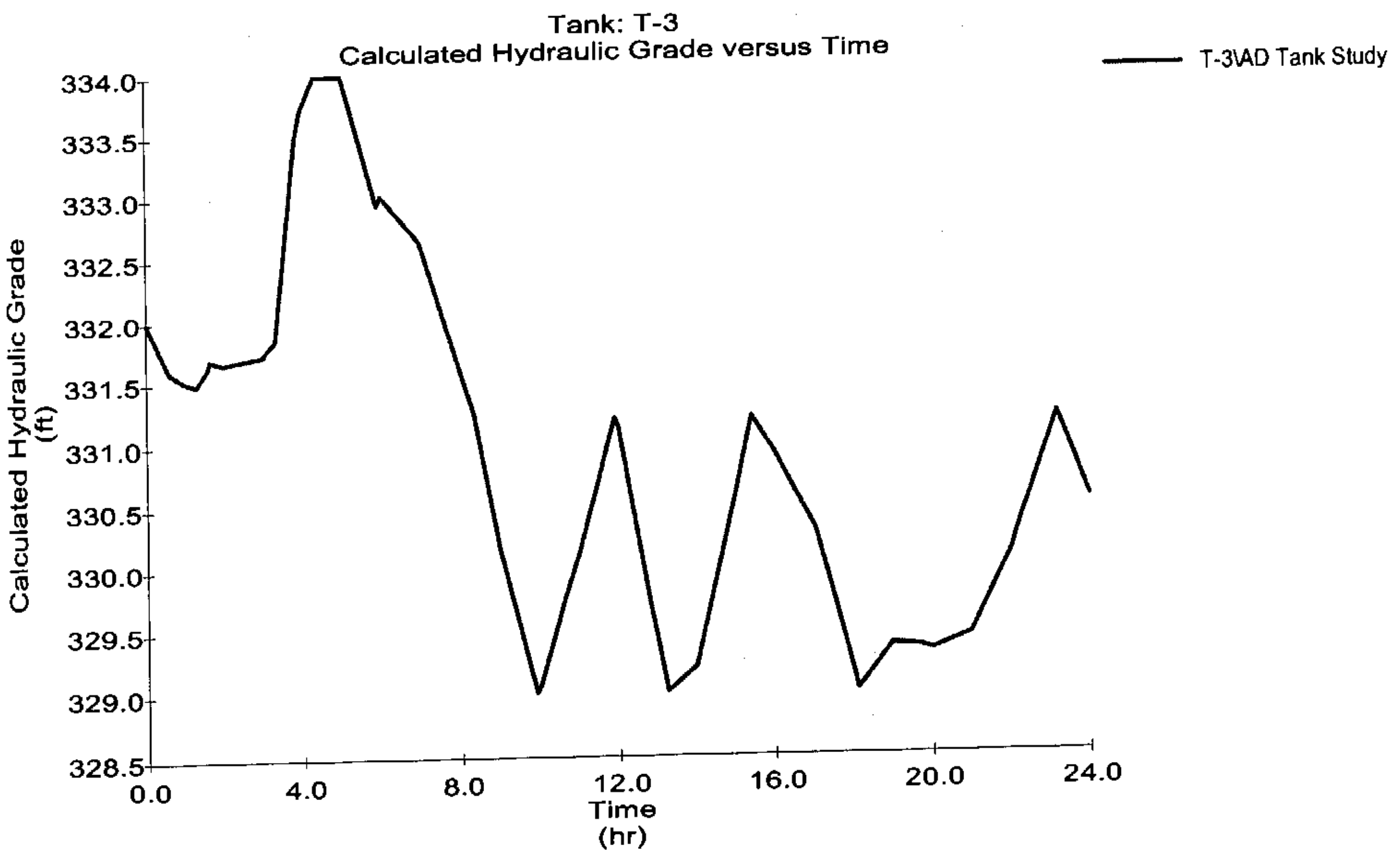
Graph

Wakefield Street Tank



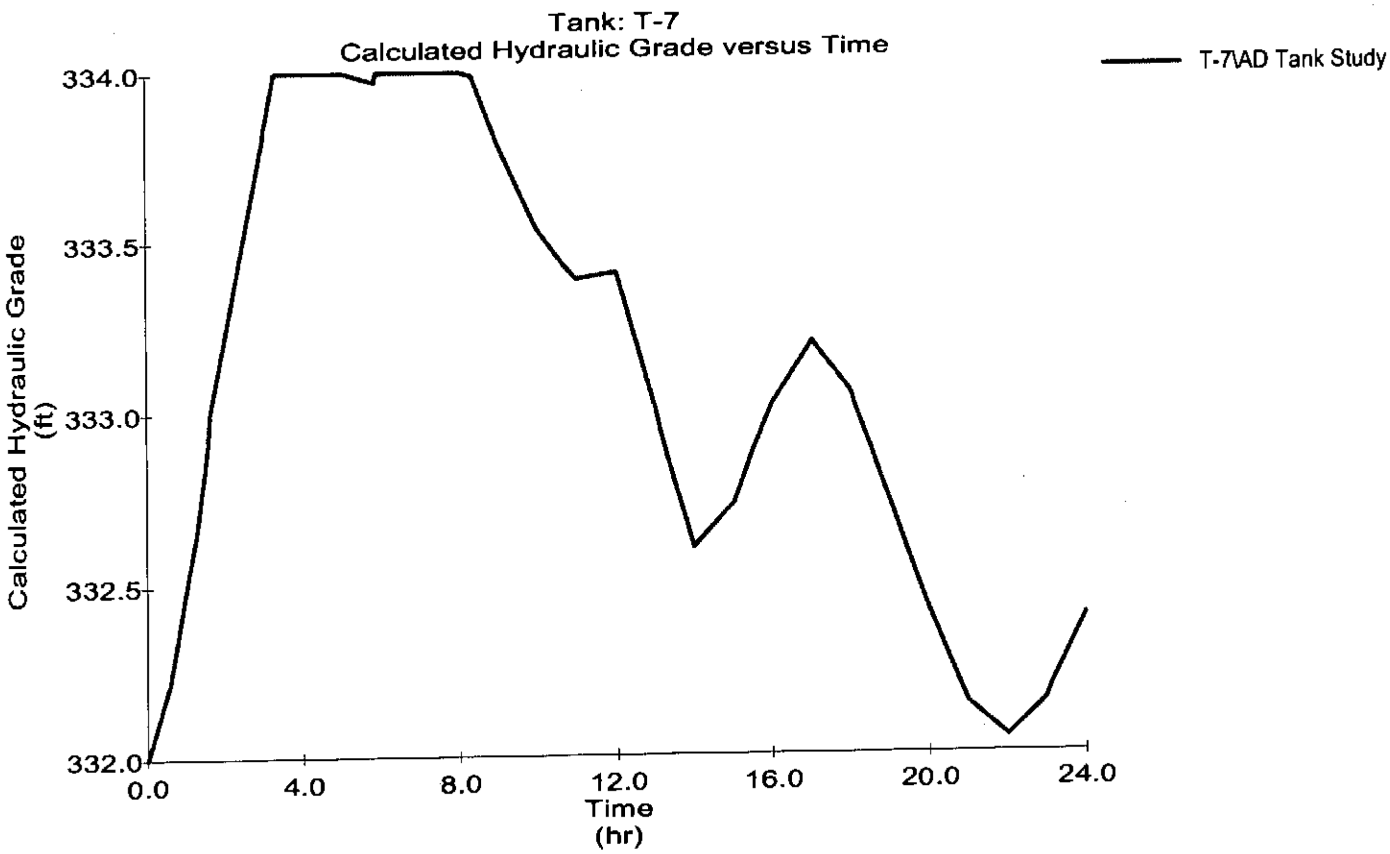
Graph

Frenchtown Road Tank



Graph

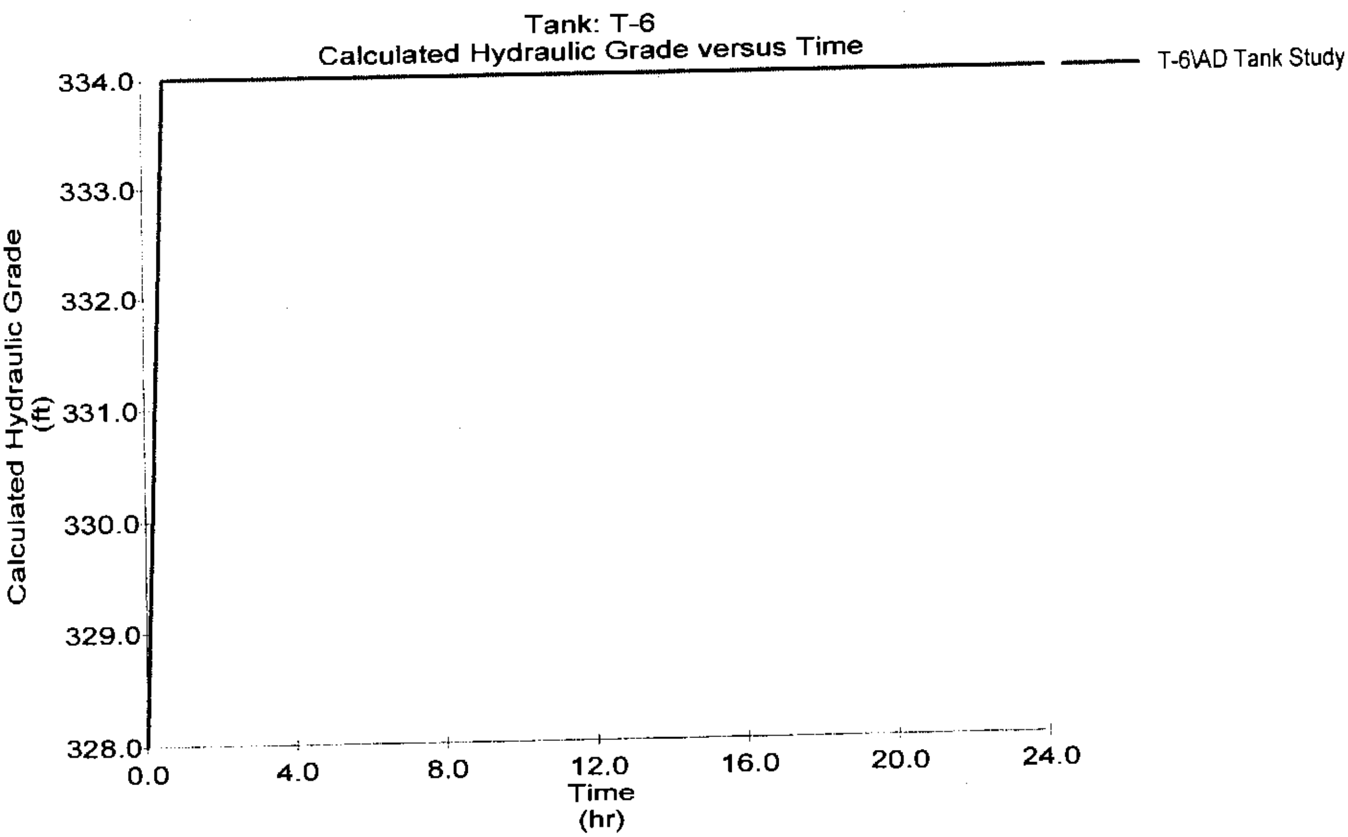
Setian Lane Tank



- 2000 gpm fire flow at node J-2005
- Centerville Rd.
- 12" AC main
- Elevation = 100 ft

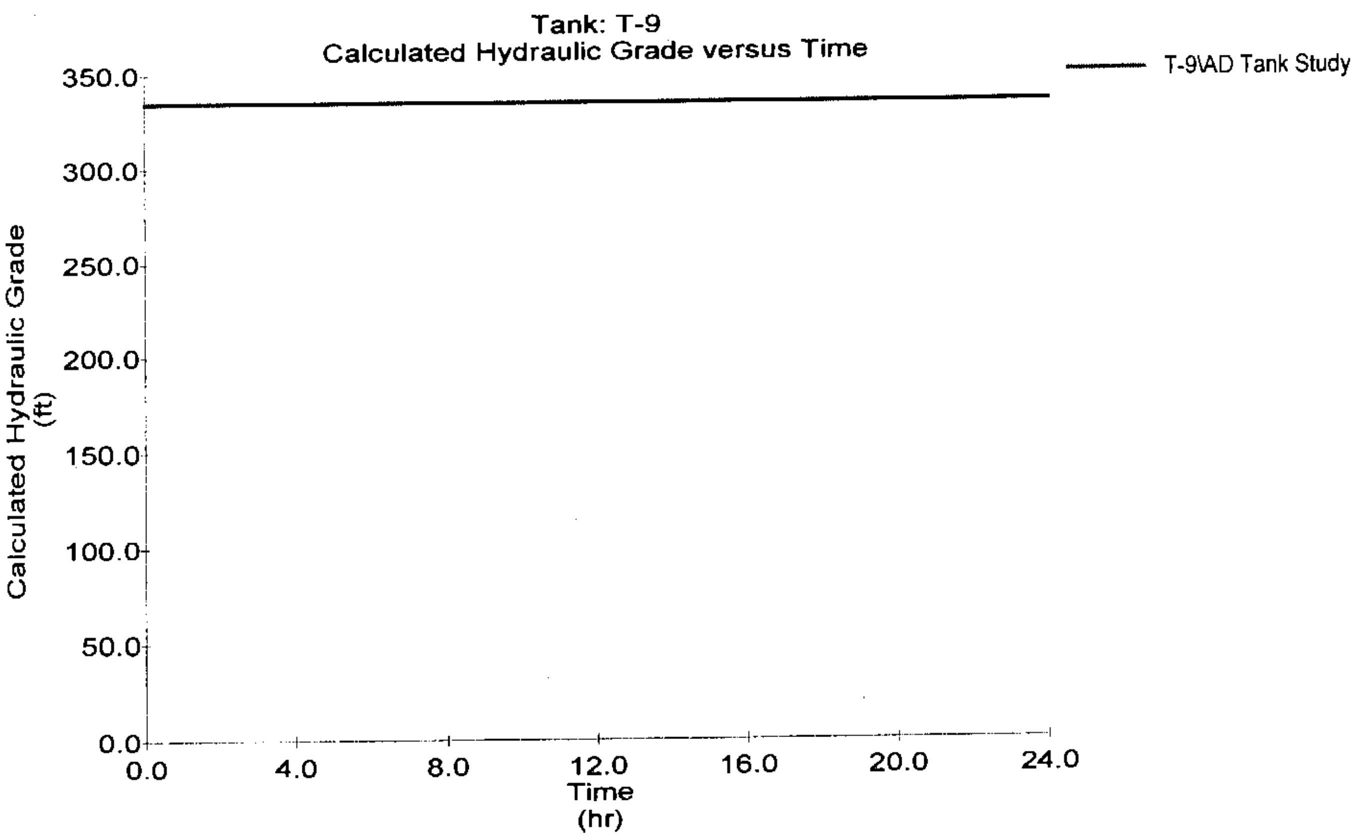
Graph

West Street Tank



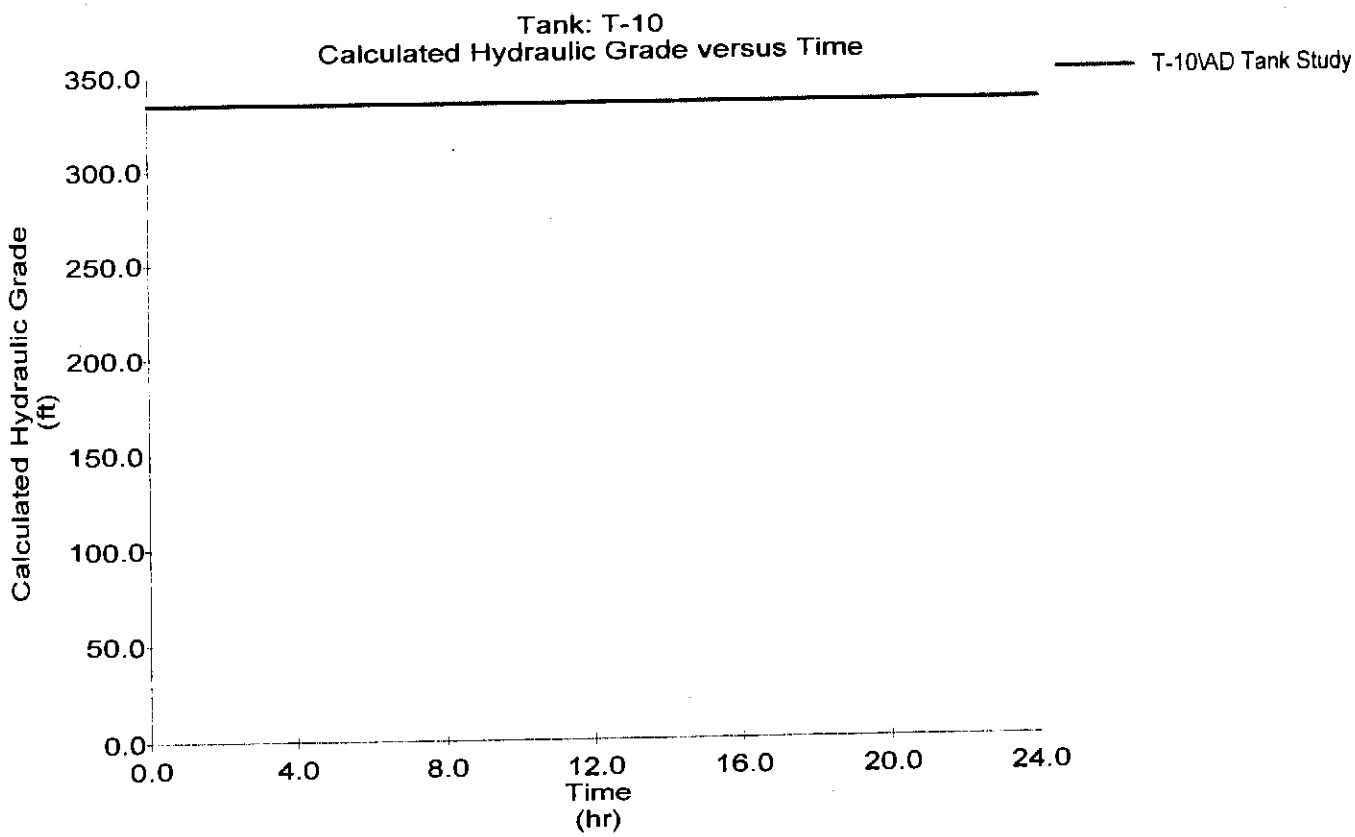
Graph

Fiskeville Reservoir #1



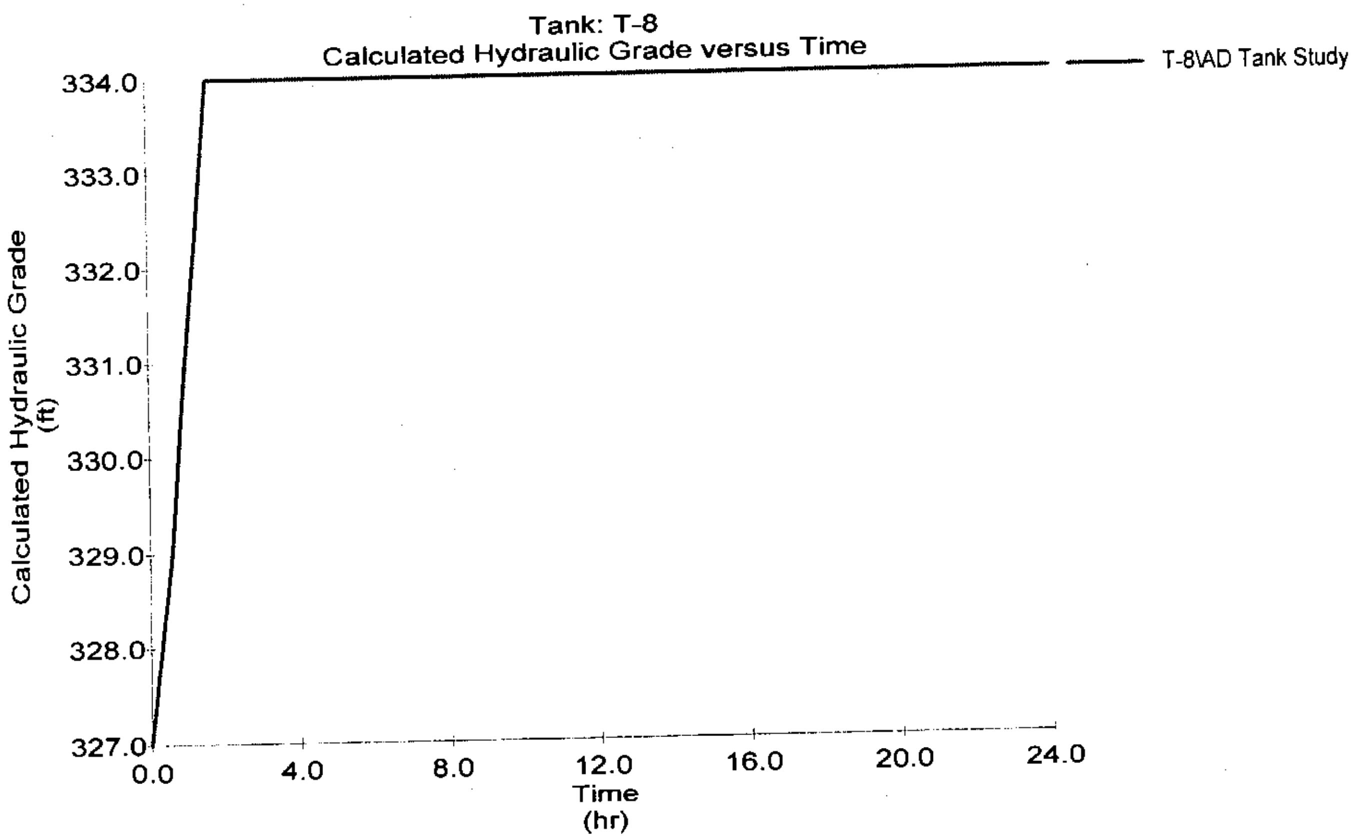
Graph

Fiskeville Reservoir #2



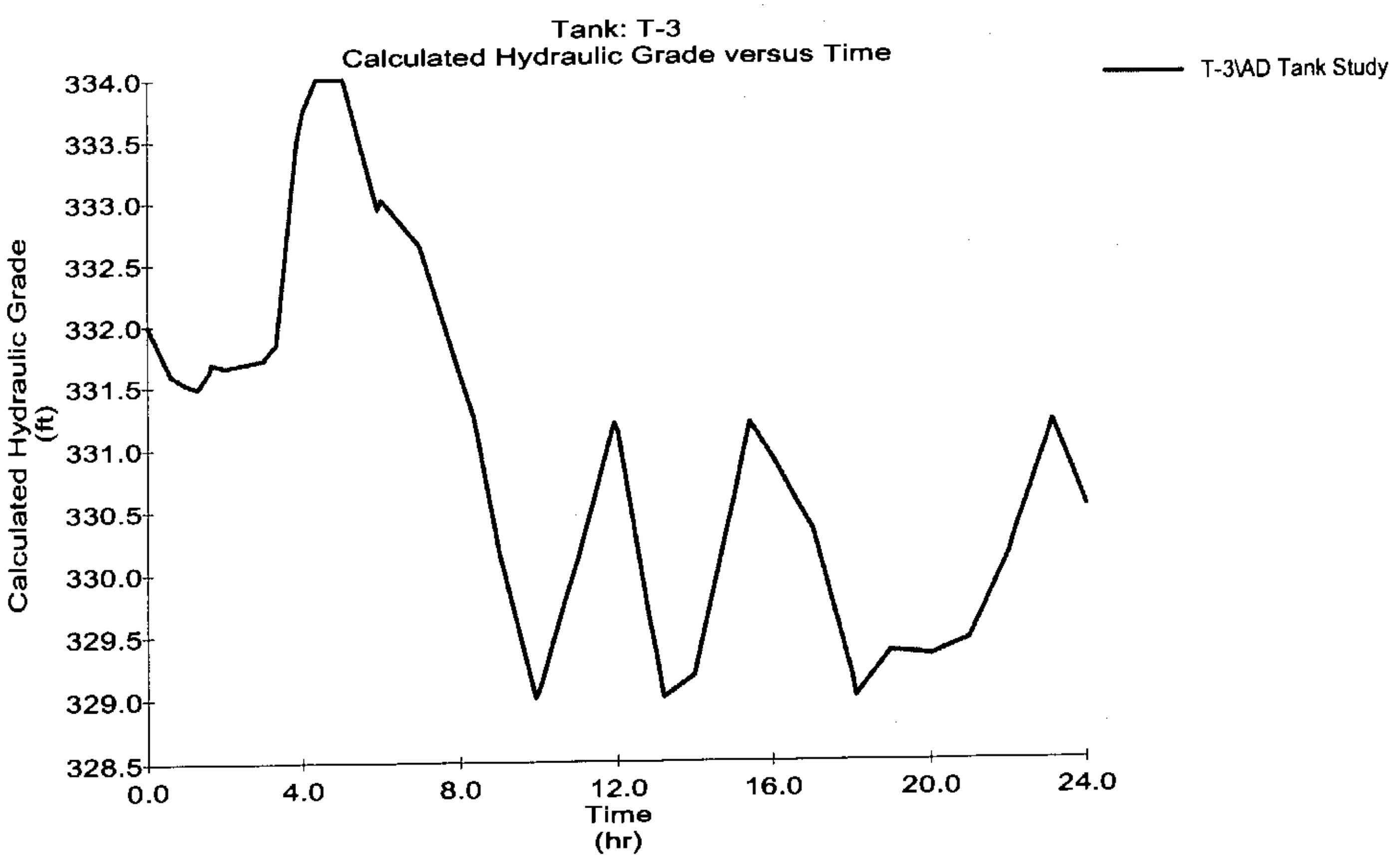
Graph

Wakefield Street Tank



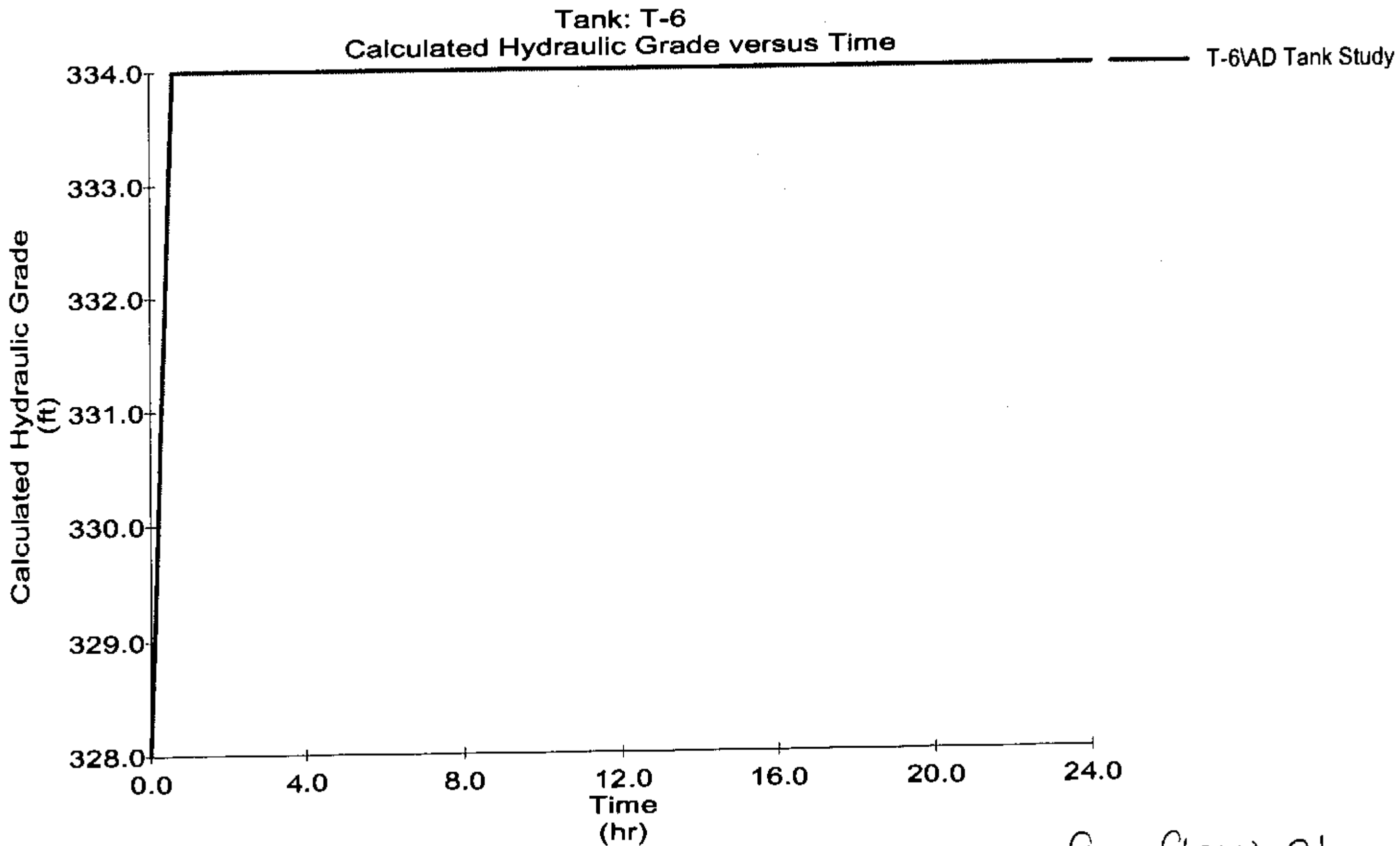
Graph

Frenchtown Road Tank



Graph

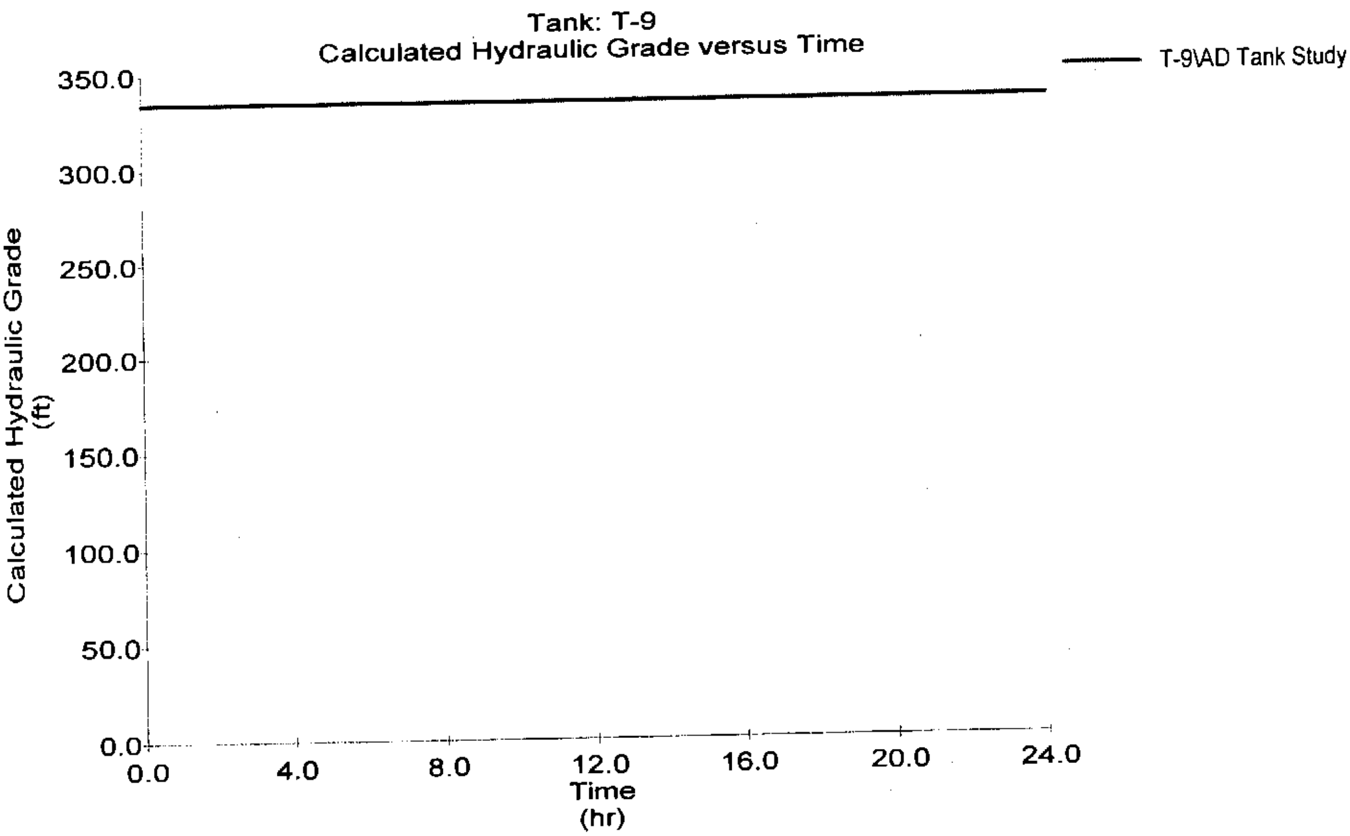
West Street Tank



- 2000 gpm fire flow at node J-626
- West St.
- 16" AC main
- Elevation = 245 ft

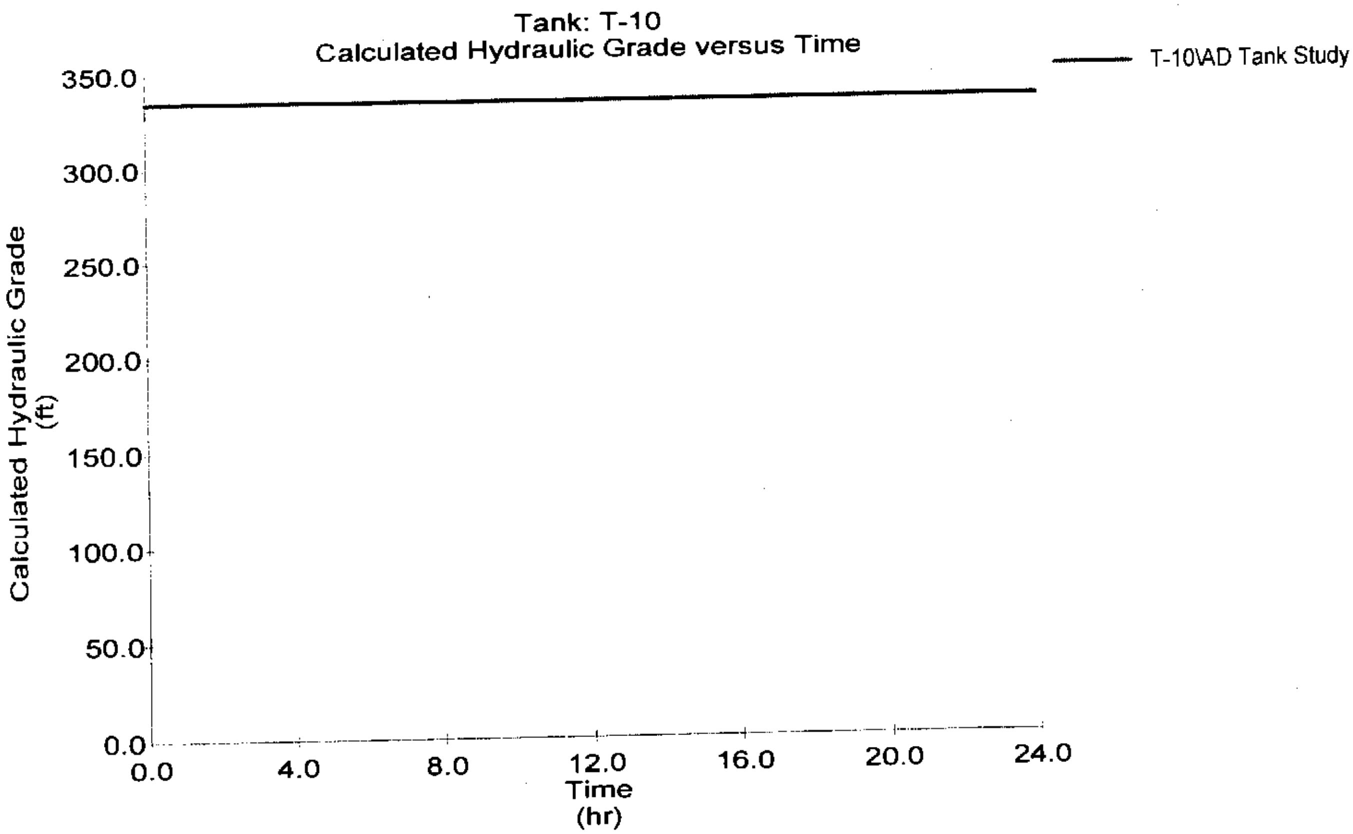
Graph

Fiskeville Reservoir #1



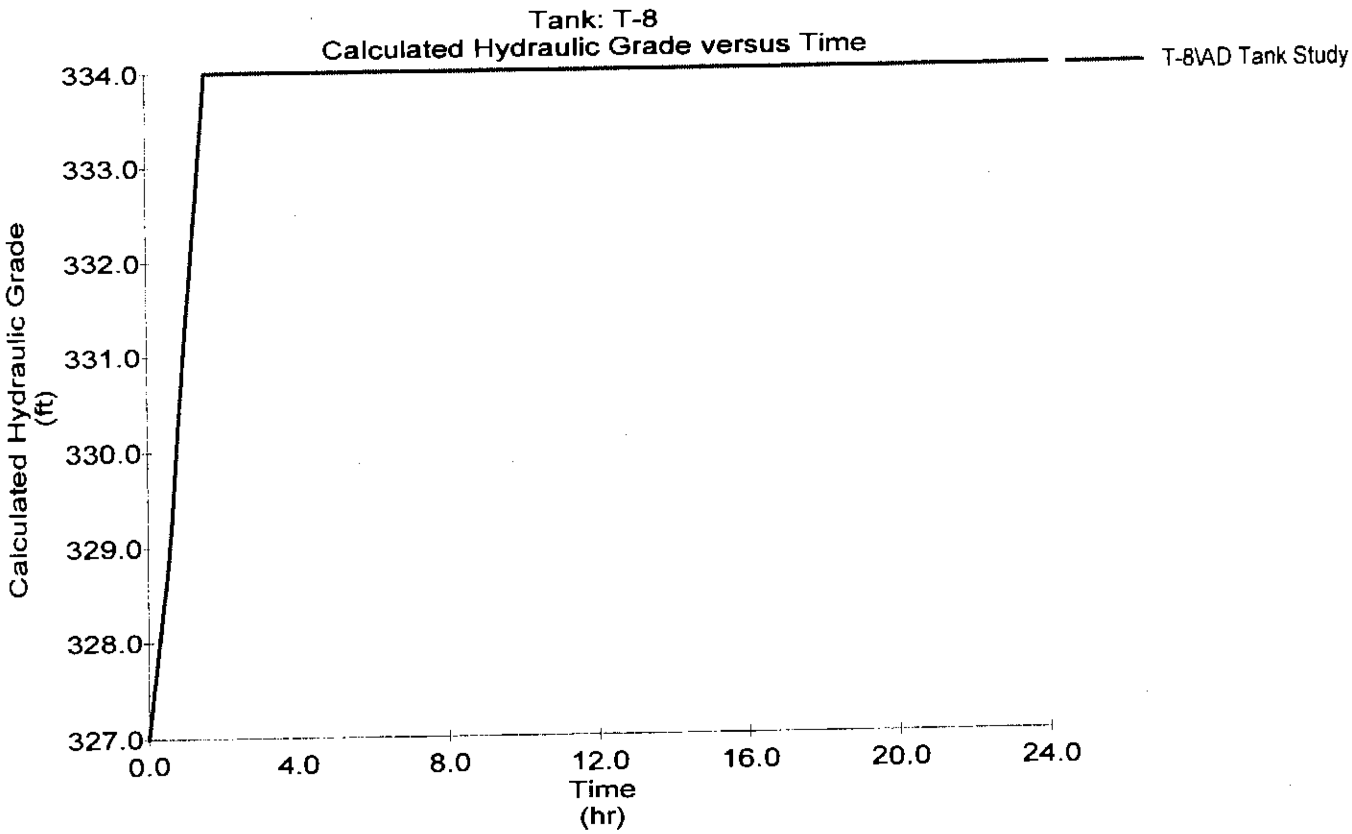
Graph

Fiskeville Reservoir #2



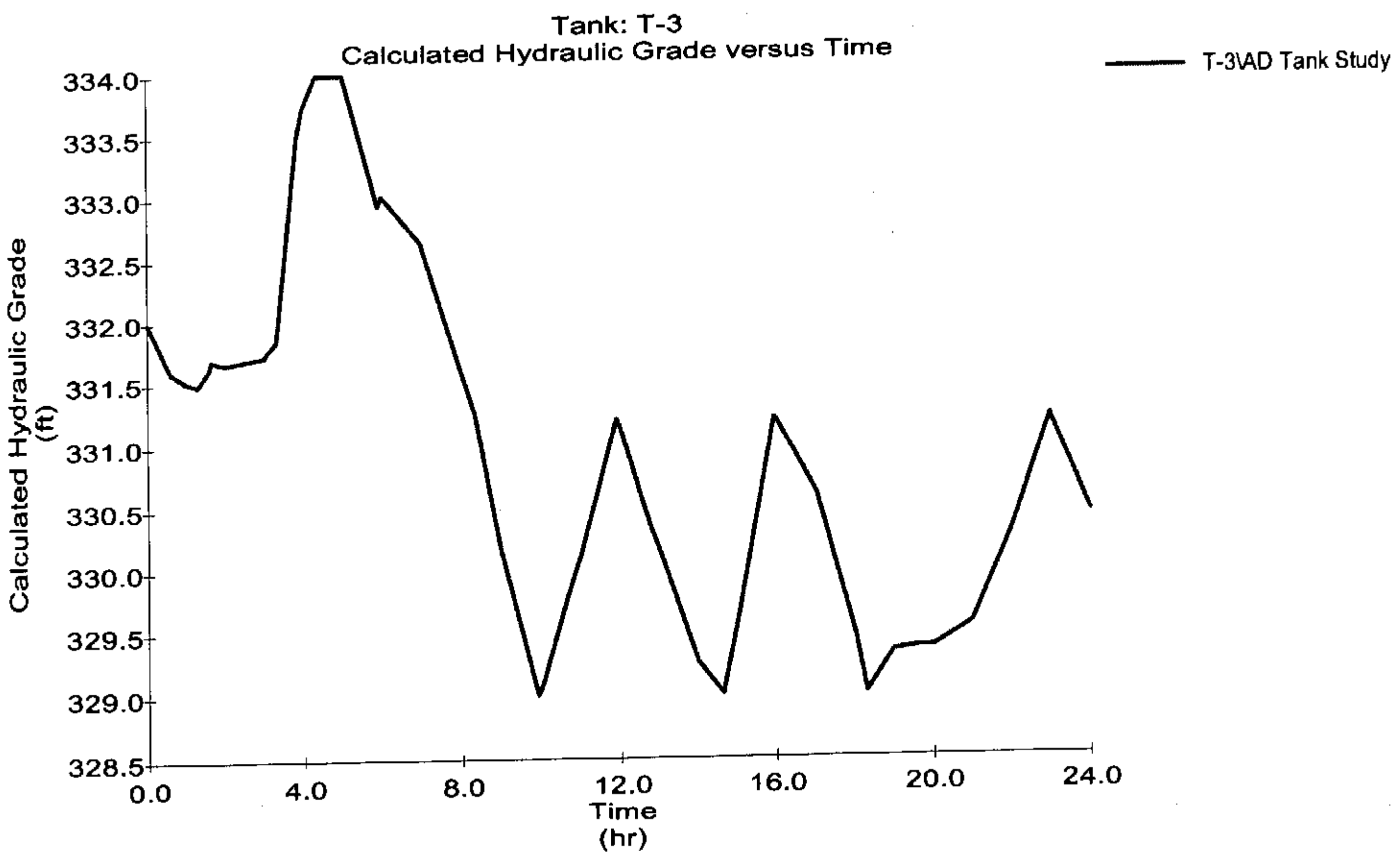
Graph

Wakefield Street Tank



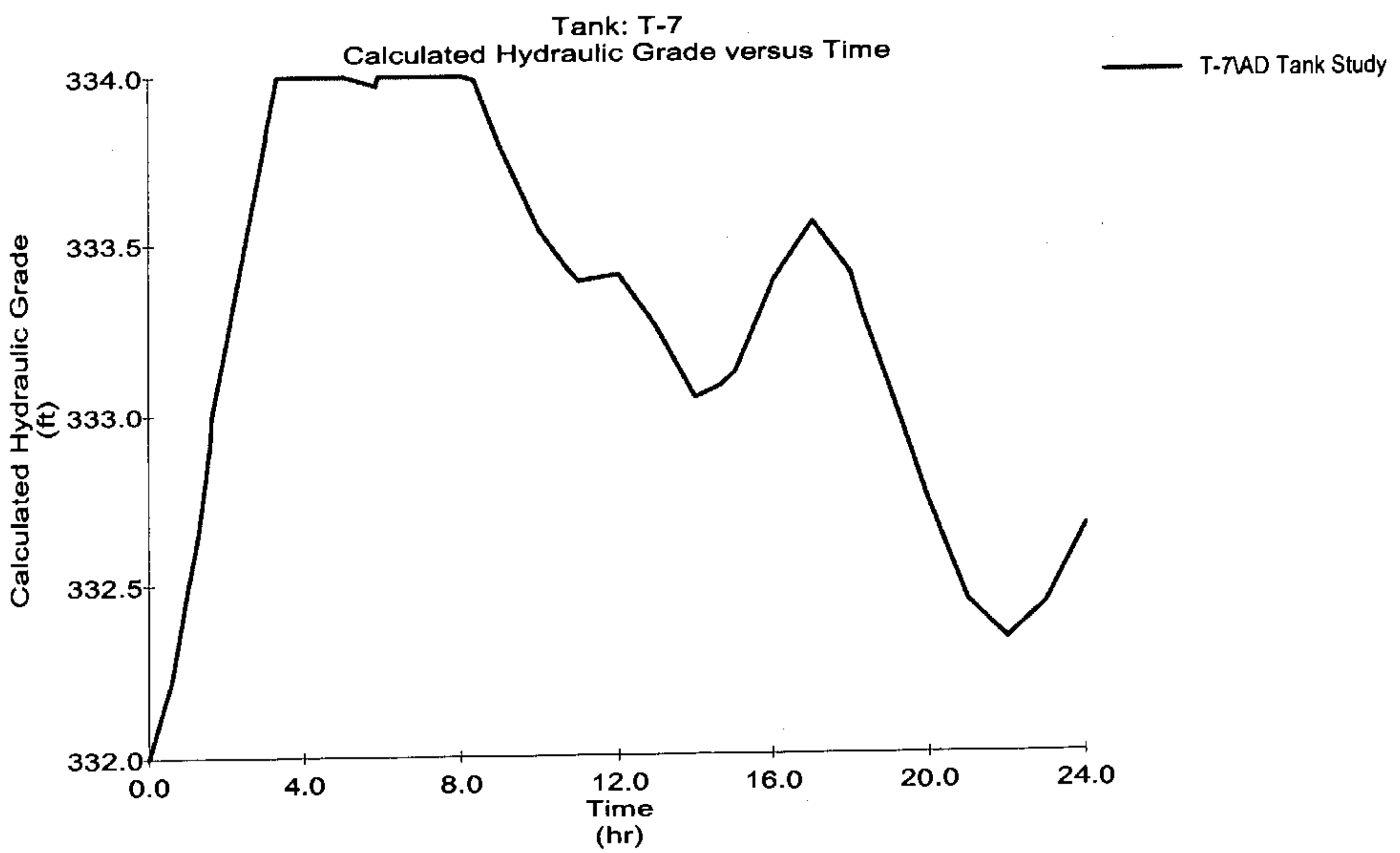
Graph

Frenchtown Road Tank



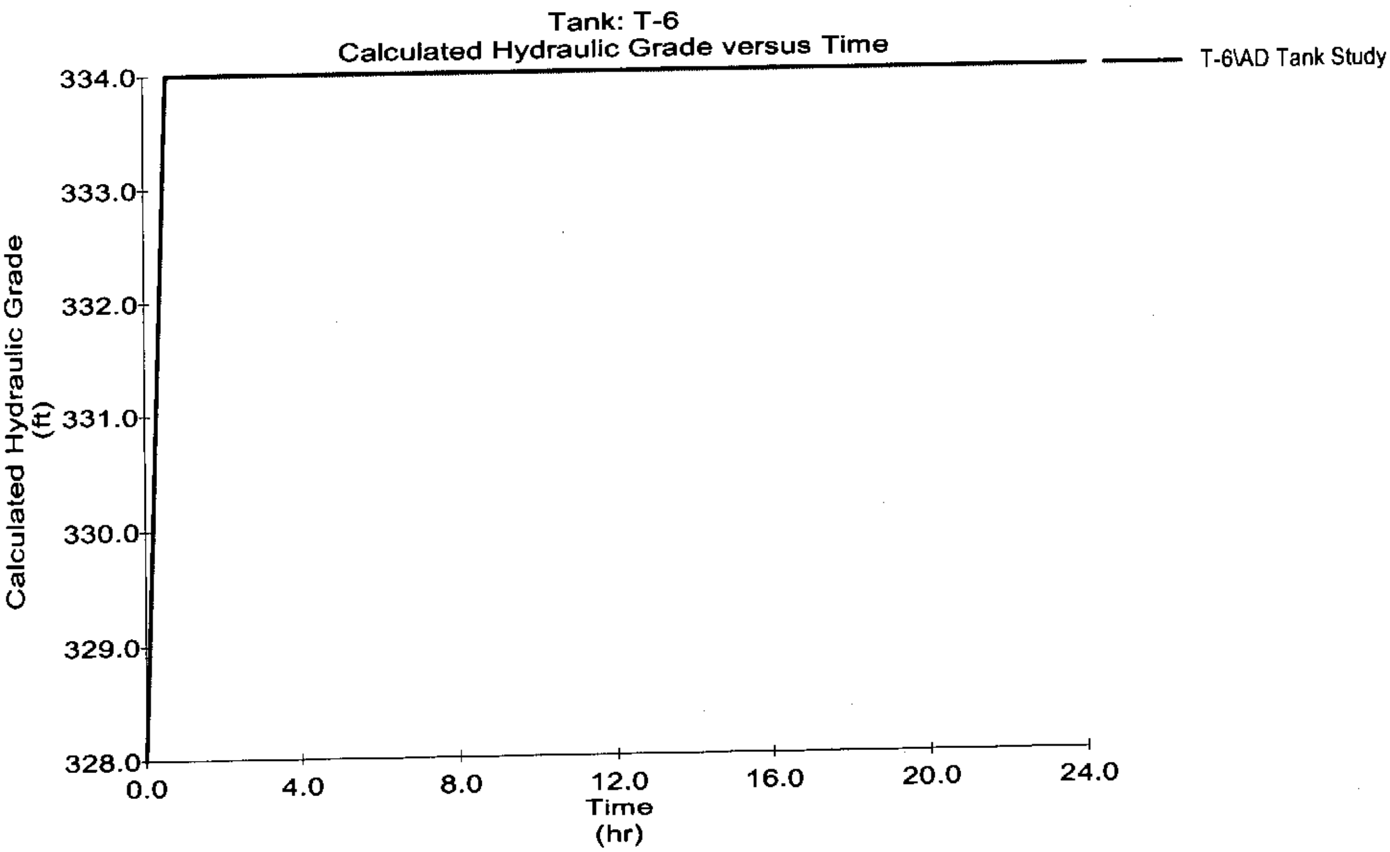
Graph

Setian Lane Tank



Graph

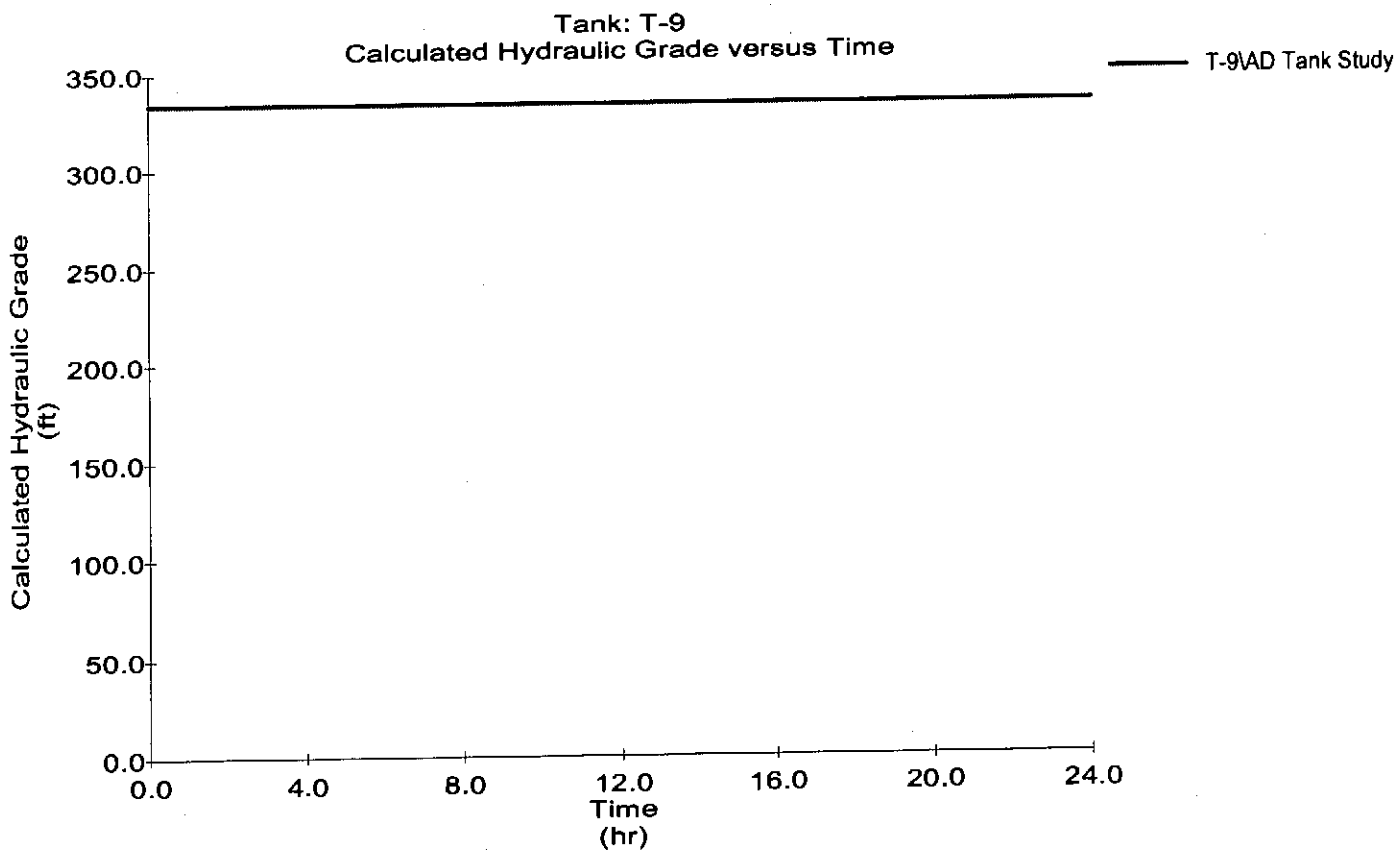
West Street Tank



- 2000 gpm fire flow at node J-7879
- Fairview Ave.
- 16" AC main
- Elevation = 255ft

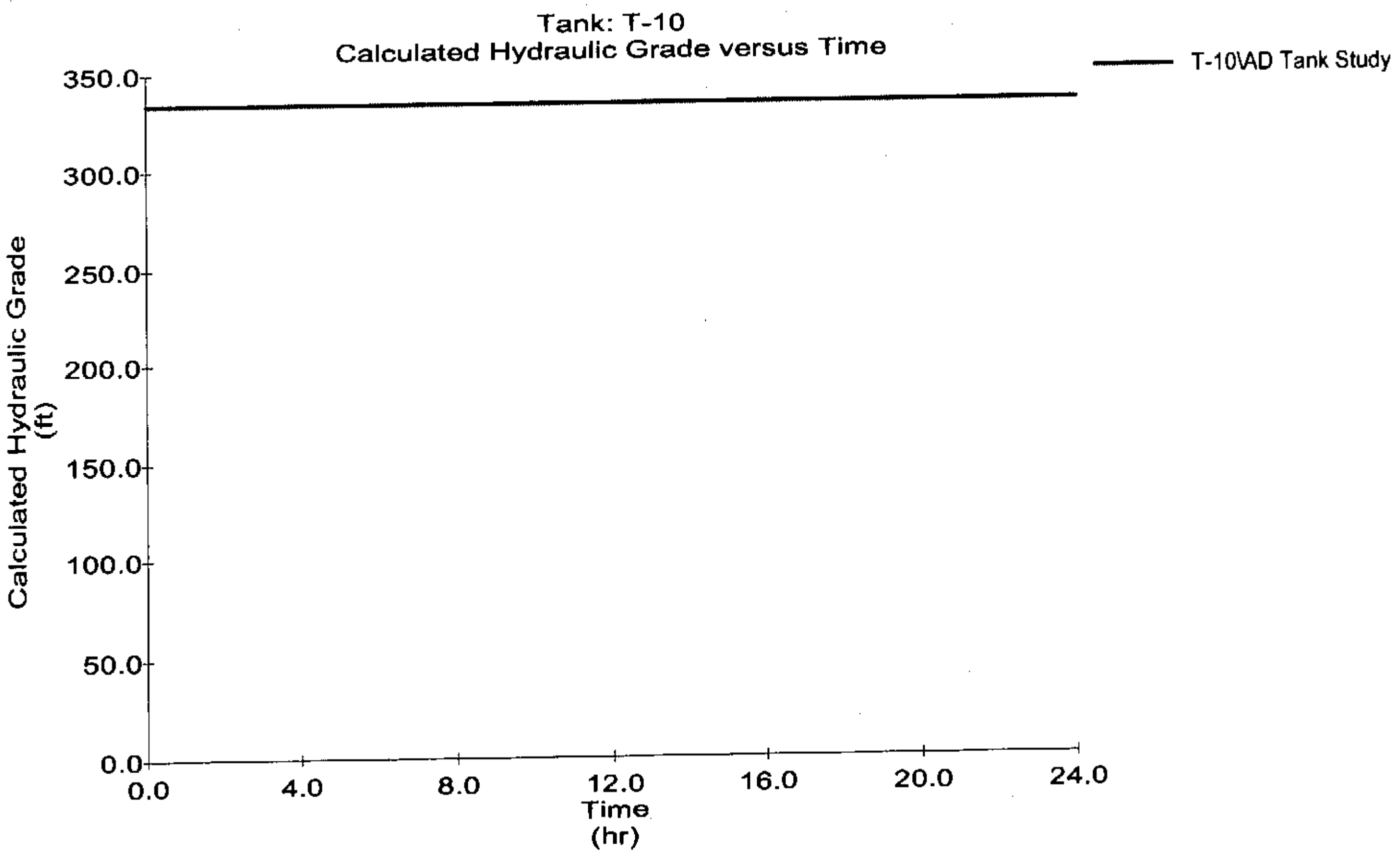
Graph

Fiskeville Reservoir #1



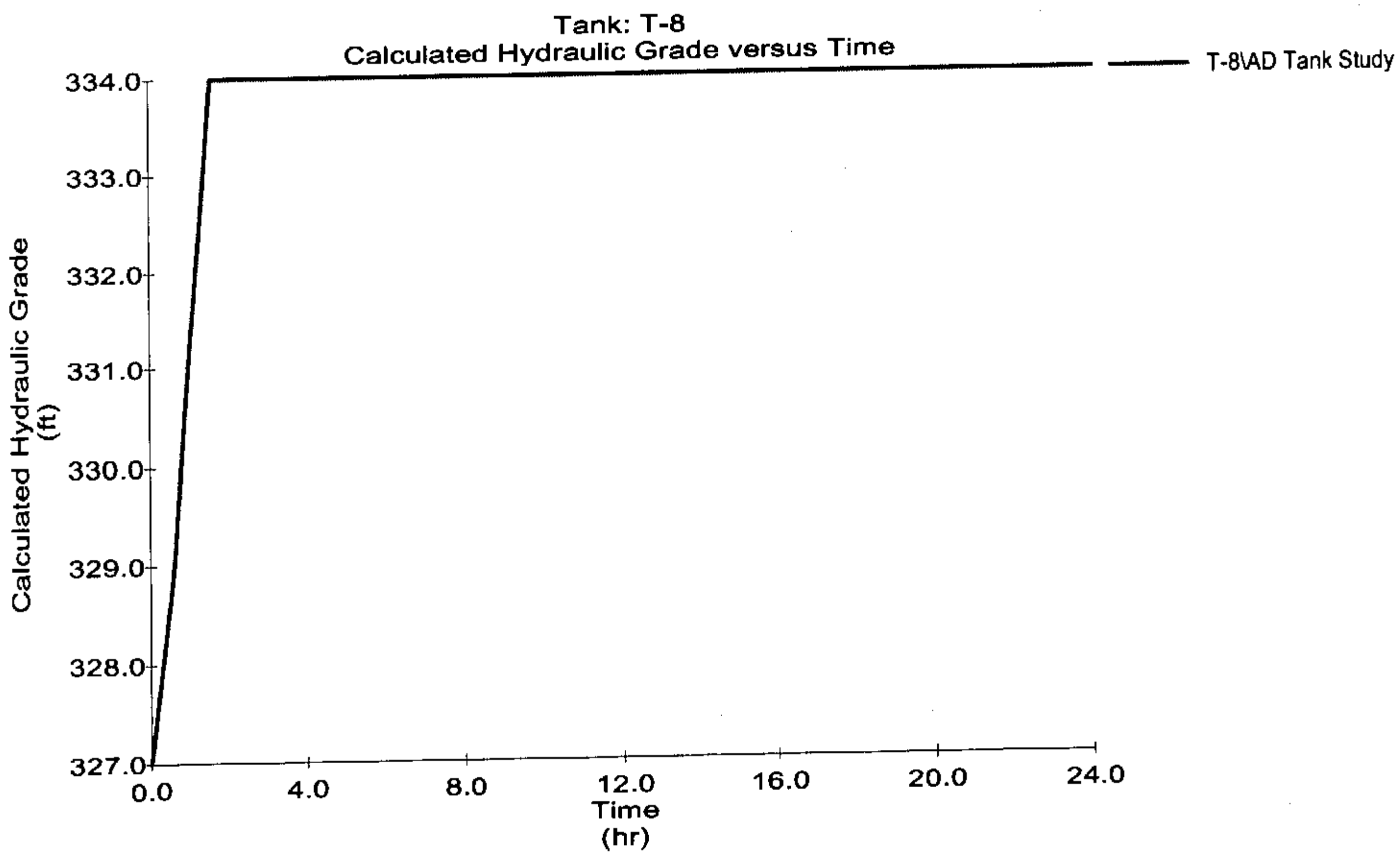
Graph

Fiskeville Reservoir #2



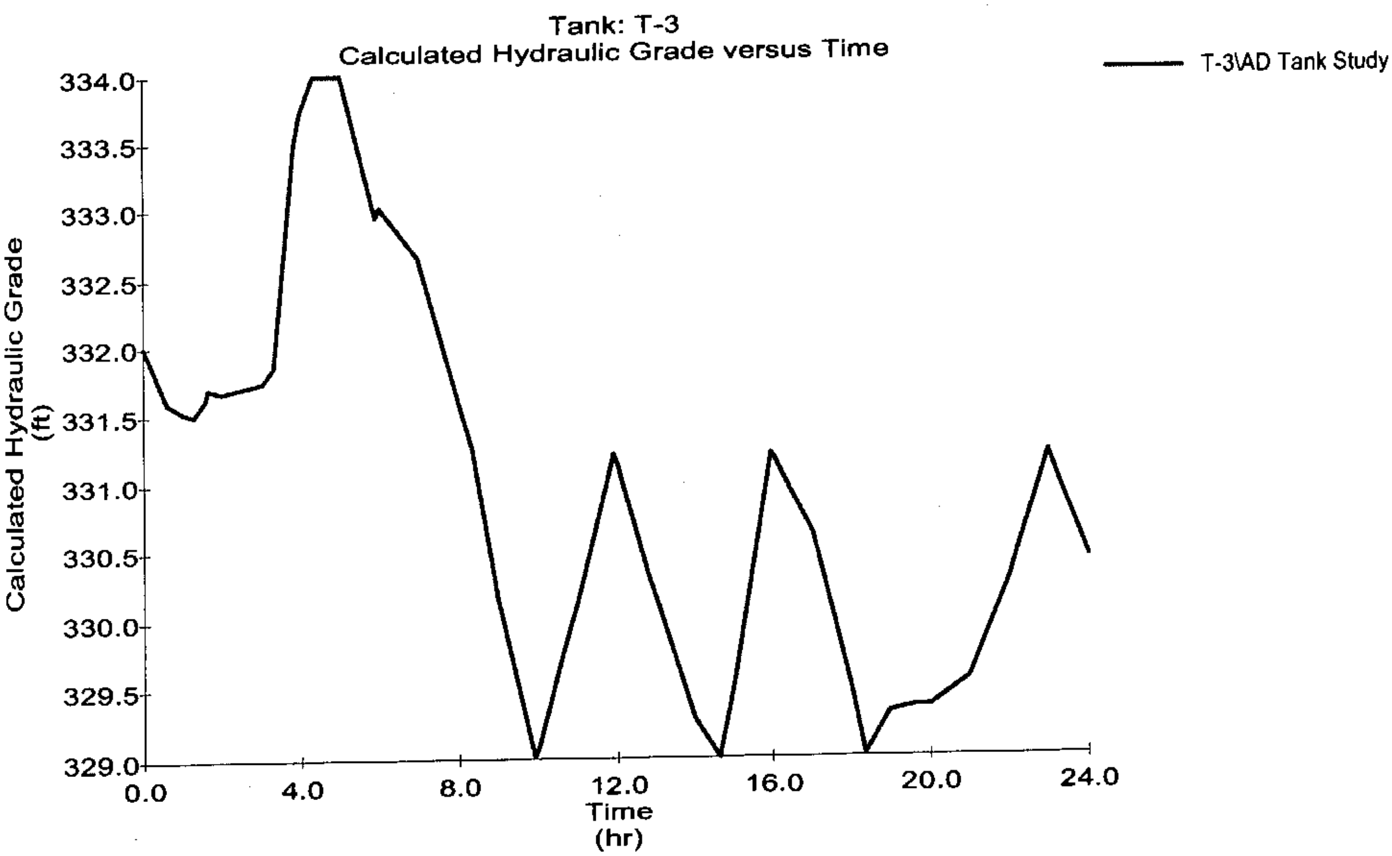
Graph

Wakefield Street Tank



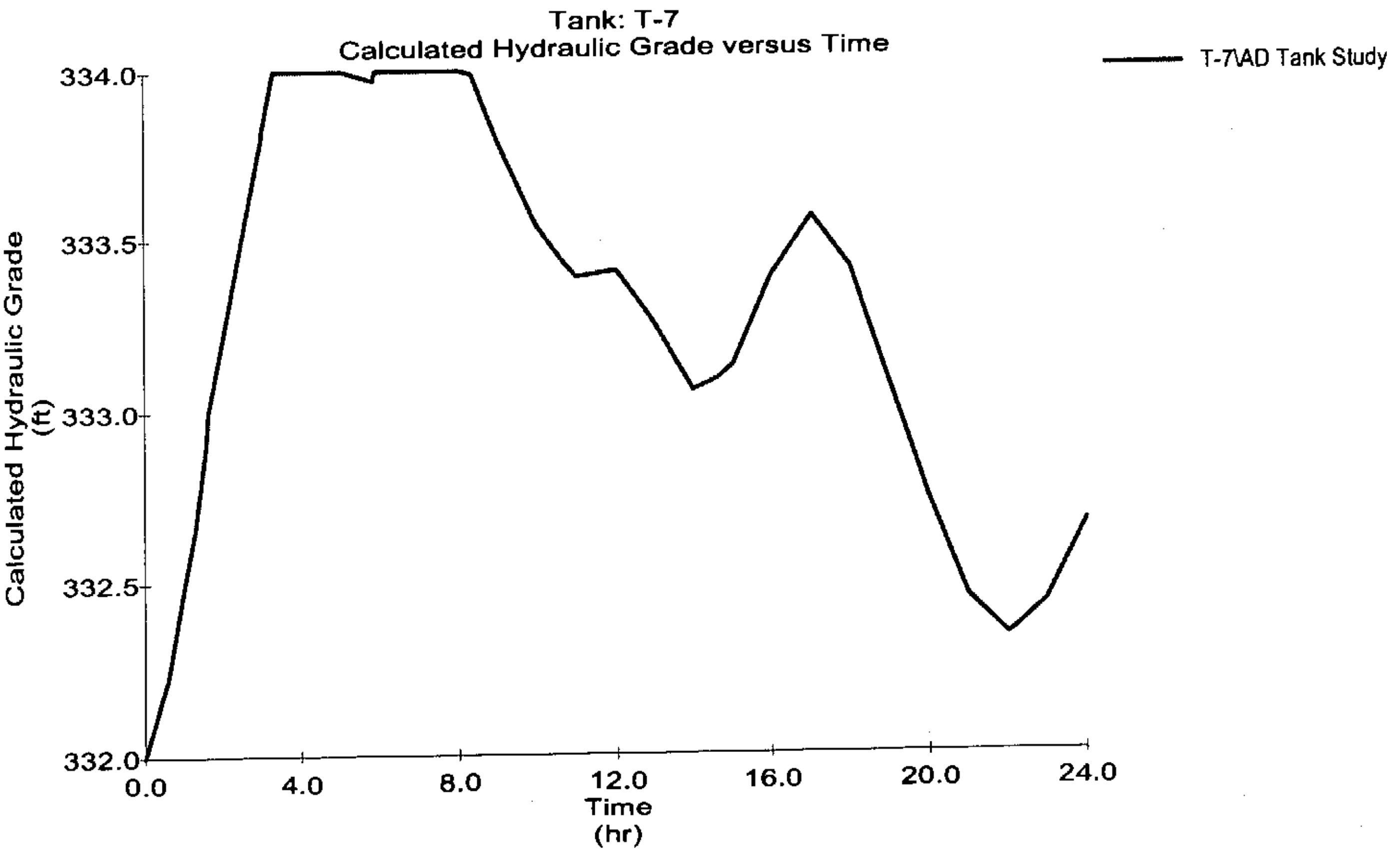
Graph

Frenchtown Road Tank



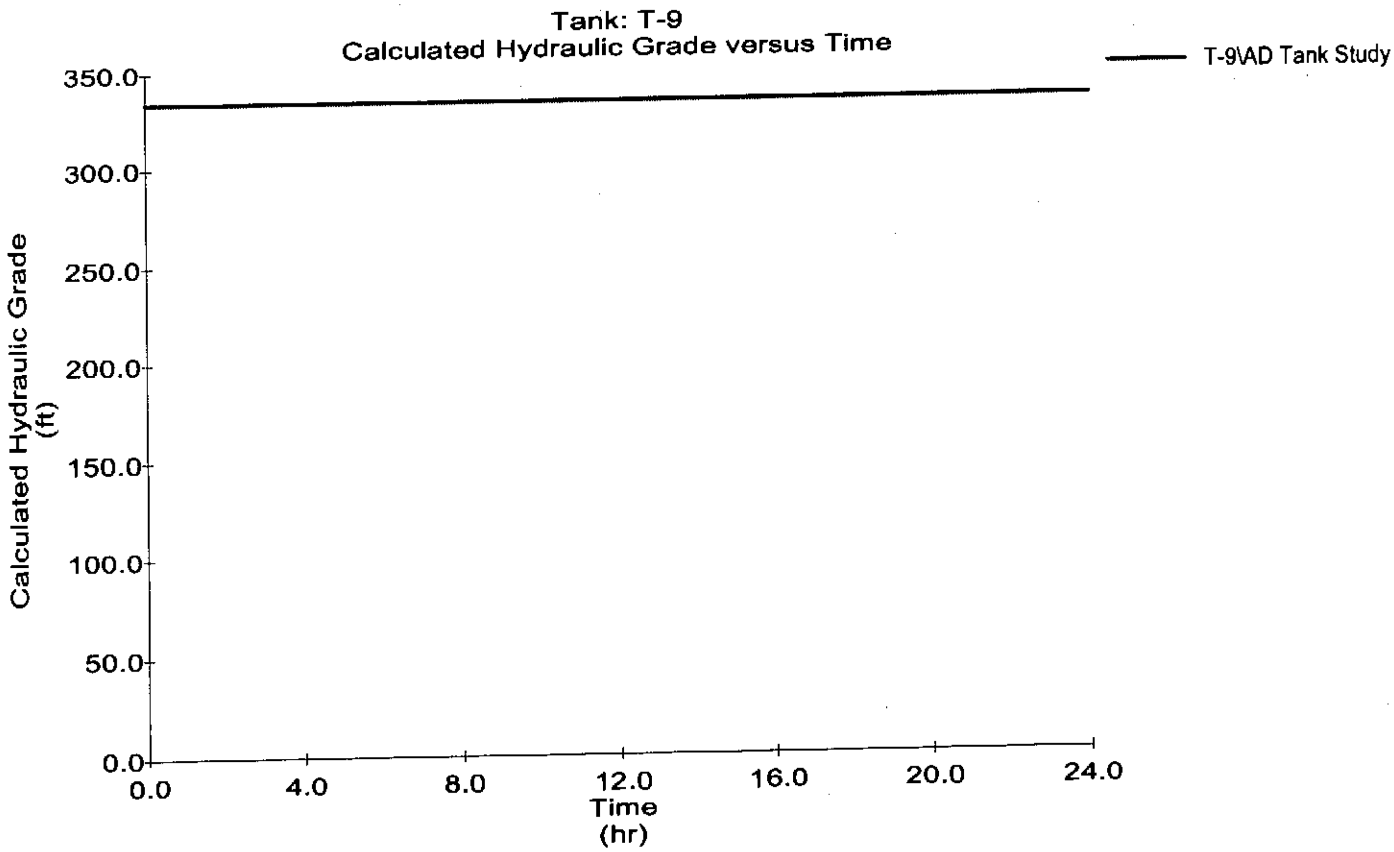
Graph

Setian Lane Tank



Graph

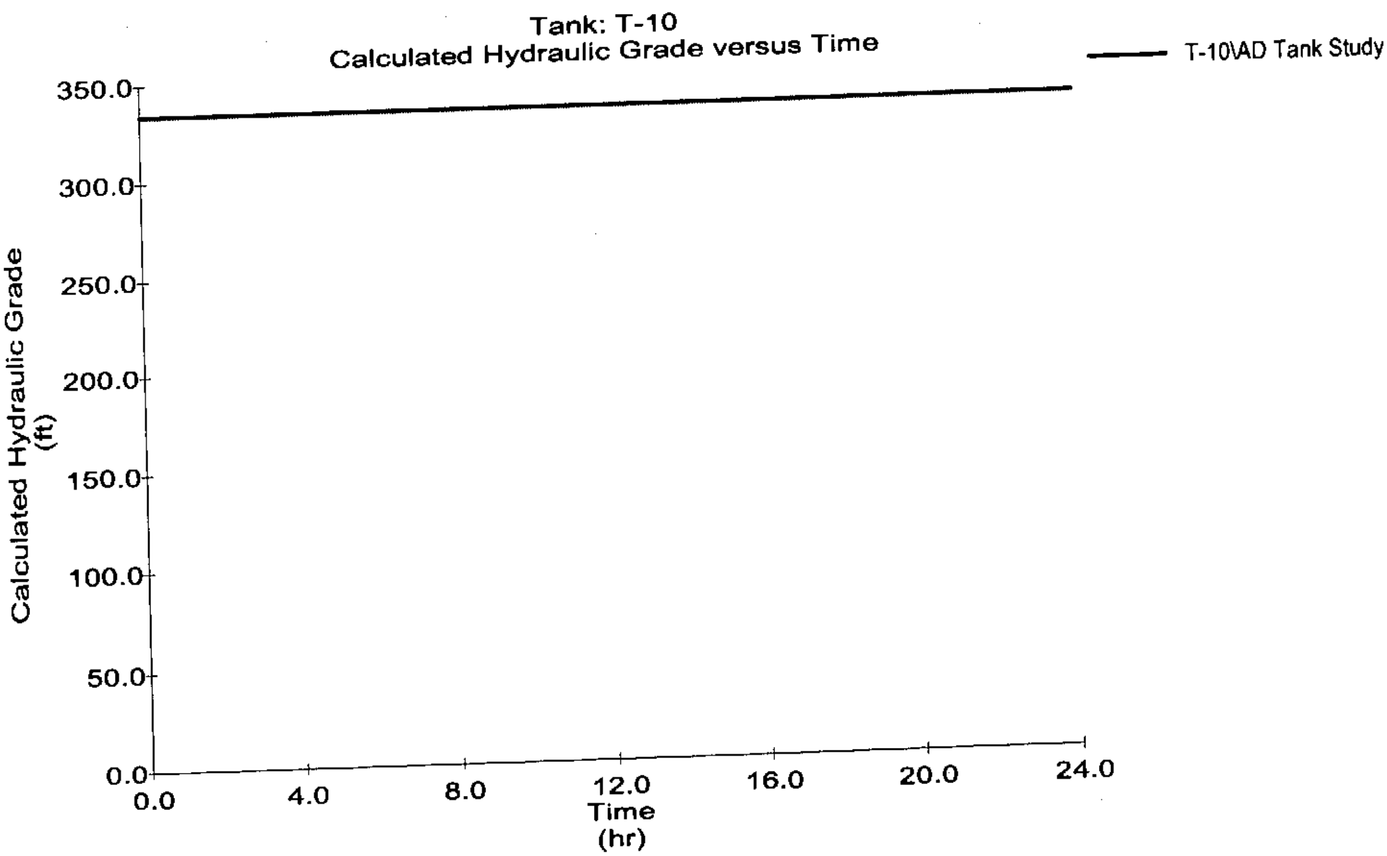
Fiskeville Reservoir #1



- 2000 gpm fire flow at node J-5112
- Seven Mile Rd.
- 16" DI main
- Elevation = 240 ft

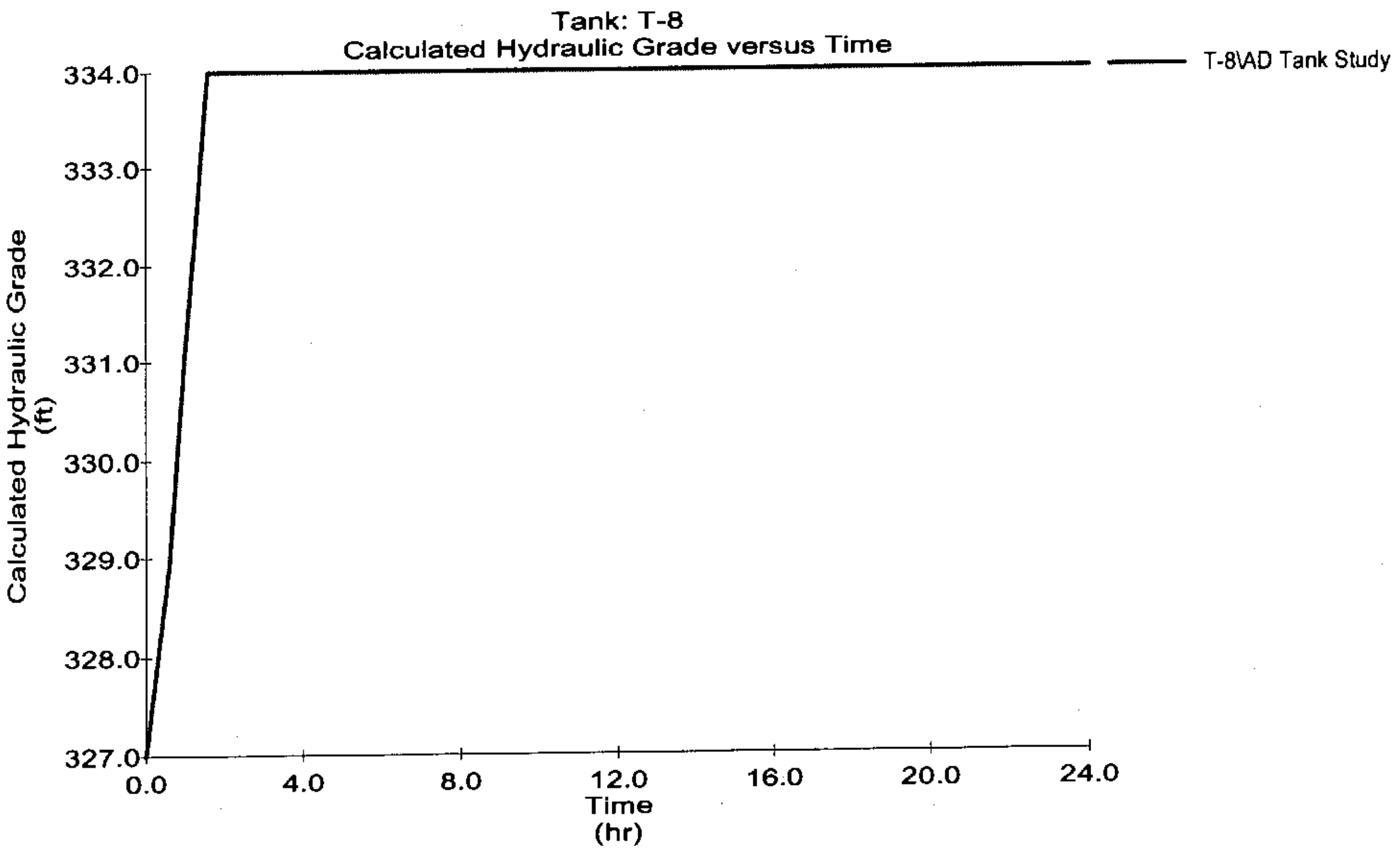
Graph

Fiskeville Reservoir #2



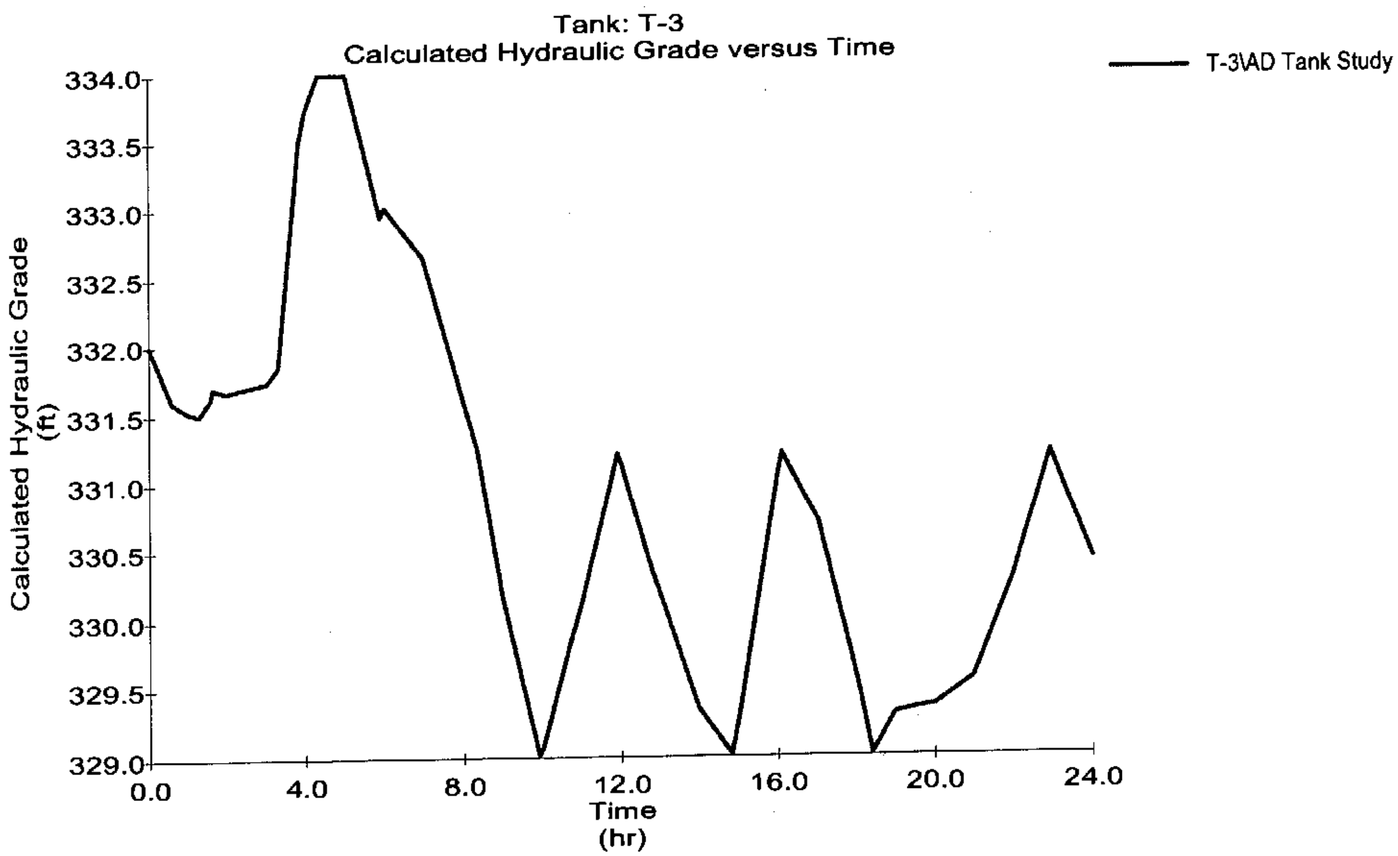
Graph

Wakefield Street Tank



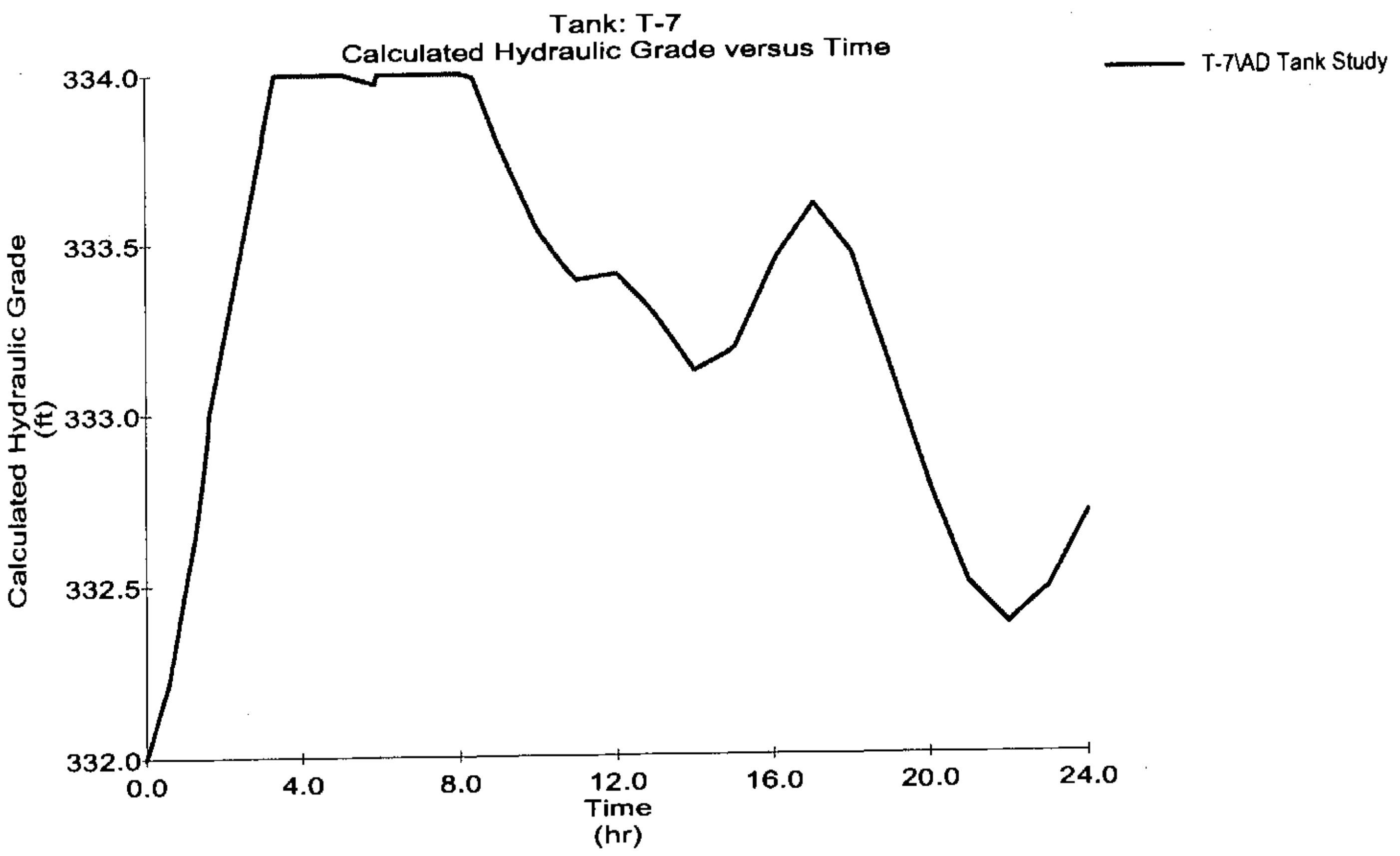
Graph

Frenchtown Road Tank



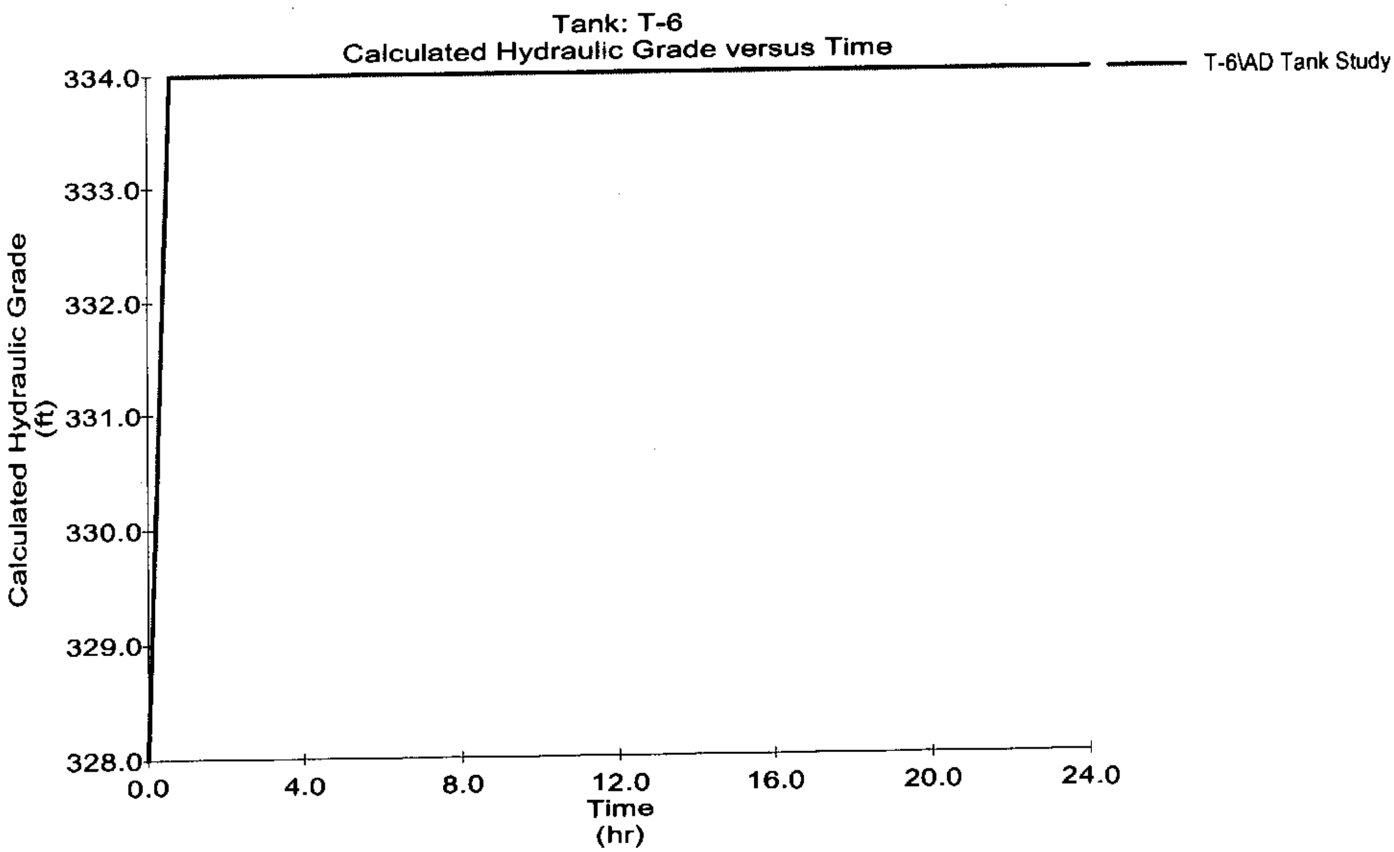
Graph

Setian Lane Tank



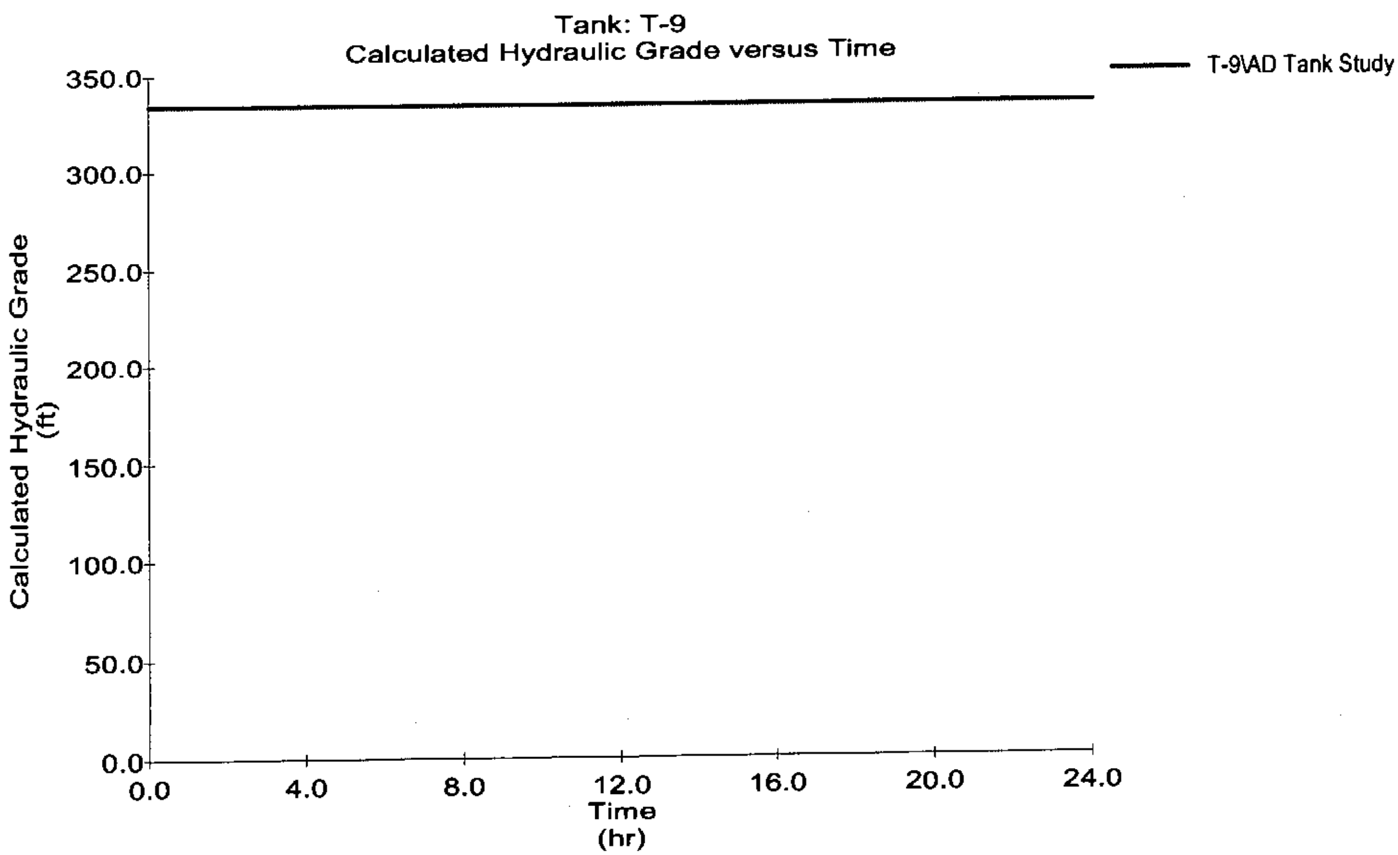
Graph

West Street Tank



Graph

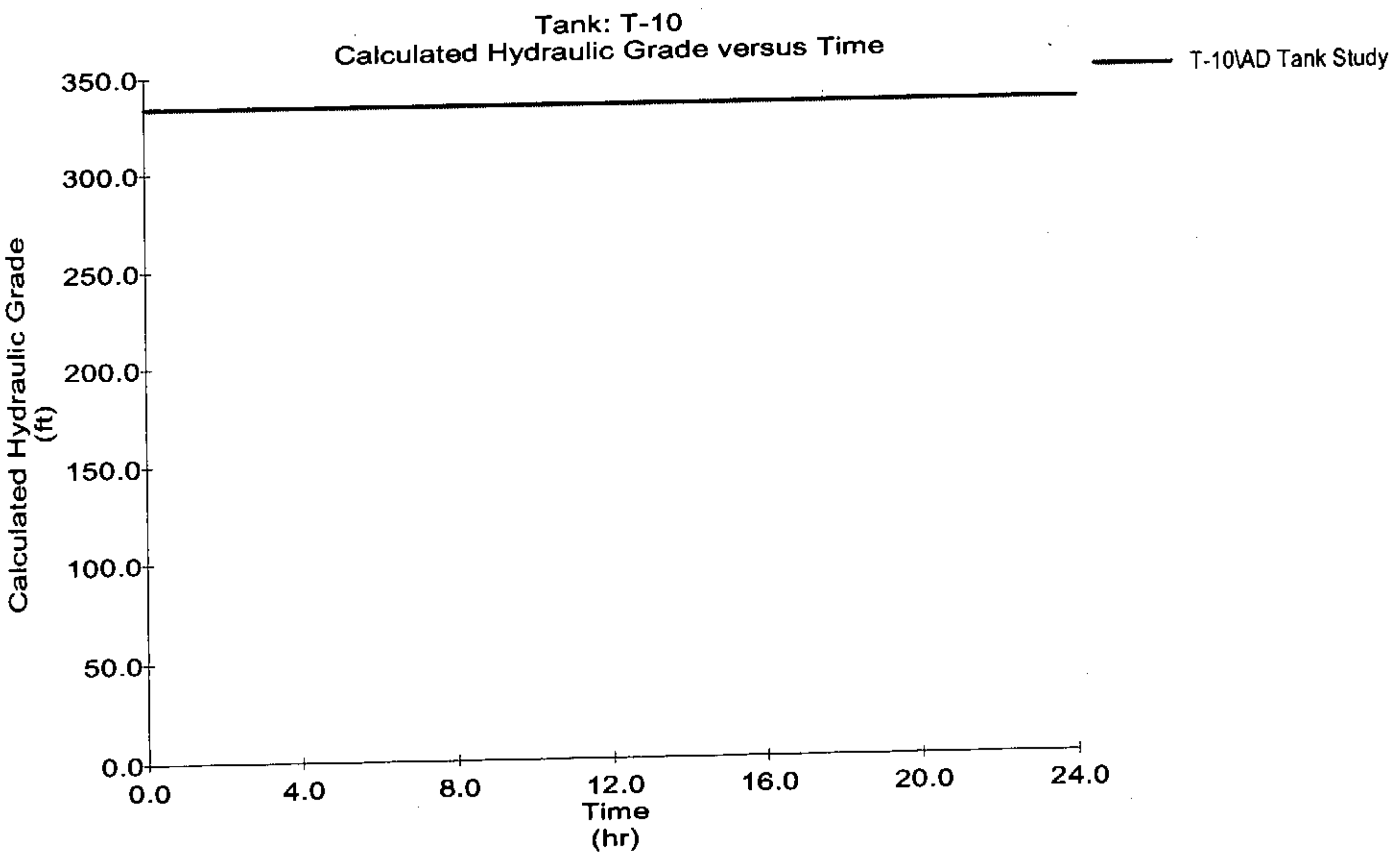
Fiskeville Reservoir #1



- 2000 gpm fire flow at node J-6027
- Hope Ave.
- 16" AC main
- Elevation = 222 ft

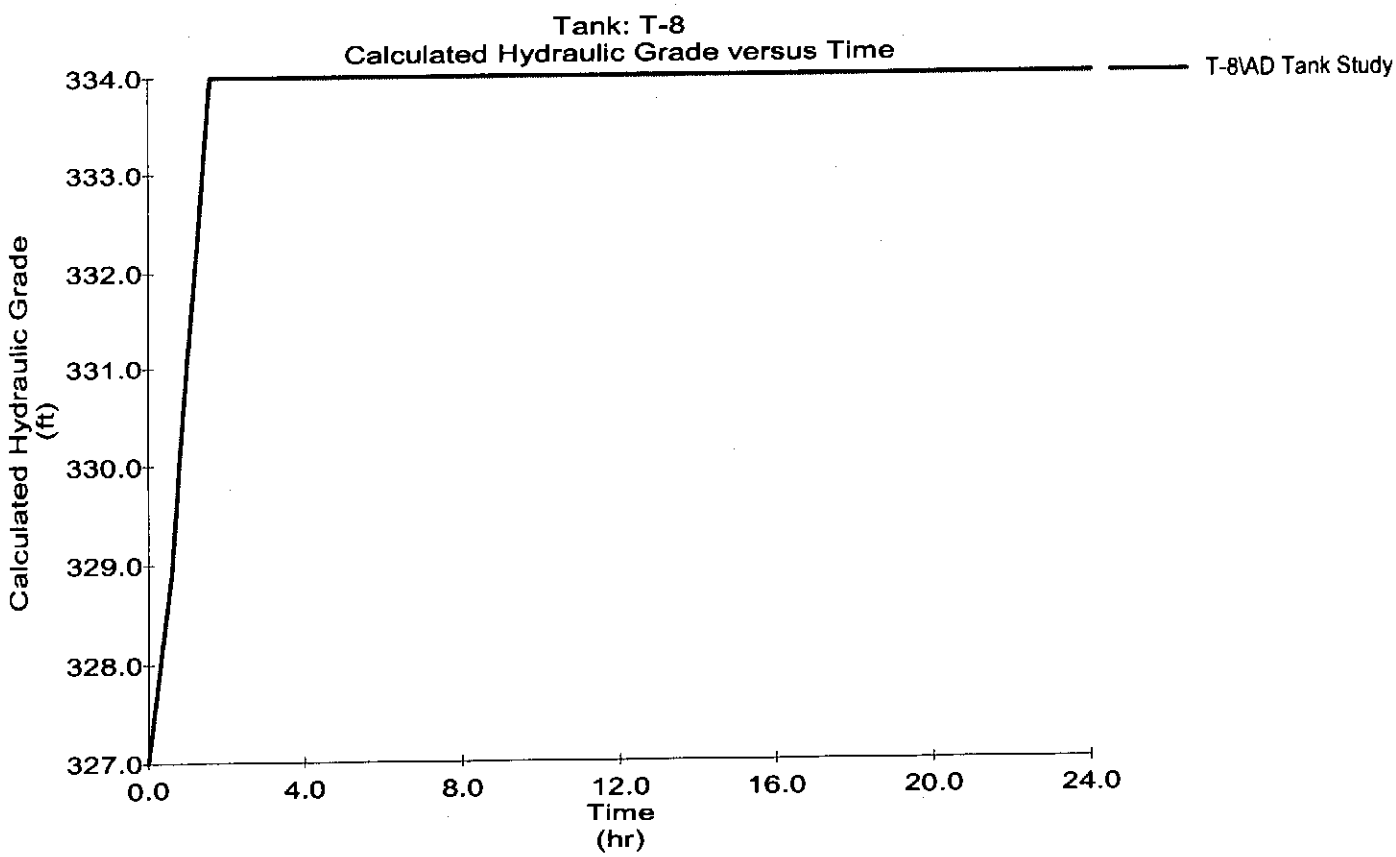
Graph

Fiskeville Reservoir #2



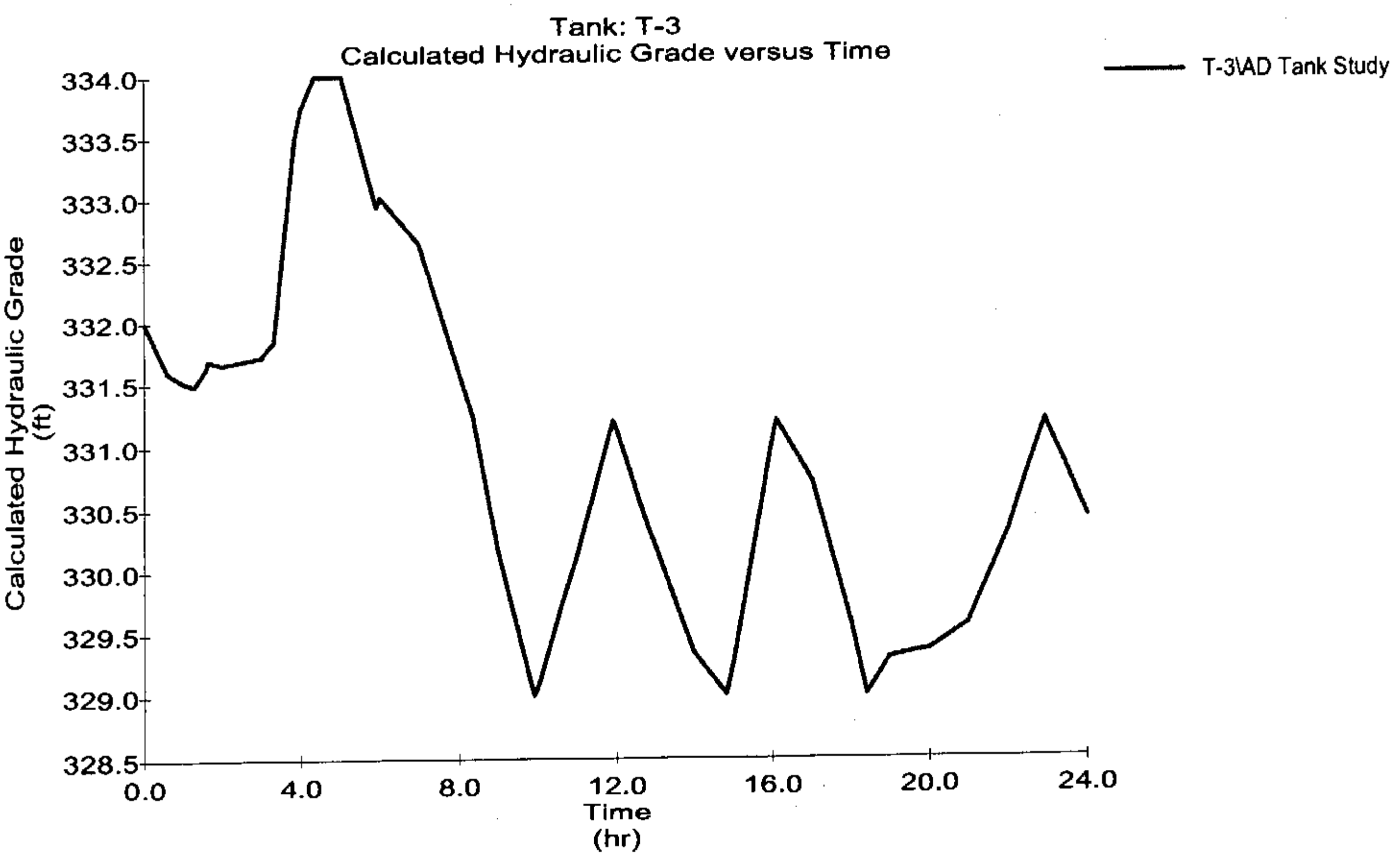
Graph

Wakefield Street Tank



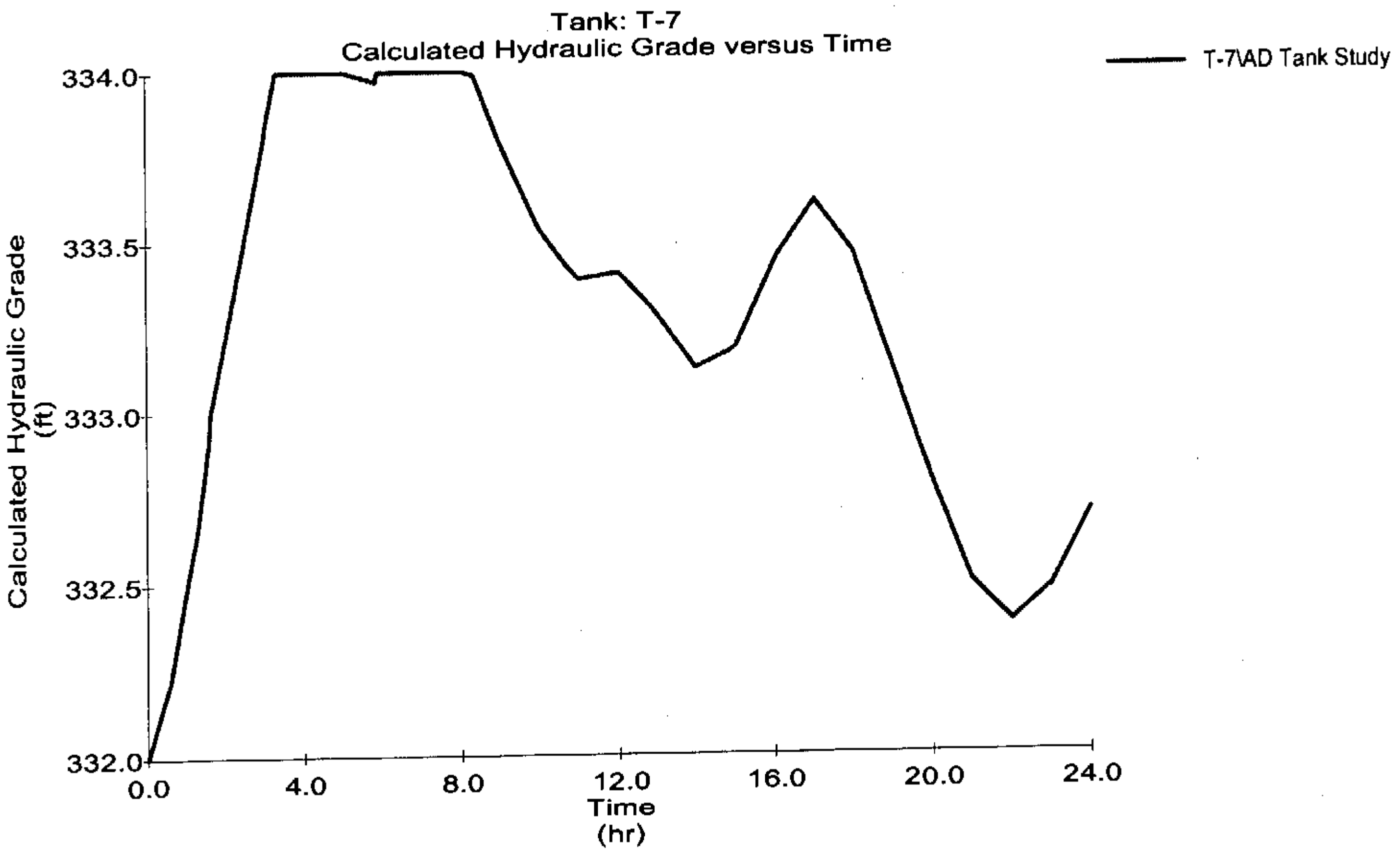
Graph

Frenchtown Road Tank



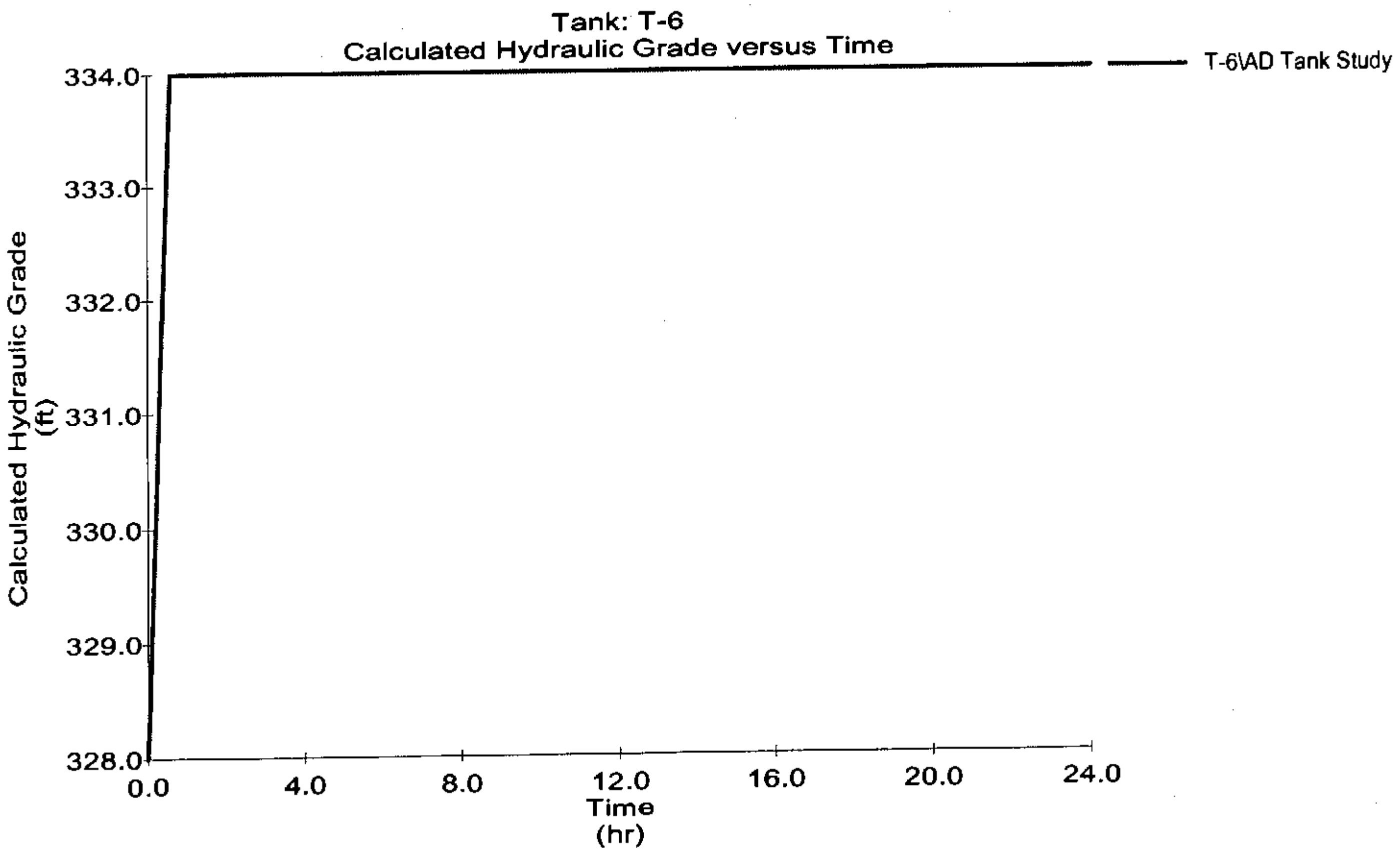
Graph

Setian Lane Tank



Graph

West Street Tank

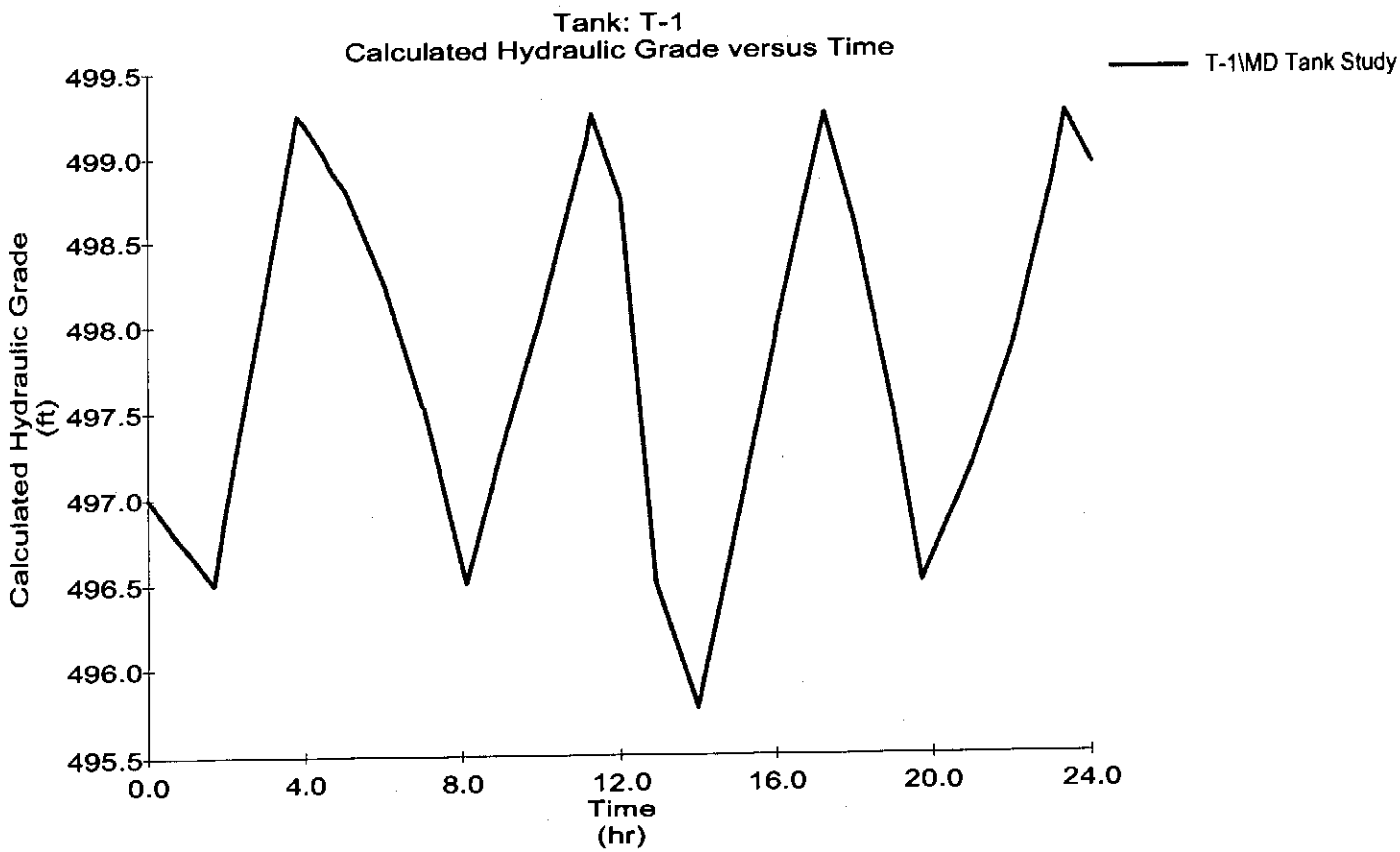


ATTACHMENT NO. 4

EXTENDED PERIOD SIMULATION
MAXIMUM DAY DEMAND WITH FIRE FLOW
STORAGE TANK GRAPHS

Graph

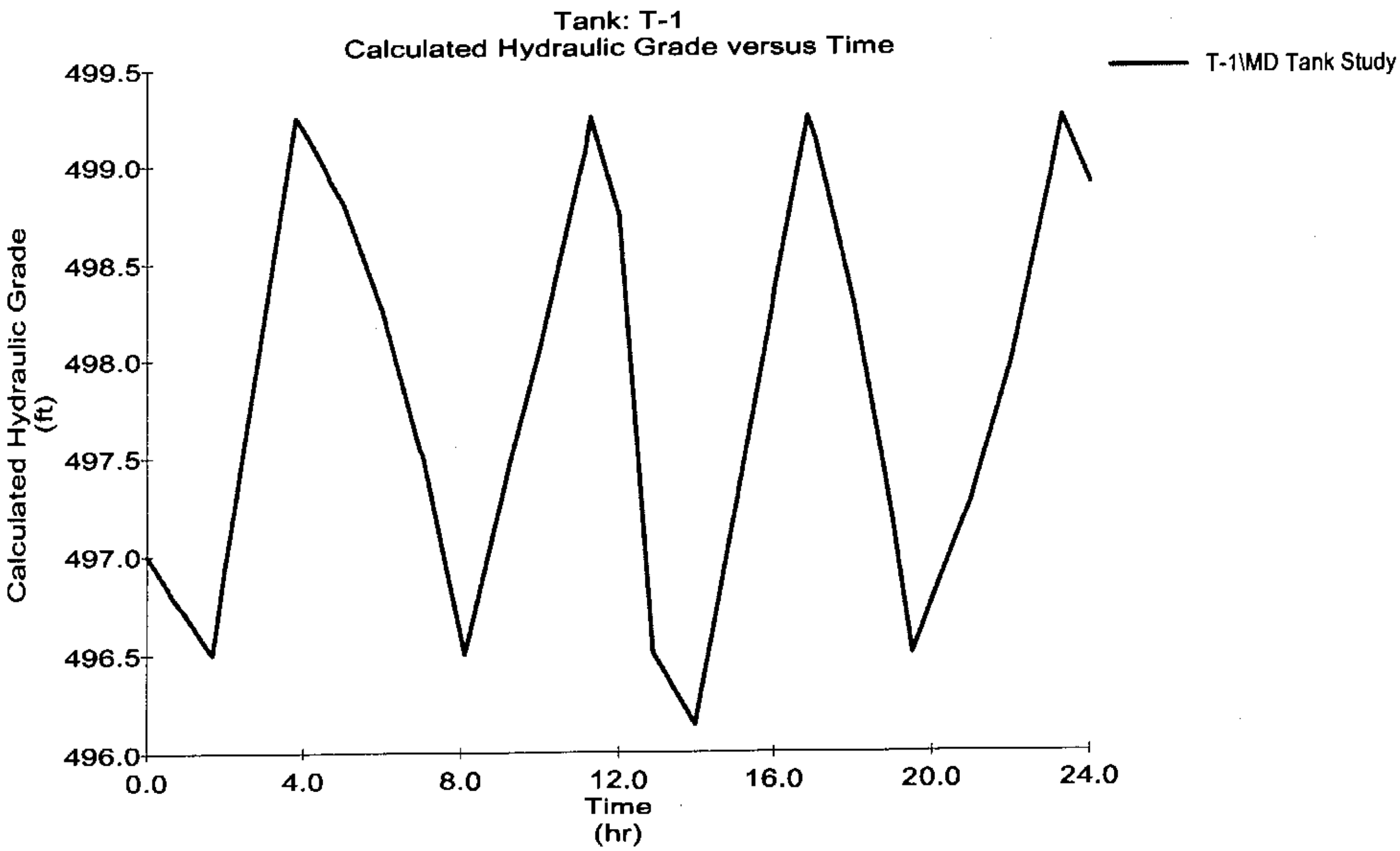
Read School House Road Tank



- 2000 gpm fire flow at node J-7154
- Flat River Rd.
- 12" AC main
- Elevation = 254 ft

Graph

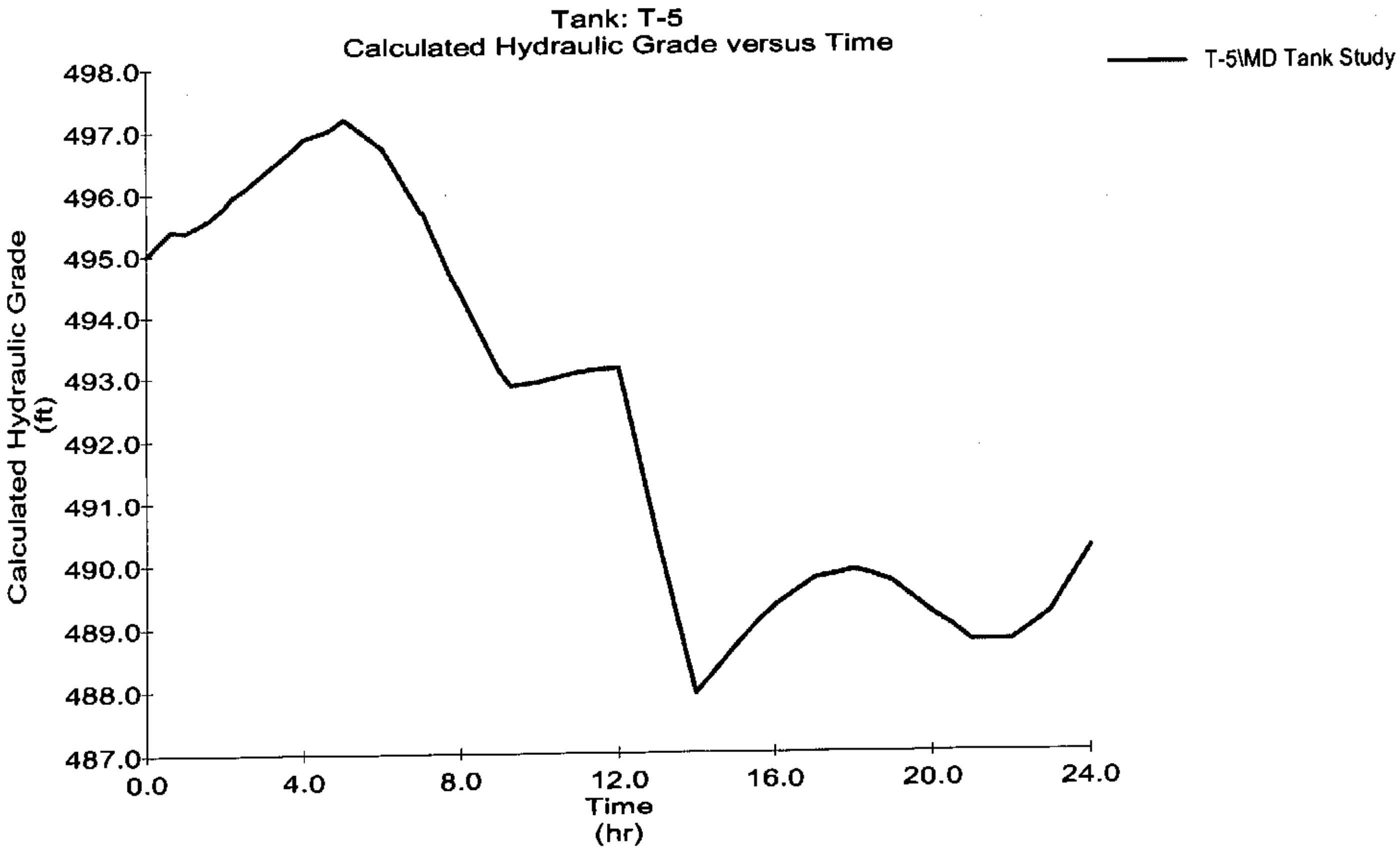
Read School House Road Tank



- 2000 gpm fire flow at node J-7258
- Hunters Crossing Dr.
- 16" DI main
- Elevation = 343 ft

Graph

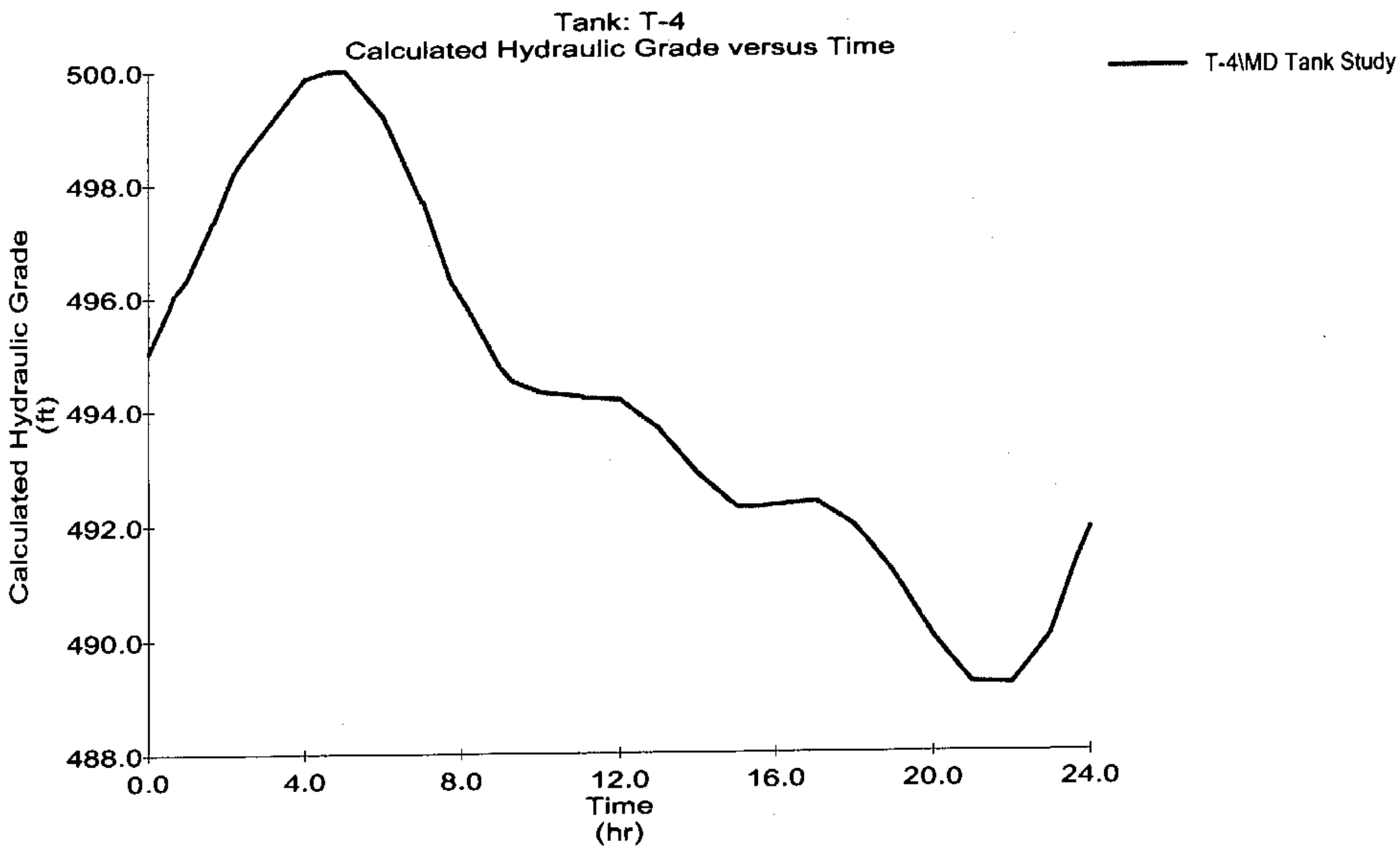
Carrs Pond Road Tank



- 2000 gpm fire flow at node J-4117
- Middle Rd.
- 16" DI main
- Elevation = 300 ft

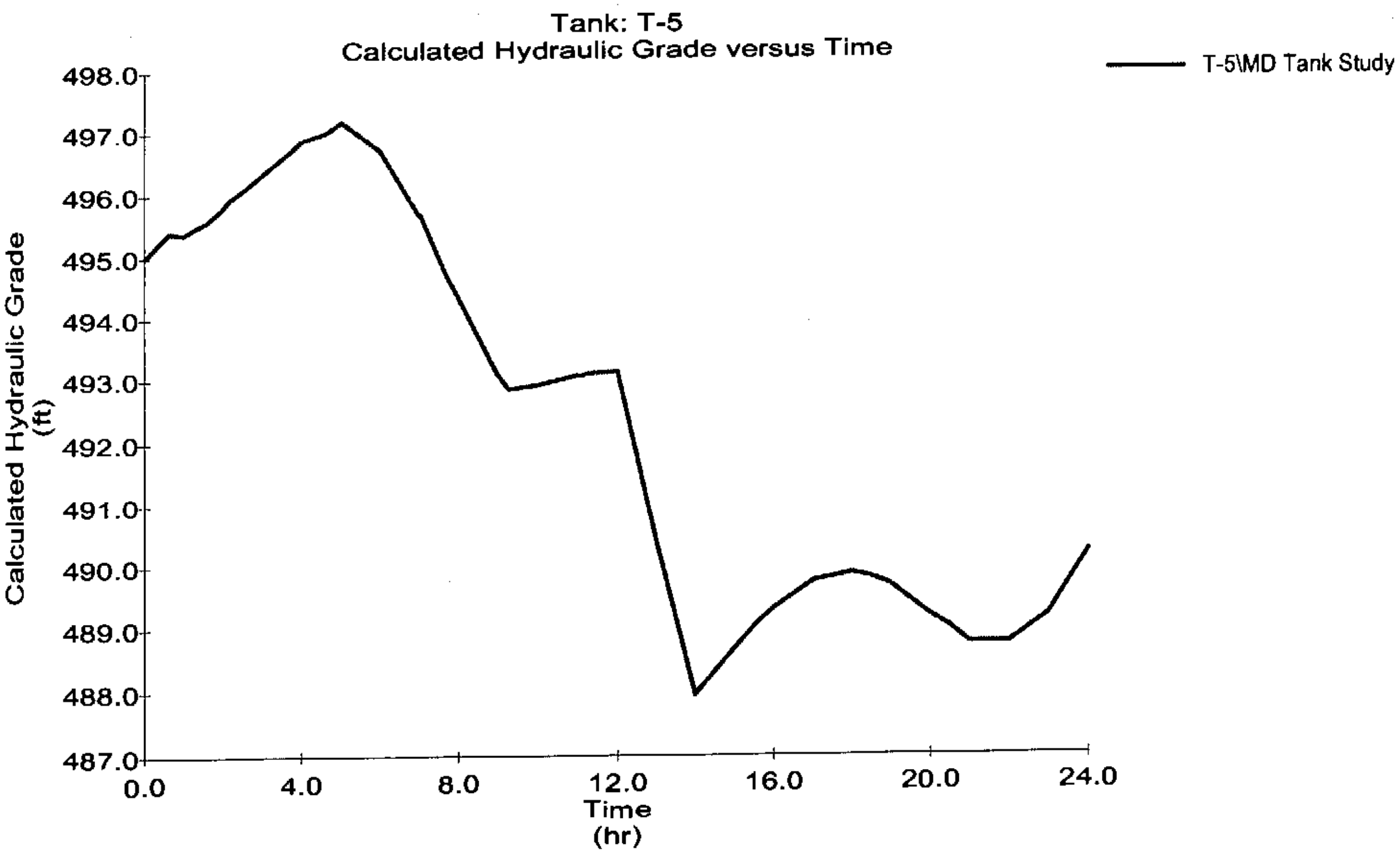
Graph

Technology Park Tank



Graph

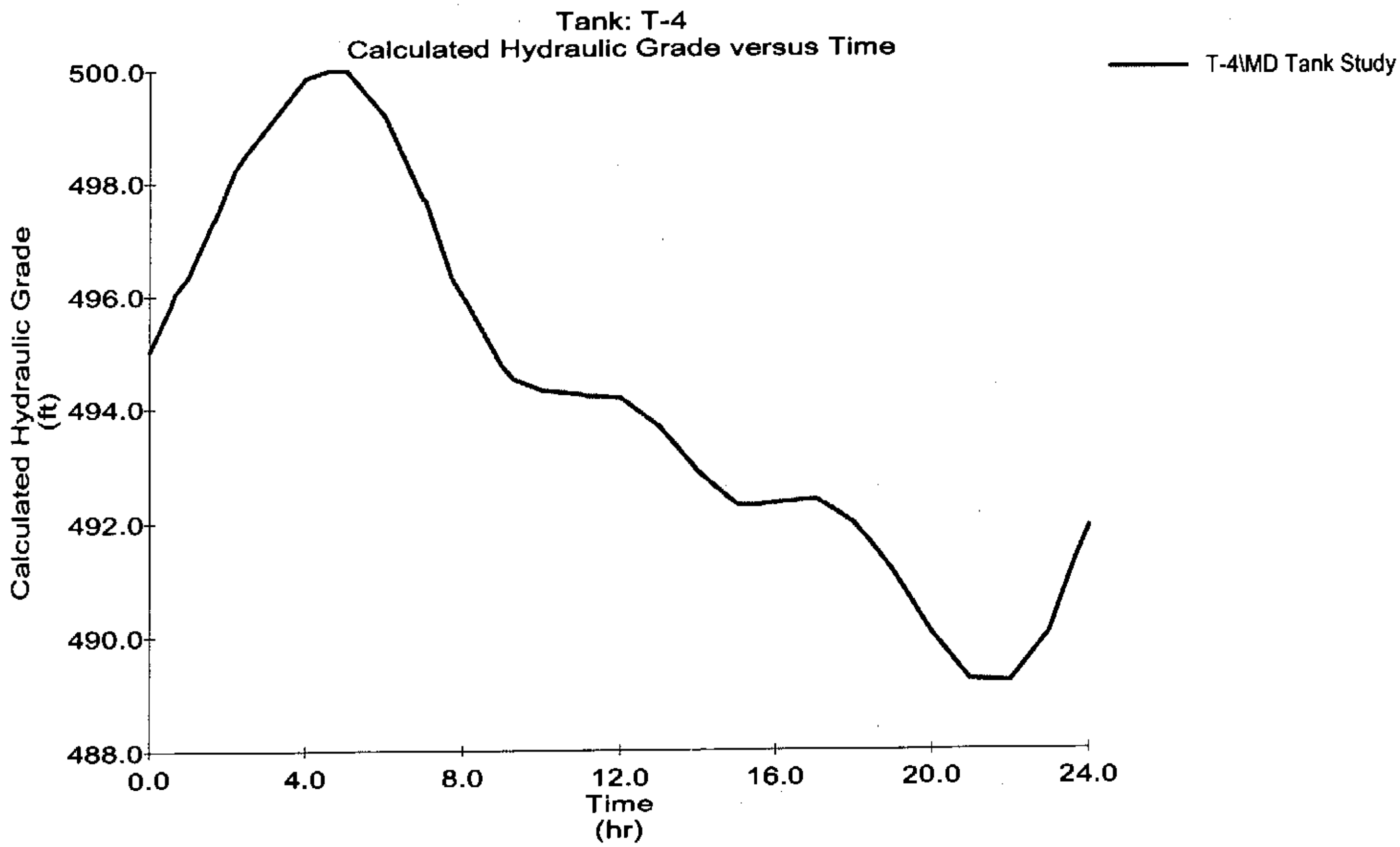
Carrs Pond Road Tank



- 2000 gpm fire flow at node J-4056
- Frenchtown Rd.
- 12" DI main
- Elevation = 246 ft

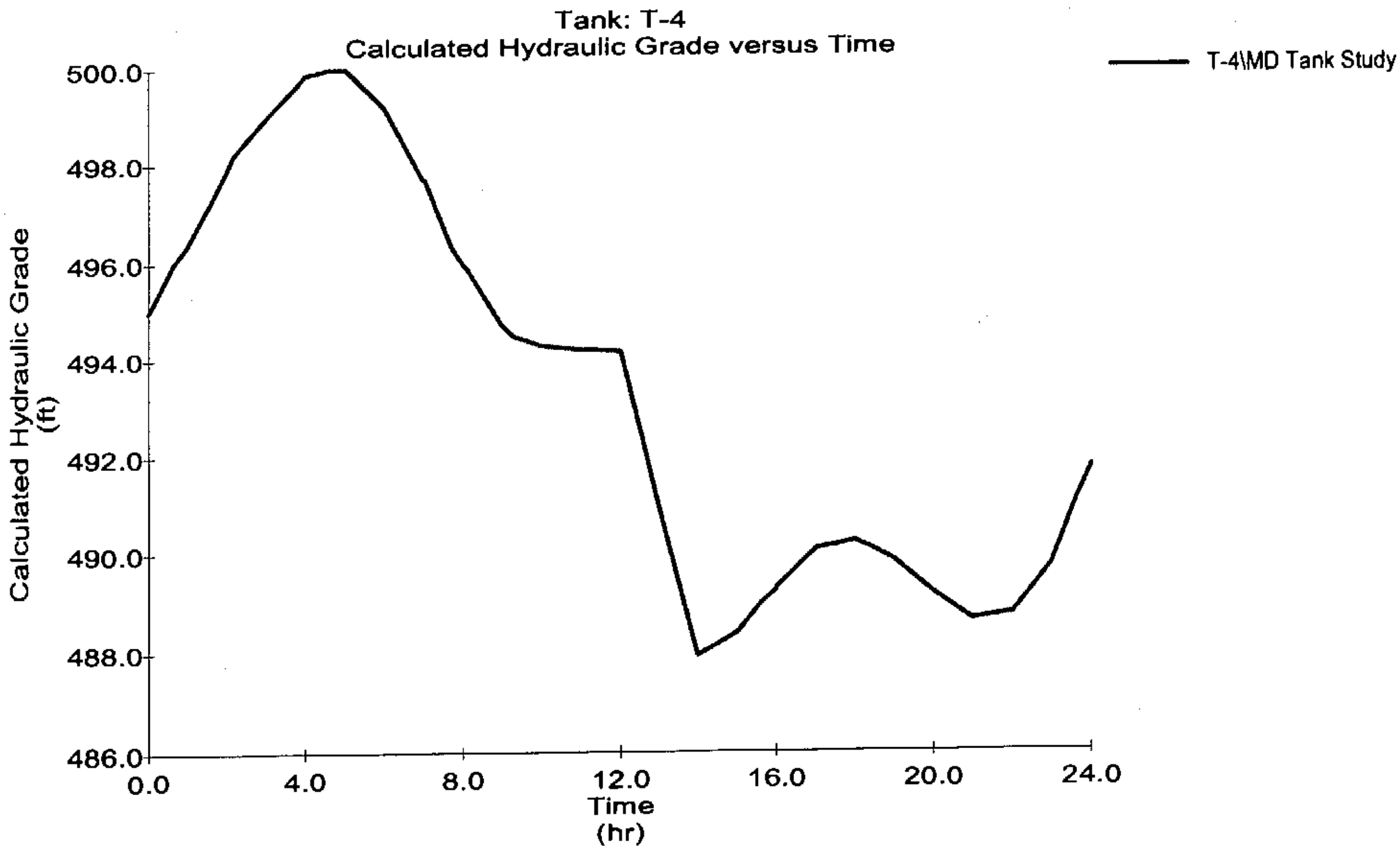
Graph

Technology Park Tank



Graph

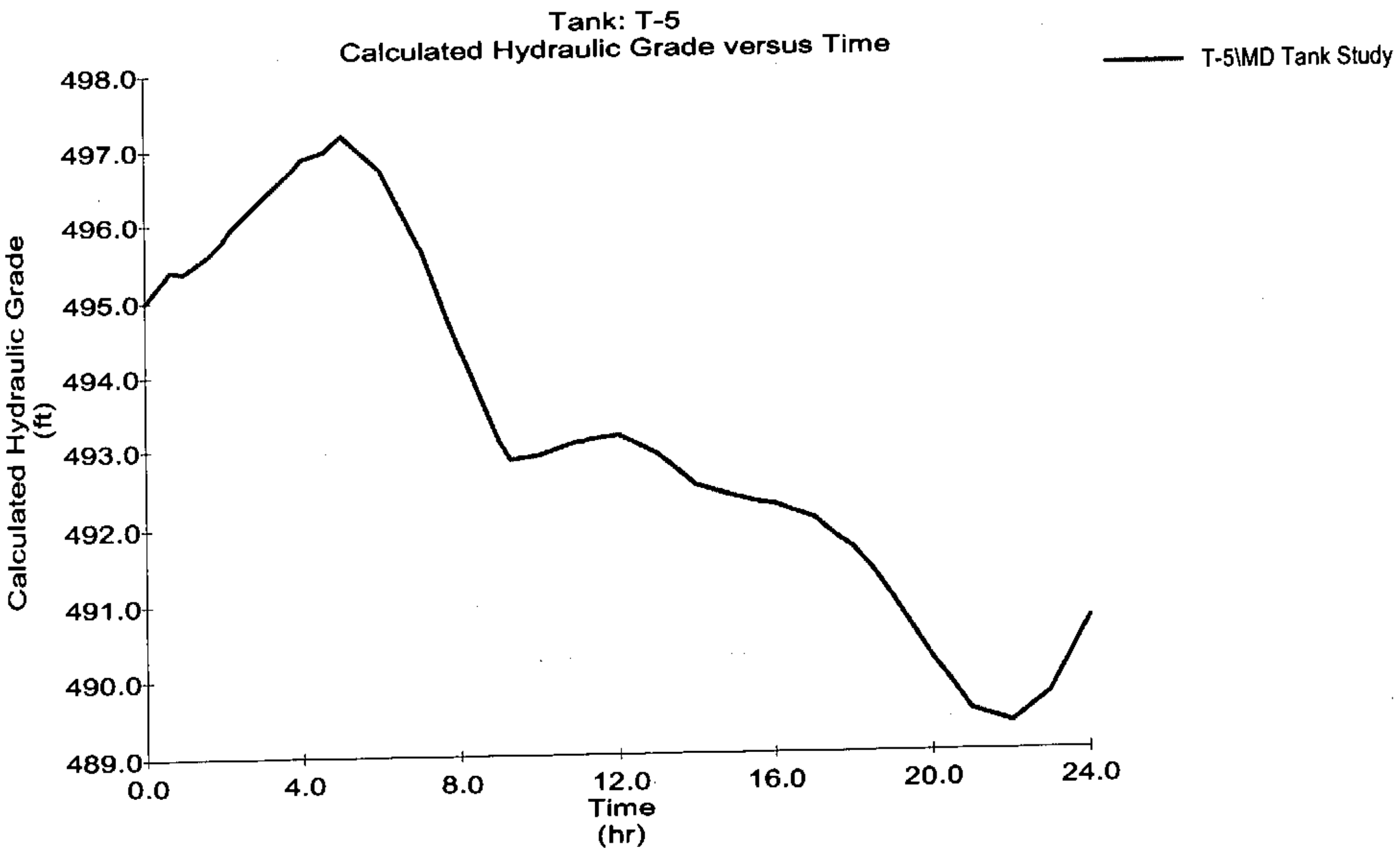
Technology Park Tank



- 2000 gpm fire flow at node J-8145
- Hopkins Hill Rd.
- 12" DI main
- Elevation = 316 ft

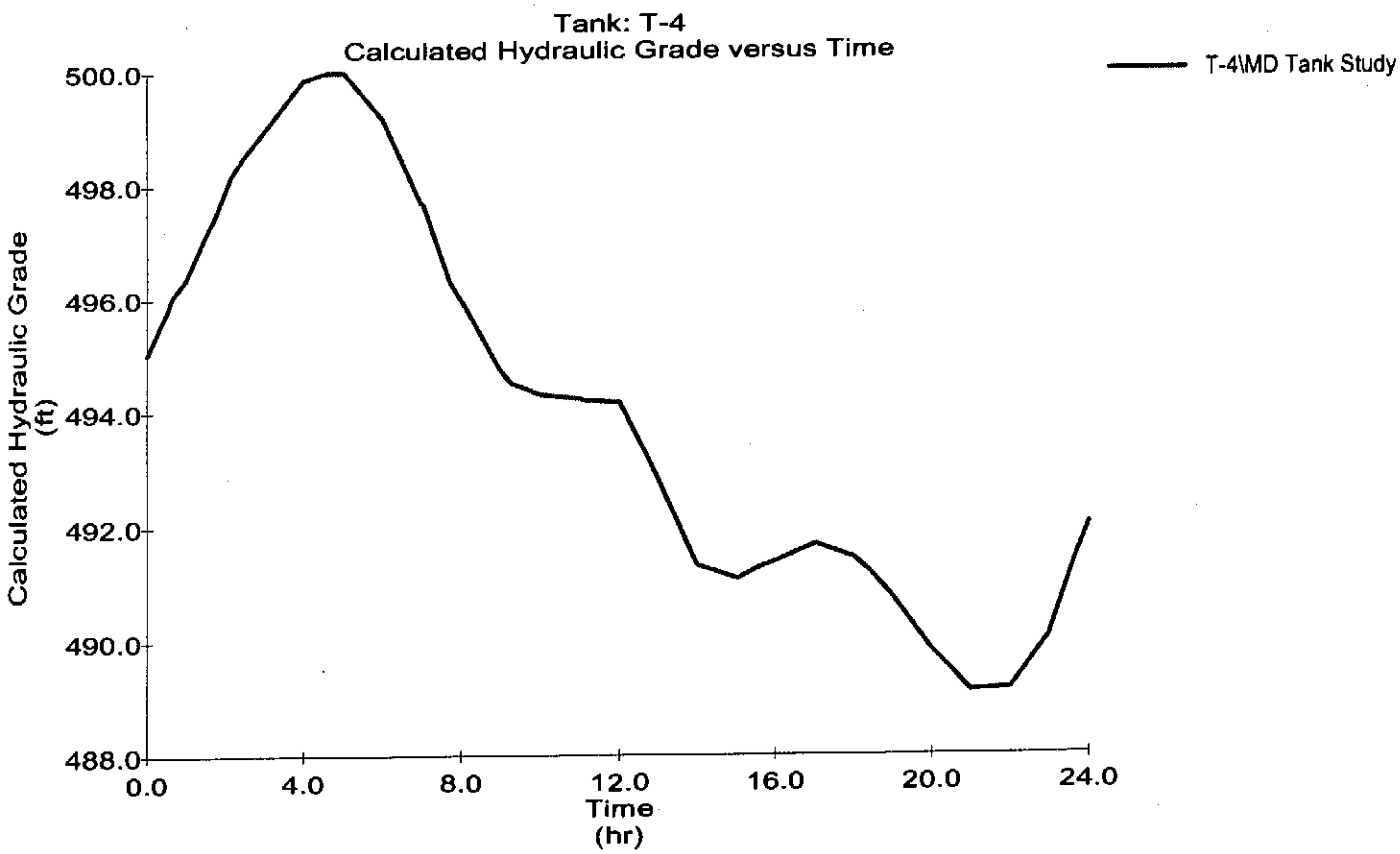
Graph

Carrs Pond Road Tank



Graph

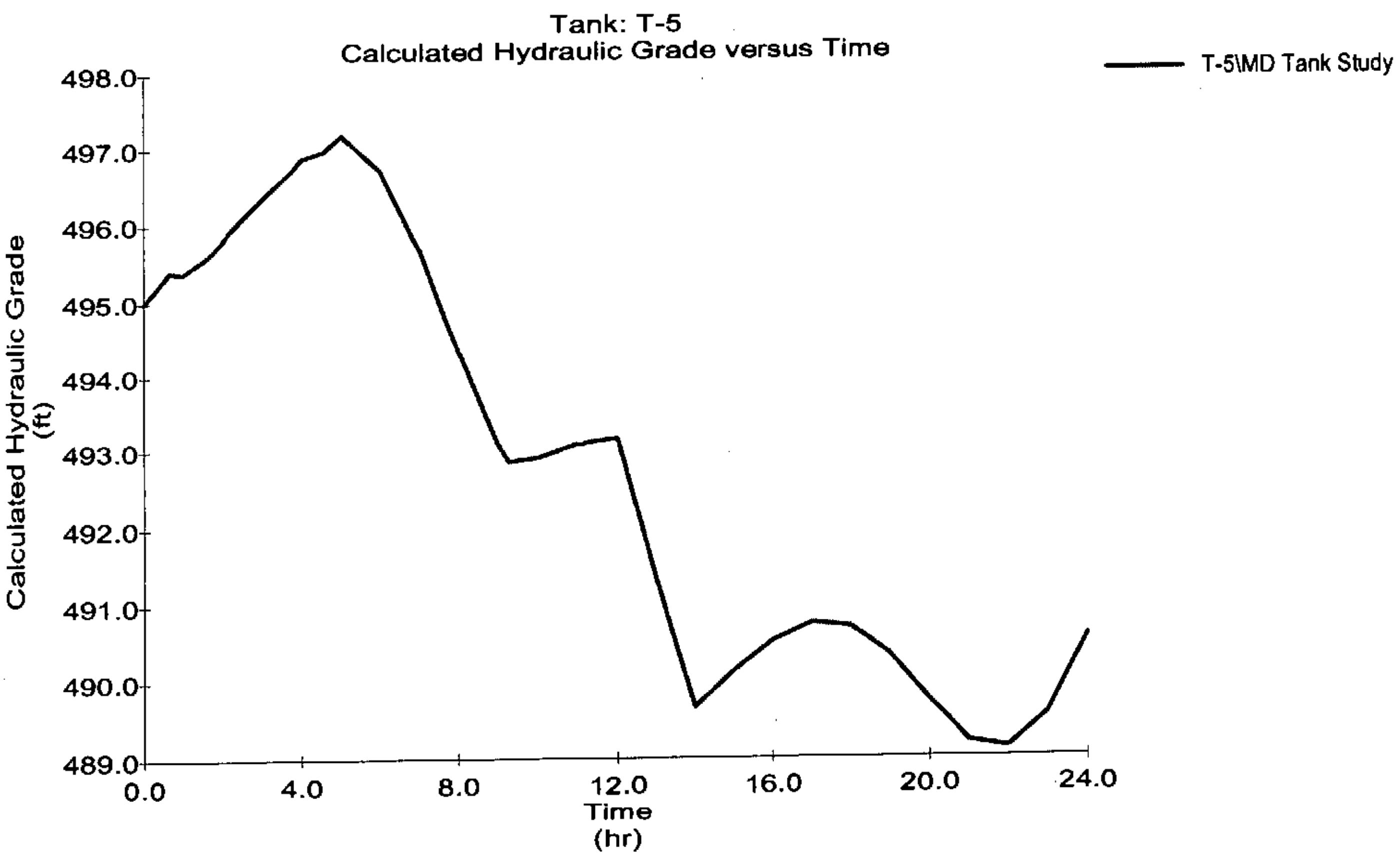
Technology Park Tank



- 2000 gpm fire flow at node J-951
- Lonsdale St.
- 12" AC main
- Elevation = 298 ft

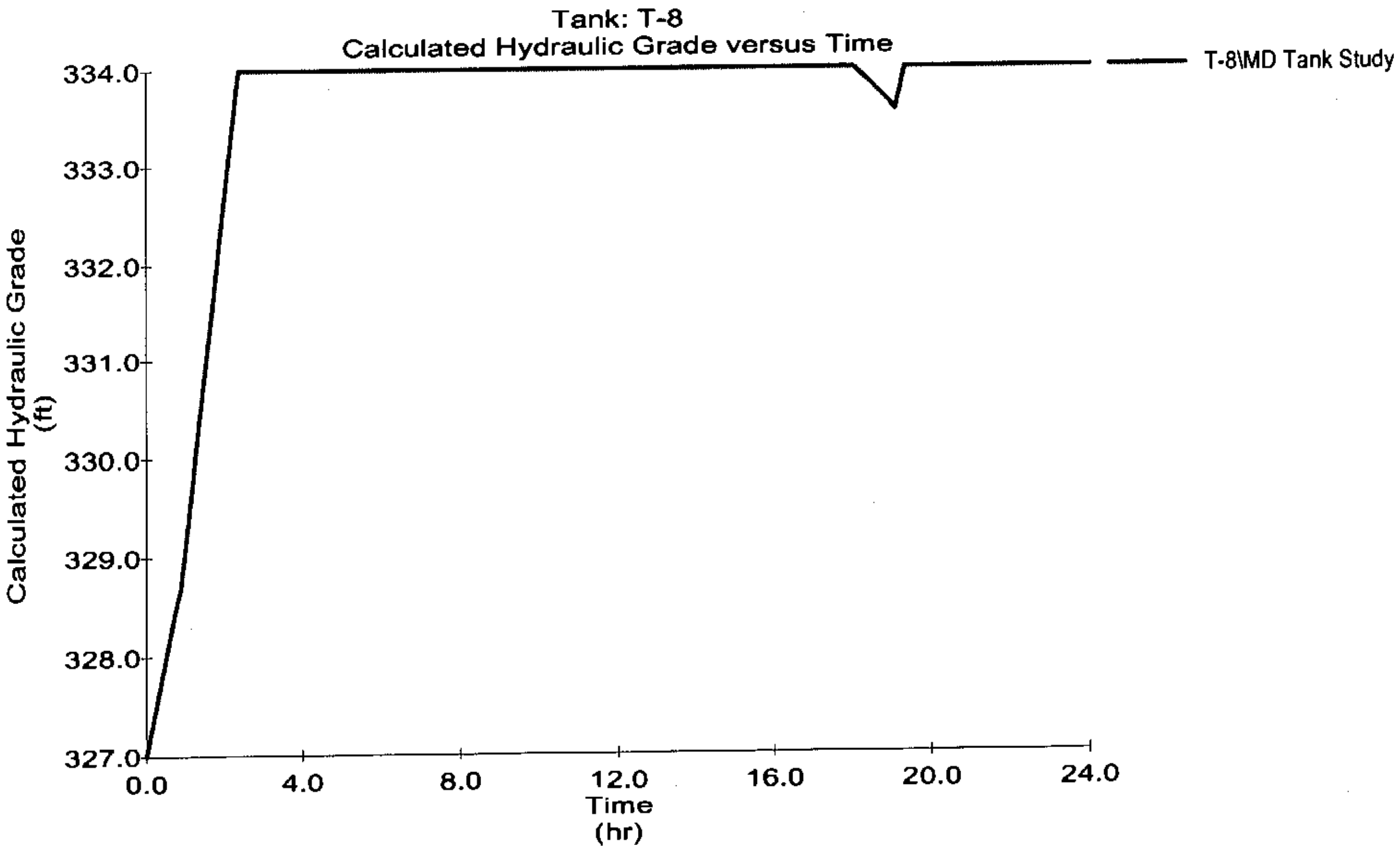
Graph

Carrs Pond Road Tank



Graph

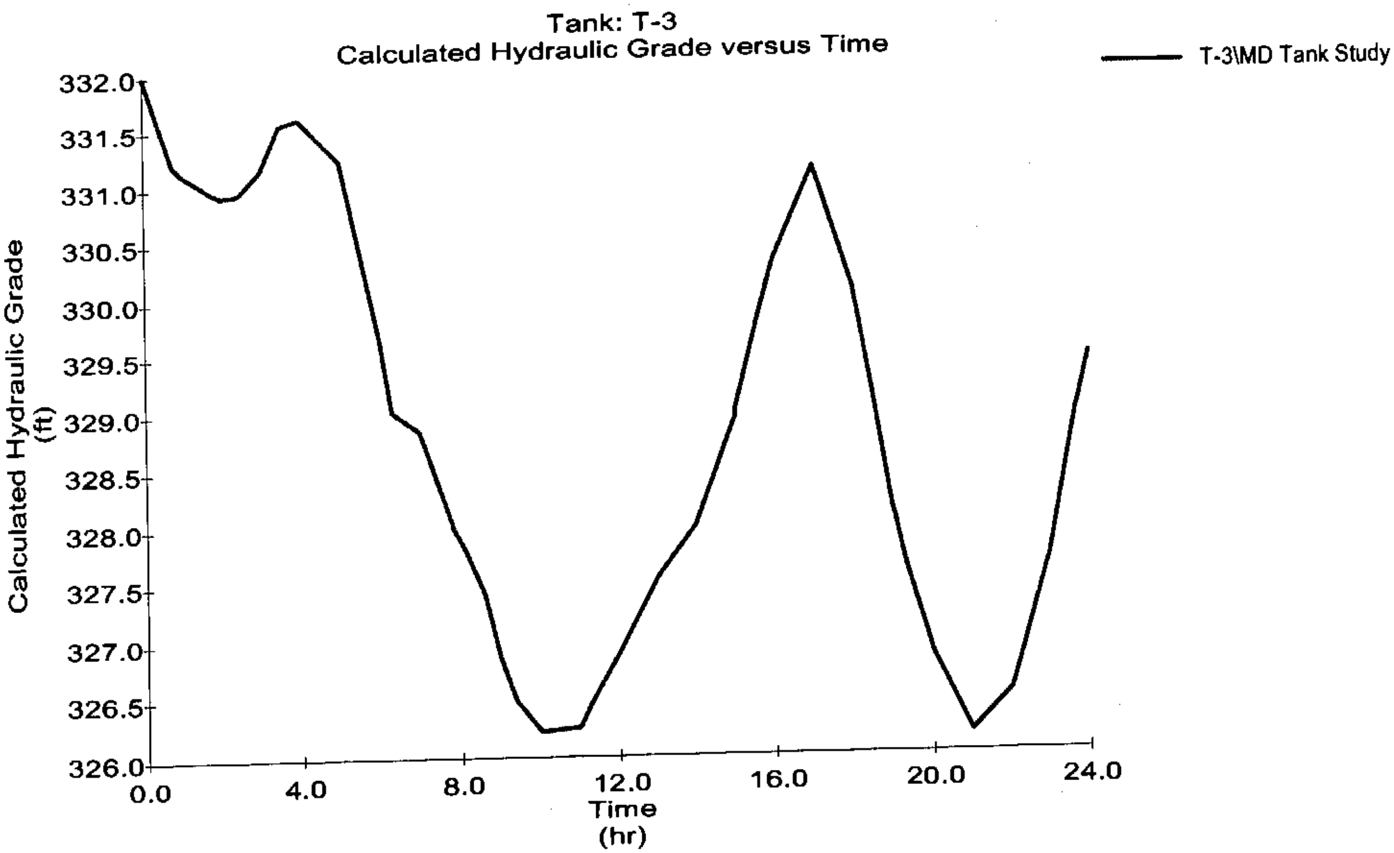
Wakefield Street Tank



- 2000 gpm fire flow at node J-727
- River Farms Dr.
- 12" PVC main
- Elevation = 190 ft

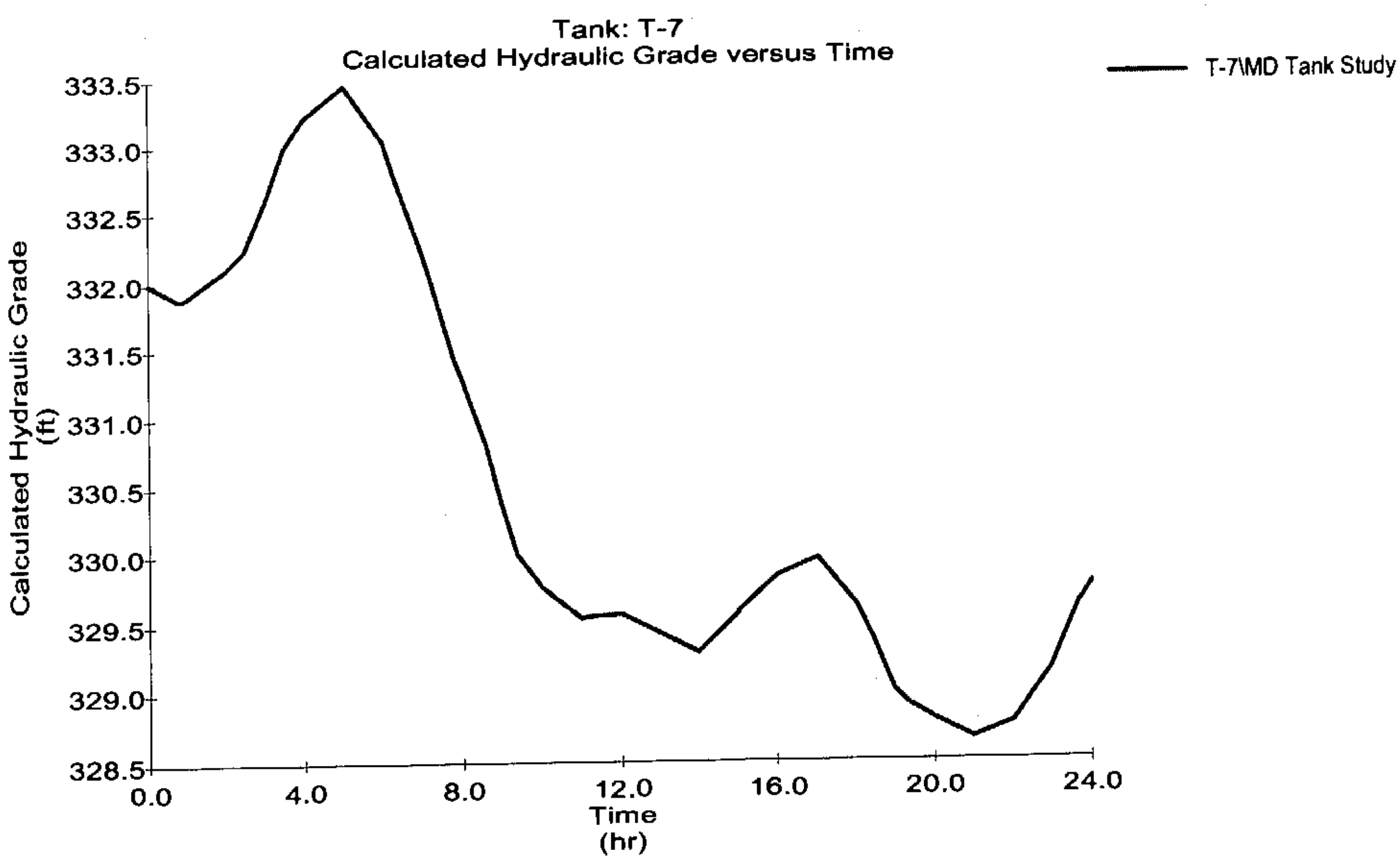
Graph

Frenchtown Road Tank



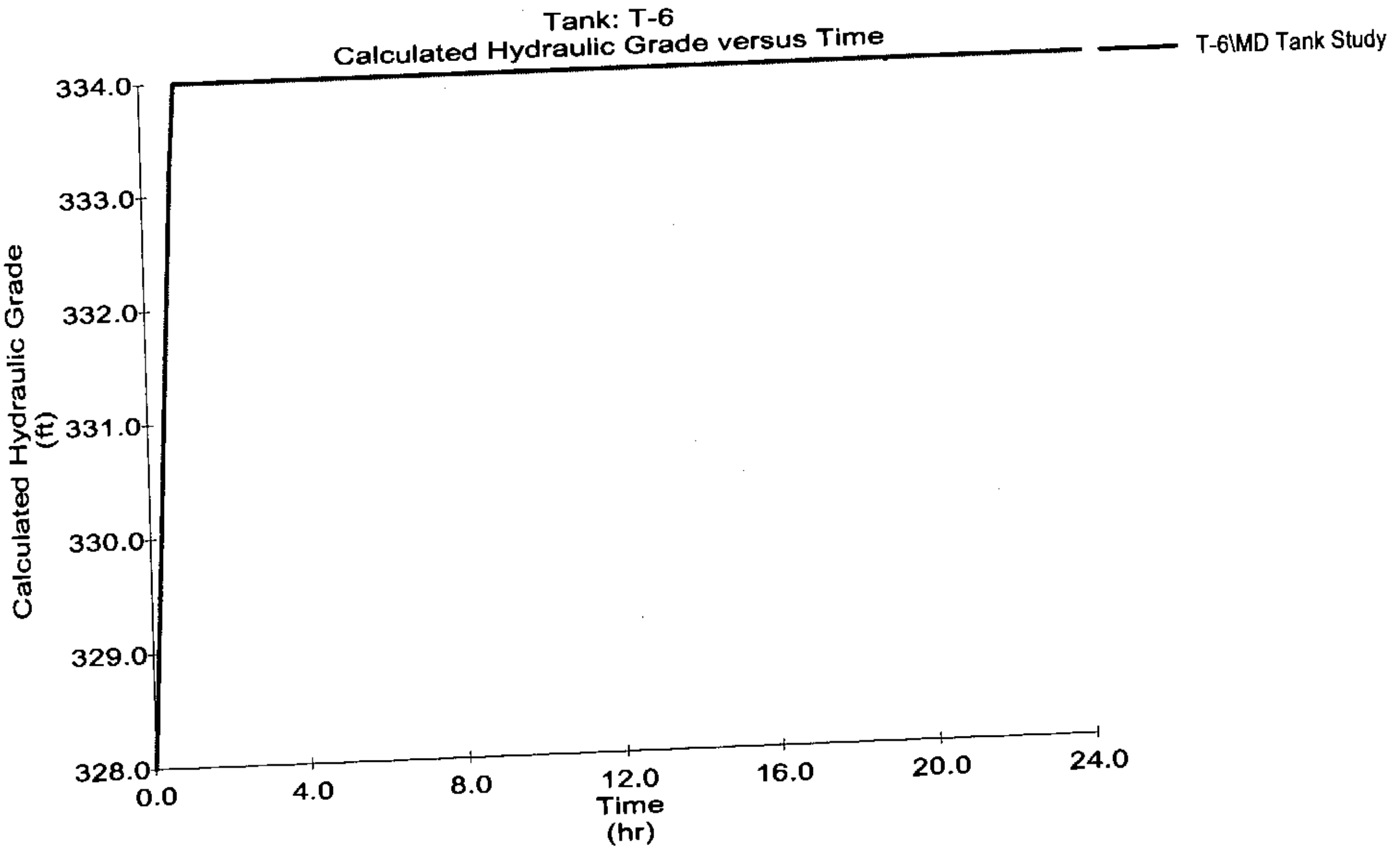
Graph

Setian Lane Tank



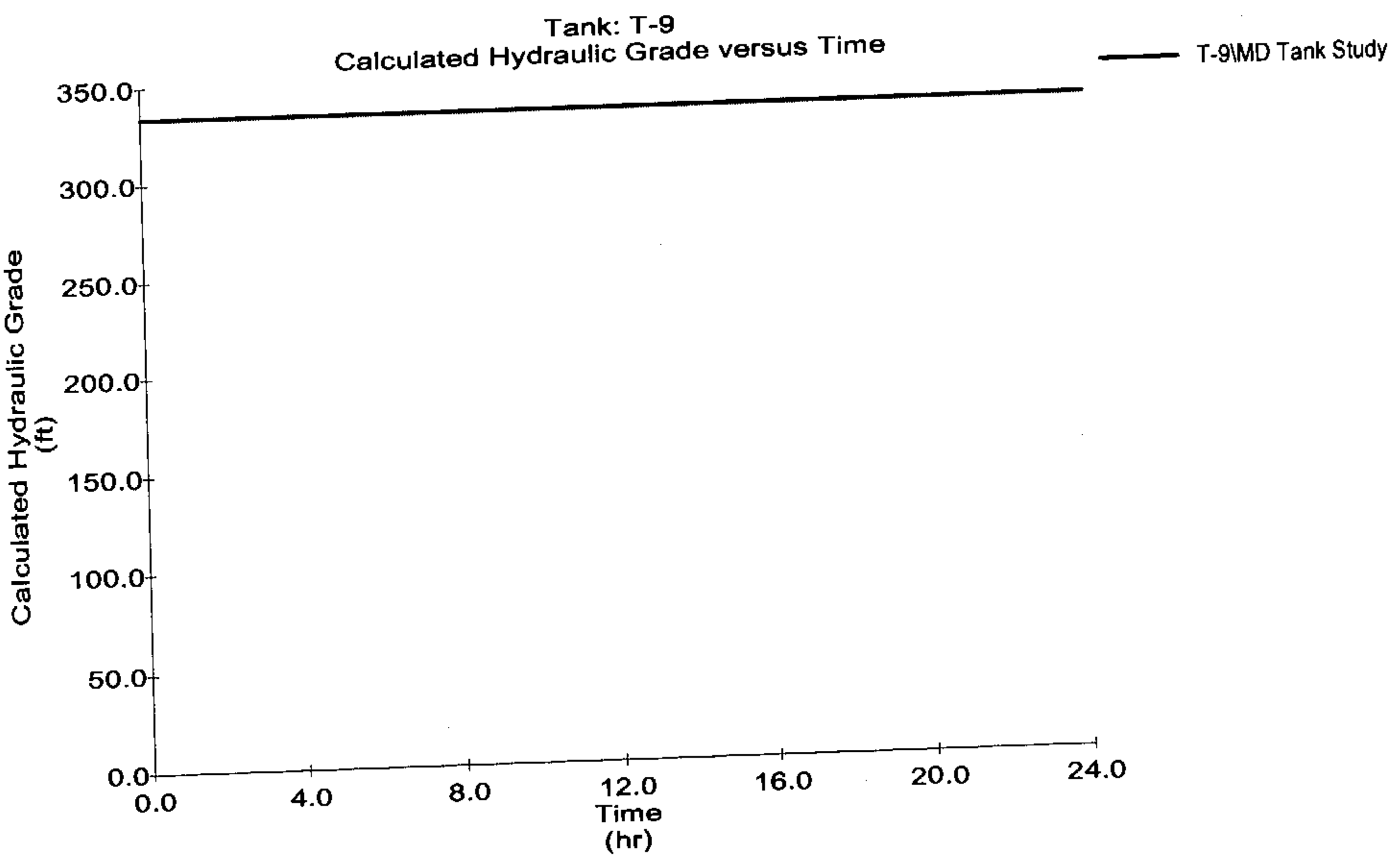
Graph

West Street Tank



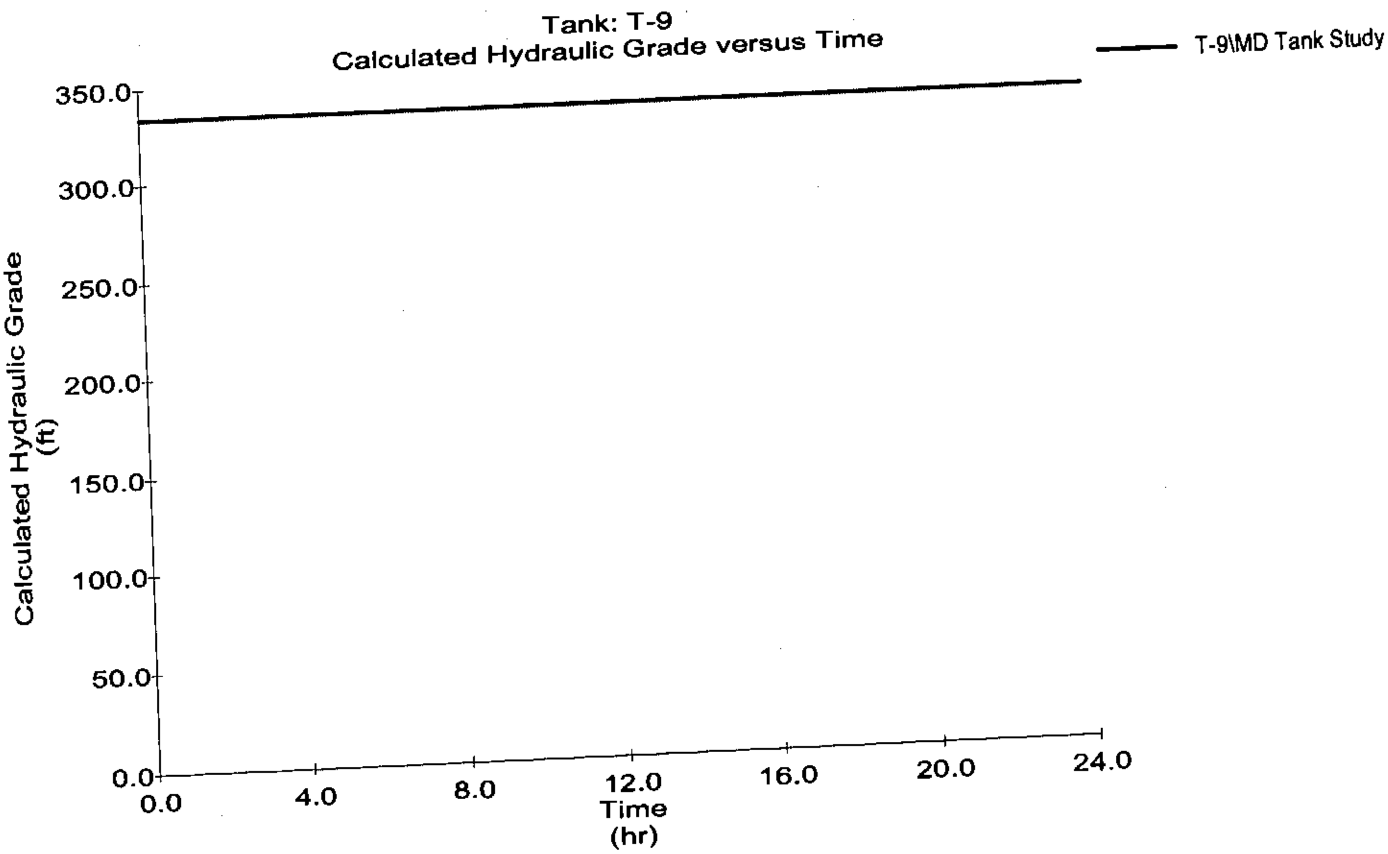
Graph

Fiskeville Reservoir #1



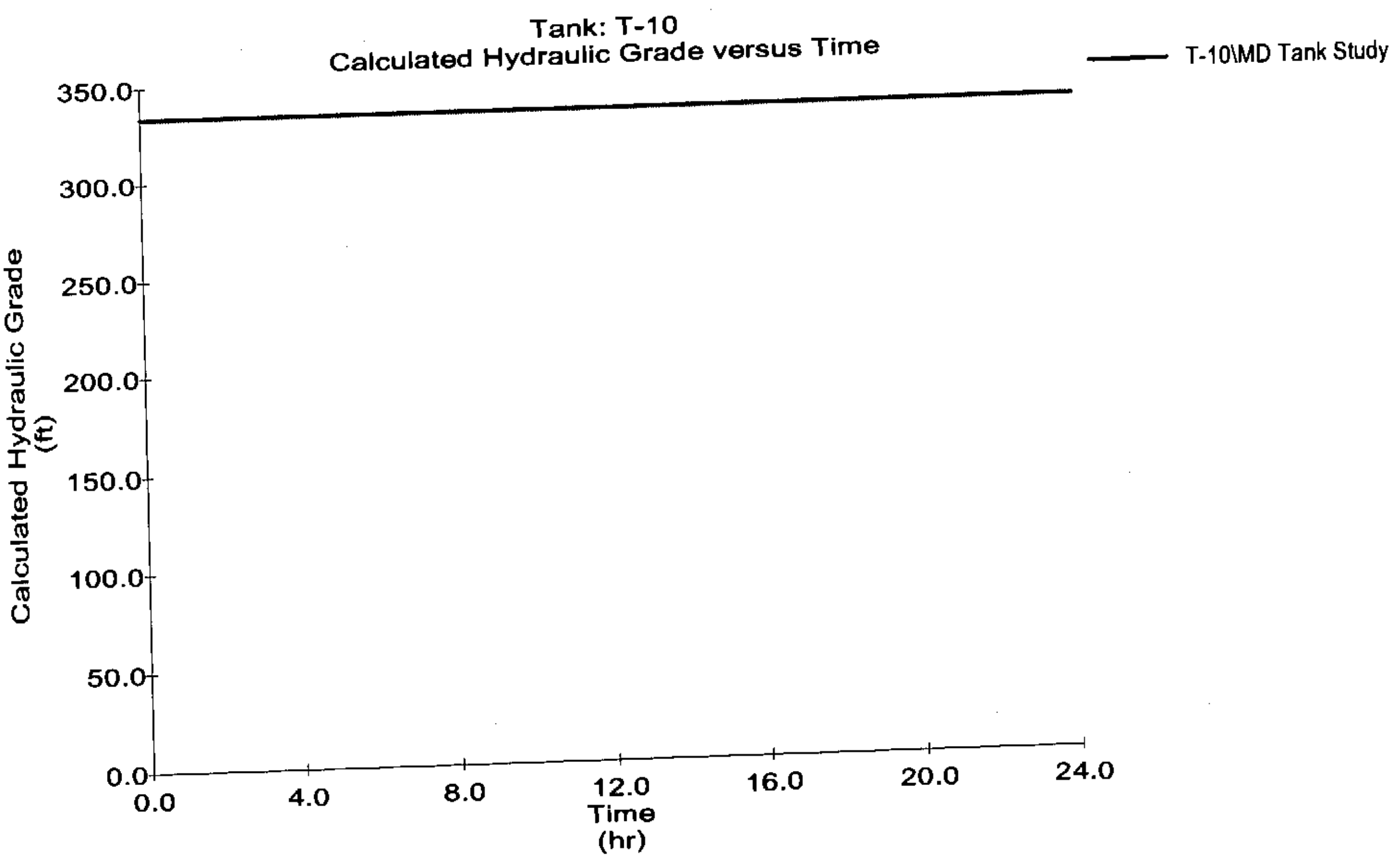
Graph

Fiskeville Reservoir #1



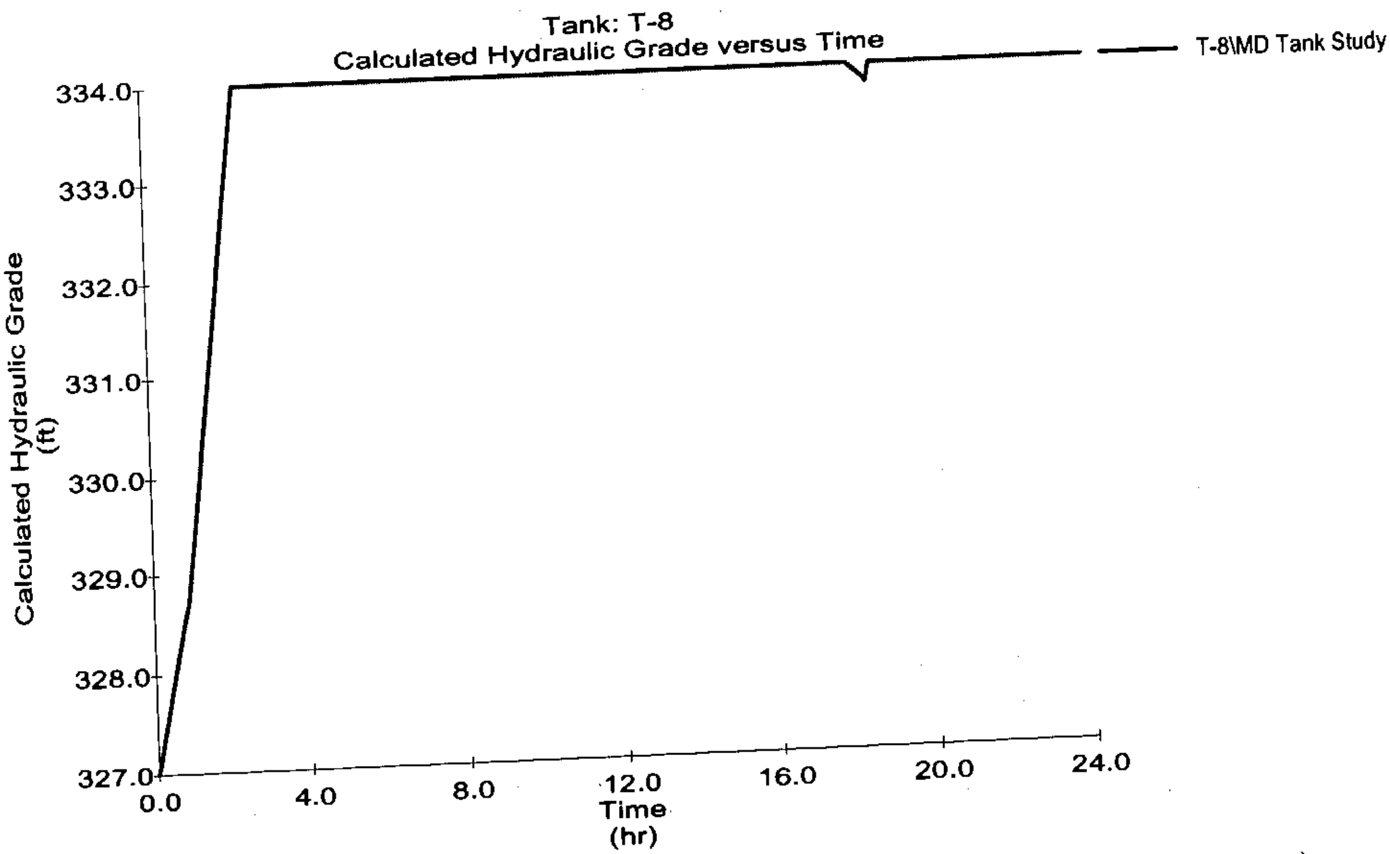
Graph

Fiskeville Reservoir #2



Graph

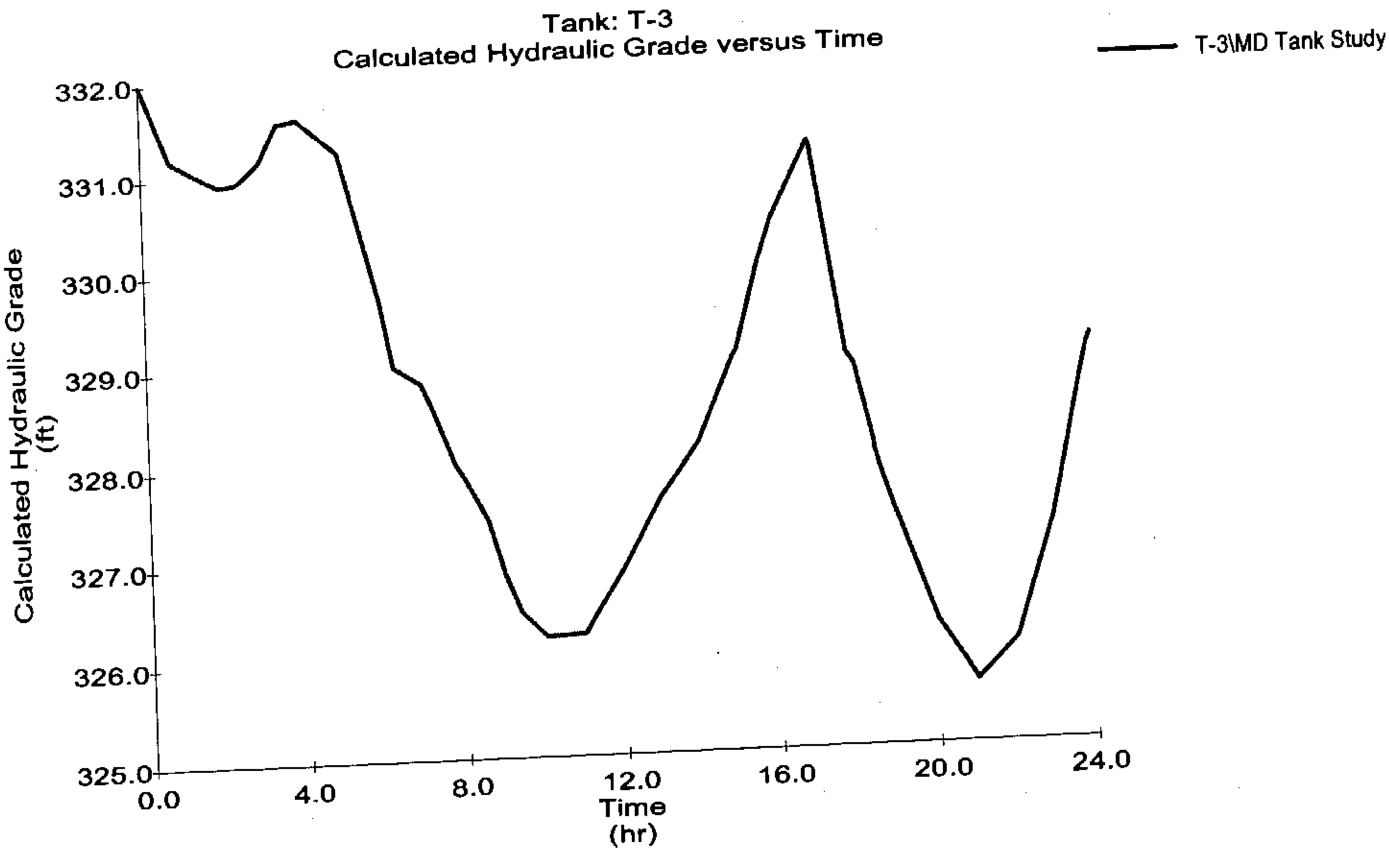
Wakefield Street Tank



- 2000 gpm fire flow at node J-769
- Main St.
- 20" DI main
- Elevation = 92 ft

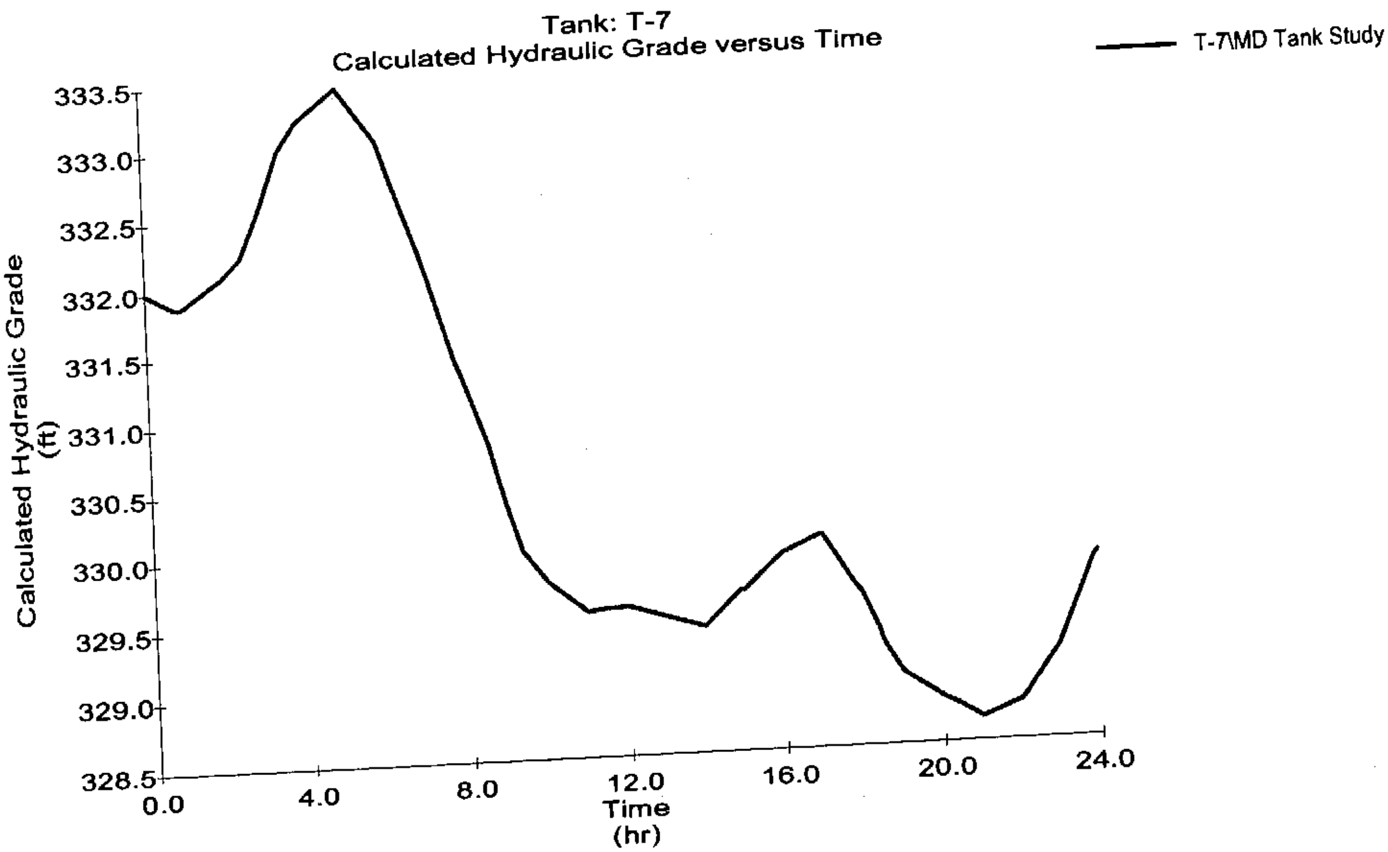
Graph

Frenchtown Road Tank



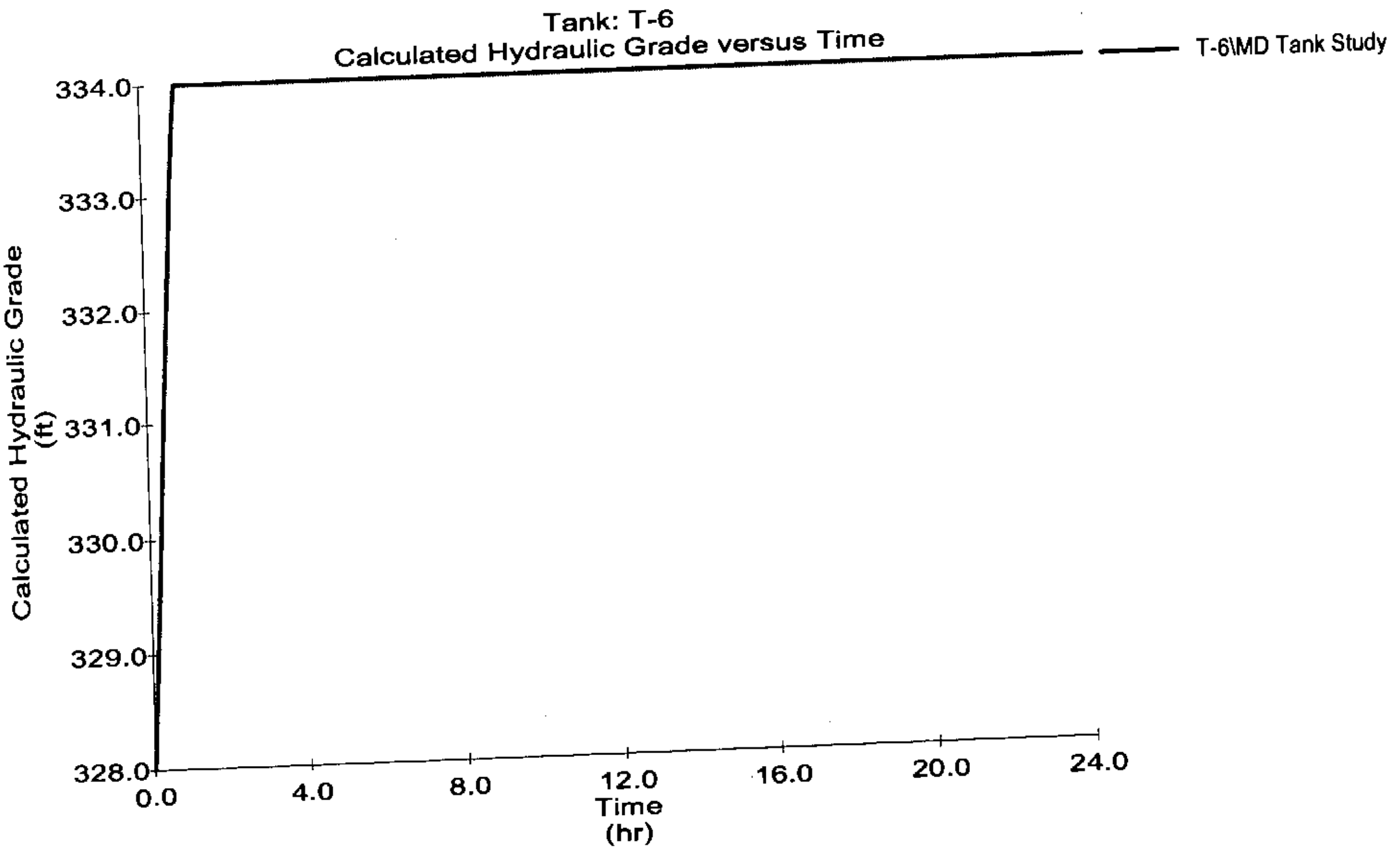
Graph

Setian Lane Tank



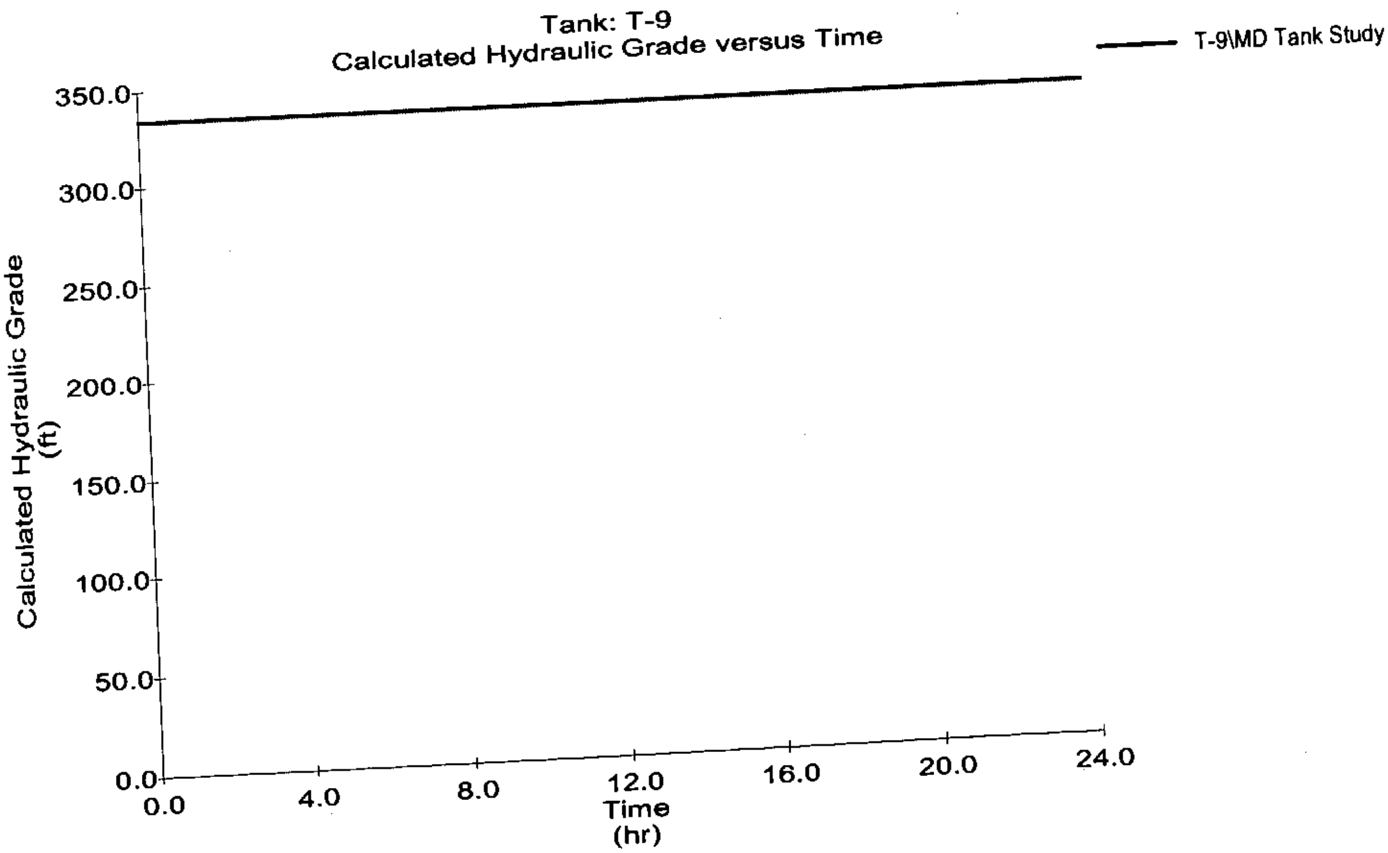
Graph

West Street Tank



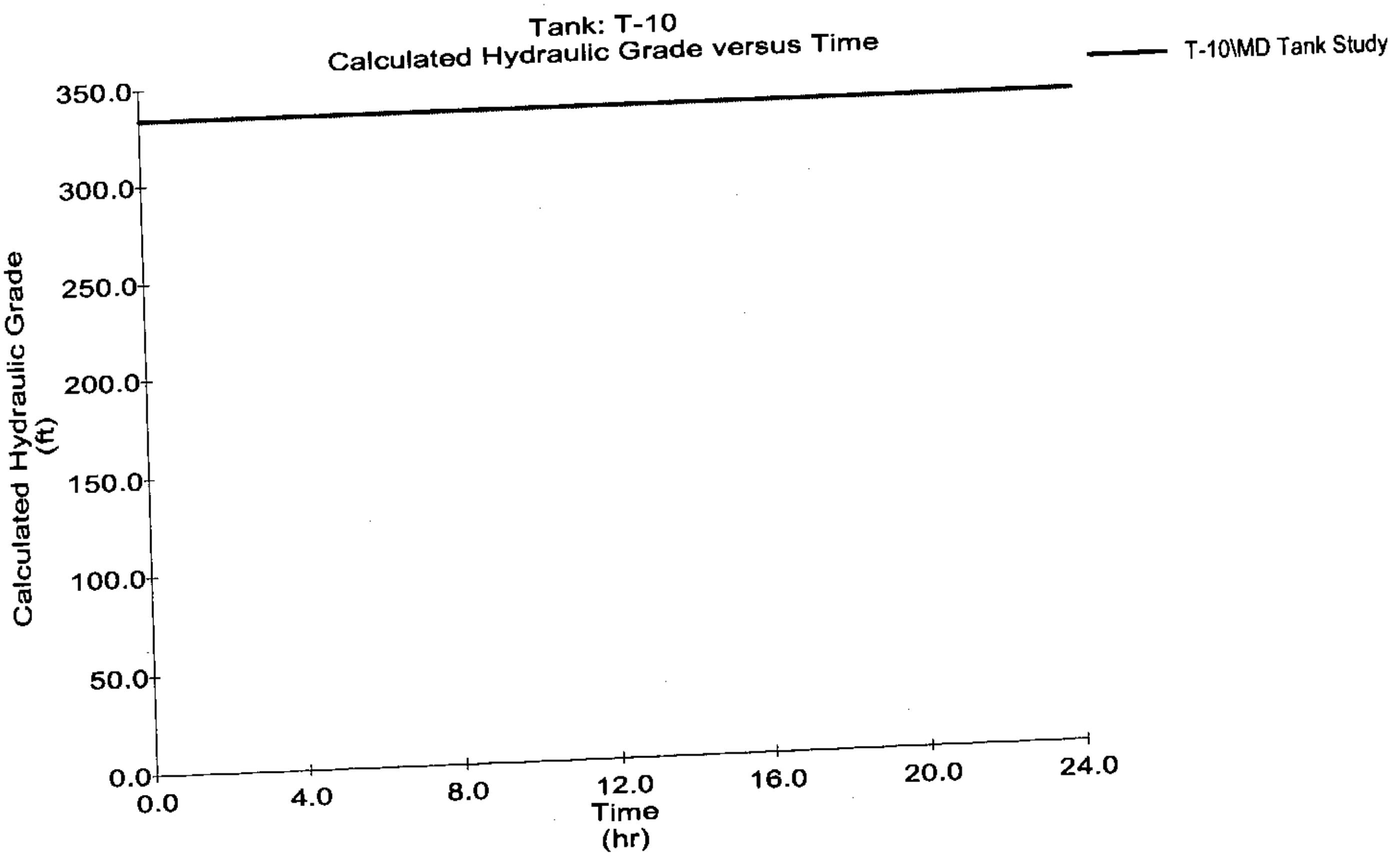
Graph

Fiskeville Reservoir #1



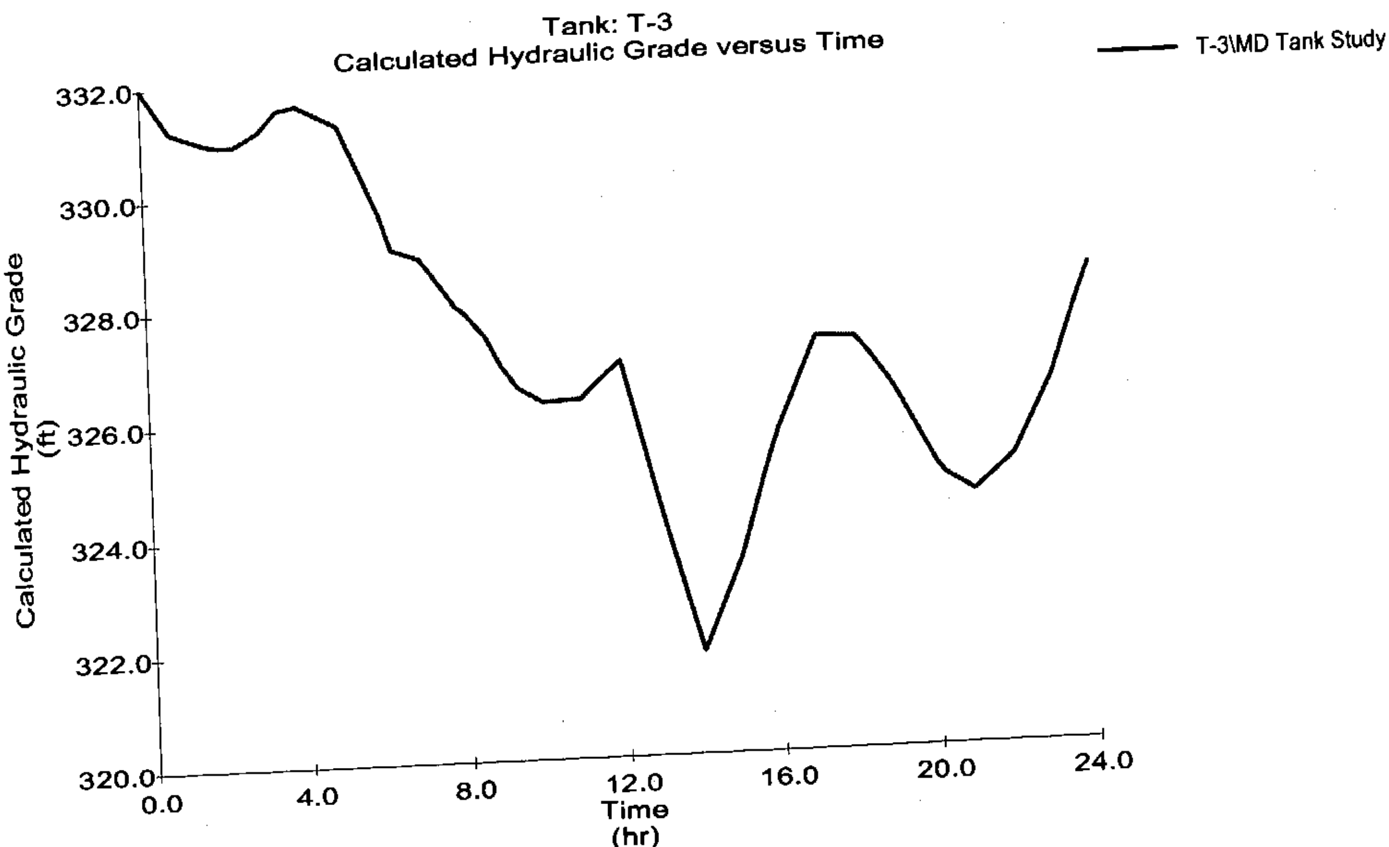
Graph

Fiskeville Reservoir #2



Graph

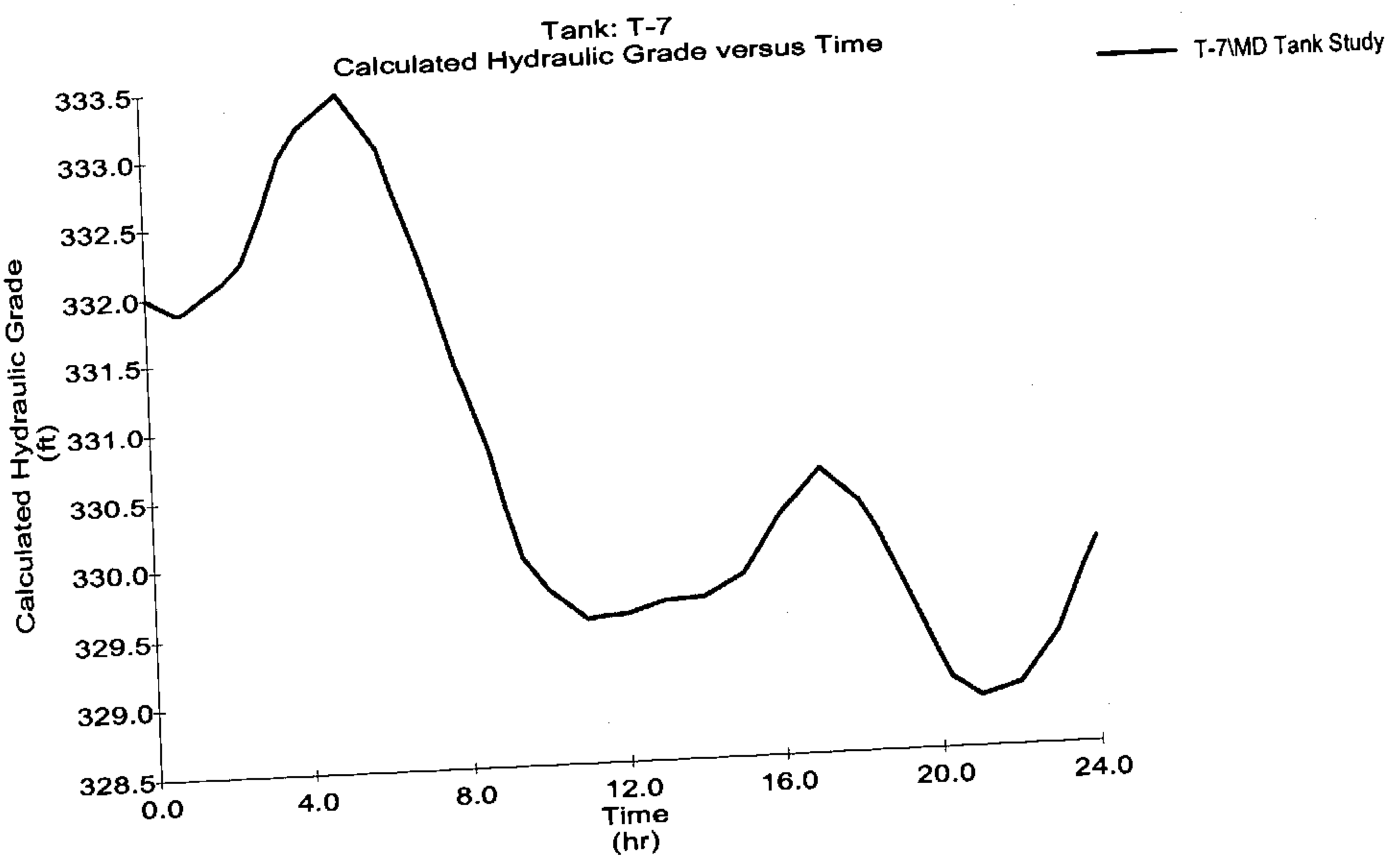
Frenchtown Road Tank



- 2000 gpm fire flow at node J-4091
- Frenchtown Rd.
- 20" AC main
- Elevation = 247 ft

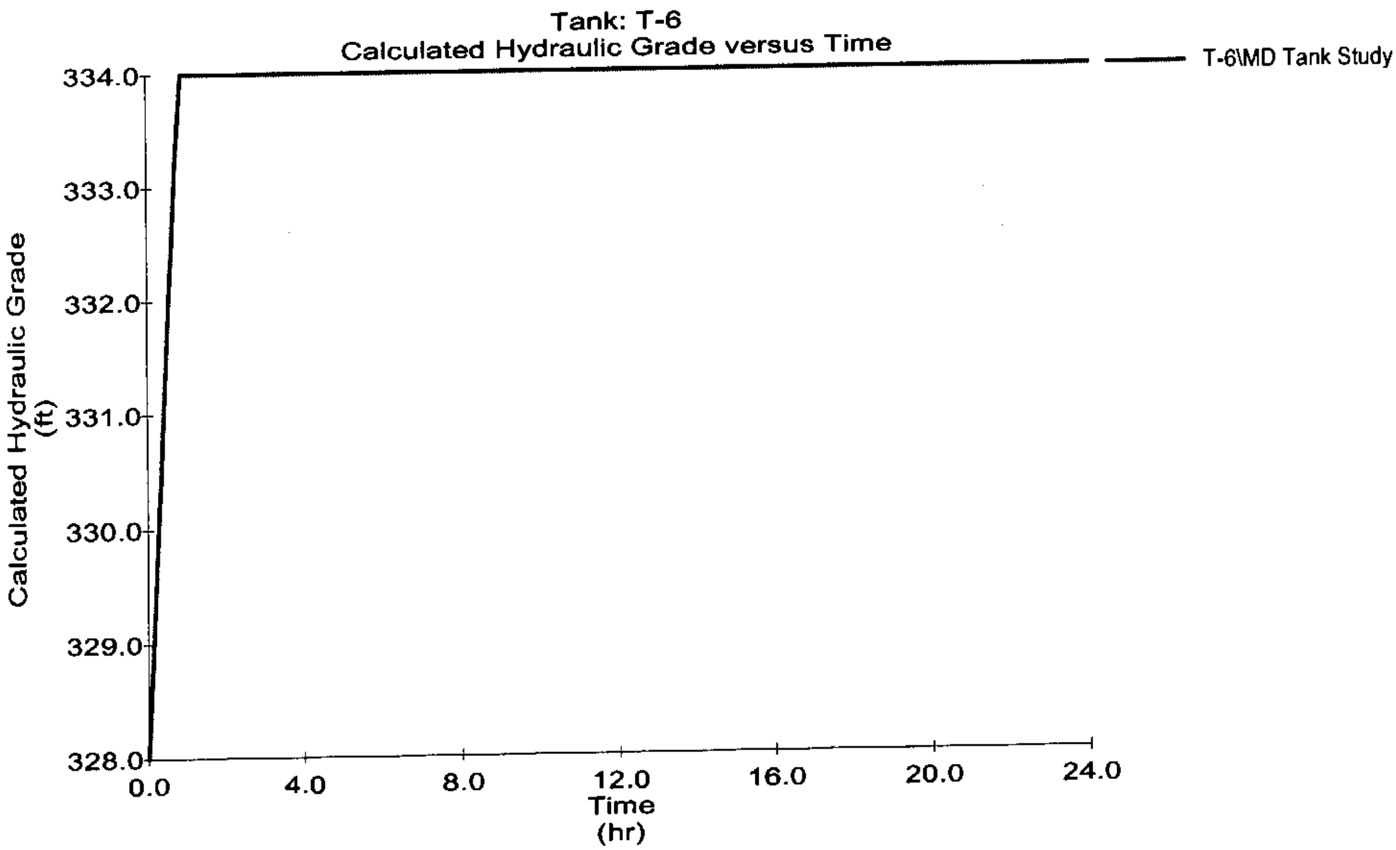
Graph

Setian Lane Tank



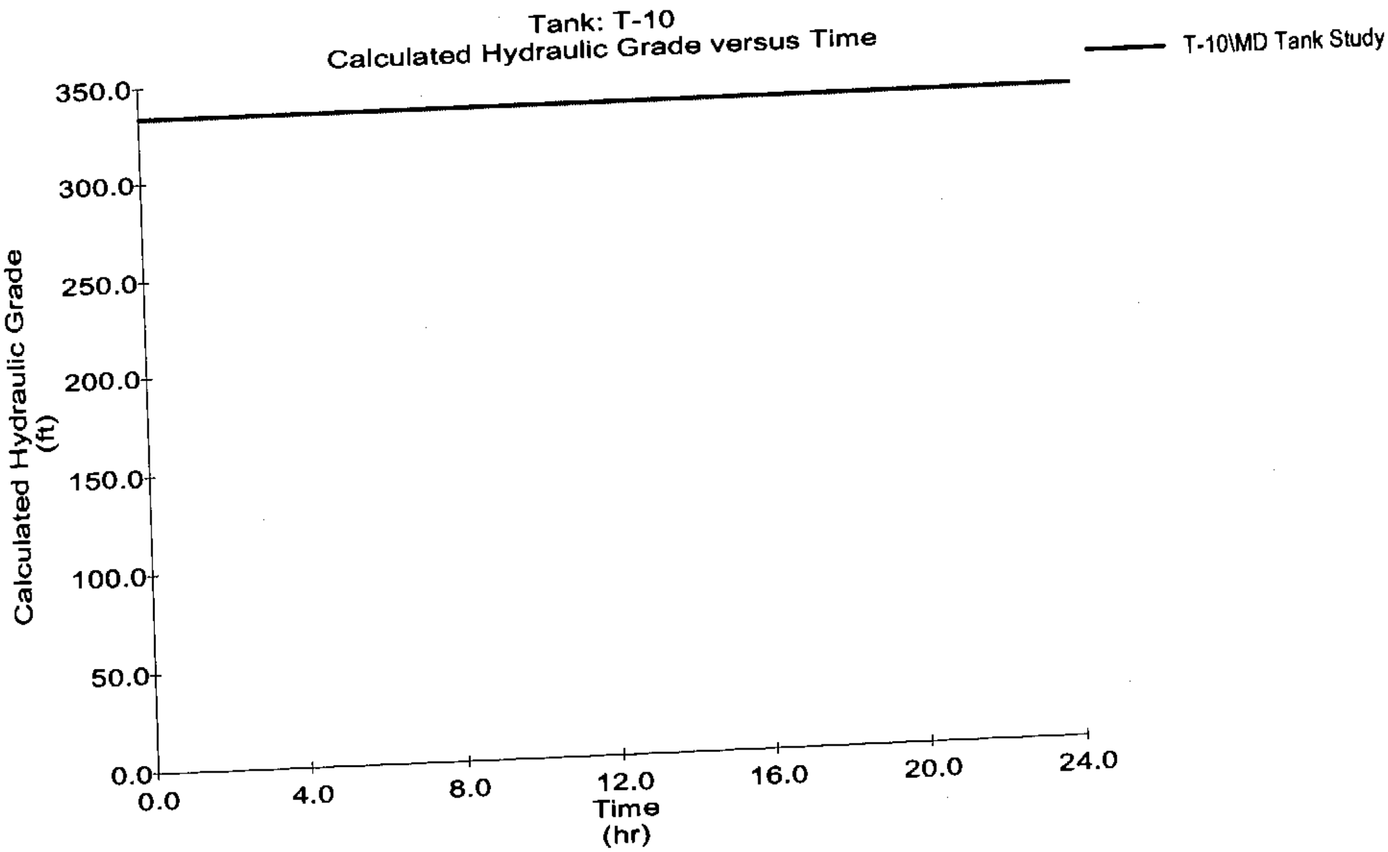
Graph

West Street Tank



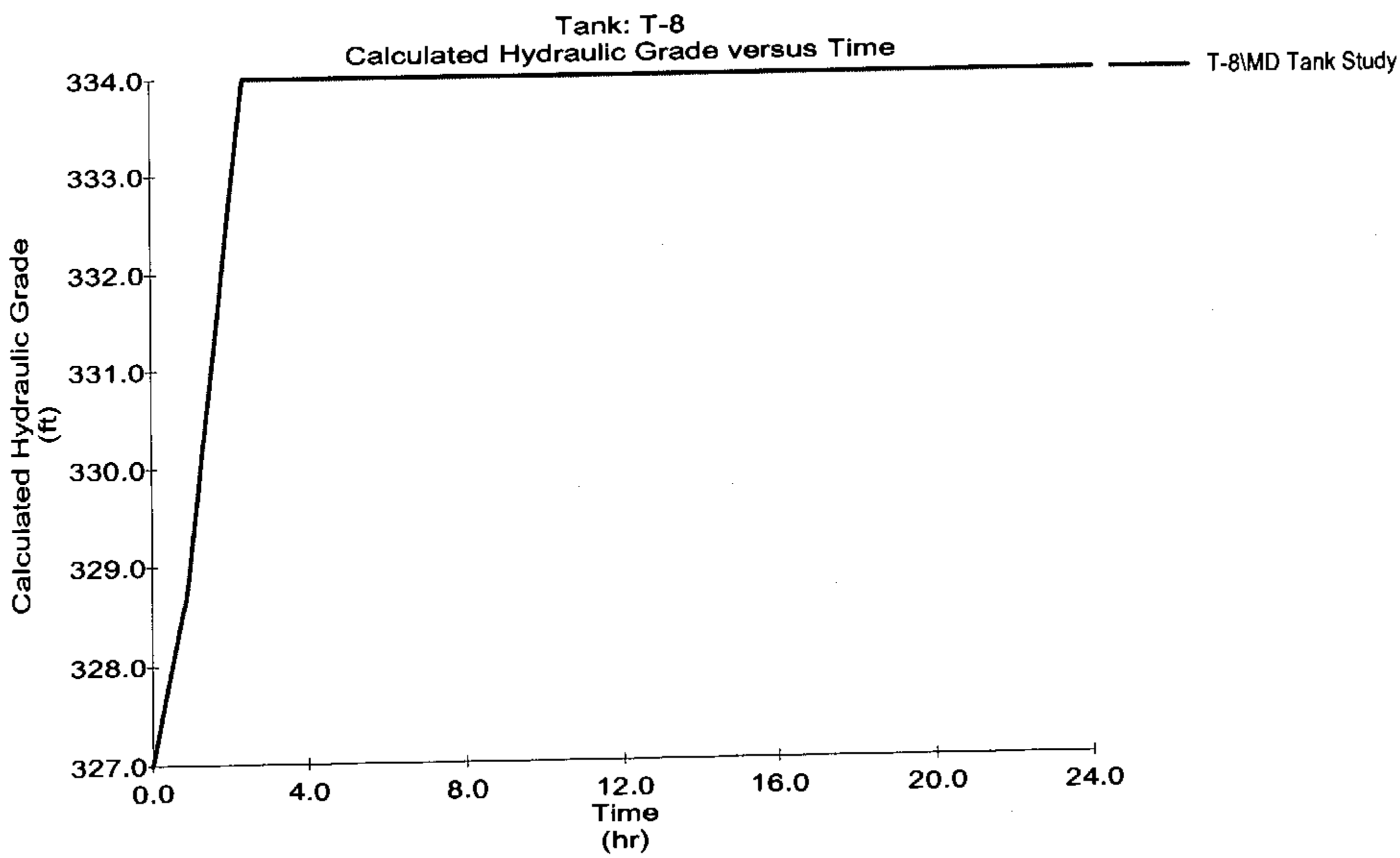
Graph

Fiskeville Reservoir #2



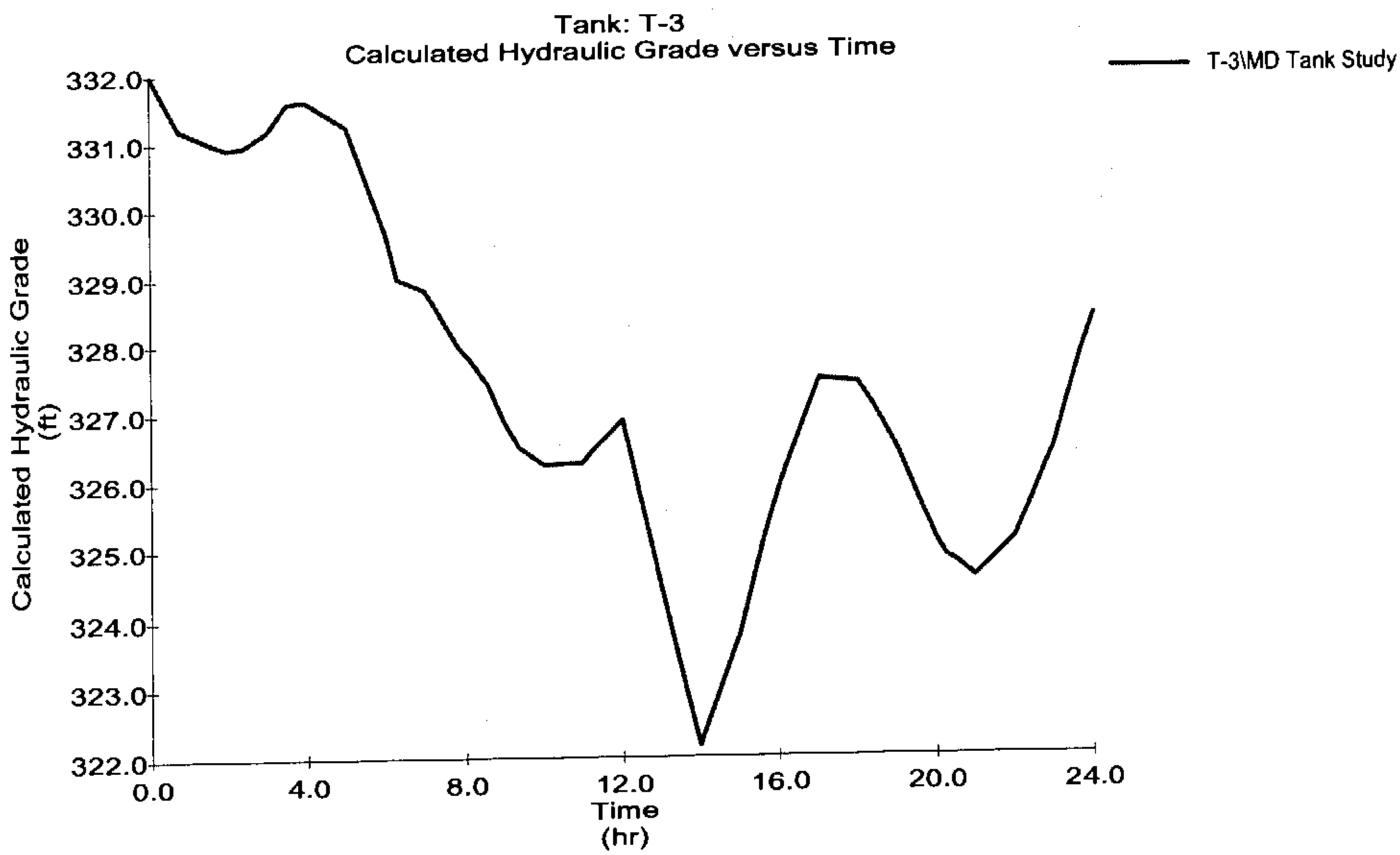
Graph

Wakefield Street Tank



Graph

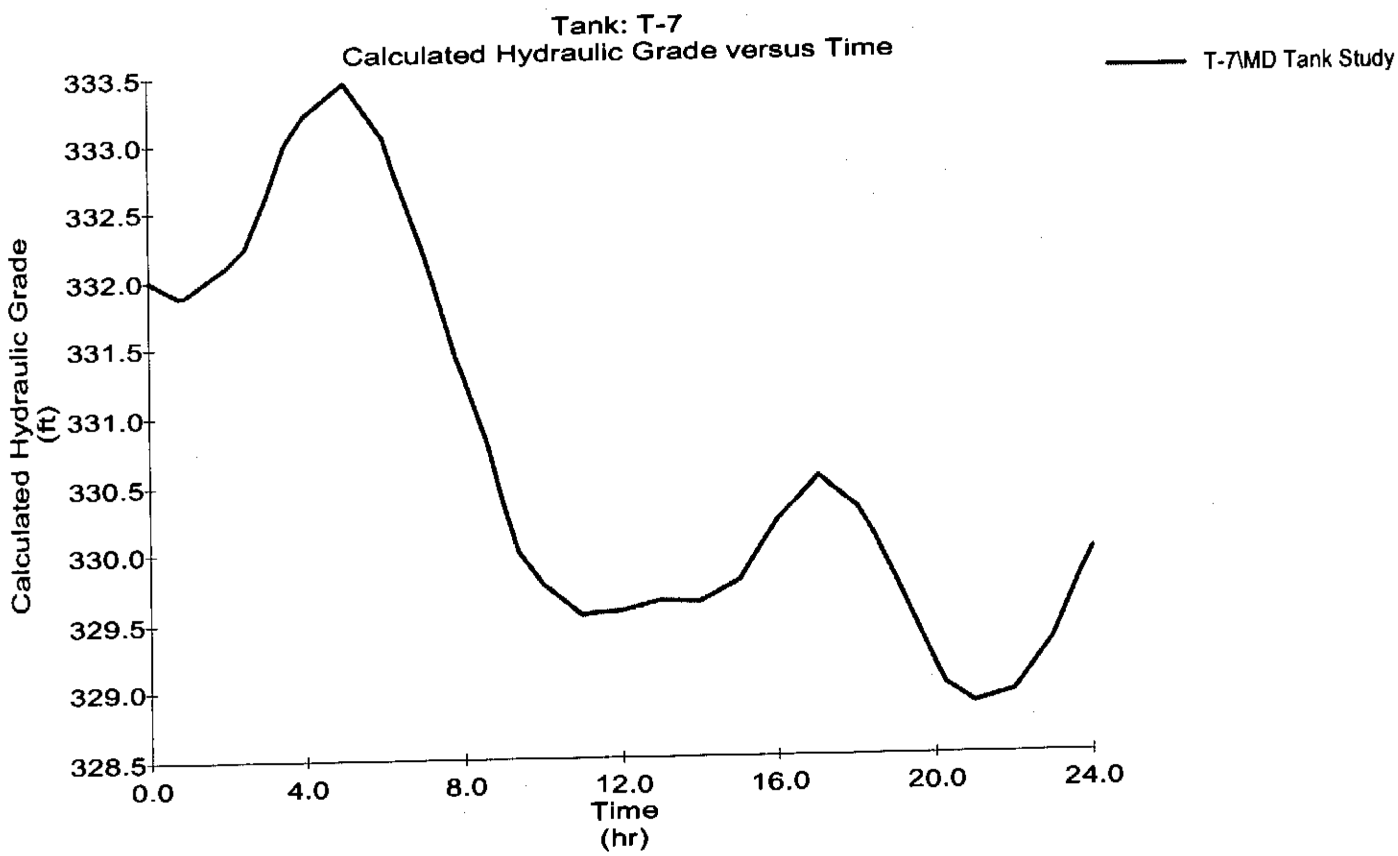
Frenchtown Road Tank



- 2000 gpm fire flow at node J-4175
- South County Tr.
- 12" AC main
- Elevation = 109 ft

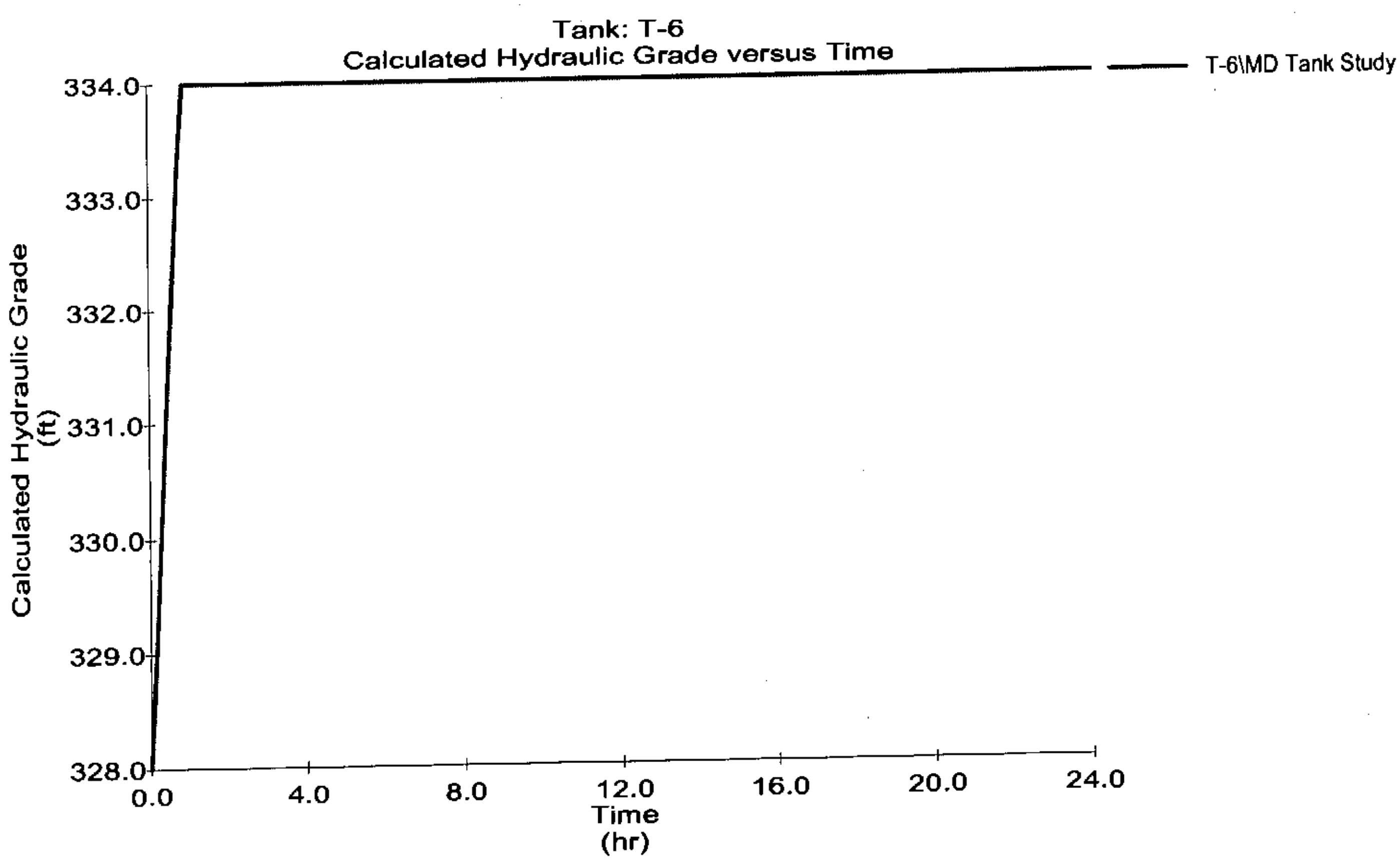
Graph

Setian Lane Tank



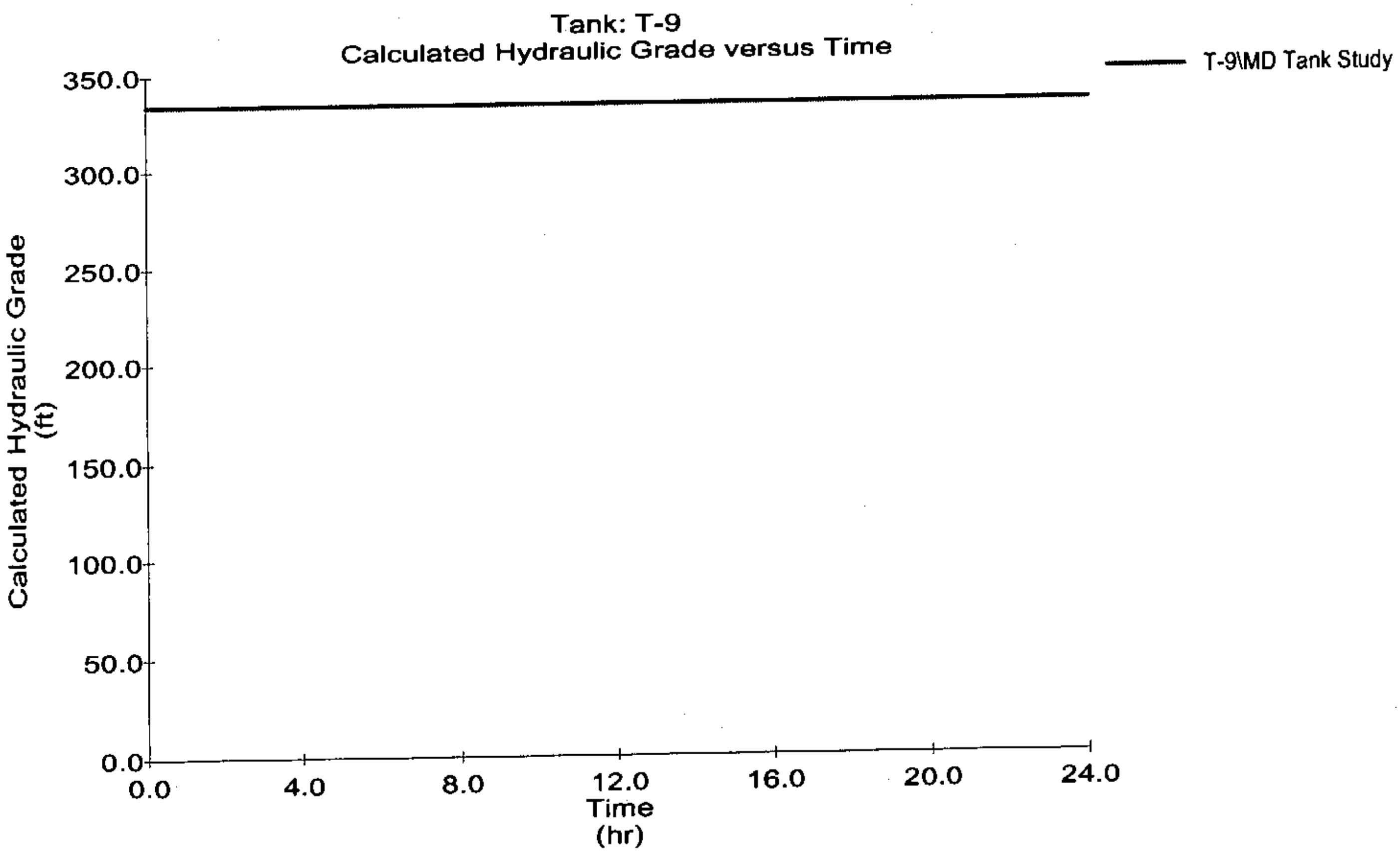
Graph

West Street Tank



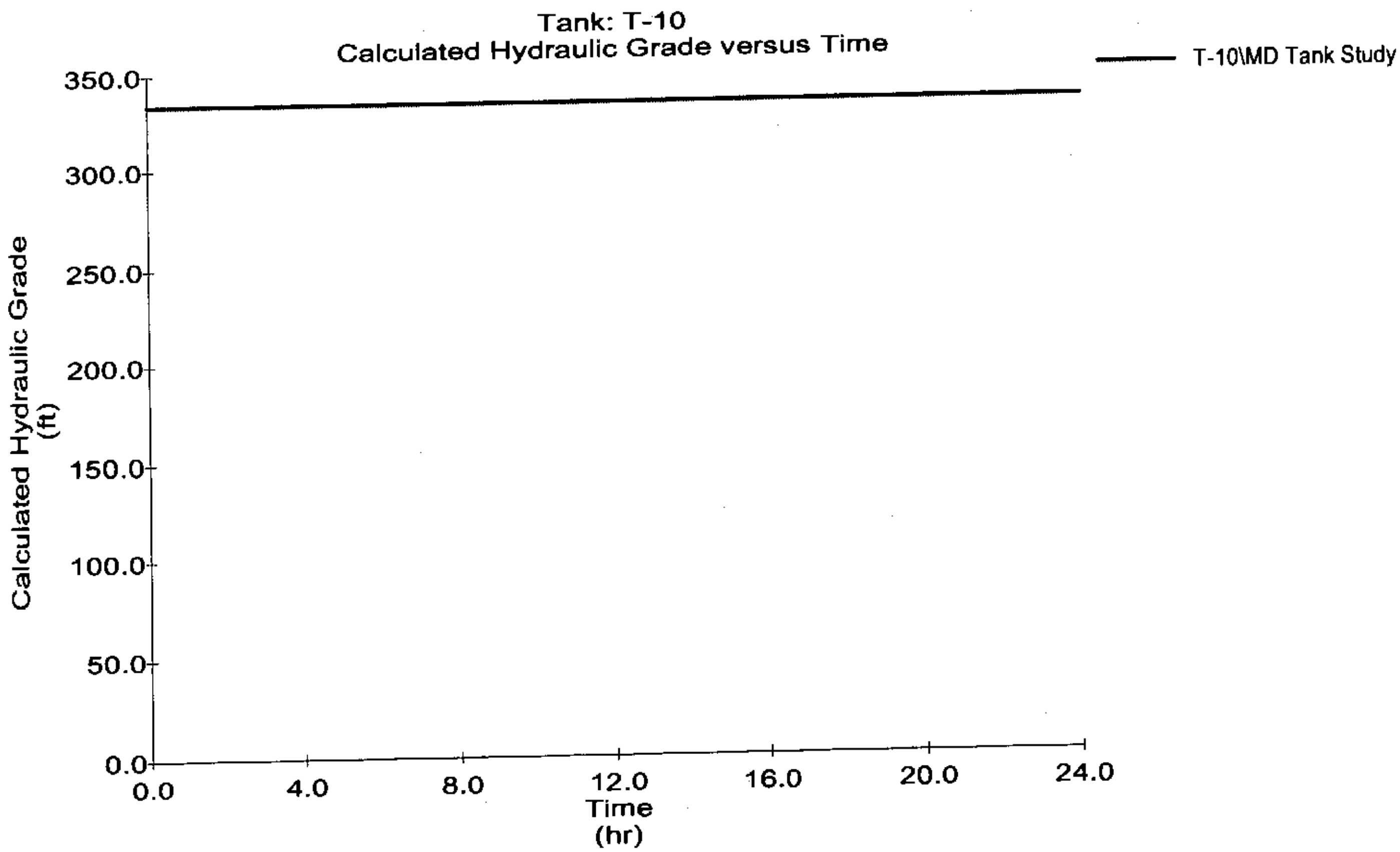
Graph

Fiskeville Reservoir #1



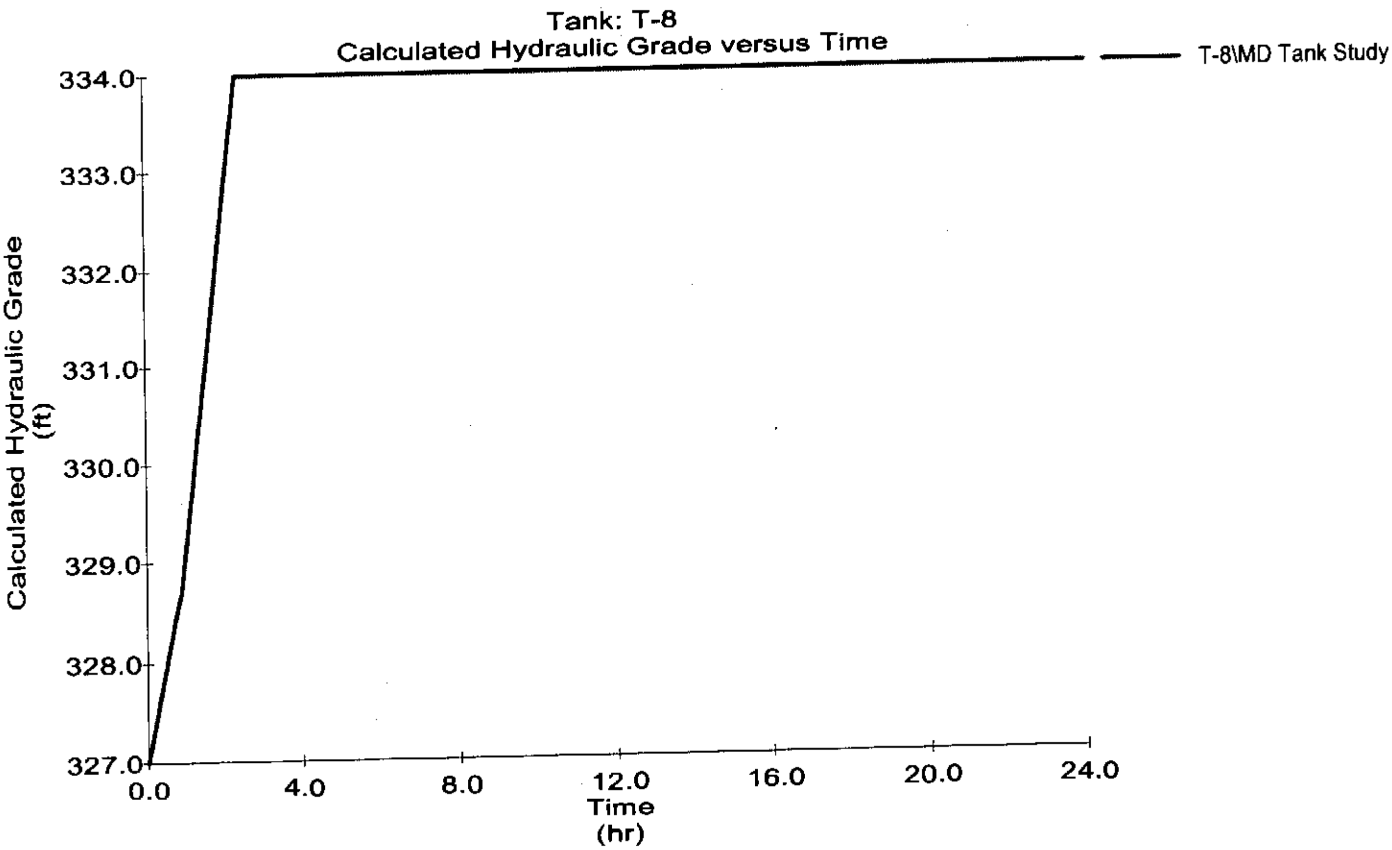
Graph

Fiskeville Reservoir #2



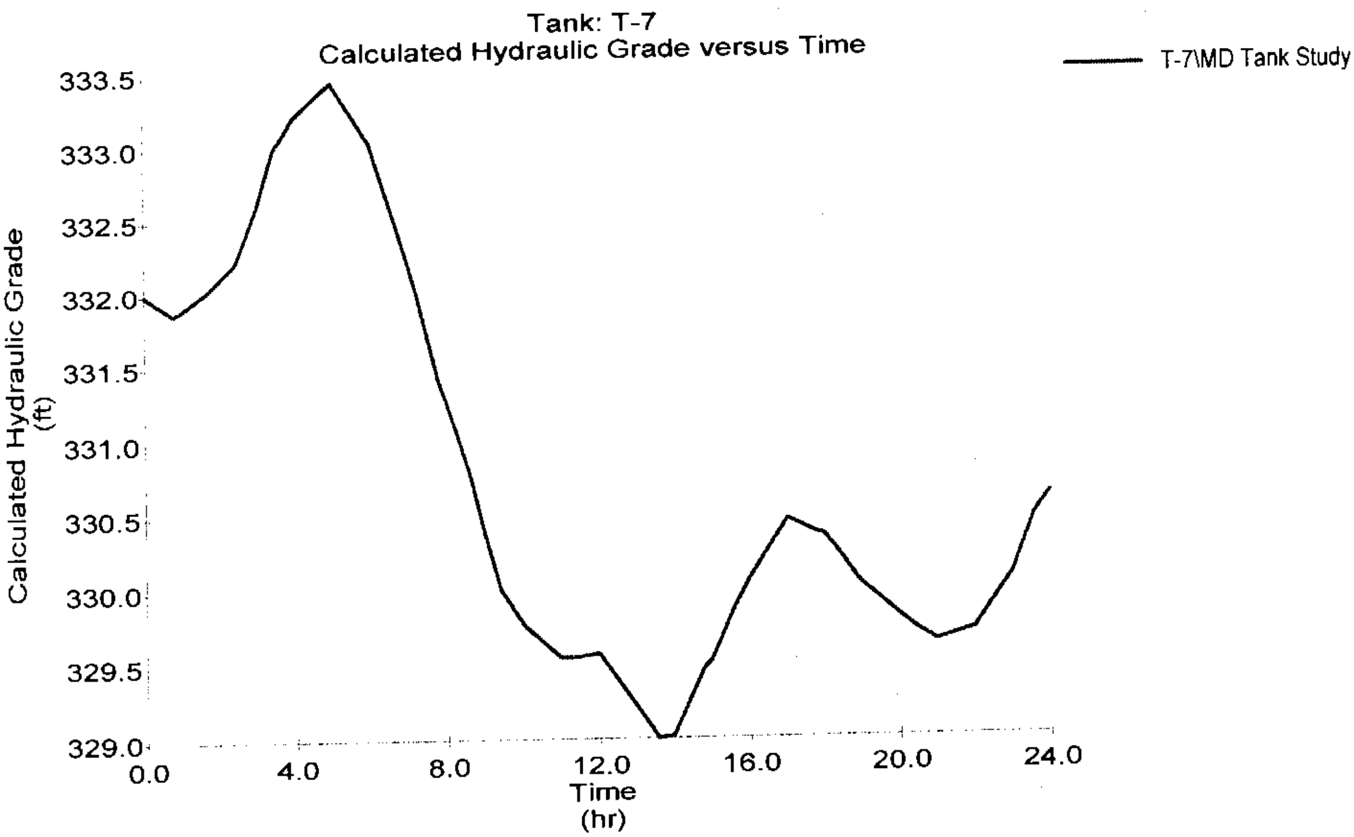
Graph

Wakefield Street Tank



Graph

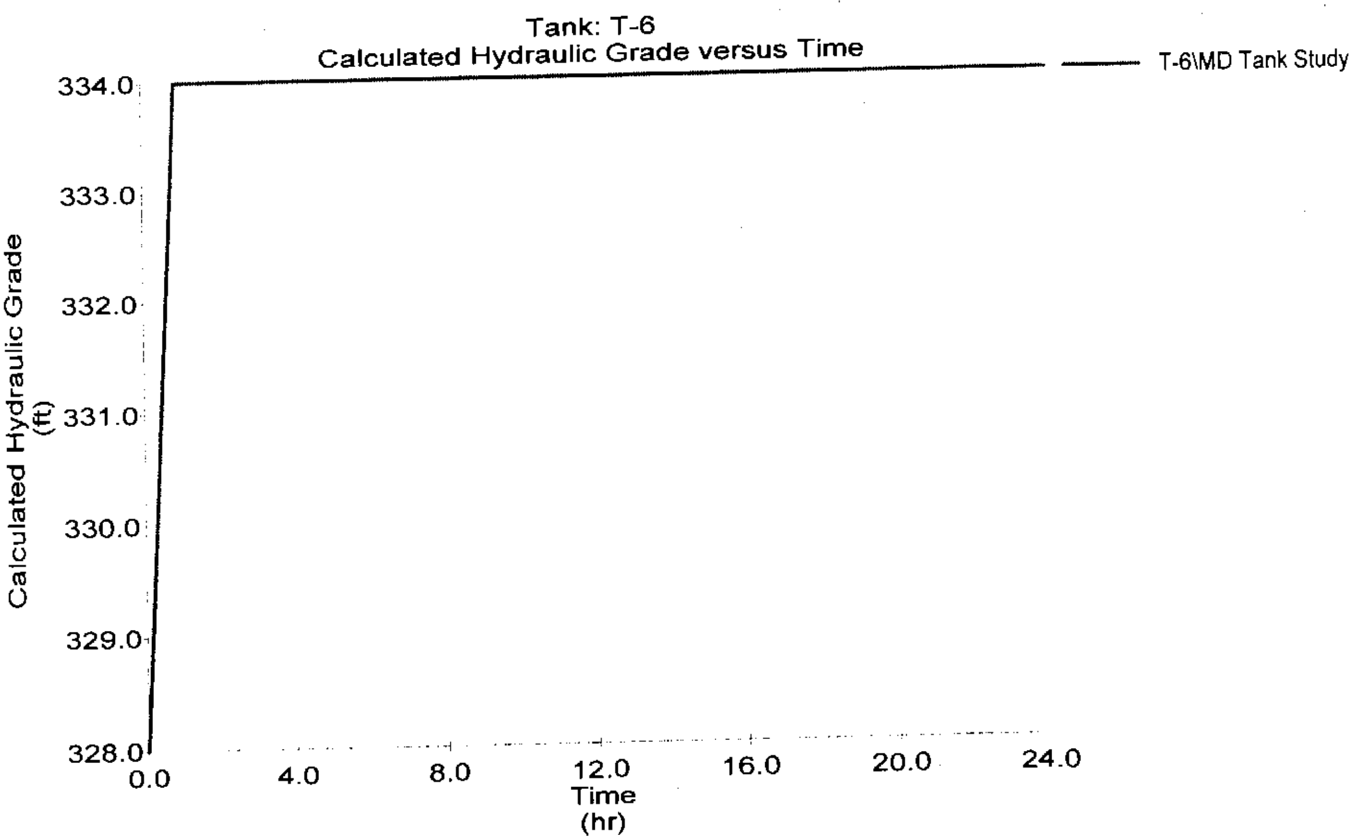
Setian Lane Tank



- 2000 gpm fire flow at node J-390
- Cowesett Rd.
- 12" AC main
- Elevation = 205 ft

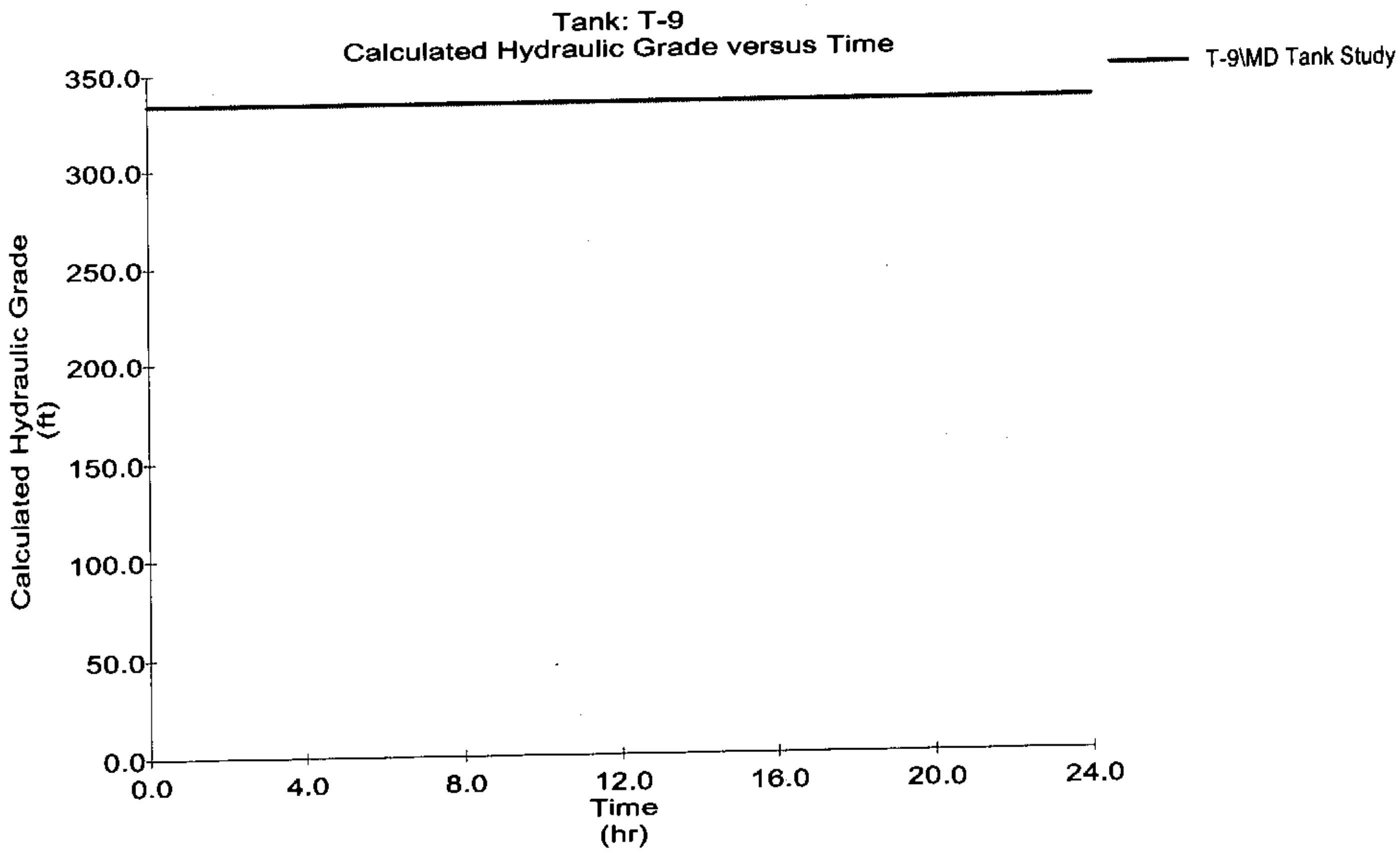
Graph

West Street Tank



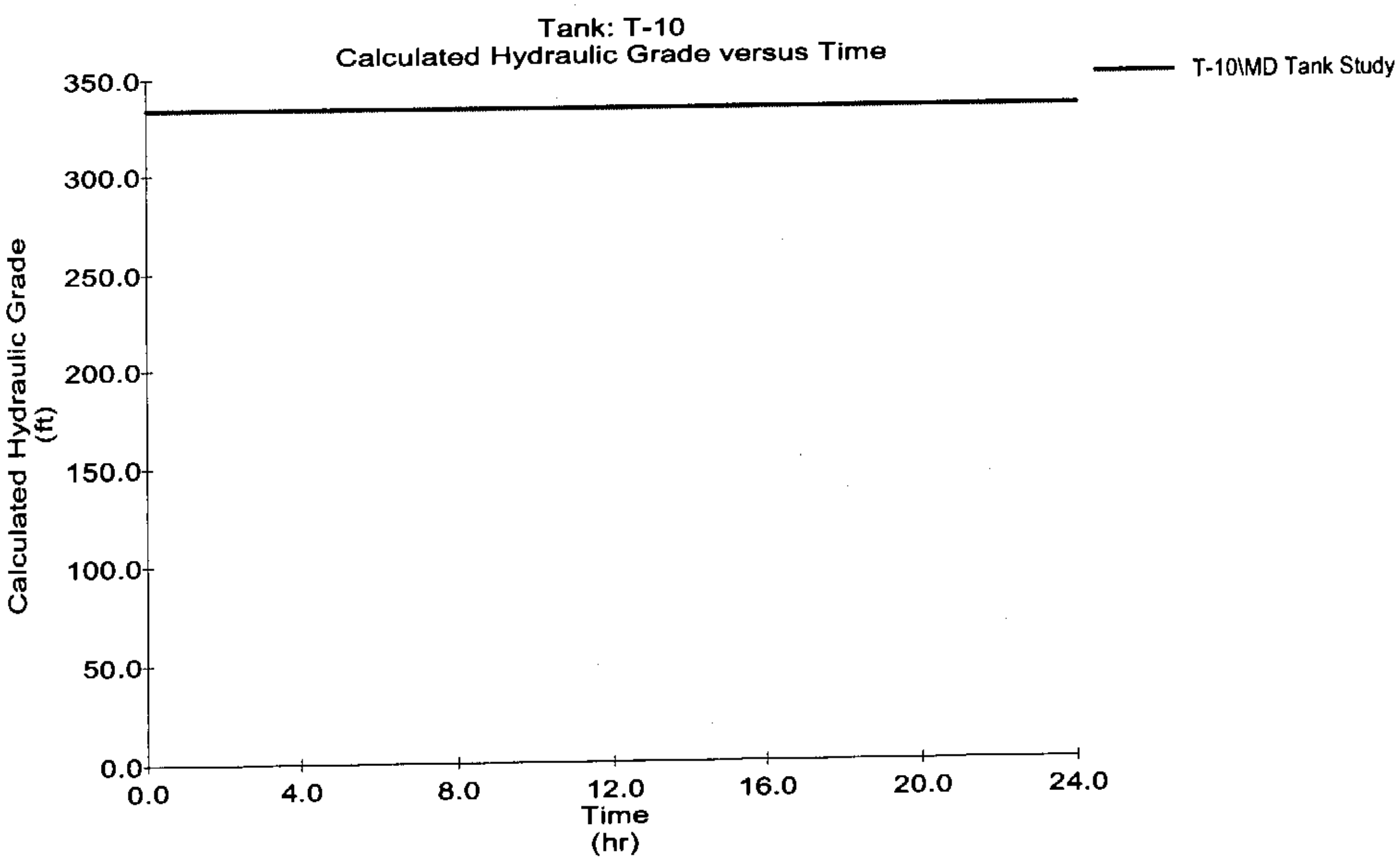
Graph

Fiskeville Reservoir # 1



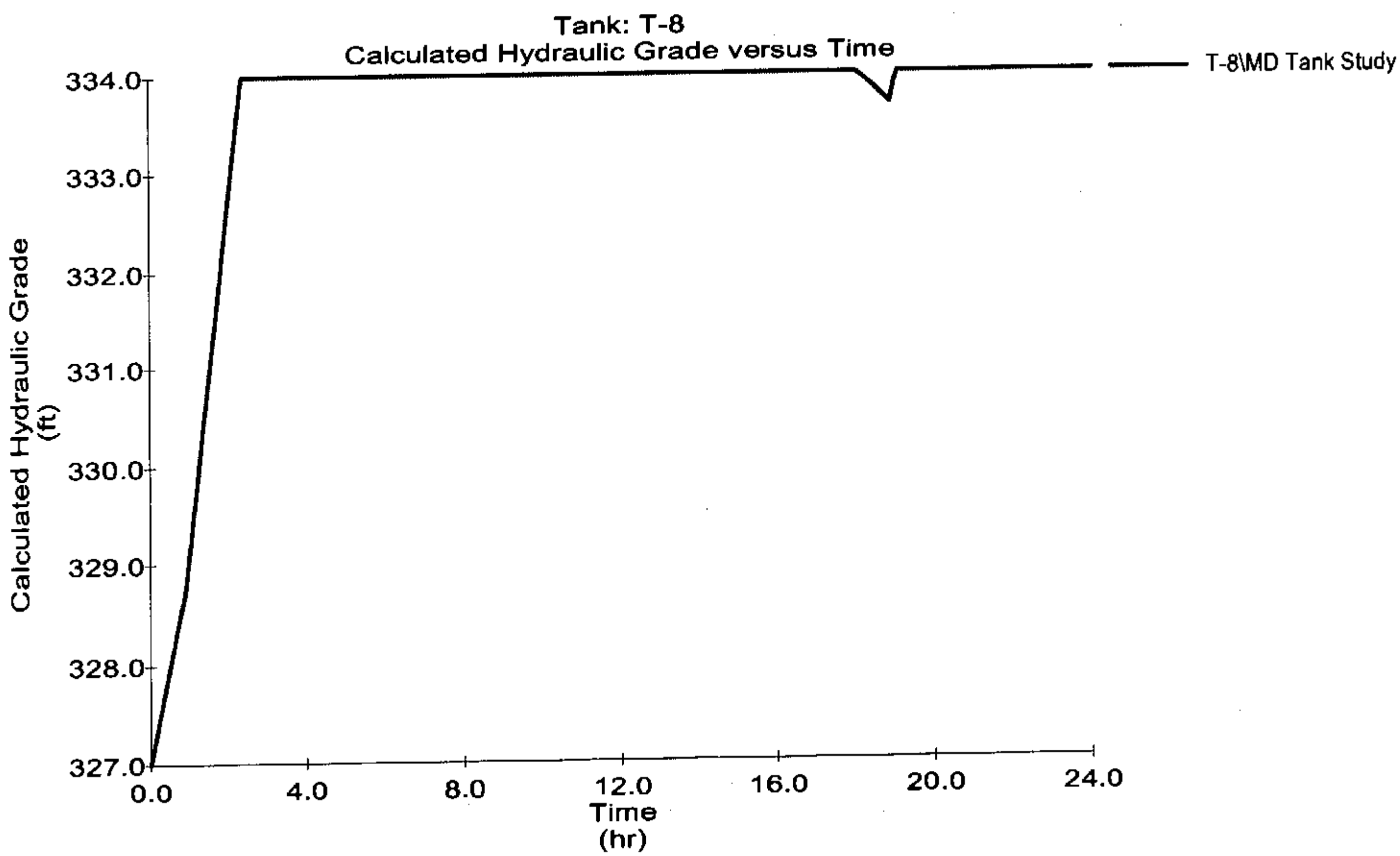
Graph

Fiskeville Reservoir #2



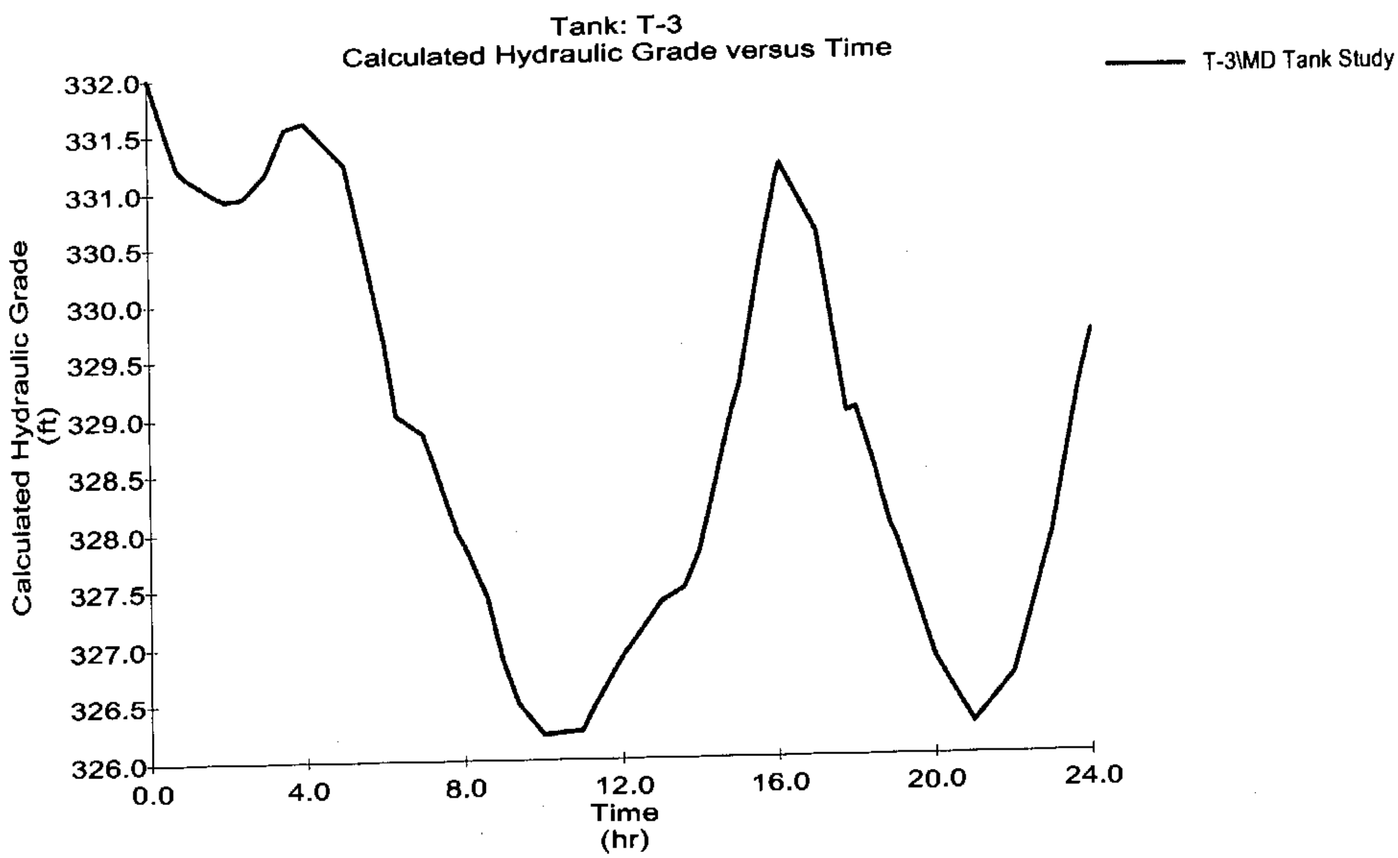
Graph

Wakefield Street Tank



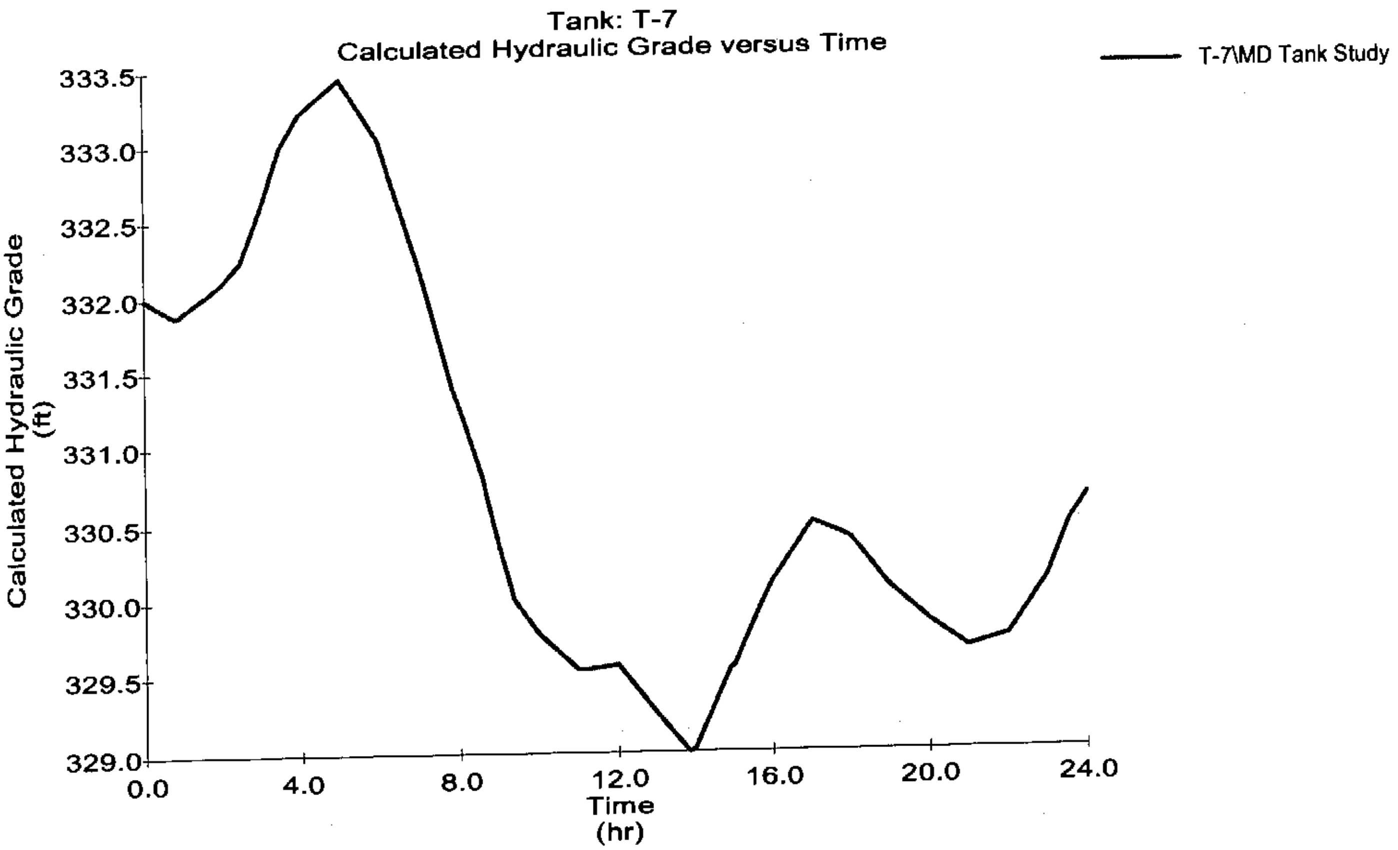
Graph

Frenchtown Road Tank



Graph

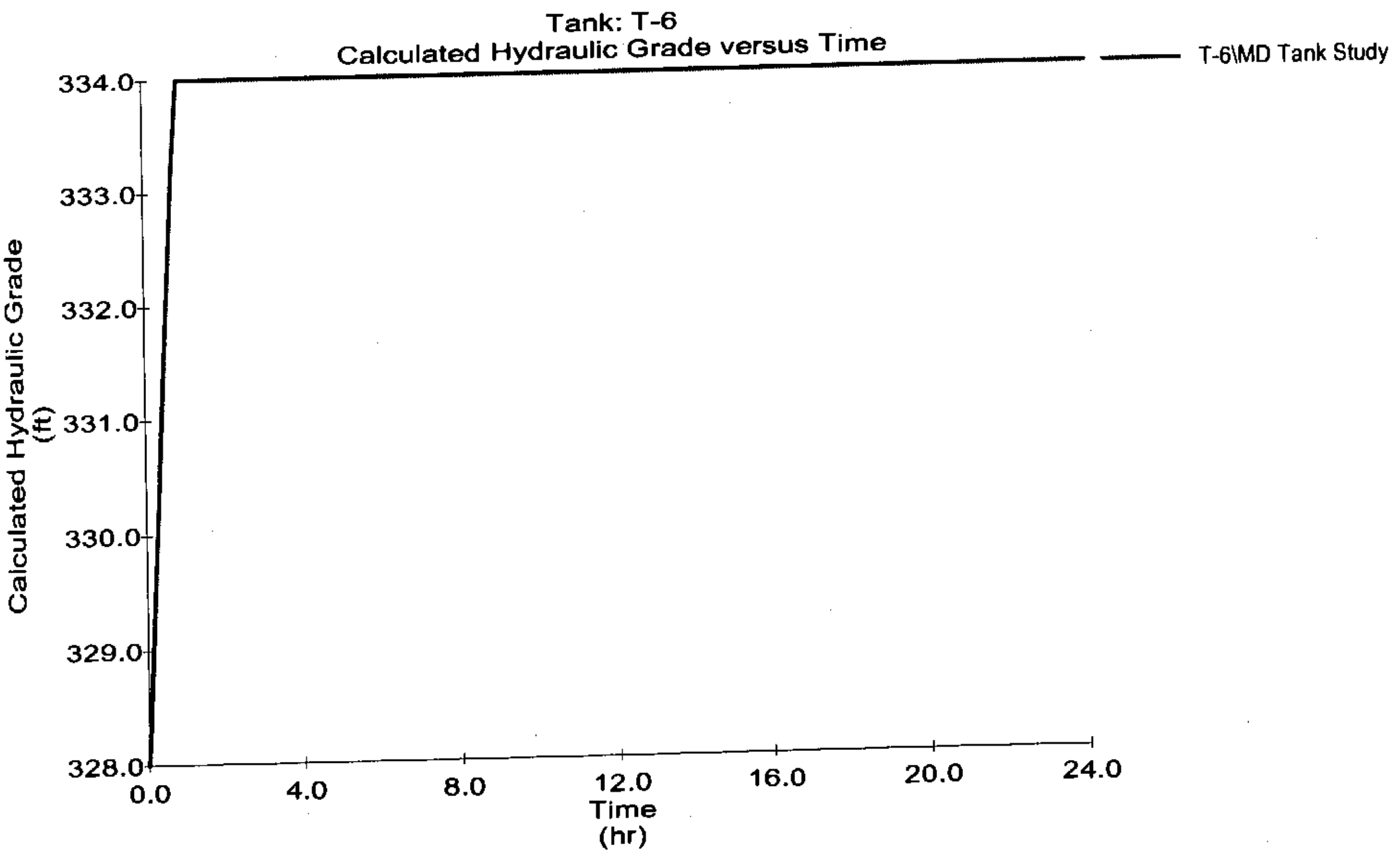
Setian Lane Tank



- 2000 gpm fire flow at node J-2005
- Centerville Rd.
- 12" AC main
- Elevation = 100 ft

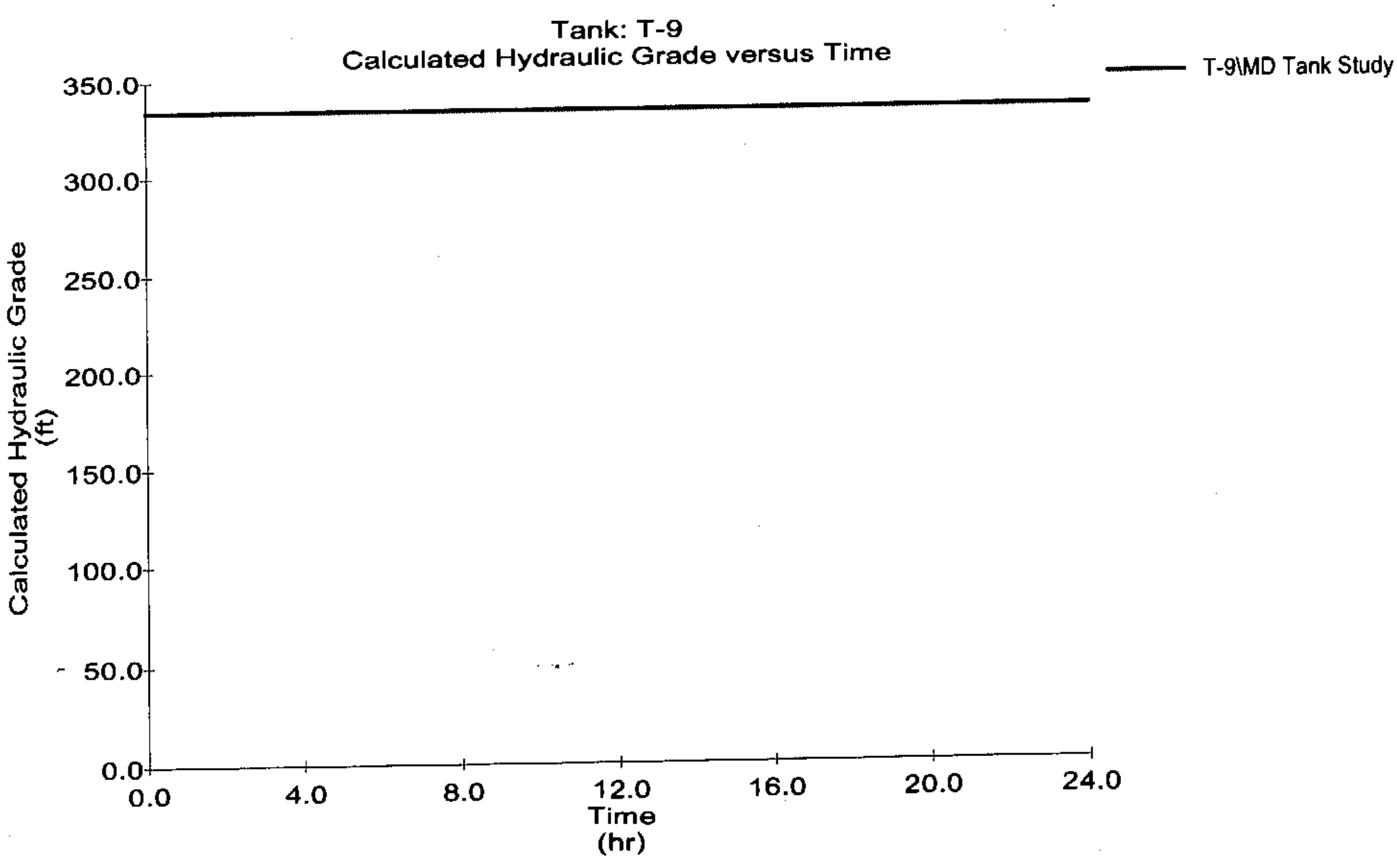
Graph

West Street Tank



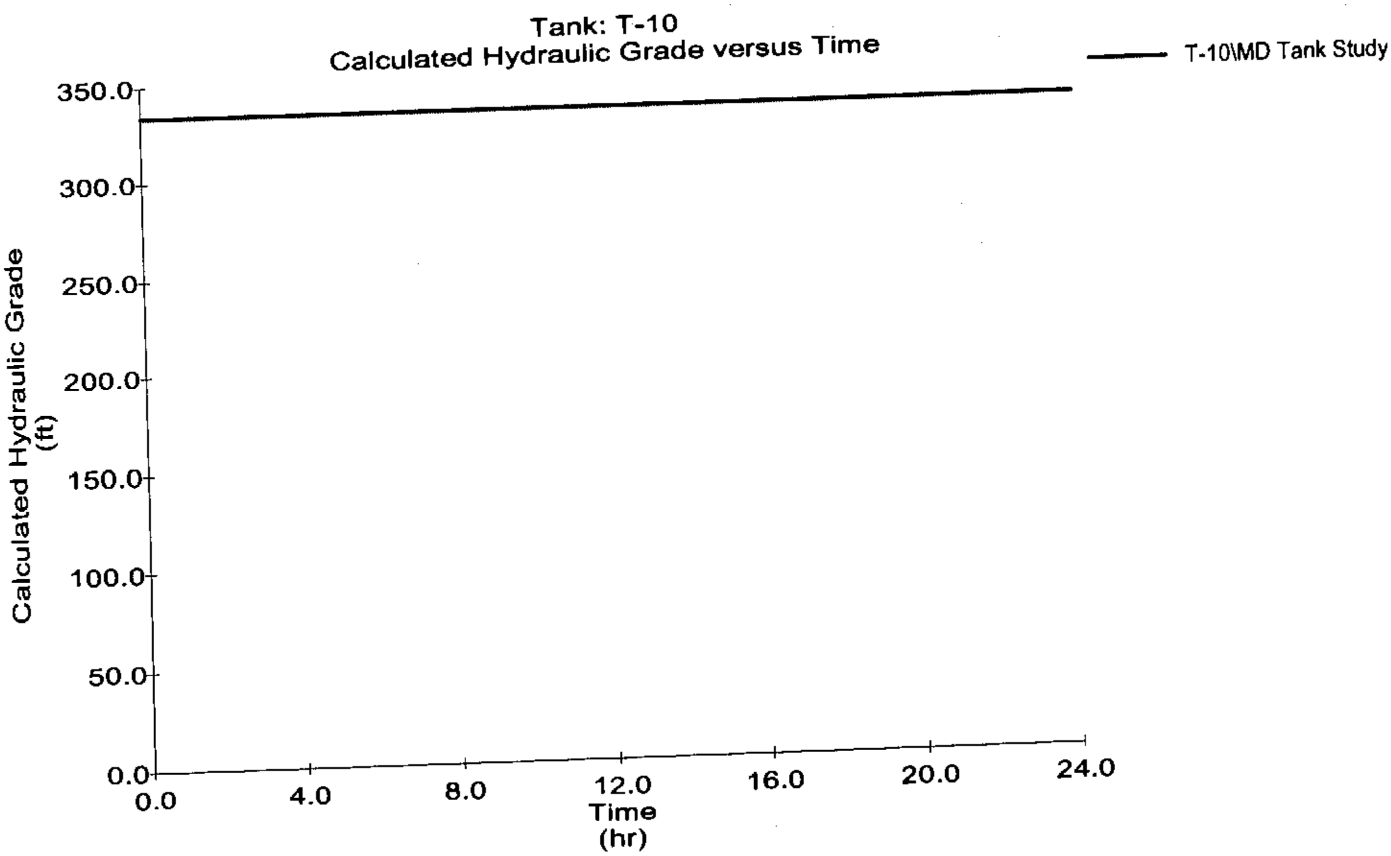
Graph

Fiskeville Reservoir #1



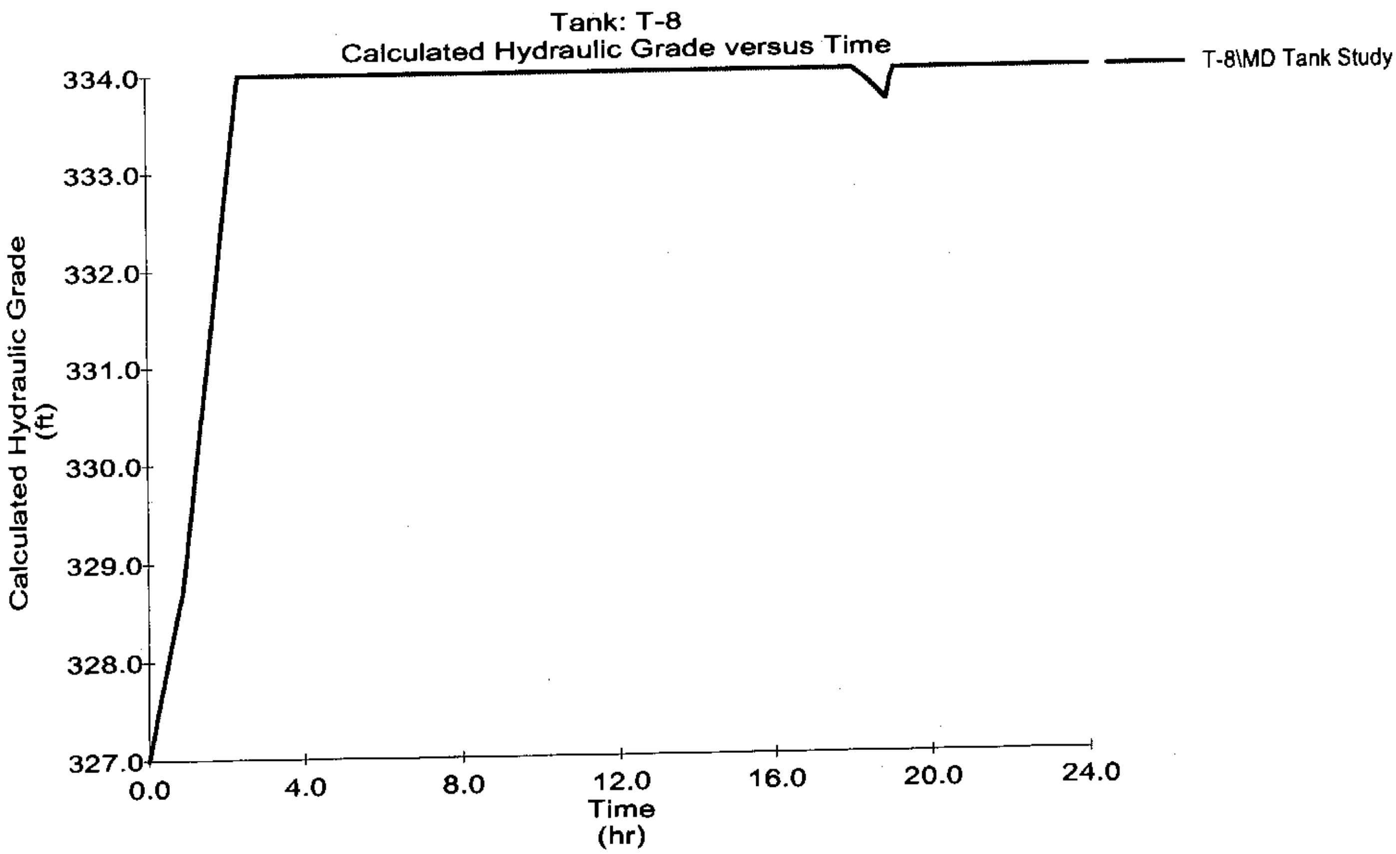
Graph

Fiskeville Reservoir #2



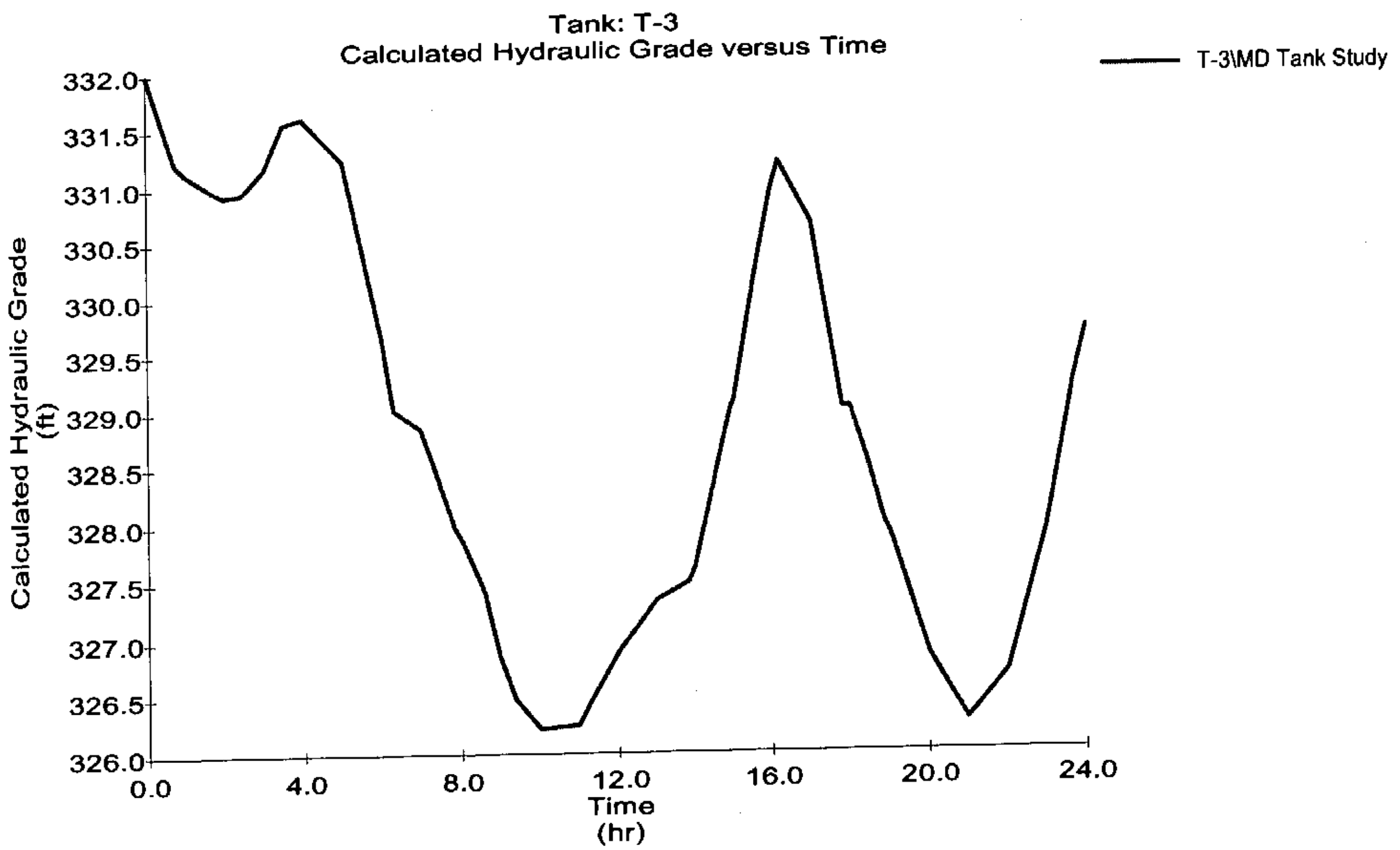
Graph

Wakefield Street Tank



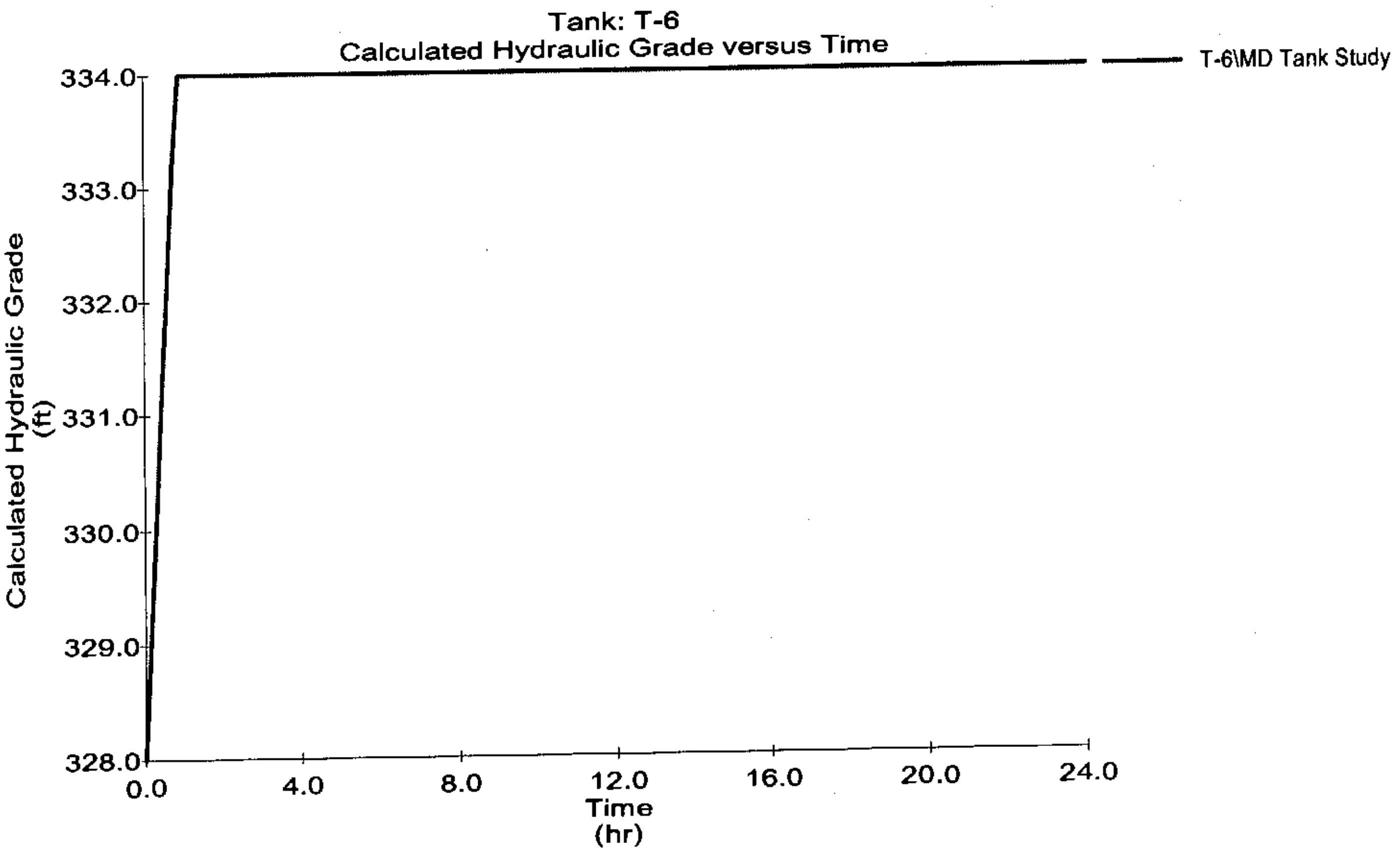
Graph

Frenchtown Road Tank



Graph

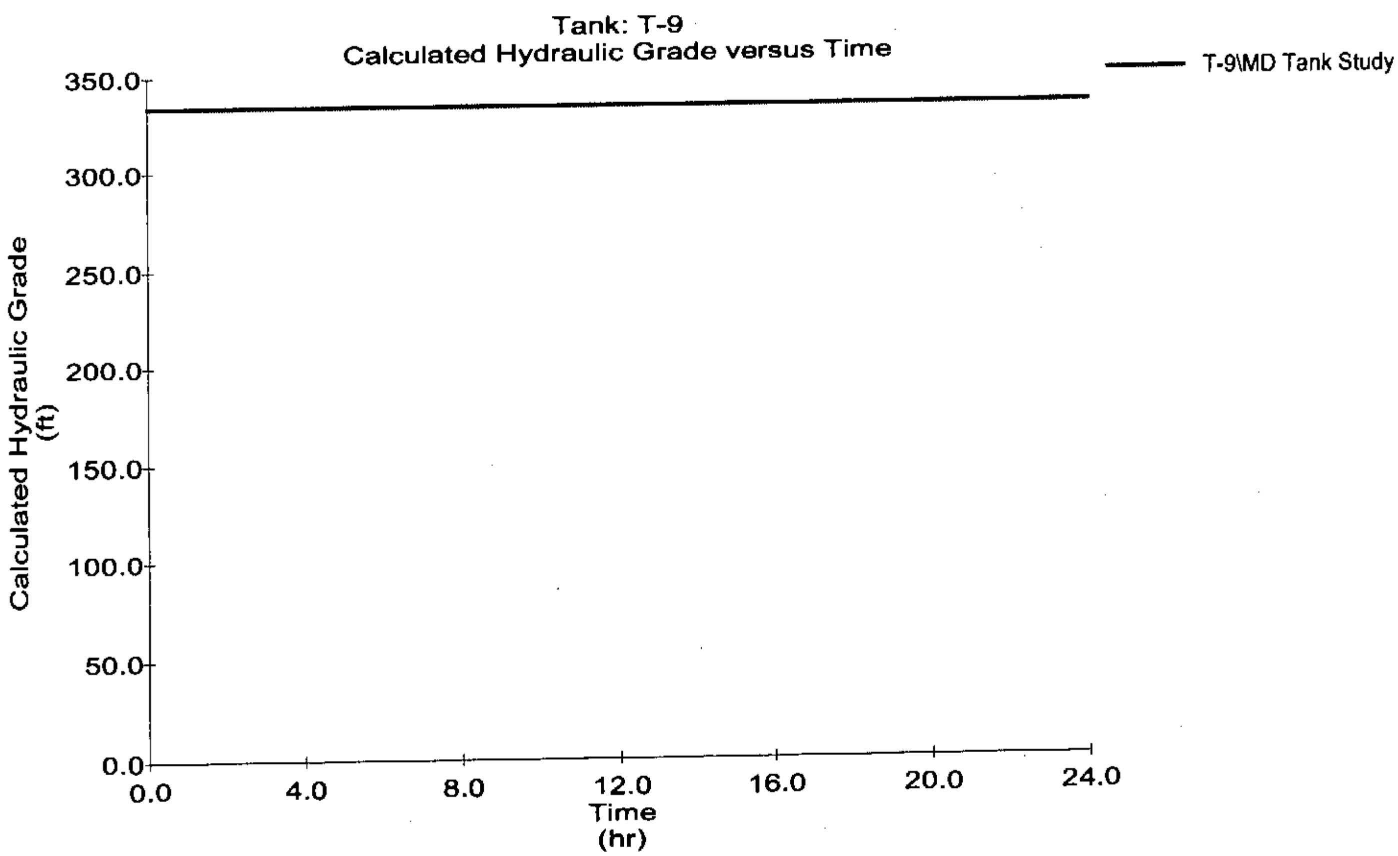
West Street Tank



- 2000 gpm fire flow at node J-626
- West St.
- 16" AC main
- Elevation = 245 ft

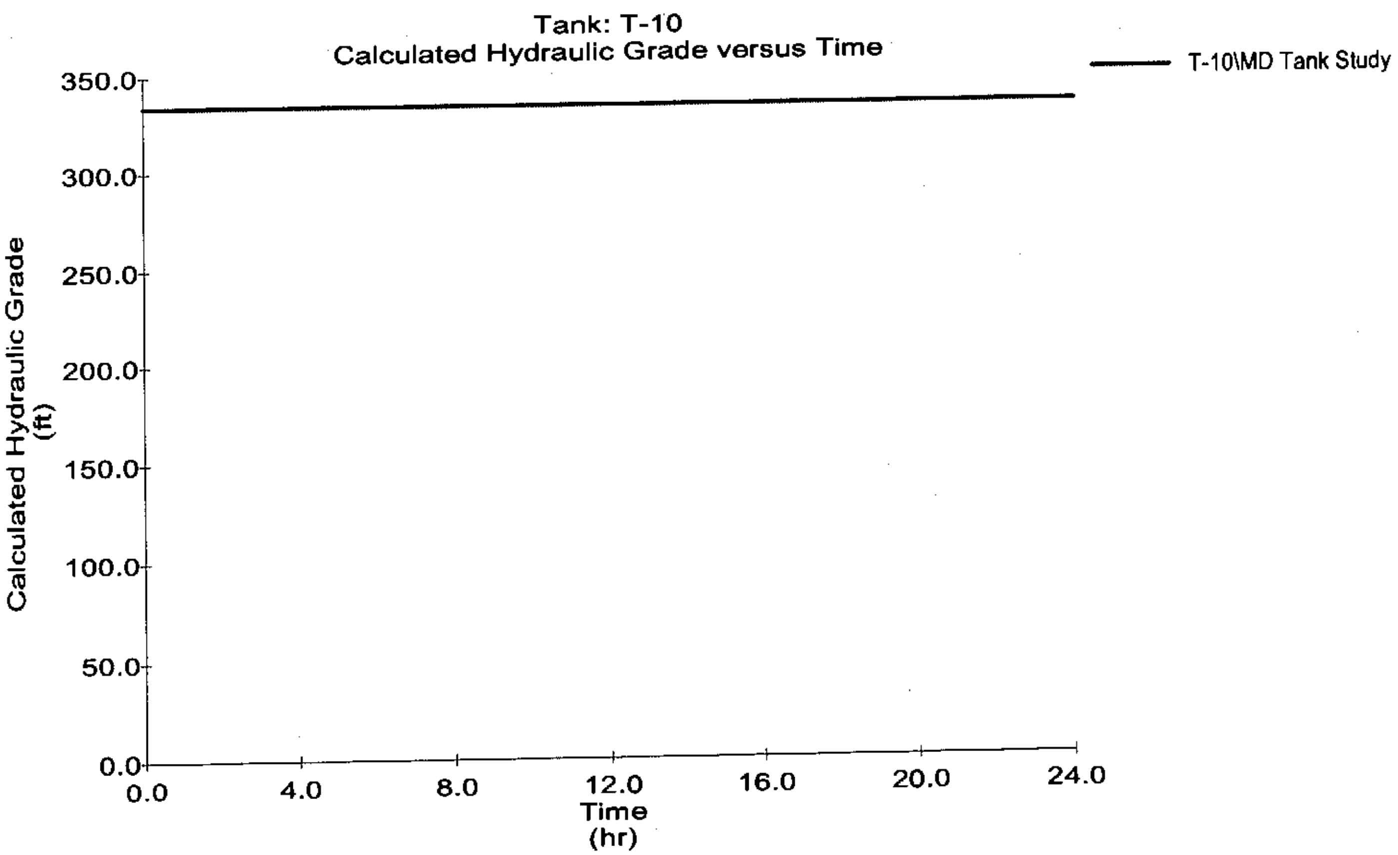
Graph

Fiskeville Reservoir #1



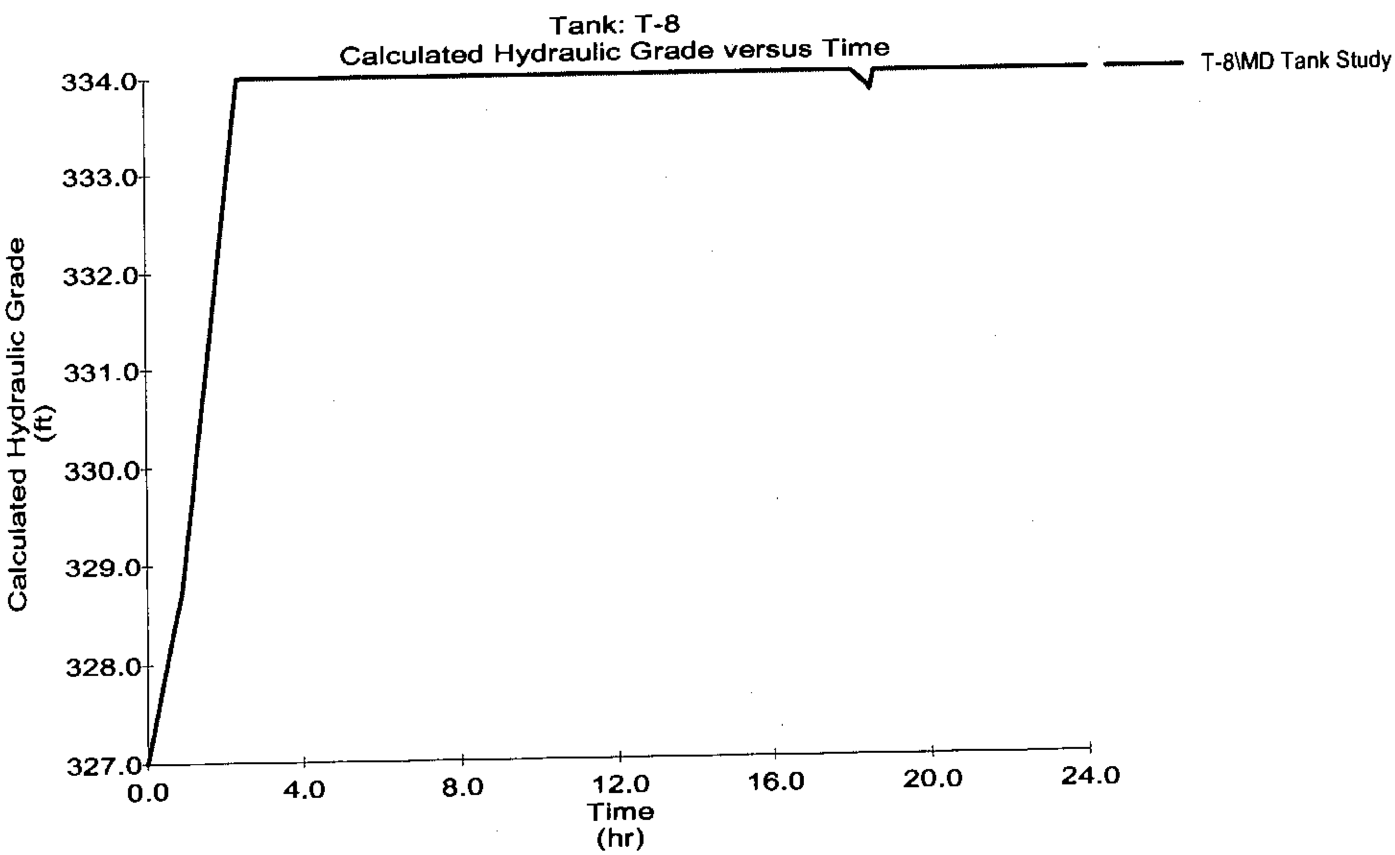
Graph

Fisteville Reservoir #2



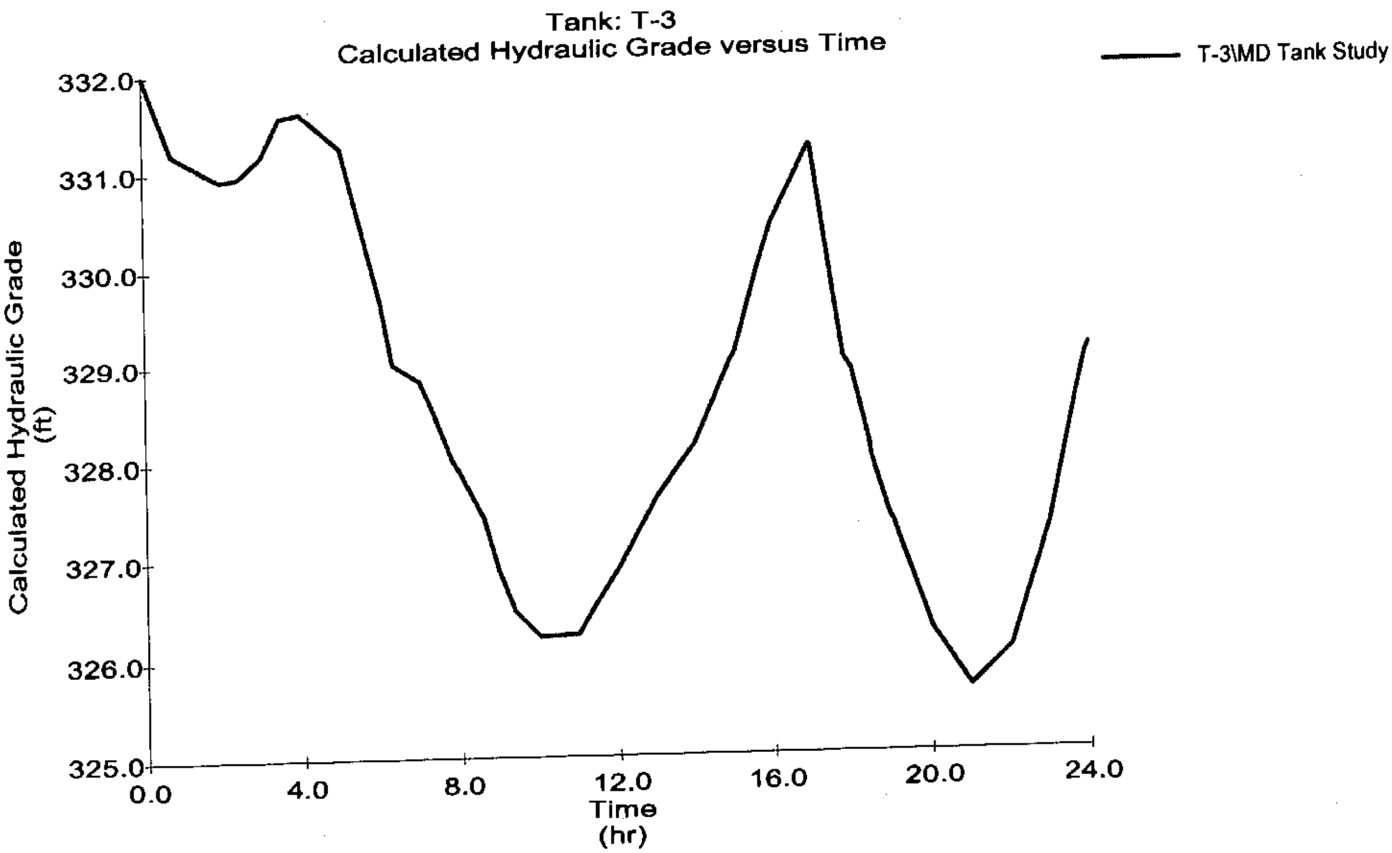
Graph

Wakefield Street Tank



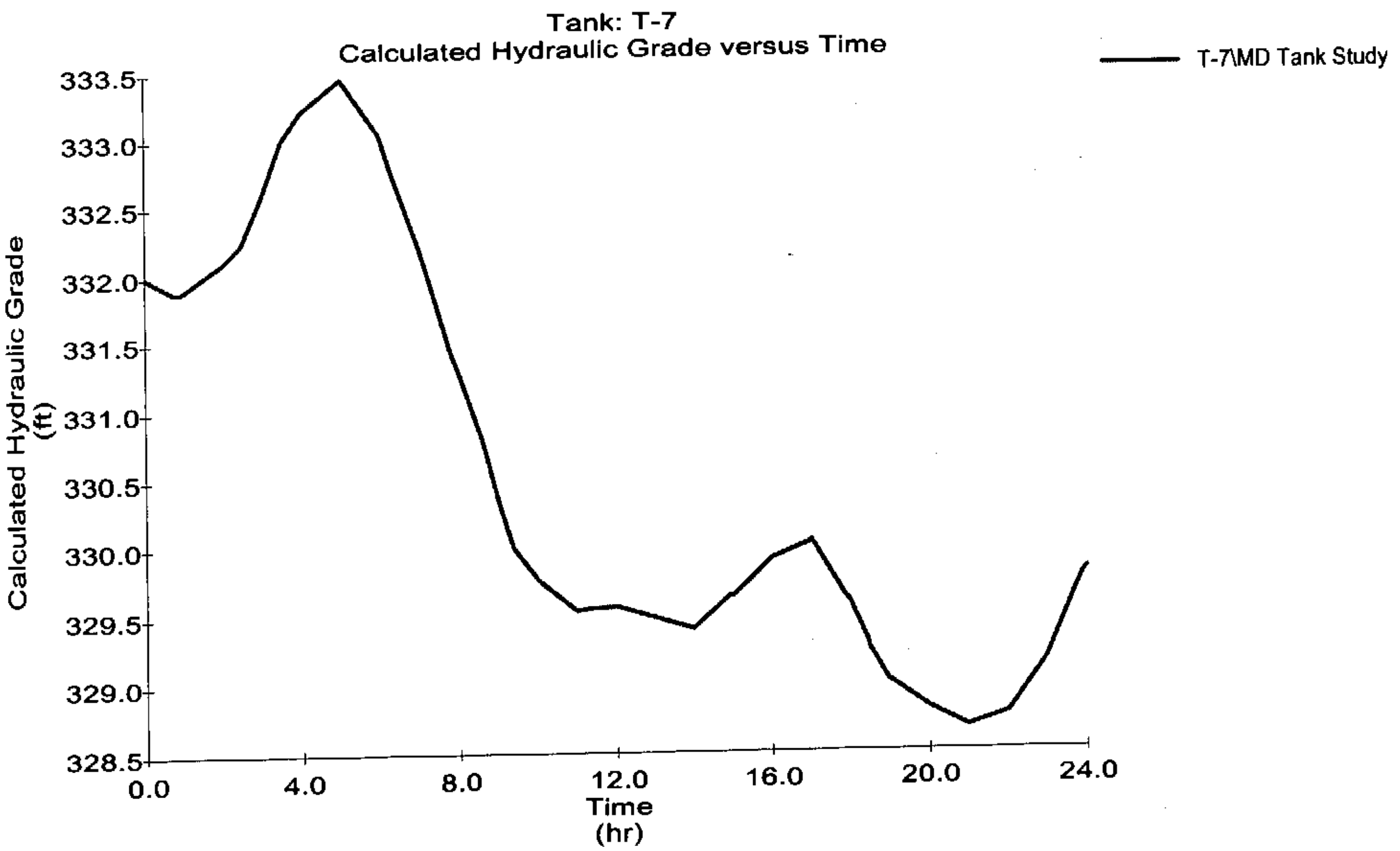
Graph

Frenchtown Road Tank



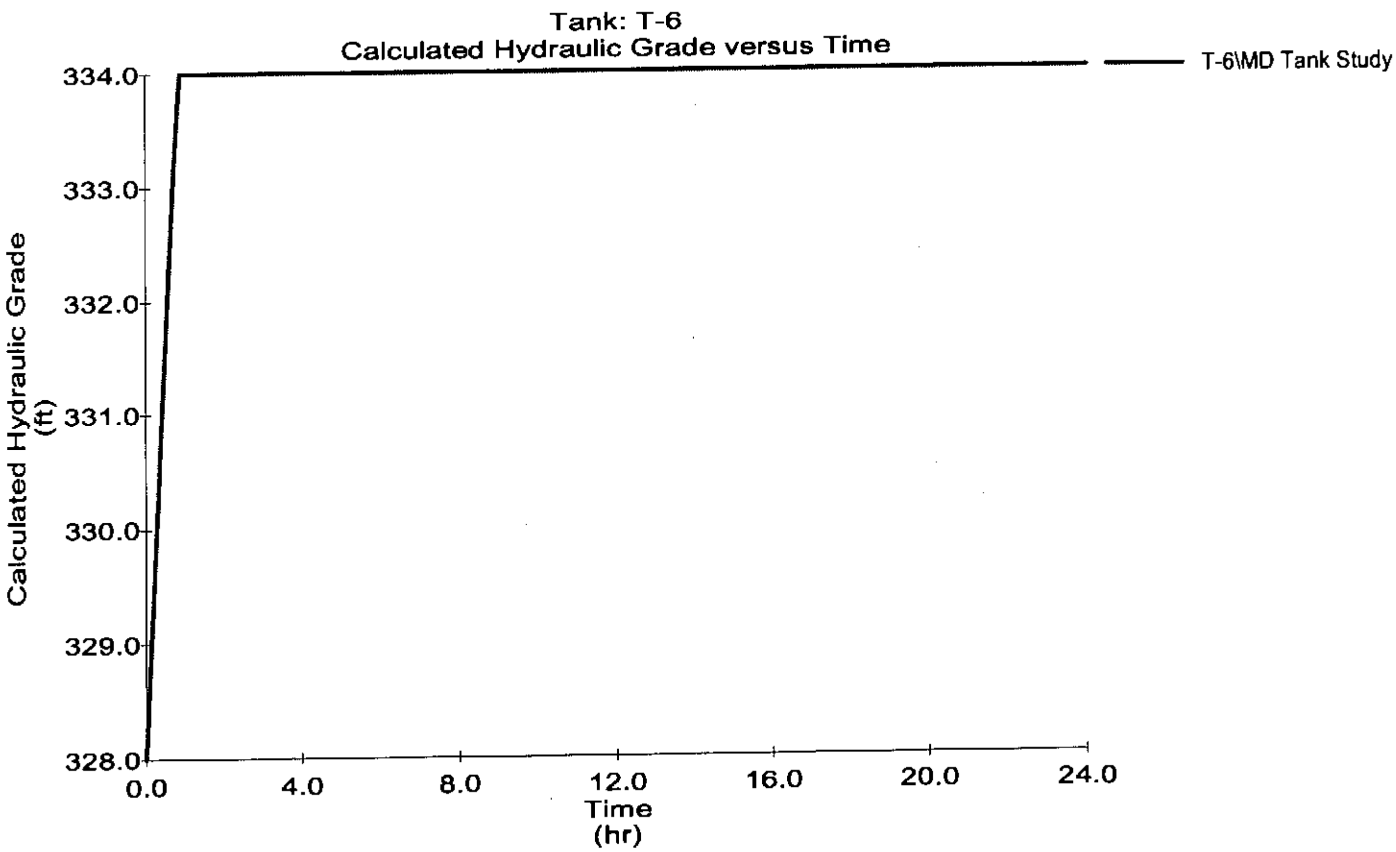
Graph

Setian Lane Tank



Graph

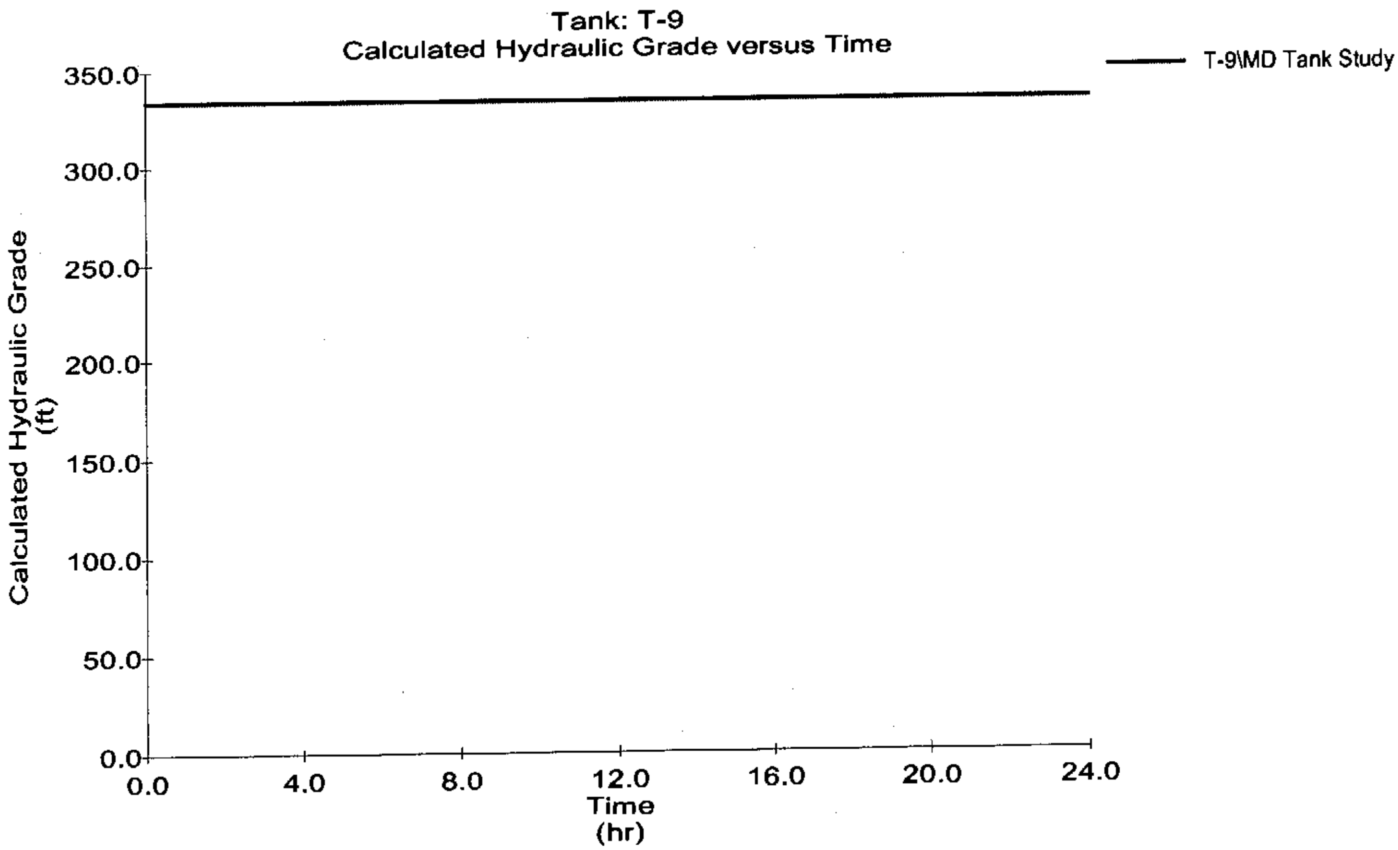
West Street Tank



- 2000 gpm fire flow at node J-7879
- Fairview Ave.
- 16" AC main
- Elevation = 255 ft

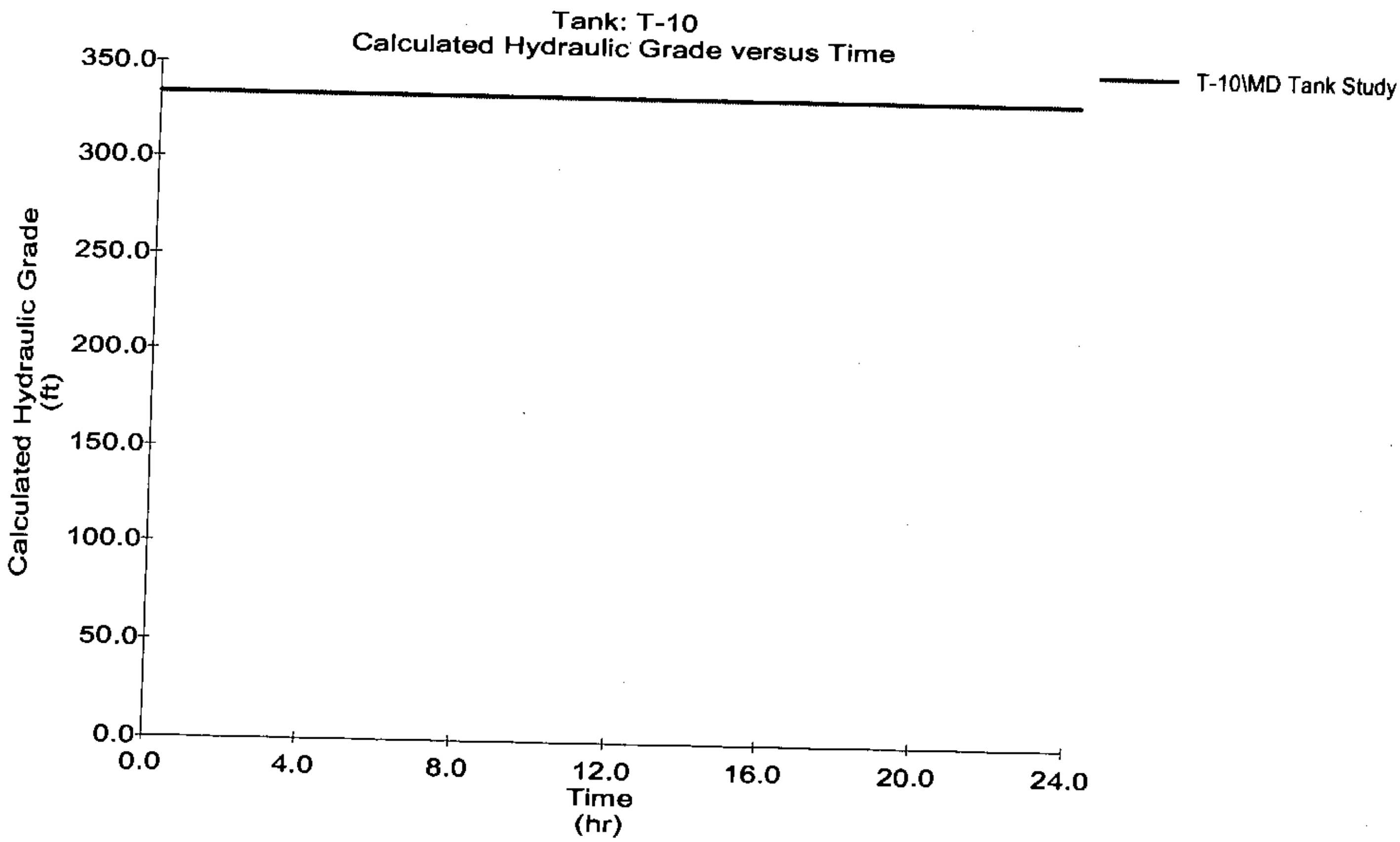
Graph

Fiskeville Reservoir #1



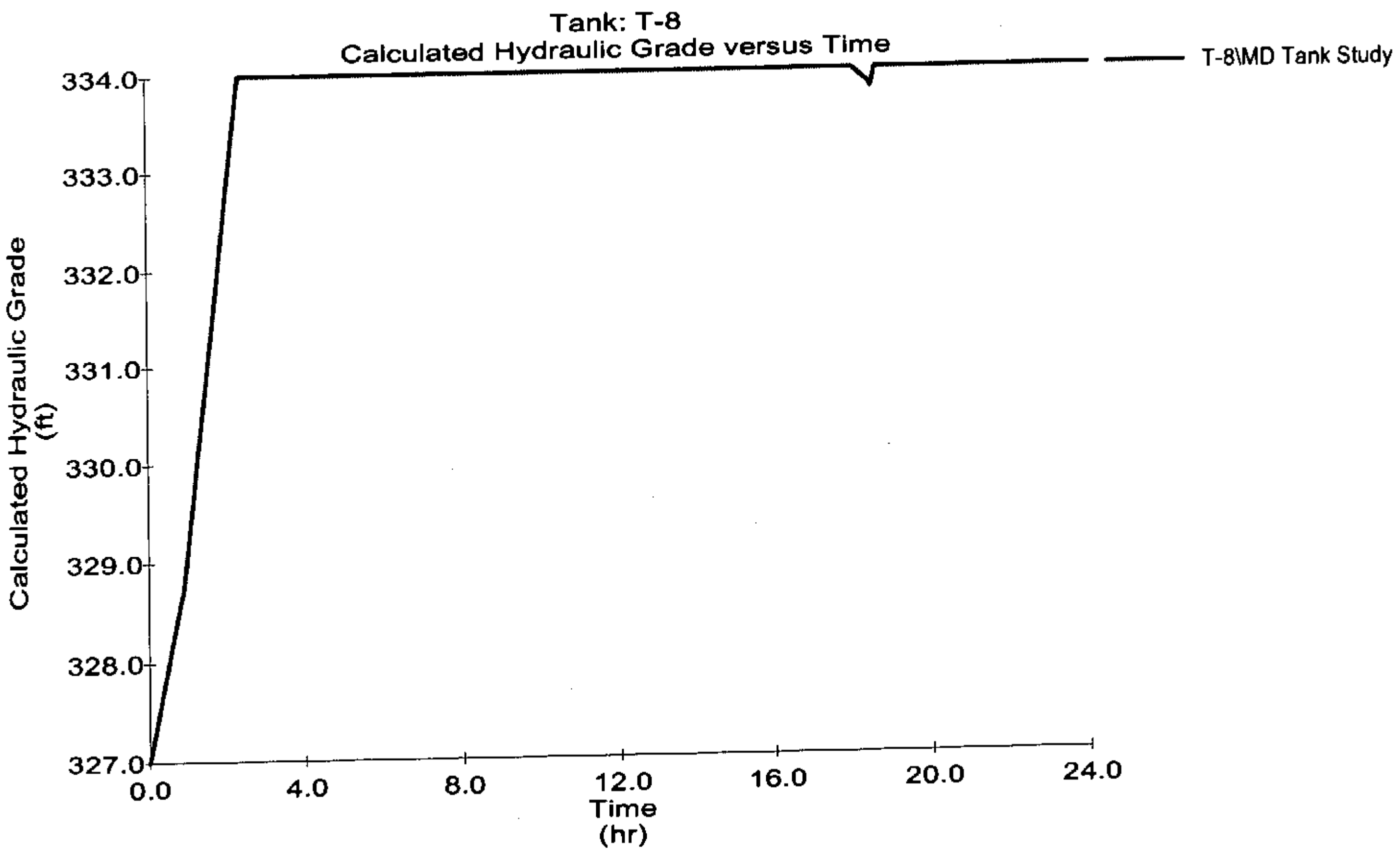
Graph

Fiskeville Reservoir #2



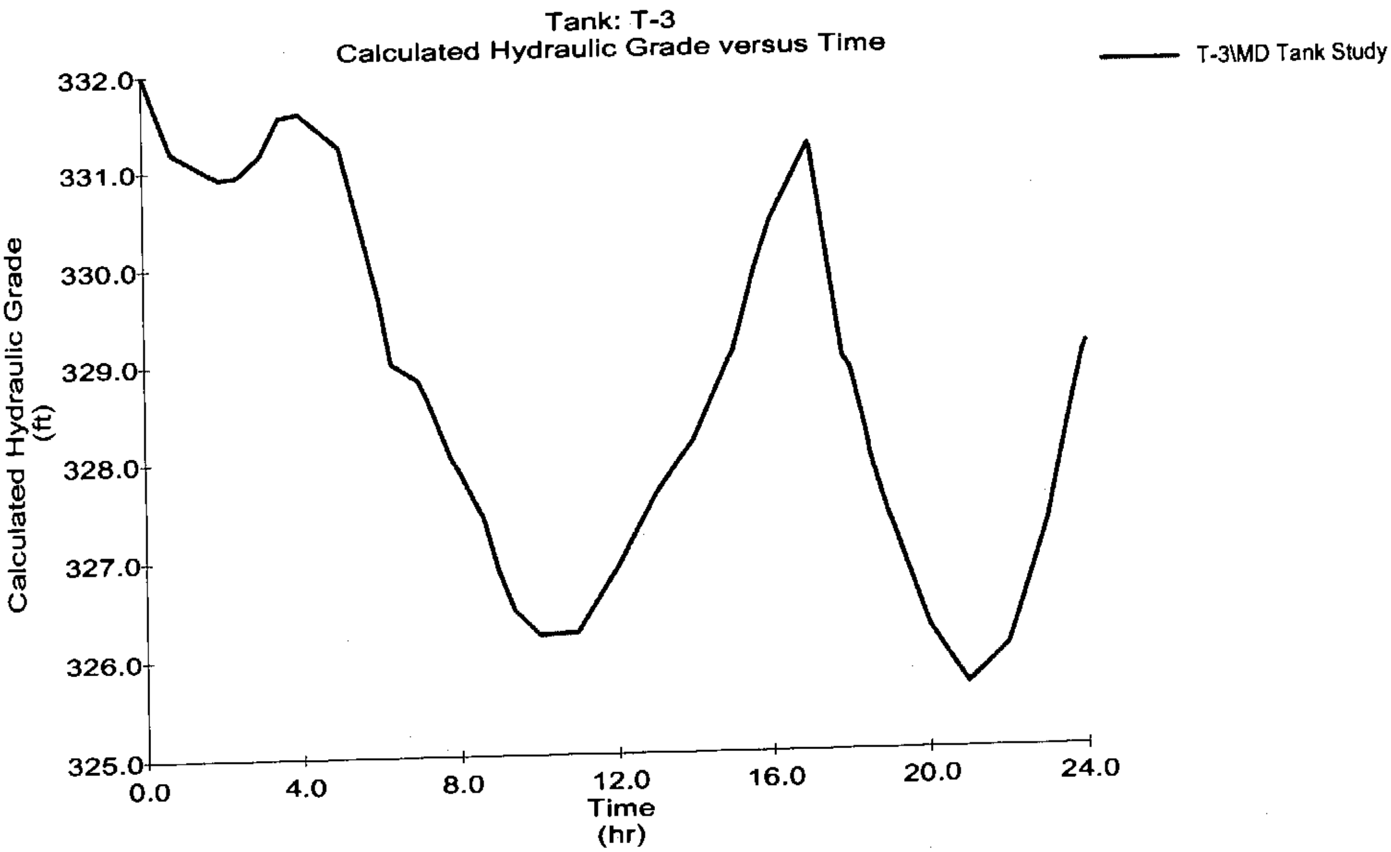
Graph

Wakefield Street Tank



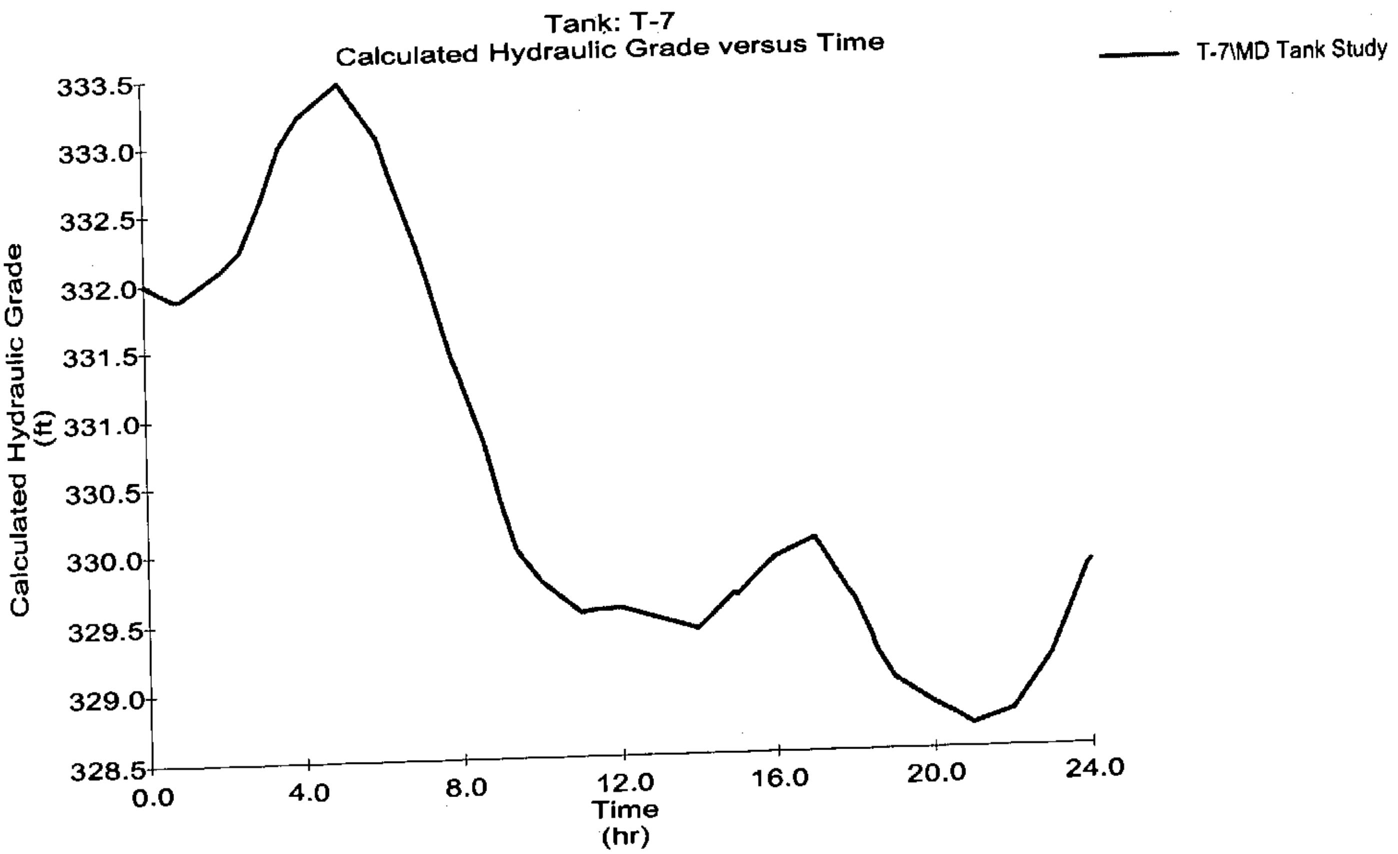
Graph

Frenchtown Road Tank



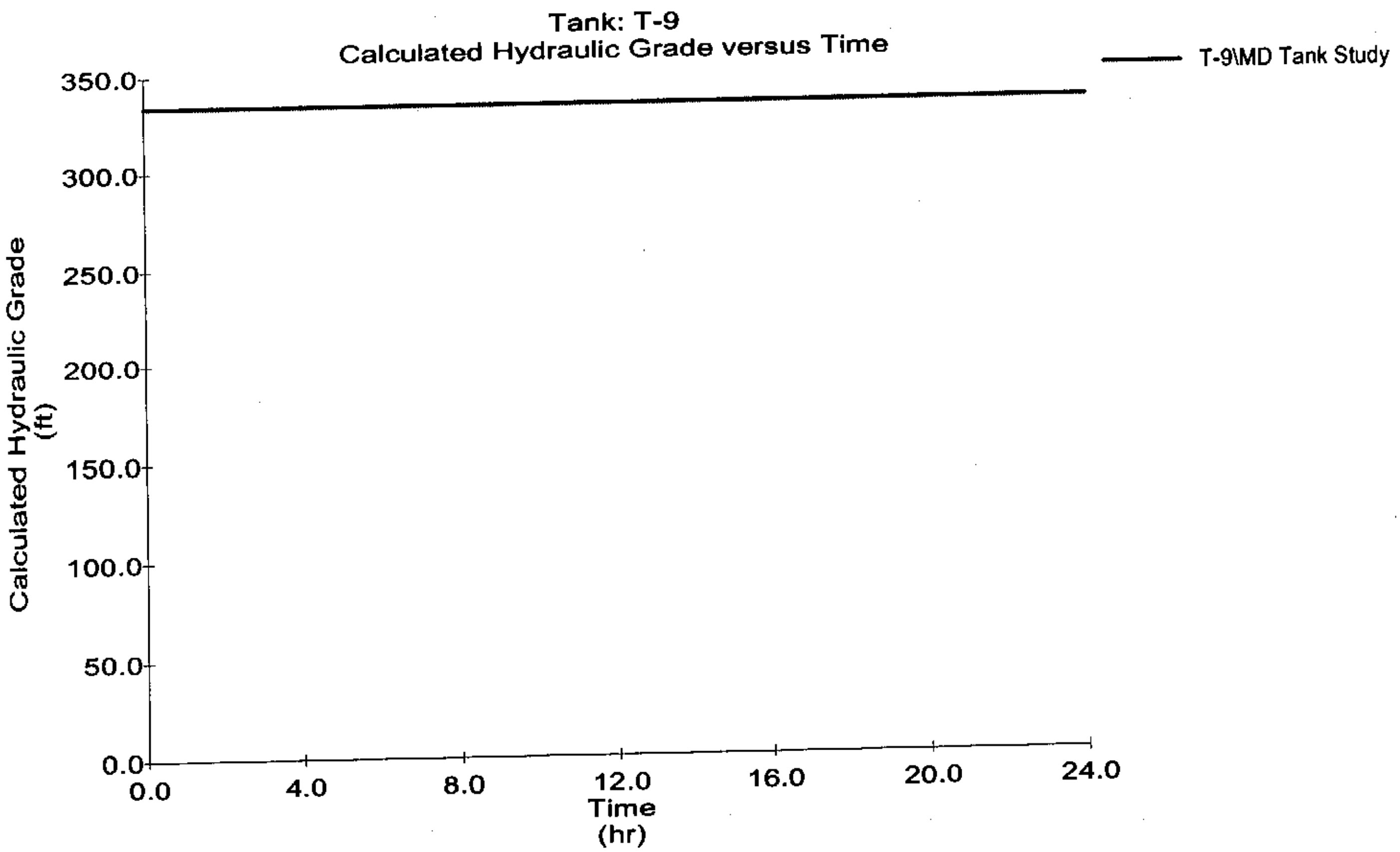
Graph

Setian Lane Tank



Graph

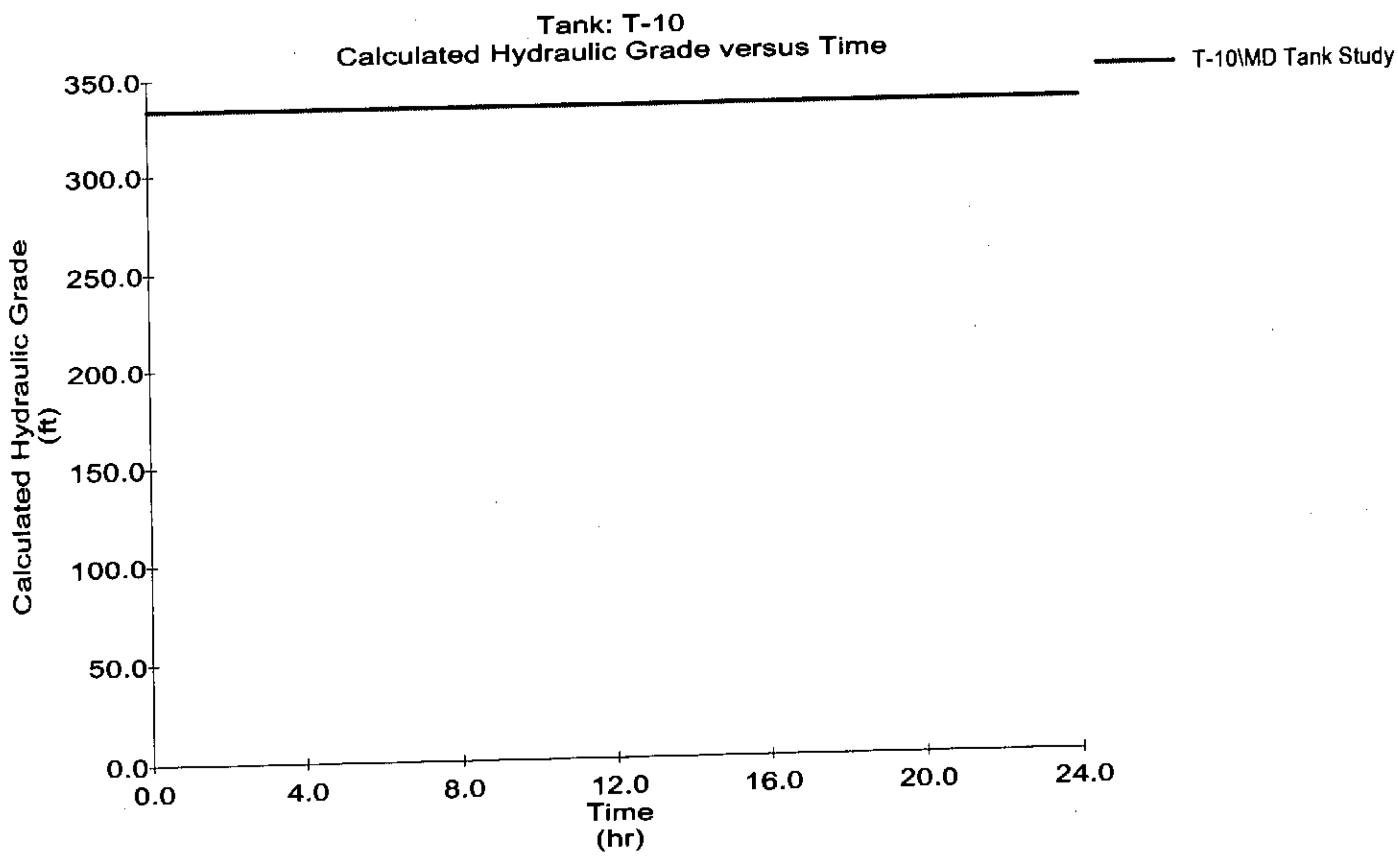
Fiskeville Reservoir #1



- 2000 gpm fire flow at node J-5112
- Seven Mile Rd.
- 16" DI main
- Elevation = 240 ft

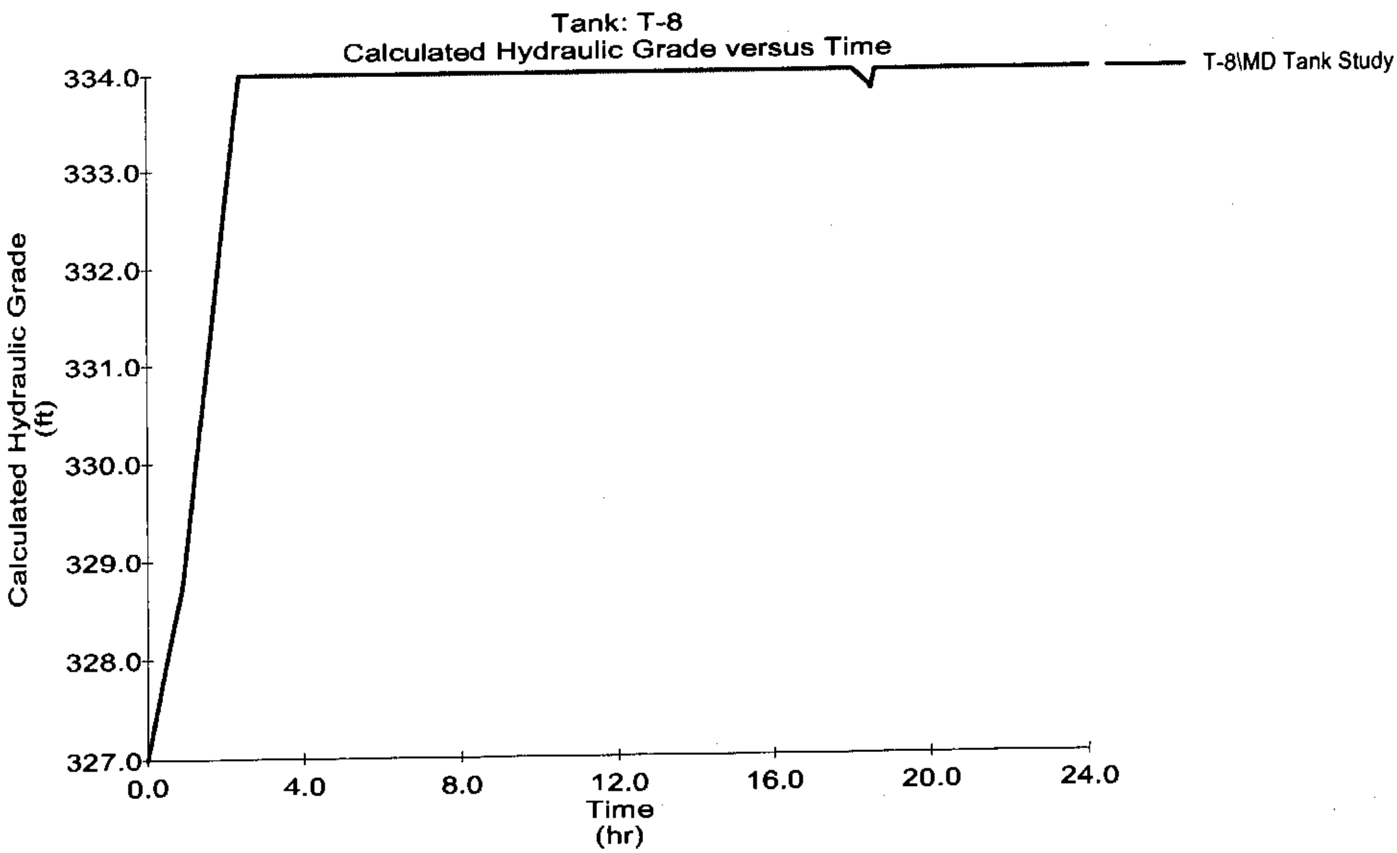
Graph

Fiskeville Reservoir #2



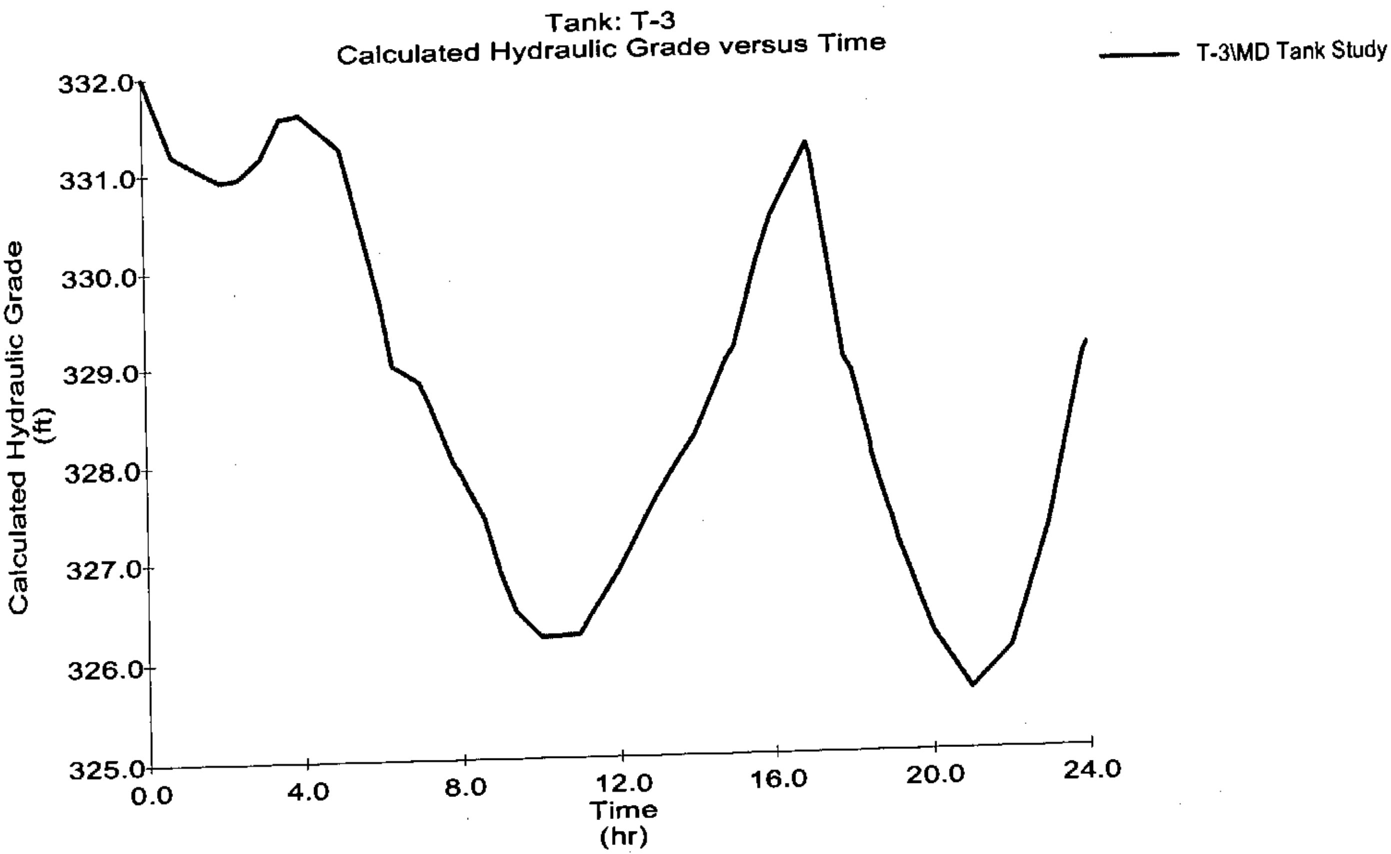
Graph

Wakefield Street Tank



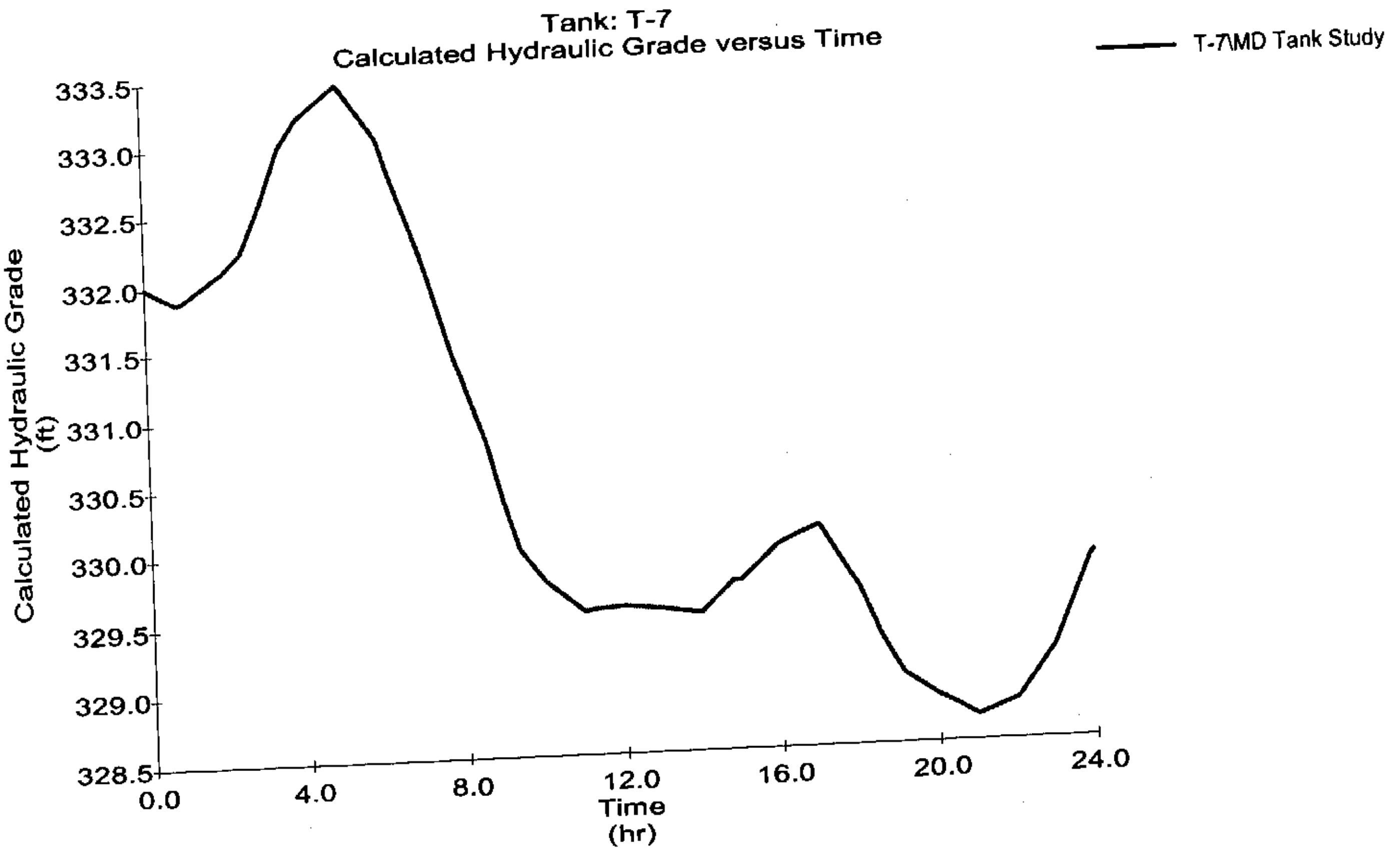
Graph

Frenchtown Road Tank



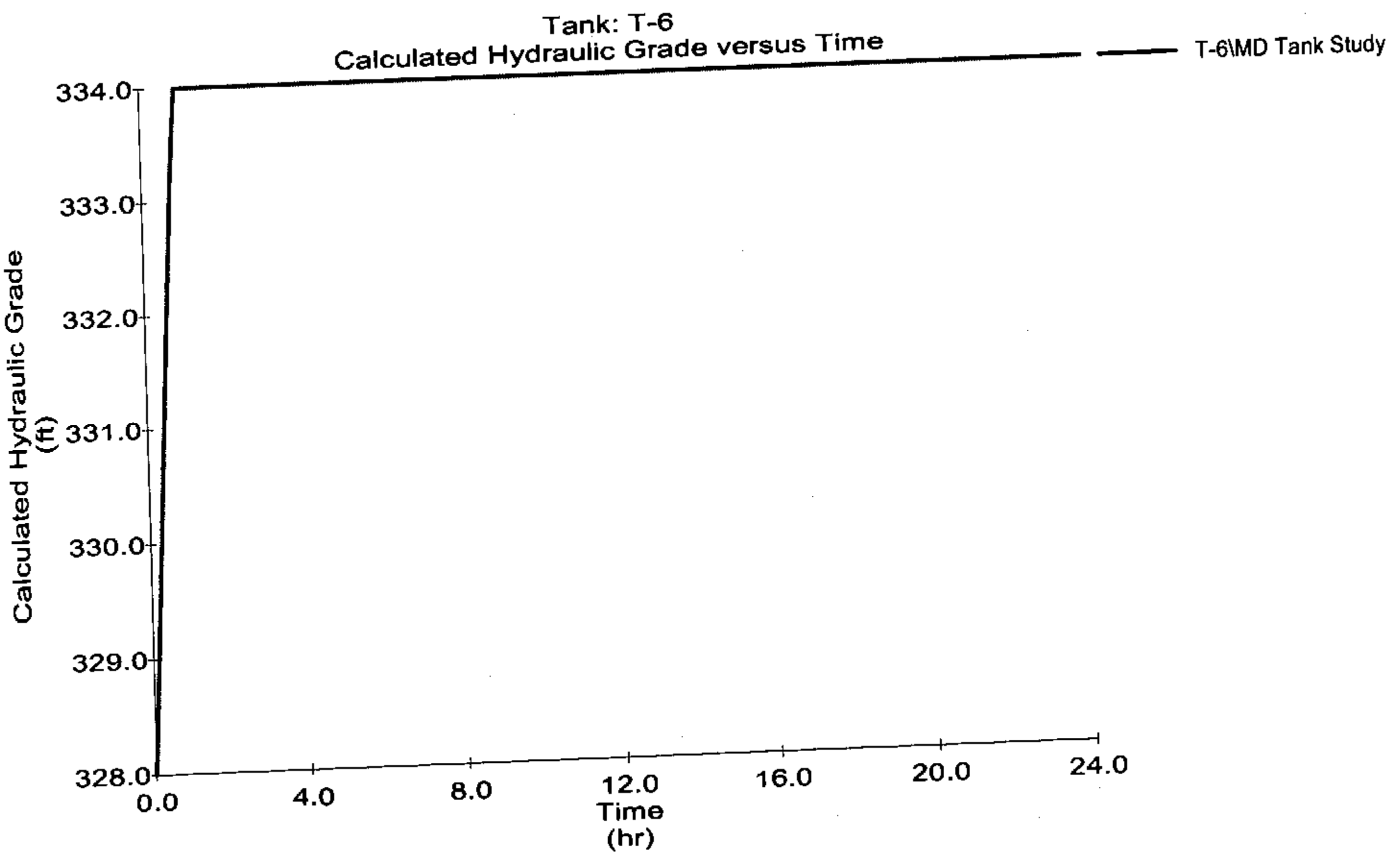
Graph

Setian Lane Tank



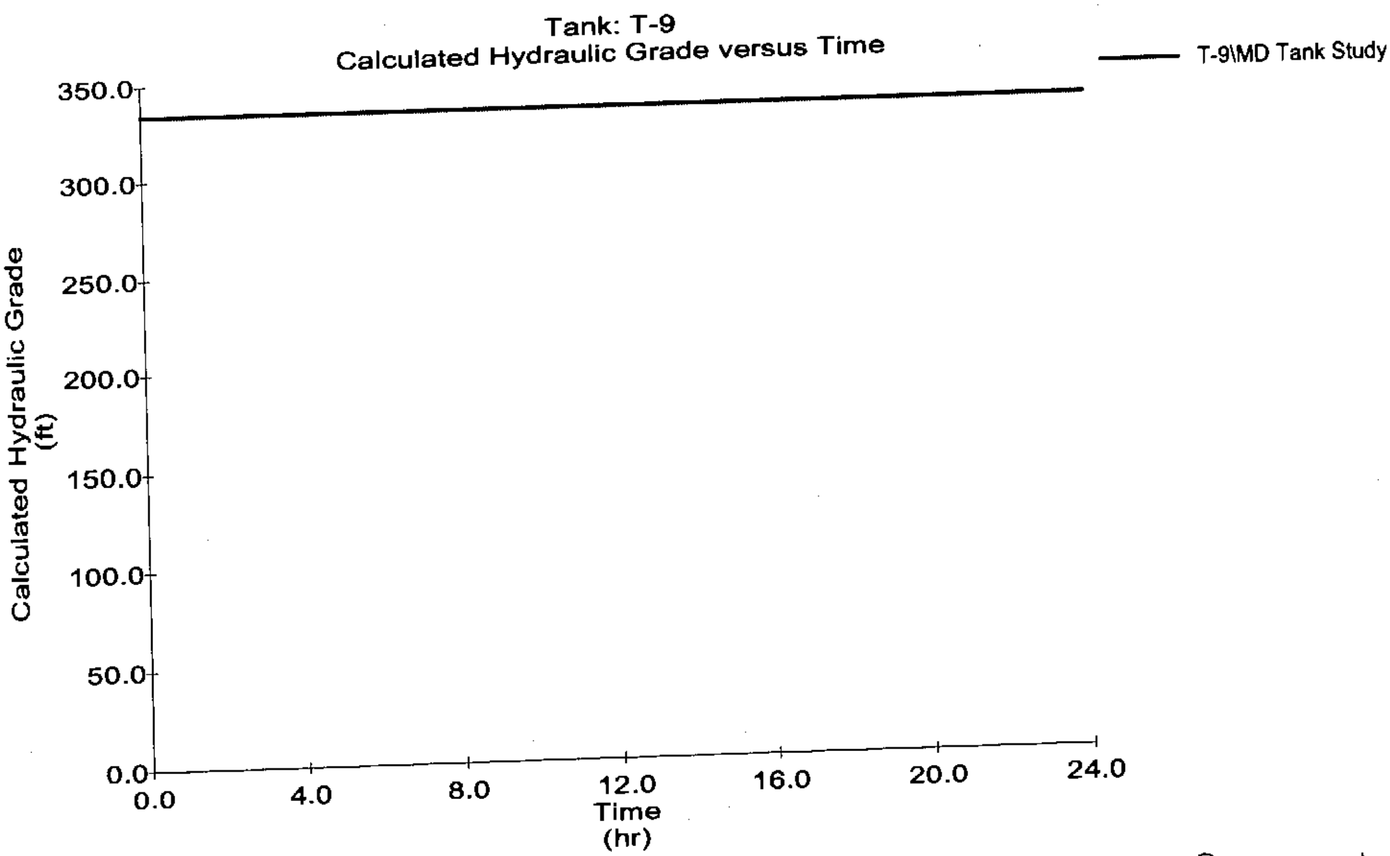
Graph

West Street Tank



Graph

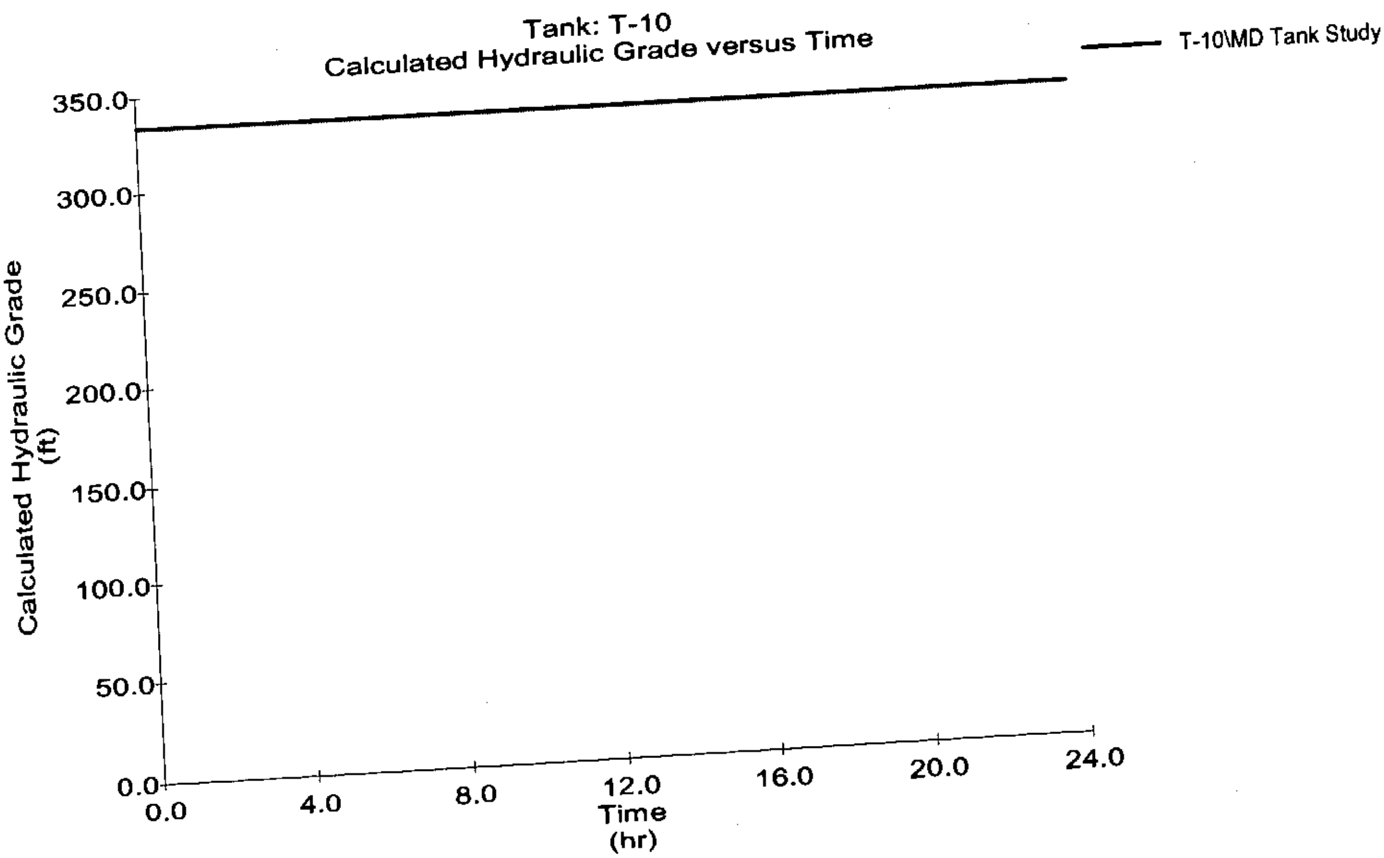
Fiskeville Reservoir #1



- 2000 gpm fire flow at node J-6027
- Hope Ave.
- 16" AC main
- Elevation = 222 ft

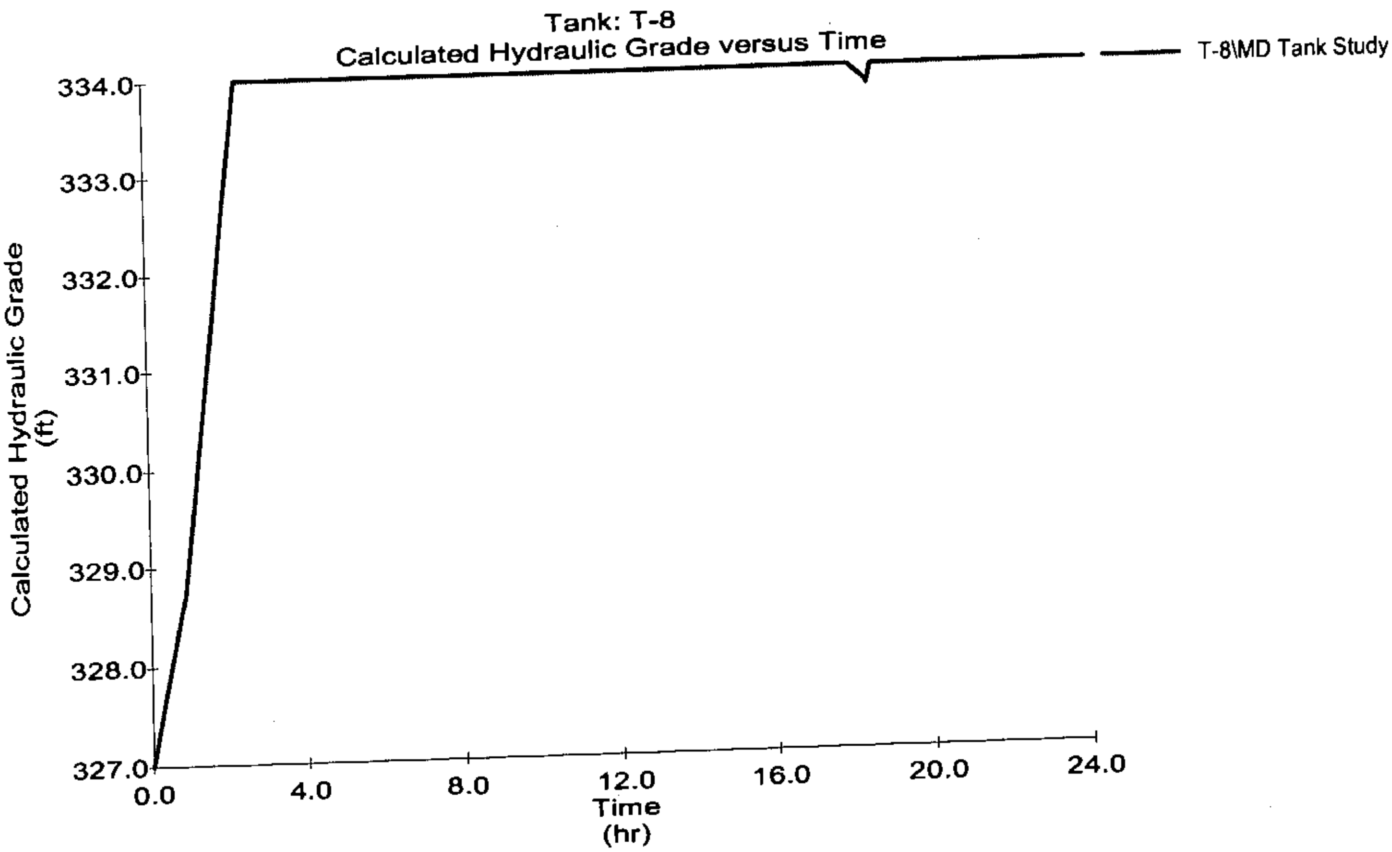
Graph

Fiskeville Reservoir #2



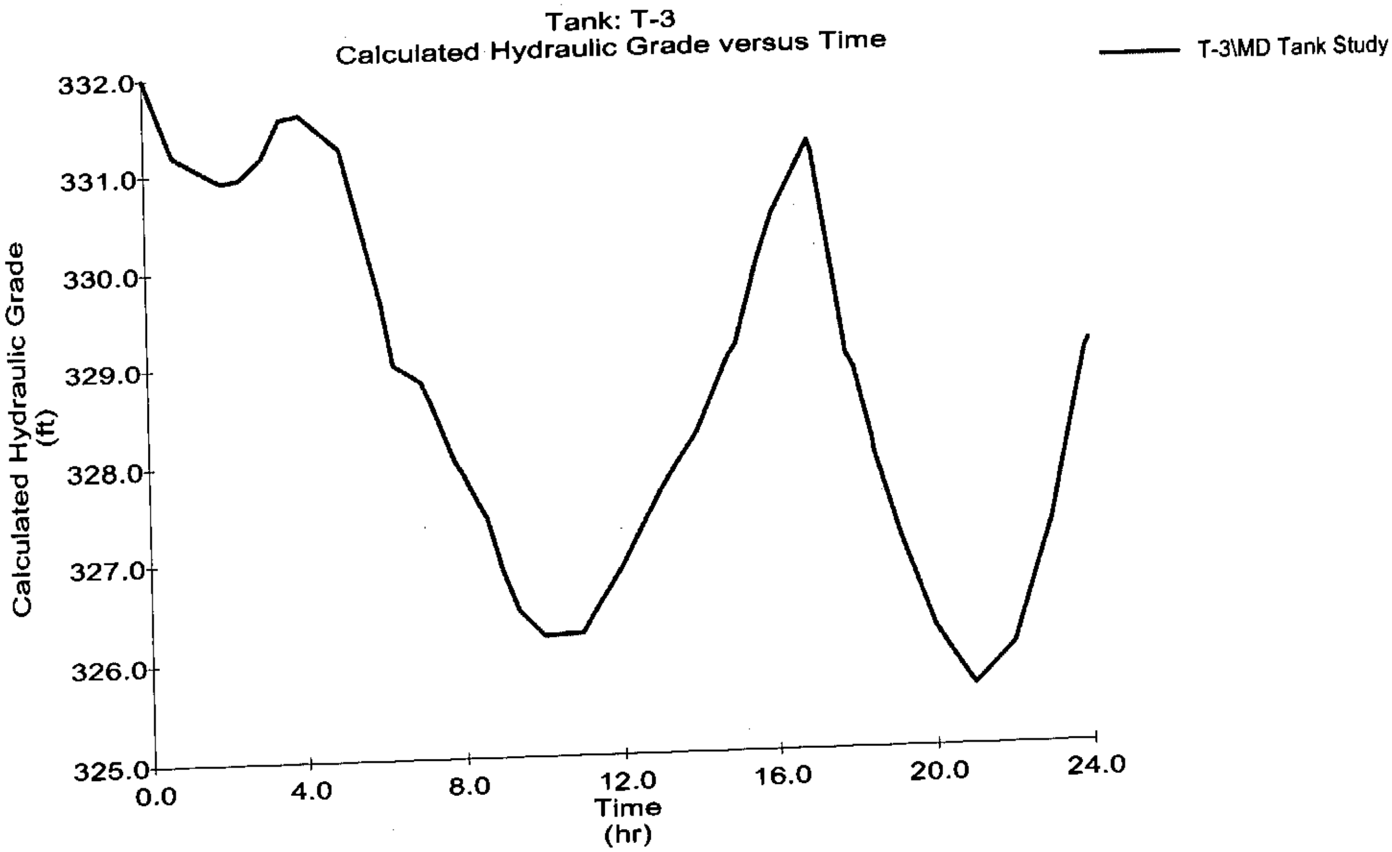
Graph

Wakefield Street Tank



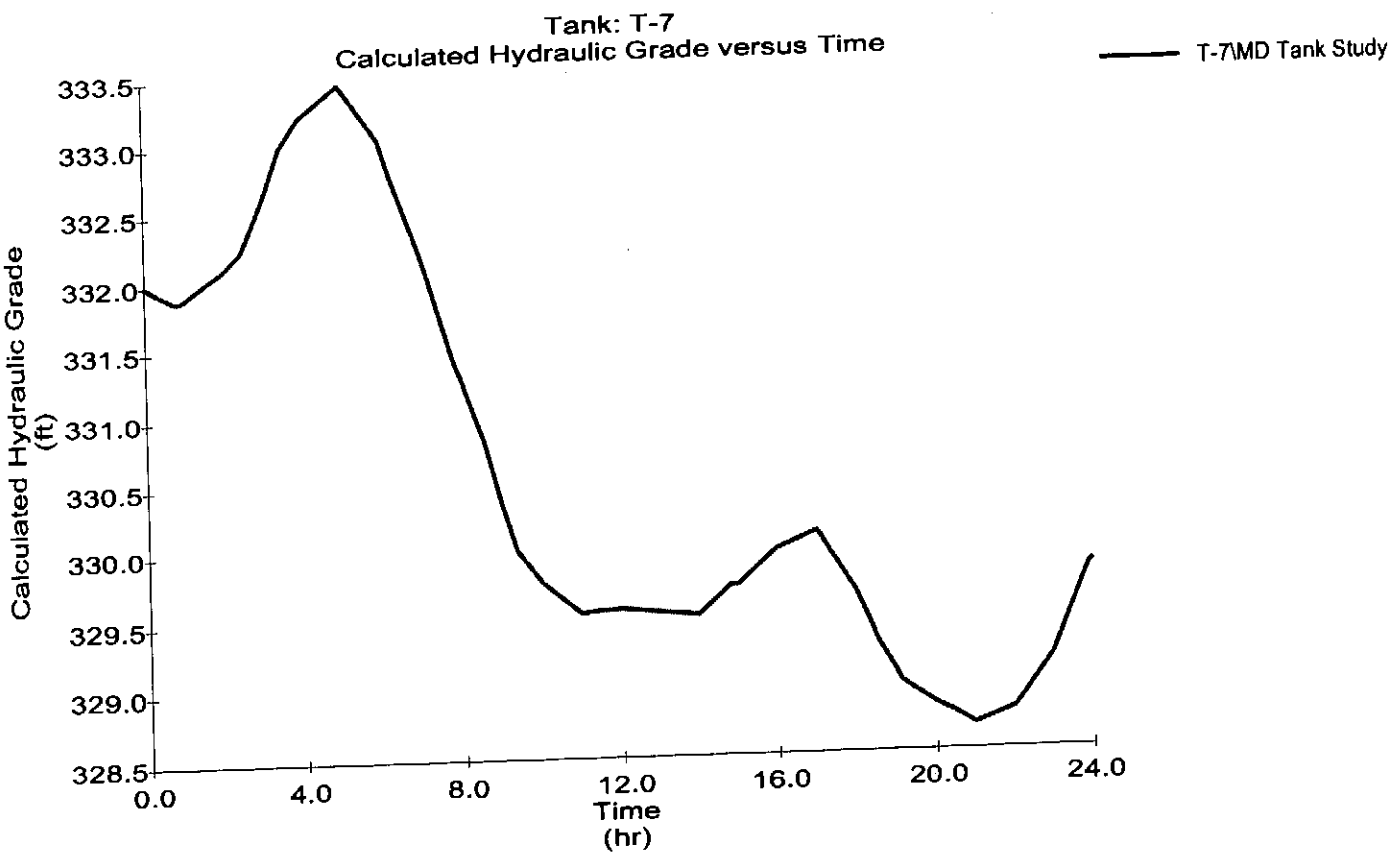
Graph

Frenchtown Road Tank



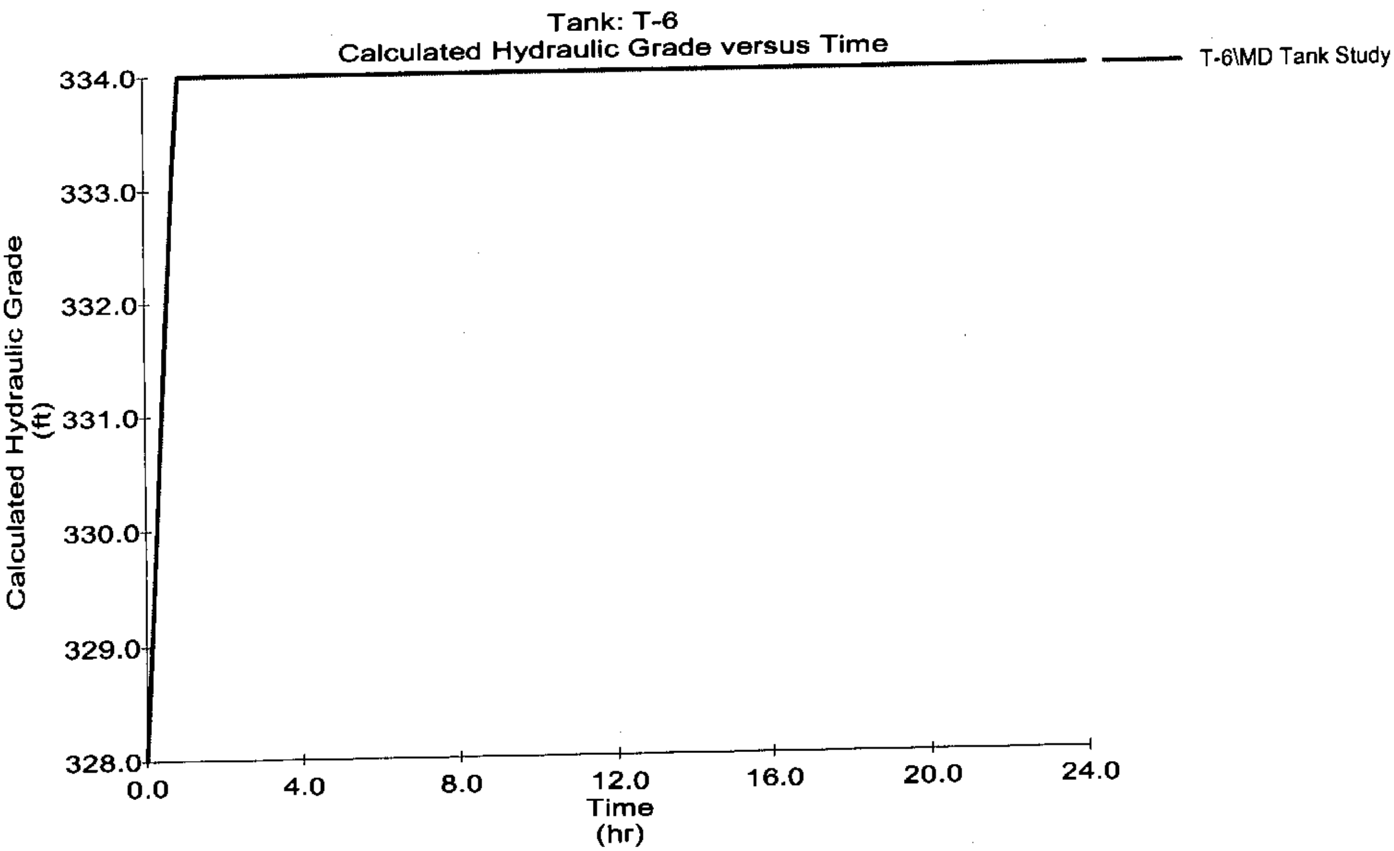
Graph

Setian Lane Tank



Graph

West Street Tank

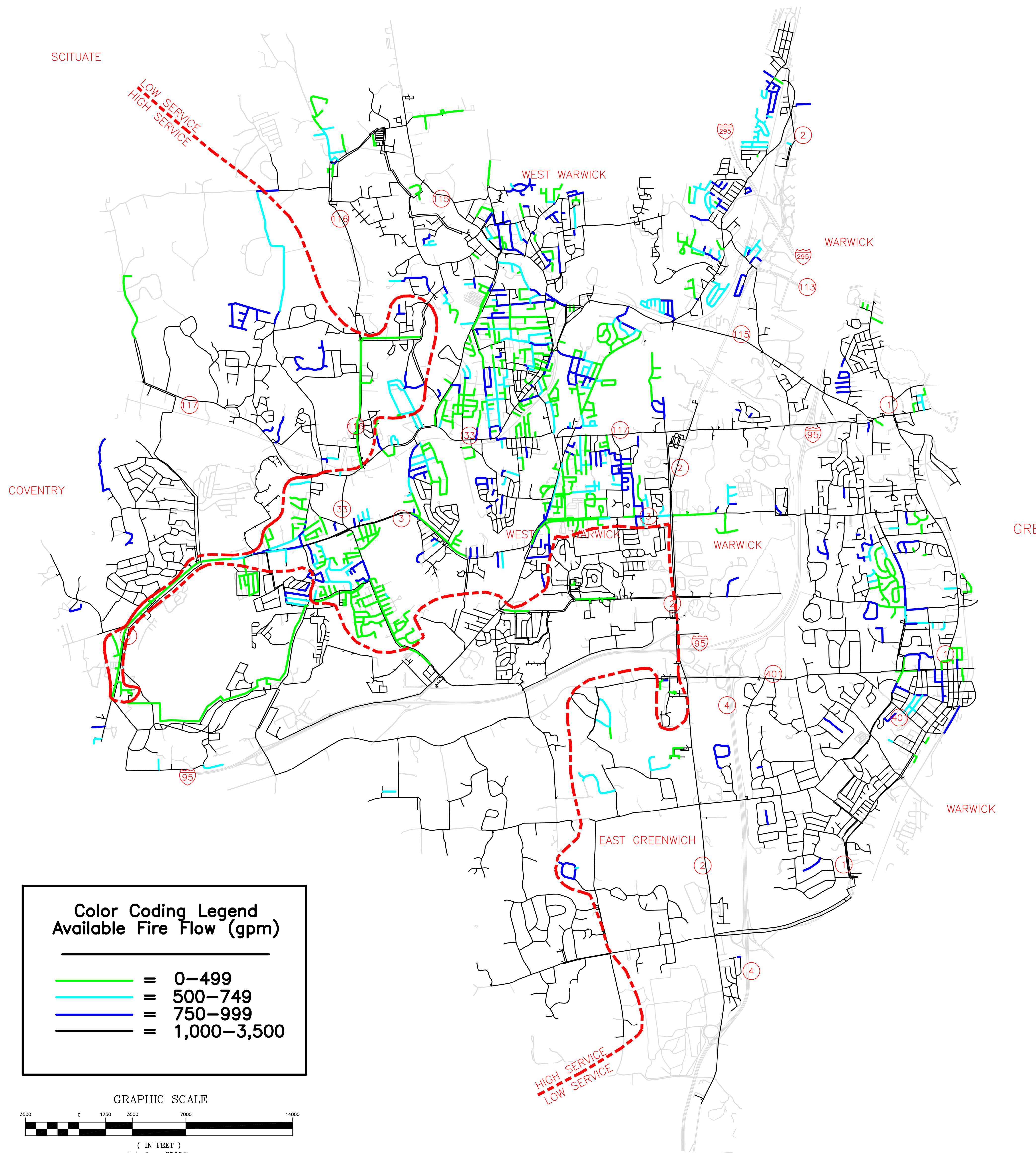


ATTACHMENT NO. 5

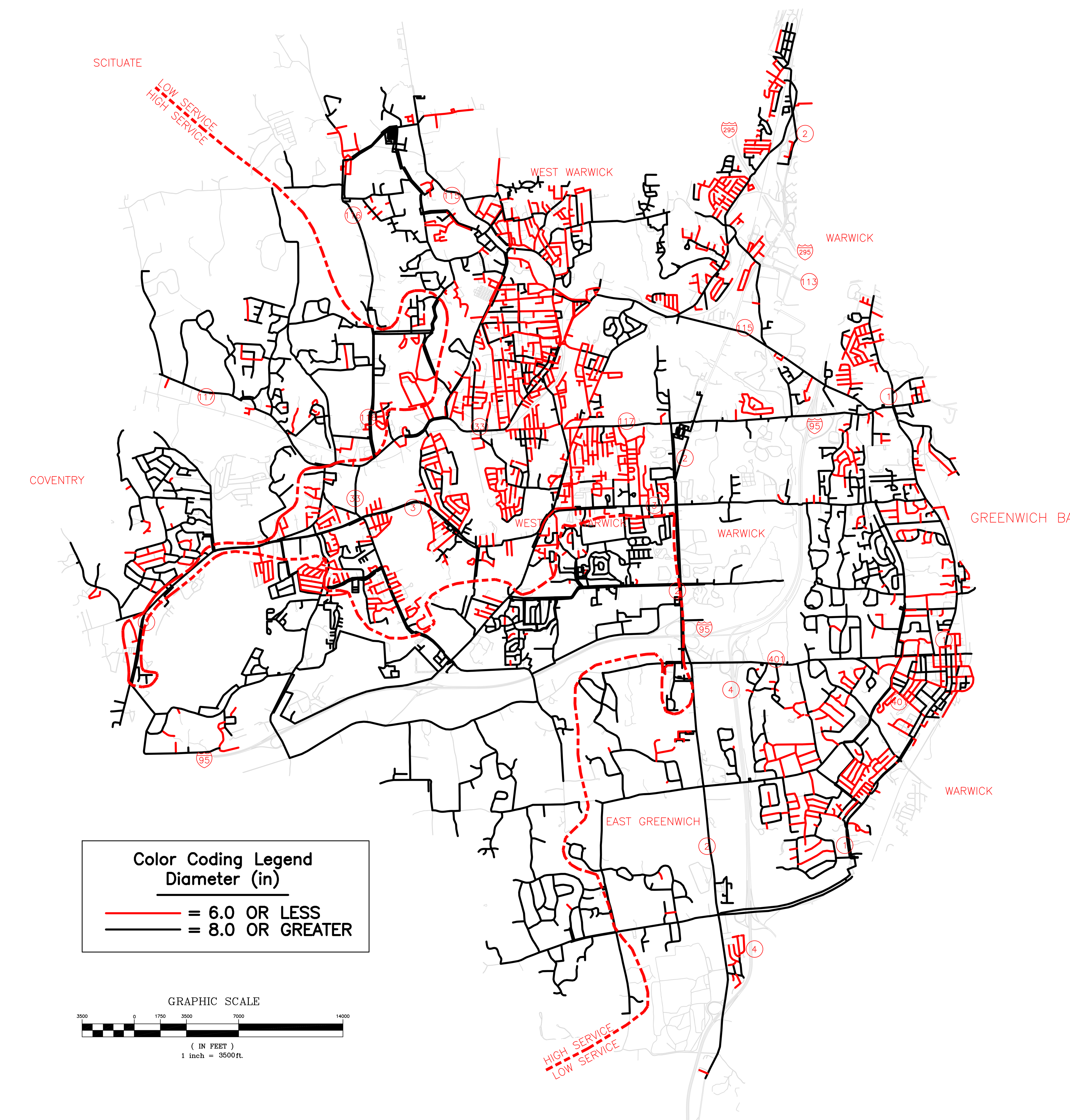
EXTENDED PERIOD SIMULATION
FIRE FLOW LOCATION SYSTEM MAP

KCWA WATER DISTRIBUTION SYSTEM MAP

FUTURE 20 YEAR AVAILABLE FIRE FLOW AND PIPE DIAMETER



AVAILABLE FIRE FLOW RATES
MAXIMUM DAY DEMAND SCENARIO



EXISTING WATER MAINS
6 INCH DIAMETER AND SMALLER

KCWA WATER DISTRICT SYSTEM MAPS
JANUARY 2008 J0612
SHEET 1 OF 1

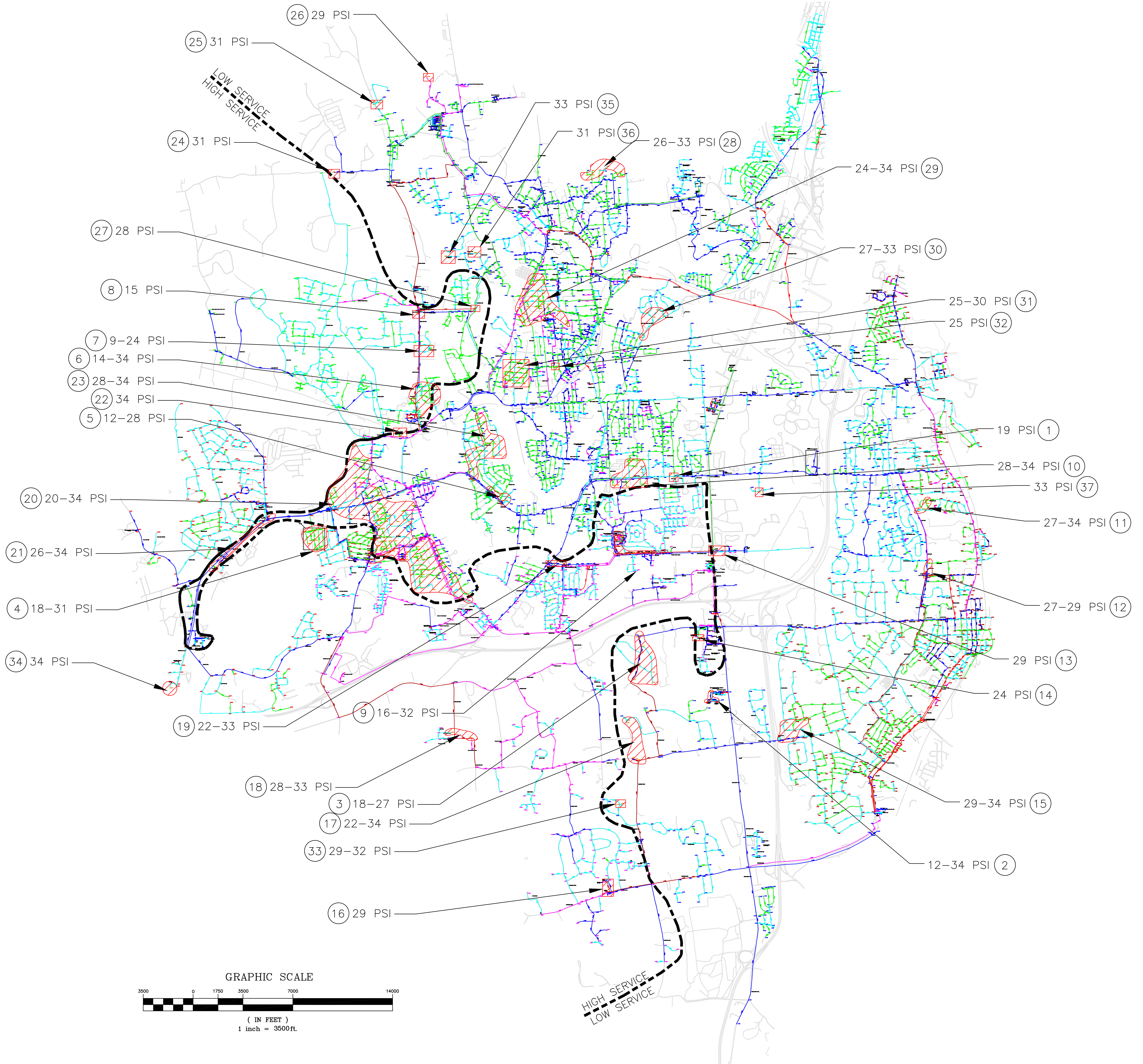
Civil & Environmental Engineering Partners, Inc.
342 Park Avenue, Woonsocket, RI 02895

ENCLOSURE NO. 1

KCWA SERVICE AREA LOW PRESSURE LOCATIONS

KCWA SERVICE AREA LOW PRESSURE LOCATIONS

FUTURE AVERAGE DAY DEMAND – STEADY STATE SIMULATION



LEGEND

Color Coding Legend
Link: Diameter (in)

<= 2.0
<= 4.0
<= 6.0
<= 8.0
<= 10.0
<= 12.0
<= 16.0
<= 20.0
<= 24.0
<= 30.0

AREAS BELOW 35 PSI WITH 1 PUMP RUNNING AT CLINTON AVE. PS

KCWA WATER DISTRICT SYSTEM MAP

JULY 2007 J0612

SHEET 1 OF 1