



Memorandum

To: Arthur Londensky, Borough of South River

From: Felipe S. Contreras, P.E., C.M.E., C.F.M., Kleinfelder

CC: Michael Furrey, Agra Environmental and Laboratory Services

Date: Revised – September 20, 2023

Re: **Water Quality Complaints Investigations**

Introduction

As outlined in Kleinfelder's May 31, 2023 proposal to South River, Kleinfelder investigated the water quality complaints that occurred in April 2023 as a result of the house fire that occurred on Thomas Street, utilizing the previously developed hydraulic model of the water distribution network. Kleinfelder compiled the operational data for the two storage tank elevations and the booster pumping station, as well as the hydrant flushing data, for April 2023. This memorandum describes the modeling scenarios that were simulated, presents the results and conclusions of the simulations, and provides recommendations to address the causes of the water quality complaints.

Modeling Scenarios

Kleinfelder developed and utilized the following modeling scenarios described in Table 1 based on the flow, pumping and elevation data for April 2023 to simulate the conditions observed in the distribution system.

Table 1: Modeling Scenarios

Scenario	Parameters of Interest
Average day demand	Velocity, flow and flow direction
Average day demand plus the additional fire flow demand of 1,500 gpm at the hydrant used to put out the fire located on Thomas Street	Velocity, flow and flow direction

The previously determined customer average day demands and weekly demand pattern were utilized for these scenarios, as the timeframe of interest was April 2023, a month where average water consumption is typically observed. A fire flow demand of 1,500 gallons per minute (gpm) was assumed using the International Fire Code (IFC) for minimum fire flow requirements for single- and two-family homes with no automatic sprinkler system. The scenarios were run using an extended period simulation (EPS) snapshot at the same day and time that the fire occurred.

Results and Conclusions

The above-described scenarios were run to determine the velocity (V) in the pipes (in ft/s), the flow (Q) in the pipes (in gpm) and the direction of the flow in each segment. The velocity and flow in the pipes as a result of the fire were compared to the average velocity and flow in the pipes during normal demand conditions. The flow directions during normal demand conditions were also compared to the flow directions observed as a result of the fire flow demand. The attached Figure A demonstrates these findings. The light blue pipes and dark blue pipes show the degree of increase in flow and velocity in pipe segments where flow did not change direction, with dark blue representing a more significant increase. The orange and red pipes show the degree of increase in flow and velocity in pipe segments where flow did change direction, with red representing a more significant increase. The figure also shows the location of the fire and the locations of the homes where brown water was observed in the week after the fire.

As shown in Figure A, a large majority of the pipe segments in the town saw a change in flow direction, and nearly all the segments saw an increase in flow and velocity as a result of the fire that occurred. This means the fire demand had a significant impact on nearly the entire distribution system, creating a disturbance to the normal conditions in the system. Such disturbances can result in the dislodging of sediment from the walls of the pipe and the movement of old water to different areas in the distribution system.

Figure B provides the diameters of the pipes in the distribution system. The red and orange pipes are 4-inch- and 6-inch-diameter pipes, respectively, and these segments make up 57% of the linear footage of water main in the distribution system (including 6-inch-diameter hydrant laterals). Under normal average day demand conditions, typical lower velocities are observed in the 4-inch and 6-inch segments, consistent with normal consumption demands, and the water in the system moves in a consistent pattern. When a high demand like the fire flow occurs, the normal flow patterns and directions are disrupted, and velocities are increased. This results in an abrupt shift of older water from one area of the system to another and a disruption to the sediment and film build-up on the interior of the pipes, which would not occur under normal demand conditions. This disturbance is even worse in smaller diameter pipes, such as 4-inch and 6-inch diameters, because for the same volume of flow, the velocity will be greater in a smaller diameter pipe compared to a larger diameter pipe.

Recommendations

Based on the findings of the modeled scenarios and knowledge of the conditions of the distribution system, it is recommended that the 4-inch- and 6-inch-diameter water mains be replaced with 8-inch-diameter water mains, contingent on further confirmation with fire flow criteria. In accordance with N.J.A.C. 5:21-5.3, water mains shall be a minimum of 8 inches, except under limited specific conditions. Increasing the size of the small diameter water mains will result in lower velocities in these pipes during events like high demand fire flow scenarios, and therefore less disturbance to the distribution system.

In addition, it is recommended that additional looping connections at strategic locations in the distribution system be added to reduce water stagnation and increase firefighting capacity, by increasing the number of pathways that the water can travel throughout the system from one area to another. A minimum of three (3) new interconnections or water main extensions of 8-inch diameter main will be made between larger diameter distribution mains to currently isolated areas of the system to improve reliability of distribution throughout the system and reduce water travel time. The first proposed extension is located by the Appleby Tank and will connect the dead end of Appleby Ave to the 8-inch main on Colin Drive, crossing through Leonardine Park. The second proposed extension is located between the dead end of Cleveland Avenue and water main on John

Street, crossing through Dailey's Pond Recreational Area. The third proposed extension is located on Hillside Avenue and connects the dead end main on Hillside Avenue to the perpendicular water main on Willet Avenue. The hydraulic model was run with the addition of these water main extensions for the same fire event, and the same flow and velocity analysis was conducted. Figures C, D, and E show these results. As seen in the figures, the water main extensions allow for greater movement of water through the system with results in less areas of significant increases in flow and velocity, with a change in direction (red pipes and orange pipes), and an increase in pipes that do not see a significant change due to the fire (black pipes).

Due to the large linear footage of total water main that is recommended to be replaced or installed, it is proposed to implement the improvements in phases, based on time and budget. Phase I shall include installation of the three (3) described proposed strategic looping locations, where new 8-inch water main will connect current dead ends in the system. Further engineering design will be required to confirm feasibility and exact alignment of the water main extensions in locations through the parks and recreational areas. Phase II shall include the replacement of all existing 4-inch water main with 8-inch water main, for a total of approximately 70,000 linear feet of 4-inch water main replacement. Phase III shall include the replacement of all 6-inch water main with 8-inch water main, for a total of 106,000 linear feet of 6-inch water main replacement. It is anticipated that these phases will be completed as multiple projects, based on budgets and proposed construction costs.

Prior to the completion of the water main replacements, temporary actions can also be taken to address sediment disturbance and the movement of old water through the system. A unidirectional flushing (UDF) program should be developed and implemented to improve operations and water quality in the system. UDF is more effective than traditional flushing programs, as each pipe is isolated to create flow in a single desired direction to effectively clean the pipe. UDF requires closing valves and operating specific hydrants, and segments are flushed in a set sequence, ensuring a clean water source is used and segments are flushed from larger to smaller diameter pipes.

FIGURES

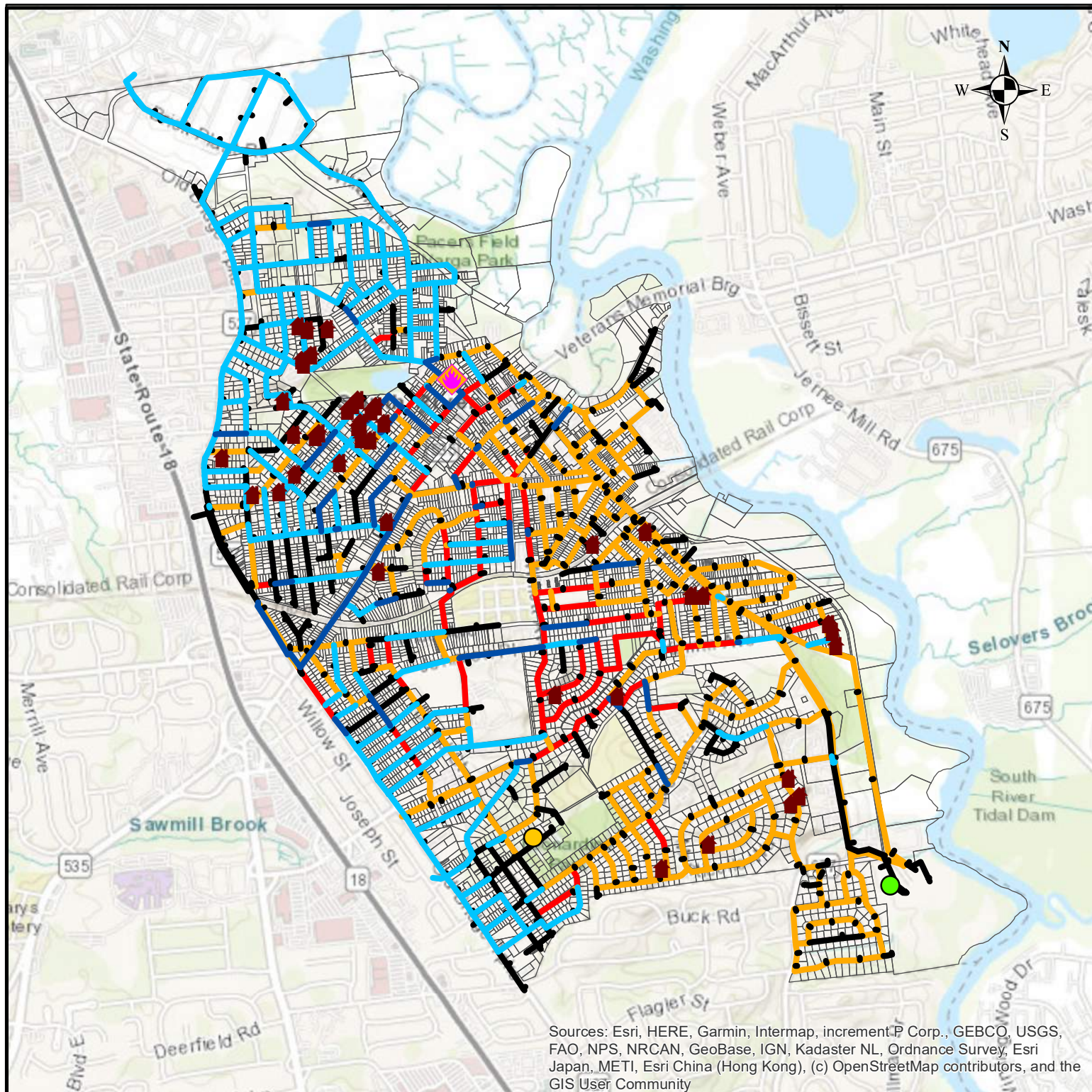


**FIGURE A -
FIRE IMPACT ON FLOW
DISTRIBUTION IN SOUTH RIVER**

SOUTH RIVER WATER DEPARTMENT
BOROUGH OF SOUTH RIVER
MIDDLESEX COUNTY, NEW JERSEY

Legend

TANKS

- Appleby Tank
- TP Tank
- ◆ Fire_location
- Home - Brown Water Observed

IMPACTS ON FIRE FLOW

- Significant Increase in Q&V with Direction Change
- Increase in Q&V with Direction Change
- Insignificant Change in Flow&Direction
- Increase in Q&V
- Significant Increase in Q&V

PROJECT #: 6838.003

DRAWN: AUGUST 2023

DRAWN BY: JRN

CHECKED BY: FSC

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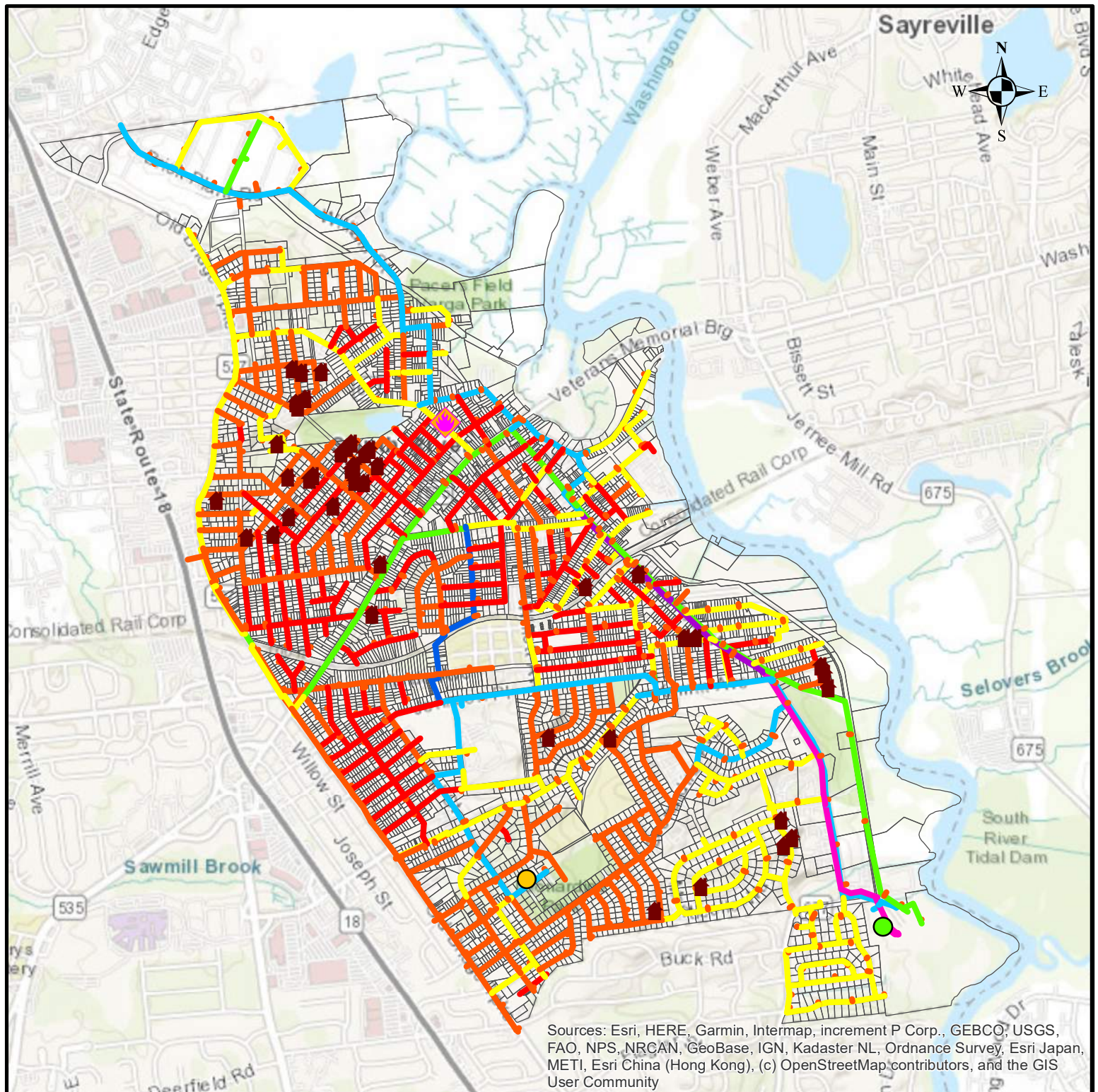


FIGURE B - WATER DISTRIBUTION SYSTEM PIPE SIZE DIAMETERS

SOUTH RIVER WATER DEPARTMENT
BOROUGH OF SOUTH RIVER
MIDDLESEX COUNTY, NEW JERSEY

Legend

- Appleby Tank
- TP Tank
- ◆ Fire_location
- Home - Brown Water Observed

Diameter

- 4
- 6
- 8
- 10
- 12
- 14
- 16
- 20

PROJECT #: 6838.001

DRAWN: AUGUST 2023

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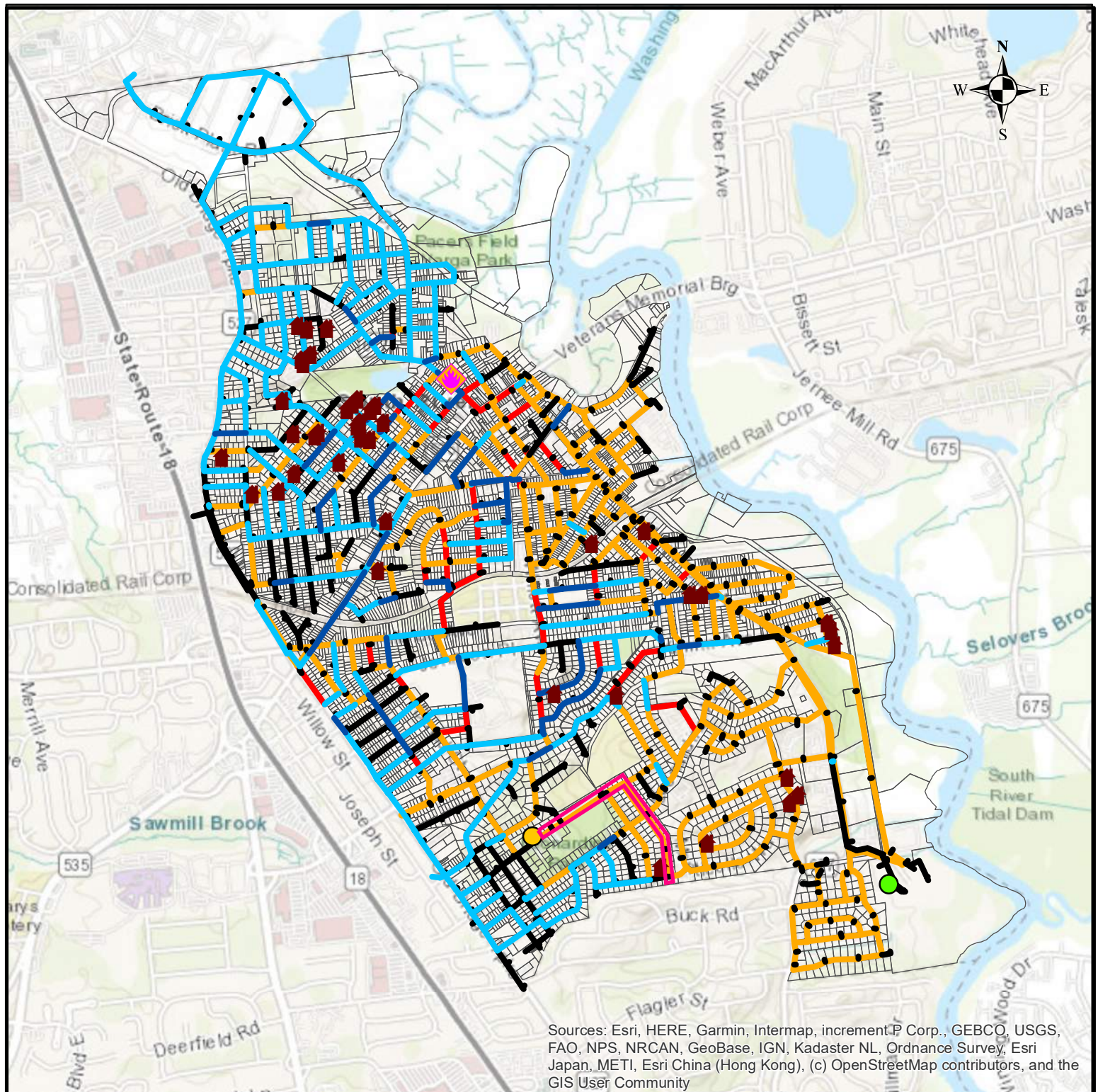


**FIGURE C -
FIRE IMPACT ON FLOW
DISTRIBUTION IN SOUTH RIVER
WITH EXTENSION 1**

SOUTH RIVER WATER DEPARTMENT
BOROUGH OF SOUTH RIVER
MIDDLESEX COUNTY, NEW JERSEY

Legend

TANKS

- Appleby Tank
- TP Tank
- ◆ Fire_location
- 🏠 Home - Brown Water Observed

IMPACTS ON FIRE FLOW

- Significant Increase in Q&V with Direction Change
- Increase in Q&V with Direction Change
- Insignificant Change in Flow&Direction
- Increase in Q&V
- Significant Increase in Q&V

PROJECT #: 6838.003

DRAWN: SEPTEMBER 2023

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FILE NAME:
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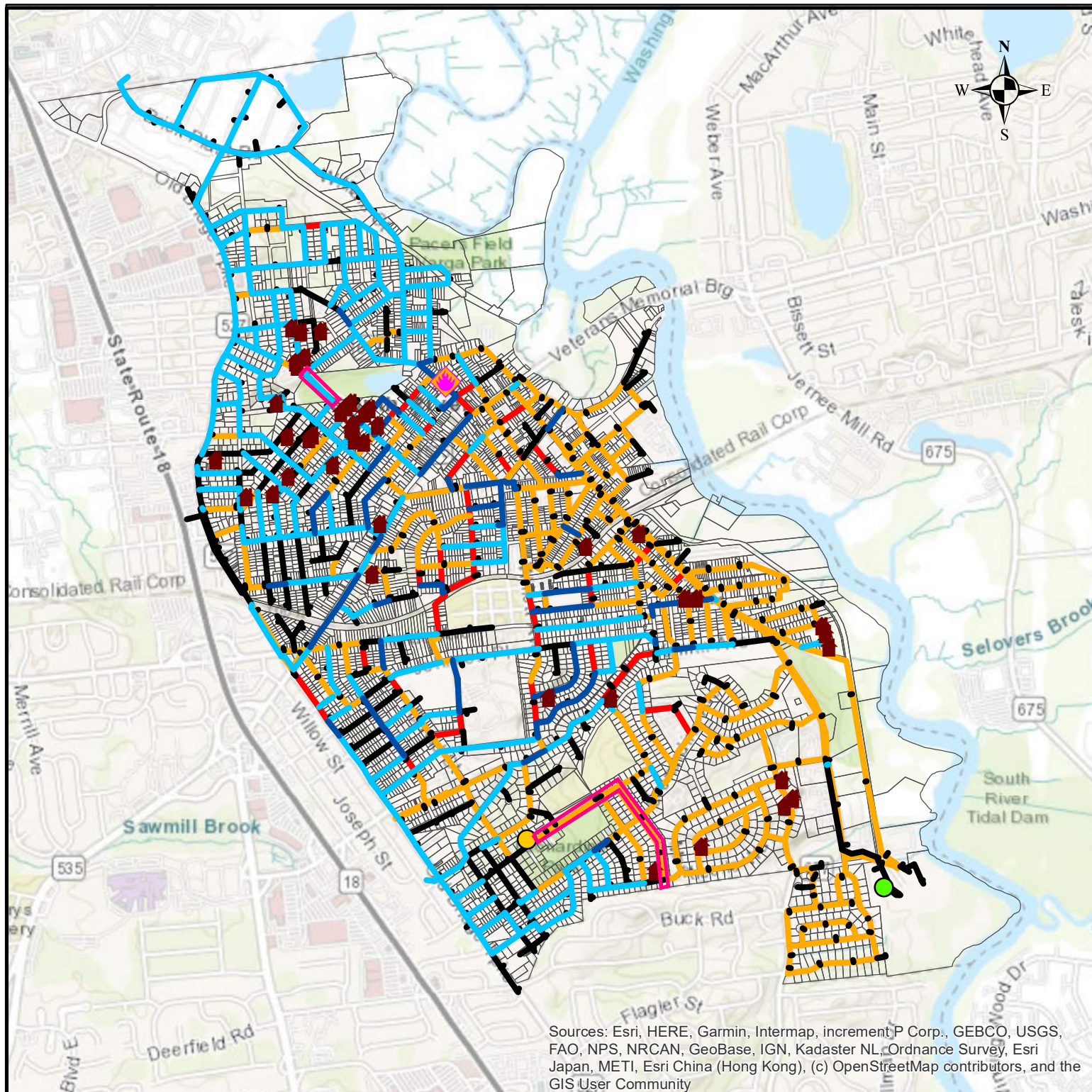


**FIGURE D -
FIRE IMPACT ON FLOW
DISTRIBUTION IN SOUTH RIVER
WITH EXTENSION 1 + 2**

SOUTH RIVER WATER DEPARTMENT
BOROUGH OF SOUTH RIVER
MIDDLESEX COUNTY, NEW JERSEY

Legend

TANKS

- Appleby Tank
- TP Tank
- ◆ Fire_location
- 🏠 Home - Brown Water Observed

IMPACTS ON FIRE FLOW

- Significant Increase in Q&V with Direction Change
- Increase in Q&V with Direction Change
- Insignificant Change in Flow&Direction
- Increase in Q&V
- Significant Increase in Q&V

PROJECT #: 6838.003

DRAWN: SEPTEMBER 2023

DRAWN BY: JRN

CHECKED BY: FSC

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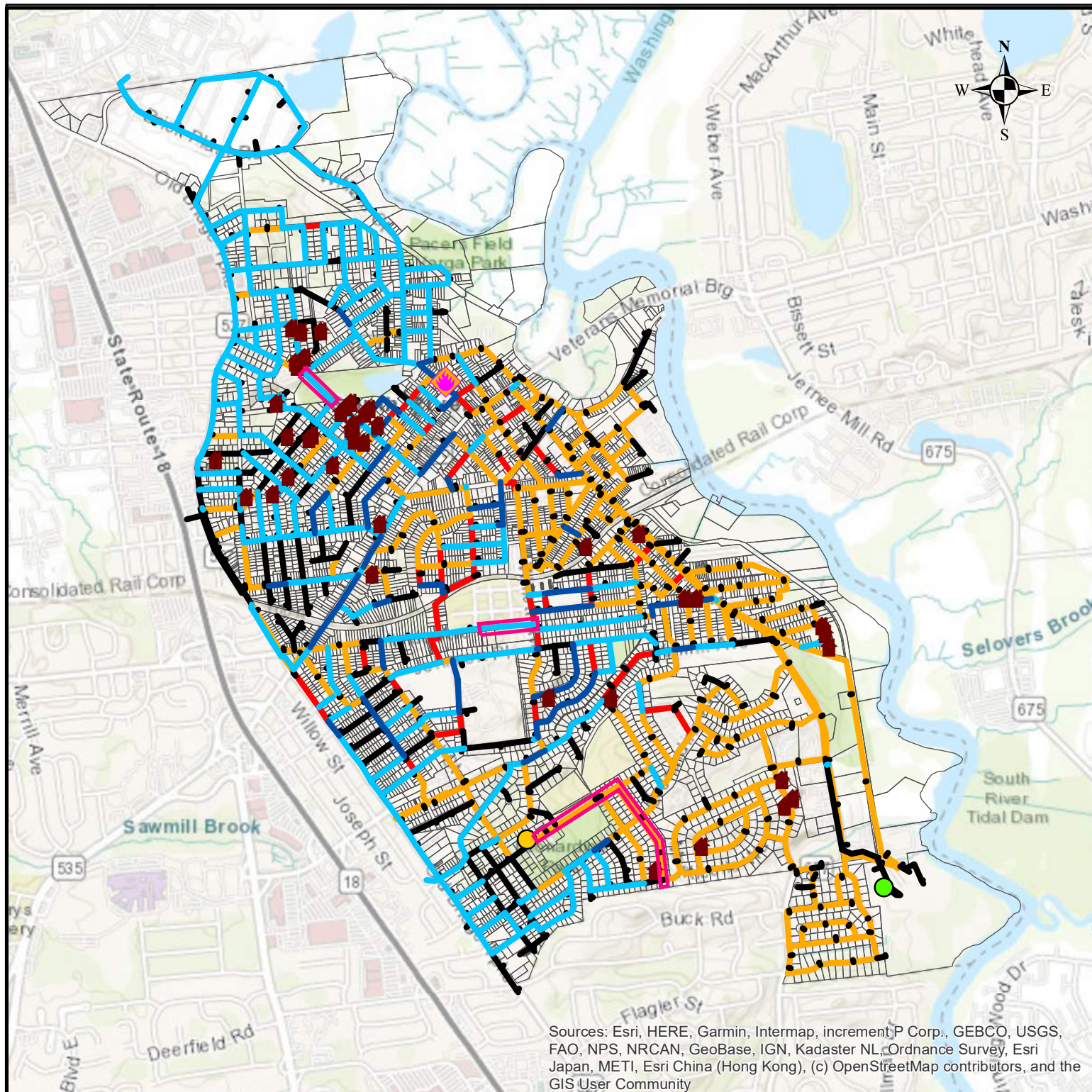


**FIGURE E -
FIRE IMPACT ON FLOW
DISTRIBUTION IN SOUTH RIVER
WITH EXTENSION 1 + 2 + 3**

SOUTH RIVER WATER DEPARTMENT
BOROUGH OF SOUTH RIVER
MIDDLESEX COUNTY, NEW JERSEY

Legend

TANKS

- Appleby Tank
- TP Tank
- ◆ Fire_location
- 🏠 Home - Brown Water Observed

IMPACTS ON FIRE FLOW

- Significant Increase in Q&V with Direction Change
- Increase in Q&V with Direction Change
- Insignificant Change in Flow&Direction
- Increase in Q&V
- Significant Increase in Q&V

PROJECT #: 6838.003

DRAWN: SEPTEMBER 2023

DRAWN BY: JRN

CHECKED BY: FSC

FILE NAME:

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\\SouthRiver_Fire Flow Impact - Extension 1+2+3.mxd

0 0.25 0.5 1
Miles

South River

Data from RS Means
Prepared By: JRN & FSC

DIP, Cement Lined, Not Including Excavation or Backfill
Class 50, Push on Joint, 18 LF sections

	Unit	Daily Output	Labor Hours	Bare Material	Bare Labor	Bare Equipment	Bare Total
8-inch	LF	133	0.21	\$ 95.45	\$ 10.17	\$ 1.16	\$ 106.78

4-inch Water Main Replacement with 8-inch = 70,000 LF
 Pipe Replacement Cost = \$ 7,474,600 *does not include excavation, backfill, paving, hydrants, services reconnections
 Time for replacement = 526.32 days
 105.26 work weeks
 2.02 years

6-inch Water Main Replacement with 8-inch = 106,000 LF
 Pipe Replacement Cost = \$ 11,318,680 *does not include excavation, backfill, paving, hydrants, services reconnections
 Time for replacement = 796.99 days
 159.40 work weeks
 3.07 years

8-inch Pipe Water Main Extensions
 Extension 1 (Appleby) = 2660 LF
 Pipe Installation Cost = \$ 284,035 *does not include excavation, backfill, paving, tree clearing
 Extension 2 (Daileys Rec Area) = 593 LF
 Pipe Installation Cost = \$ 63,321 *does not include excavation, backfill, paving, tree clearing
 Extension 3 (Hillside Ave) = 608 LF
 Pipe Installation Cost = \$ 64,922 *does not include excavation, backfill, paving, tree clearing