DRAINAGE STUDY AND ANALYSIS
SHANDON/ ROSEWOOD DRAINAGE AREA

Prepared for:
The City of Columbia, South Carolina
CIP Project Number SD8392
October 2014

724 Beltline Boulevard
Columbia, SC 29205
803-254-0518— Fax 803-765-0993

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Isaac B. Cox, R.L.S. (1918-1989)

Gene L. Dinkins, P.L.S., P.E.
Gene L. Dinkins, Jr., P.L.S., LEED A.P.
Sanford B. Dinkins, LEED A.P.
McTilden Atkins, III, P.E.
Laura M. Baker, P.E., LEED A.P.

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Robert T. Blackwell, P.E.
Darren Holcombe, P.E., LEED A.P.
J. Donald Rawls, Jr., P.L.S.
Daniel C. Lam, P.E., LEED A.P.
James L. Pruitt, P.E.
Jesse T. McNeal, P.E.
James D. Hazzard, P.E., LEED AP

Cox and Dinkins, Inc.
724 Beltline Boulevard
Columbia, South Carolina 29205

(803) 254-0518, fax (803) 765-0993
cdinc@coxanddinkins.com
coxanddinkins.com

OCTOBER, 2014

EXECUTIVE SUMMARY

Cox and Dinkins, Inc. performed civil engineering and land surveying services for the Shandon/Rosewood Drainage Basin in 2009 and 2010 under City of Columbia CIP Project Number SD8325 (original project). The original project consisted of field surveying of all major drainage structures in the approximate 750-acre drainage basin and mapping of those structures and the extents of the overall drainage basin. The original project also included an engineering analysis of the drainage system and development of a computer model of the existing drainage system, with division into the **east branch watershed** and the **west branch watershed**. Finally, the original project included identification of major potential flooding areas through the drainage model analysis and development of a conceptual plan for overall drainage system upgrades within the **east branch watershed** and the **west branch watershed**.

As a follow up to the original project, Cox and Dinkins, Inc. has been requested to perform further drainage study and analysis, under City of Columbia CIP Project Number SD8392 (current project), to determine the benefit that limited conventional drainage system improvements may have on certain identified flooding areas during the 10-year, 24-hour rainfall event. Specifically, Cox and Dinkins, Inc. has been requested to determine what potential benefit(s) conventional drainage improvements costing in the range of one million dollars ($1,000,000.00) may have on critical flooding areas in either the **east branch watershed**, **west branch watershed**, or both, with selection of the watershed at the discretion of Cox and Dinkins, Inc. For the purposes of the current project, conventional drainage system improvements are considered to be those improvements that are typically associated with new storm drainage infrastructure including hard pipes and structures that collect and convey surface runoff.

SURVEYING AND MAPPING

No field surveying has been performed in conjunction with the current project. Survey data used for this study was taken from the original project (CIP Project Number SD8325).

DRAINAGE MODELING APPROACH

During the original project Cox and Dinkins, Inc. delineated the overall 750± acre Shandon-Rosewood watershed and further divided that watershed into two primary sub-watersheds, namely the **east branch watershed** and the **west branch watershed**. The **east branch watershed** and the **west branch watershed** initially discharge into two independent open channels and those open channels converge into one open channel near the downstream limits of the original project area.

Since the time of the original project (SD8325) the City of Columbia has contracted for drainage pilot studies (pilot studies) in the **east branch watershed** and the **west branch watershed.** Those pilot

studies were based on green infrastructure and those pilot studies relied upon infiltration as the primary component of their model.

Cox and Dinkins, Inc. modeling for the current project began by incorporating the pilot areas identified by the green infrastructure project into the original Cox and Dinkins, Inc. models for both the **east and west branch watersheds**. Incorporating the green infrastructure pilot areas resulted in the removal of all or portions of certain subwatersheds from the original Cox and Dinkins, Inc. models, the details of which are further described within this report. The revised Cox and Dinkins, Inc. models were then used as the basis for evaluation of certain conventional drainage system improvement scenarios for both the **east and west branch watersheds**.

DRAINAGE SOFTWARE AND MODEL PARAMETERS

XPSWMM 2012 (service Pack 1) was again selected to conduct this further study of the Shandon-Rosewood storm drainage network. Independent **XPSWMM** models have again been developed for the **east branch watershed** and the **west branch watershed.** Runoff has been routed through the two separate models using the SCS Hydrology Routing Method. The rainfall events selected for routing were the 2-year, 24-hour rainfall event (3.6" accumulated rainfall) and the 10-year, 24-hour rainfall event (5.3" accumulated rainfall). City of Columbia regulations typically require the 25-year, 24-hour rainfall event be used for watersheds in excess of forty (40) acres. However, the City of Columbia instructed that the 10-year, 24-hour rainfall event be used for modeling associated with the analysis of the 750± acre Shandon-Rosewood watershed. Tailwater conditions (10-year flood) used in the model have been taken from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) last revised September 29, 2010.

SUMMARY OF MODELING SCENARIOS – EAST

As identified during the original project, the "backbone" of the drainage collection/conveyance system for the **east branch watershed** runs between Walker Street and Ravenel Street. It is along this "backbone" that the majority of the surcharge and ponding occurs, primarily north of Rosewood Drive. In the **east branch watershed,** modeling scenarios 1, 2A and 2B have a common downstream point of commencement being the pipe junction located along the east side of S. Ott Road, south of Rosewood Drive and north of Moss Avenue. Each of the scenarios considered also have in common the need to cross Rosewood Drive. For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination.

CONCEPTUAL RECOMMENDATIONS FOR IMPROVEMENTS - EAST

Given the history of the **east branch watershed**, the application of conventional drainage system improvements focused on reducing the drainage area that contributes runoff to the "backbone". Each of the scenarios considered contemplate the installation of a new drainage collection/conveyance system from the beginning junction on the east side of S. Ott Road, south of Rosewood Drive and north of Moss Avenue, and continuing to the northwest across the Rosewood Elementary School site, then west along the south side of Rosewood Drive to the Ravenel Street intersection, then crossing Rosewood Drive to proceed north along Ravenel Street and ultimately intercepting the existing "backbone" along various points upstream, with the most upstream location being along Monroe Street, west of Ravenel Street. That preceding description applies to Scenario 2A, which constitutes approximately 1,900 feet of 72" diameter pipe. The various improvements associated with each scenario, as measured by remedy to surcharge and ponding in certain critical areas, have been summarized and compared. Without regard for costs, Scenario 2A clearly produces the better results as measured by remedy to surcharge and ponding.

OPINION OF PROBABLE CONSTRUCITON COST - EAST

The Opinion of Probable Construction Cost (OPCC) for each of the considered scenarios in the **east branch watershed** exceeds the $1,000,000.00 target that was defined in the criteria for this study. The anticipated costs associated with the Rosewood Drive crossing are a major contributor to that overage. Reduction of those costs will require that future design of the Rosewood Drive crossing focus on a means of supplementing the pipe that presently crosses Rosewood Drive and the pipe that presently crosses the Rosewood Elementary School site. If supplemental drainage pipes can parallel these existing pipes the cost associated with crossing Rosewood drive can be reduced, but in order to achieve that savings the intercept of the "backbone" on the north side of Rosewood Drive (along Ravenel Street) will be the critical component. That intercept will need to include a diversion that will proportionately "split" drainage between the new piping and existing piping. However, in order to achieve this savings the existing pipe that runs through the through the block east of Ravenel Street, between Cannon Street and Rosewood Drive will have to remain in service. Additional savings may also be achieved if drainage routes can be arranged so as to eliminate or reduce the impacts upon existing utilities (water, sanitary sewer, natural gas, electric and telephone lines, CATV lines, etc.)

The Opinion of Probable Construction Cost (OPCC) for each of the considered scenarios in the **east branch watershed** are summarized below.

DRAINAGE IMPROVEMENT SCENARIO EAST	Opinion of Probable Construction Costs (OPCC)
Scenario 1	$1.5M
Scenario 2	$2.2M
Scenario 2A	$2.8M

SUMMARY OF MODELING SCENARIOS – WEST

As identified during the original project, the **west branch watershed** does not have a single, central "backbone" drainage collection/conveyance system. Instead, the **west branch watershed** has two primary drainage collection/conveyance systems north of Rosewood Drive. The **first primary** system is the drainage collection/conveyance system associated with Maple Street, from the Maple Street / Wilmot Avenue intersection south to Burney Drive, then east along Burney Drive to Sloan Street where it turns southeasterly through the block and extends to Rosewood Drive, east of the S. Holly Street intersection. The **second primary** system is the drainage collection/conveyance system associated with Woodrow Street, from the Woodrow Street / Monroe Street intersection south to Rosewood Drive, then east along the north side of Rosewood Drive to the west side of the S. Holly Street intersection. The **first primary** and the **second primary** systems then converge along Hope Avenue, south of Rosewood Drive and east of S. Holly Street.

Four scenarios for parallel drainage collection/conveyance systems were considered for this portion of the **west branch watershed** area. One scenario that was considered has a downstream point of commencement at a junction described situated on the **second primary** collection/conveyance system. The other three scenarios that were considered have a common downstream point of commencement

situated on the **first primary** collection/conveyance system. For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination

CONCEPTUAL RECOMMENDATIONS FOR IMPROVEMENTS - WEST

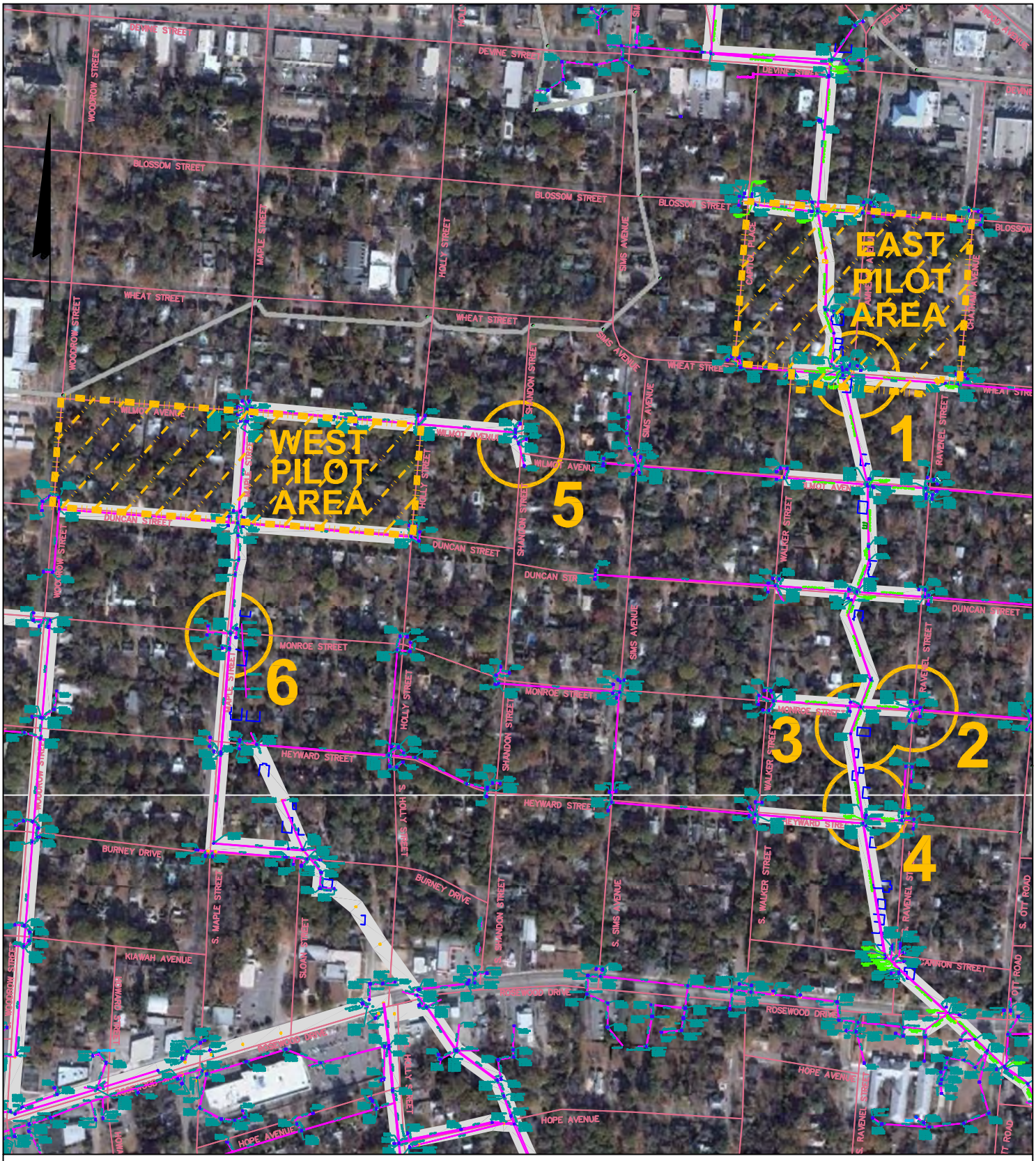
Given the history of the **west branch watershed**, the application of conventional drainage system improvements focused on parallel drainage routes. Scenario 1 has a downstream point of commencement at a junction situated on the **second primary** collection/conveyance system. Scenarios 2, 2A and 2B have a common downstream point of commencement at a junction situated on the **first primary** collection/conveyance system. For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination. Scenario 2A includes the installation of a 48" diameter pipe beginning on the **first primary** system at a junction along the north side of Rosewood Drive, between S. Holly Street and S. Shandon Street and continues north along S. Holly Street to Burney Drive, then west along Burney Drive to Maple Street, then north along Maple Street to the Maple Street / Monroe Street intersection. That described route constitutes approximately 2,050 feet of 48" diameter pipe. The various improvements associated with each scenario, as measured by remedy to surcharge and ponding in certain critical areas, have been summarized and compared. Without regard for costs, Scenario 2A clearly produces the better results as measured by remedy to surcharge and ponding.

OPINION OF PROBABLE CONSTRUCITON COST - WEST

Two of the scenarios considered in in the **west branch watershed** exceed the $1,000,000.00 target that was defined in the criteria for this study. Those two scenarios produce more desirable results when measured by remedy to surcharge and ponding. Due to length of the collection system in the **west branch watershed,** reduction of those costs associated with Scenarios 2A and 2B will require that future design focus on a means of supplementing existing pipes. Future design must also focus on drainage routes that can be arranged so as to eliminate or reduce the impacts upon existing utilities (water, sanitary sewer, natural gas, electric and telephone lines, CATV lines, etc.). Consideration can also be given to parallel drainage routes that will leave certain "through the block" pipes in place, while "splitting" drainage amongst existing pipes and new pipes. However, some of the "through the block" drainage in the **west branch watershed** may prove to be problematic if left in service.

The Opinion of Probable Construction Cost (OPCC) for each of the considered scenarios in the **west branch watershed** are summarized below.

DRAINAGE IMPROVEMENT SCENARIO WEST	Opinion of Probable Construction Costs (OPCC)
Scenario 1	$0.8M
Scenario 2	$0.9M
Scenario 2A	$2.1M
Scenario 2B	$2.2M



PROJECT:

SHANDON-ROSEWOOD WATERSHED

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 500 1000

GRAPHIC SCALE IN FEET
SCALE: 1"=500'

PROBLEM AREA AS IDENTIFIED BY THE CITY OF COLUMBIA

EAST BRANCH-
1. Wheat Street at Amherst Avenue
2. Monroe Street at Ravenel Street and running to Wheat Street
3. Monroe Street between Ravenel Street and Wheat Street
4. Heyward Street between Ravenel Street and Wheat Street

WEST BRANCH-
5. Shandon Street north of Wilmot Avenue
6. Monroe Street at Maple Street

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SECTION 1

EAST BRANCH

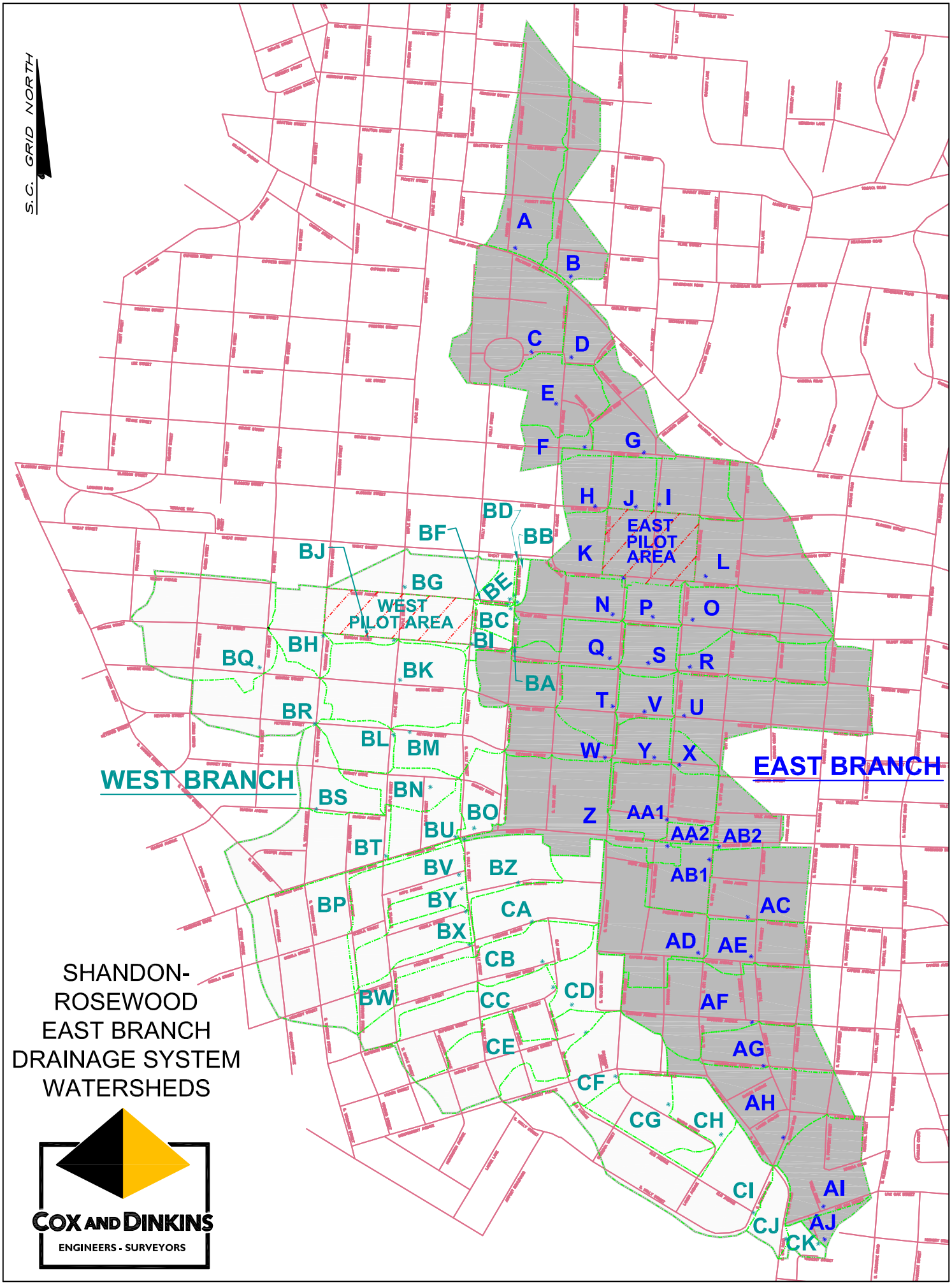
ORIGINAL MODEL WITH GREEN INFRASTRUCTURE PILOT AREAS INCORPORATED

East Branch Watershed (Original Model Revised to Incorporate Green Infrastructure Pilot Areas)

As originally modeled by Cox and Dinkins, Inc., the **east branch watershed** contained approximately 413 acres and was divided into thirty-six (36) subwatersheds ranging in size from 1.9 acres to 24.3 acres. Since the time of the original project the City of Columbia has contracted for a drainage pilot study within the **east branch watershed** and that pilot study was based on green infrastructure, namely infiltration. For the **east branch watershed** the pilot study identified three problem intersections, namely Wheat Street/Amherst Avenue, Monroe Street / Ravenel Street and Heyward Street / Ravenel Street. Those intersections were also identified by the City of Columbia as problem areas in advance of the original project. The pilot study focused on the **east pilot area**, a 12.5± acre area consisting of the two blocks bound by Blossom Street (N), Chatham Avenue (E), Wheat Street (S) and Capitol Place (W) and containing the problem intersection of Wheat Street/Amherst Avenue.

Cox and Dinkins, Inc. modeling for the current project began by incorporating the **east pilot area** (approximately 12.5 acres as identified by the green infrastructure pilot project) into the original Cox and Dinkins, Inc. model for the **east branch watershed**. Incorporating the **east pilot area** resulted in the removal of all or portions of certain subwatersheds from the original Cox and Dinkins, Inc. model. More specifically, watershed **M** was removed entirely from the original **east branch watershed** model and portions of watersheds **I**, **J**, **K** and **P** were also removed from the original **east branch watershed** model.

The following graphic shows the original arrangement of the **east branch watershed,** along with the locations of the referenced problem intersections and the **east pilot area**. That graphic is followed by the original **east branch** subwatershed data.


S.C. GRID NORTH
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SHANDON-
ROSEWOOD
EAST BRANCH
DRAINAGE SYSTEM
WATERSHEDS
COX AND DINKINS
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ROSEWOOD-SHANDON STORM DRAINAGE EVALUATION EAST BRANCH WATERSHED

WATER-SHED ID NO	NODE NO	AREA (ACRES)	IMPERVIOUS PERCENTAGE	OVERLAND SLOPE	TIME OF CONCEN TRATION	PERVIOUS AREA CURVE NO	2-YR PEAK FLOW AREA (CFS)	2-YR TOTAL SURFACE RUNOFF (INCHES)	10-YR PEAK FLOW AREA (CFS)	10-YR TOTAL SURFACE RUNOFF (INCHES)
A	10123	20.88	42	1.99	44.72	76	18.49	1.36	37.72	2.69
B	10113	12.63	49	2.15	37.78	79	14.69	1.54	28.17	2.93
C	10391	21.04	26	1.16	52.83	71	12.11	1.04	27.66	2.23
D	10273	5.66	61	1.49	24.03	83	10.54	1.85	18.81	3.34
E	10272	10.9	40	1.01	22.76	76	14.88	1.35	29.98	2.66
F	10294	3.69	85	0.88	18.26	92	10.94	2.63	17.17	4.28
G	10296	10.13	55	1.25	31.05	81	14.81	1.7	27.44	3.15
H	5715	5.24	56	1.79	14.28	81	11.68	1.75	21.34	3.23
I (old)	5726	8.76	68	1.56	21.5	86	19.47	2.08	33.19	3.63
I (new)	**5726**	**8.47**	**68**	**1.56**	**21.5**	**86**	**18.83**	**2.08**	**32.09**	**3.63**
J (old)	5719	4.66	61	3.14	10.32	84	12.66	1.94	22.03	3.45
J (new)	**5719**	**4.4**	**62**	**3.14**	**10.32**	**84**	**11.96**	**1.94**	**20.8**	**3.45**
K (old)	5606	5.89	38	2.22	22.04	75	7.83	1.3	16.03	2.6
K (new)	**5606**	**5.47**	**38**	**2.22**	**22.04**	**75**	**7.27**	**1.29**	**14.89**	**2.6**
L	5646	22.21	49	1.23	41.83	79	24.17	1.55	46.44	2.95
M (deleted)	5609	10.7	43	2.83	16.17	77	18.73	1.44	36.56	2.81
N	5541	11.5	52	1.17	34.21	80	15.04	1.63	28.36	3.05
O	5575	13	48	1.55	34.97	79	15.98	1.55	30.63	2.96
P (old)	5547	4.58	48	2.41	12.88	79	9.4	1.56	17.72	2.96
P (new)	**5547**	**4.29**	**48**	**2.84**	**12.88**	**79**	**8.8**	**1.56**	**16.6**	**2.96**
Q	5512	7.05	48	2.23	22.97	79	11.2	1.56	21.37	2.96
R	5478	10.82	38	1.96	37.6	75	10.21	1.28	21.16	2.58
S	5492	5.18	48	2.72	12.32	79	10.84	1.56	20.36	2.96
T	5376	7.44	38	3.14	17.84	75	11.07	1.3	22.48	2.61
U	5397	24.31	35	1.51	68.09	74	14.1	1.22	30.06	2.48
V	5382	4.62	48	5.89	9.22	79	10.35	1.56	19.47	2.97
W	5342	15.4	43	1.28	57.43	77	12.01	1.41	24.03	2.76
X	5304	2.6	38	3.26	13.03	75	4.39	1.3	8.85	2.6
Y	5306	4.94	38	1.63	26	75	5.97	1.3	12.27	2.6
Z	11001	19.82	46	1.6	47.11	78	18.78	1.48	36.86	2.85
AA (old)	2072	14.34	51	2.26	23.82	80	23.44	1.62	43.89	3.05
AA1 (new)	**10434**	**12.55**	**55**	**2.32**	**19.11**	**79**	**22.07**	**1.56**	**41.82**	**2.96**
AA2 (new)	**2072**	**1.79**	**65**	**2.15**	**6.26**	**85**	**5.65**	**2.03**	**9.73**	**3.58**
AB (old)	1999	13.83	54	1.49	33.3	81	19.3	1.7	35.81	3.14
AB1 (new)	**2000**	**6.94**	**54**	**1.49**	**33.3**	**81**	**9.69**	**1.7**	**17.97**	**3.14**
AB2 (new)	**1998**	**6.89**	**55**	**2.65**	**17.12**	**82**	**14.61**	**1.78**	**26.35**	**3.26**

All Hydrographic Shapes are Curvilinear.

All Shape Factors are 484.

ROSEWOOD-SHANDON STORM DRAINAGE EVALUATION EAST BRANCH WATERSHED

WATER-SHED ID NO	NODE NO	AREA (ACRES)	IMPERVIOUS PERCENTAGE	OVERLAND SLOPE	TIME OF CONCEN TRATION	PERVIOUS AREA CURVE NO	2-YR PEAK FLOW AREA (CFS)	2-YR TOTAL SURFACE RUNOFF (INCHES)	10-YR PEAK FLOW AREA (CFS)	10-YR TOTAL SURFACE RUNOFF (INCHES)
AC	1950	13.47	48	2.52	24.6	79	20.52	1.56	39.15	2.96
AD	1809	17.65	40	1.24	55.48	76	13.39	1.34	27.34	2.67
AE	1806	9.18	39	3.05	18.86	76	13.95	1.35	27.84	2.68
AF	1700	22.36	42	2.38	32.18	77	26.13	1.42	51.91	2.77
AG	1617	9.58	34	2.96	19.38	74	12.85	1.23	26.66	2.51
AH	1589	17.21	46	2.19	36.84	78	19.33	1.48	37.71	2.85
AI	1565	13.6	56	2.96	21.49	82	25.74	1.77	46.47	3.23
AJ	10440	1.91	56	2.69	12.24	82	4.58	1.78	8.22	3.26

All Hydrographic Shapes are Curvilinear.

All Shape Factors are 484.

Following removal of the **east pilot area** from the original **east branch watershed** model the downstream remainder of the **east branch watershed** was studied for areas in which conventional drainage system improvements may have application. The focus of that study area was further influenced by the following:

(1) the green infrastructure pilot study extrapolated pilot results to determine that green infrastructure management is required on 37.5 acres within the **east branch watershed;**

(2) the green infrastructure pilot study contemplates application of infiltration practices in the areas of the intersections of Monroe Street / Ravenel Street and Heyward Street / Ravenel Street;

(3) the original model by Cox and Dinkins, Inc. indicated underperformance of the stormwater collection system in the **east branch watershed** occurred primarily north of Rosewood Drive.

As a result of these influences, the primary study for application of conventional drainage system improvements in the **east branch watershed** has been focused on the area downstream of the intersection of Heyward Street/Ravenel Street and north of Rosewood Drive.

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SECTION 2

EAST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS (SCENARIOS 1, 2 & 2A)

Background for East Branch Drainage Improvement Scenarios

As identified during the original project, the “backbone” of the drainage collection/conveyance system for the **east branch watershed** runs between Walker Street and Ravenel Street. It is along this "backbone" that the majority of the surcharge and ponding occurs, primarily north of Rosewood Drive. Given that history, the study area for application of conventional drainage system improvements in the **east branch watershed** has focused on reducing the drainage area that contributes runoff to the "backbone". As with the original project, establishing one or more parallel drainage collection/conveyance systems that will intercept runoff prior to its entry into the “backbone” is a priority. The original project identified Ott Road as the primary potential corridor for such a parallel installation and the current project has focused on the pipe junction located along the east side of Ott Road, south of Rosewood Drive and north of Moss Avenue. Survey and mapping data from the original project identifies this junction as NODE 1999 and indicates that this junction includes a 48" diameter inlet pipe and a 72" diameter outlet pipe. The 48" diameter inlet pipe extends upstream to the north side of Rosewood Drive and continues as what the original project identified as the “backbone” of the drainage collection/conveyance system between Walker Street and Ravenel Street. Survey and mapping data from the original project indicates that the 48" diameter pipe continues further north between Walker Street and Ravenel Street to Monroe Street, where it reduces to 42" diameter.

A number of scenarios for parallel drainage collection/conveyance systems were considered for this portion of the **east branch watershed** area. All of the scenarios that were considered have a common downstream point of commencement at the junction described above (48" diameter inlet; 72" diameter outlet; NODE 1999). For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination.

Descriptions of the three primary parallel drainage improvement scenarios follow. The descriptions include summary observations resulting from comparison of model data from the current project as compared to the original project, especially for the following **critical areas**:

- The low point along Heyward Street between Ravenel Street and Walker Street (NODE 5306; Problem Area 4 in this study; also referred to as Problem Area 4 in original model)

- The low point along Monroe Street between Ravenel Street and Walker Street (NODE 5382; Problem Area 3 in this study; also referred to as Problem Area 3 in original model)

- The Monroe Street / Ravenel Street intersection (NODE 5397; Problem Area 2 in this study; also referred to as Problem Area 2 in original model)

*The Wheat Street / Amherst Avenue intersection was referred to as Problem Area 1 in the original model. That location is the subject area for the green infrastructure pilot and is therefore excluded from comparison.

As with the original project, observations pertaining to both **surcharge** [indicated when the hydraulic grade line (HGL) exceeds the pipe crown for a particular reach] and **ponding** [indicated when the hydraulic grade line (HGL) exceeds the ground elevation or top elevation at a particular structure] are included for areas north of Rosewood Drive. Similar observations are also included for areas downstream of Rosewood Drive since improvements to the system north of Rosewood Drive must consider negative impacts upon the system downstream of Rosewood Drive. Since increased **surcharge** is not typically considered a nuisance or cause for public complaint, for the purposes of this project **surcharge** is not considered a negative impact. Increased **ponding**, to the extent that it becomes a nuisance or a public complaint, is considered a negative impact.

Parallel Drainage Improvement Scenario 1 (EAST)

This scenario is based on the installation of a 72" diameter pipe from the beginning junction (east side of S. Ott Road, south of Rosewood Drive and north of Moss Avenue @ NODE 1999) and continuing to the northwest across the Rosewood Elementary School site, then west along the south side of Rosewood Drive to the Ravenel Street intersection, then crossing Rosewood Drive to proceed north along Ravenel Street and ultimately intercepting the existing "backbone" along Ravenel Street, south of the intersection of Ravenel Street and Cannon Street.

Critical Area Observations for Parallel Drainage Improvement Scenario 1 (EAST) (north of Rosewood Drive)

- 2-year and 10-year event ponding remains at the Monroe Street / Ravenel Street intersection (NODE 5397; Problem Area 2). The original model indicated the same 2-year and 10-year event ponding at that location.

- No 2-year event ponding at low point along Monroe Street (between Ravenel Street and Walker Street @ NODE 5382; Problem Area 3), but 10-year event ponding remains at a somewhat reduced level. The original model indicated the same, no 2-year event ponding at that location but 10-year event ponding was evident and at a level higher than indicated by Improvement Scenario 1.

- No 2-year or 10-year event ponding at low point (NODE 5306; Problem Area 4) along Heyward Street (between Ravenel Street and Walker Street). The original model indicated 10-year event ponding at this location.

Additional Observations for Parallel Drainage Improvement Scenario 1 (EAST) (north of Rosewood Drive)

- Notice given to some relief effects on "backbone" system starting at Wilmot Avenue (NODE 5547) and continuing downstream but ponding effects remain on "backbone" downstream to Monroe Street (NODE 5382). This is consistent with the original model except 2-year event ponding is eliminated at Wilmot Avenue (NODE 5547).

- No 2-year or 10-year ponding on "backbone" from Heyward Street (NODE 5305) downstream to Rosewood Drive. The original model indicated 10-year ponding from Heyward Street (NODE 5305) down through the drainage structures in the vicinity of the intersection of Cannon Street and Ravenel Street (the last being NODE 5898).

- No 2-year or 10-year event surcharge on "backbone" from Cannon Street (NODE 5897) downstream to Rosewood Drive. The original model indicated 2-year and 10-year event surcharge in the vicinity of the intersection of Cannon Street and Ravenel Street with 10-year event surcharge continuing downstream and through Rosewood Drive to NODE 5919 (in Rosewood Drive near Rosewood Elementary School).

- No 2-year or 10-year event surcharge or ponding on Rosewood Drive across from Ravenel Street (NODE 2039 to NODE 2042). The original model indicated 2-year and 10-year event surcharge at those nodes along with 2-year and 10-year event ponding at NODE 2039 (south side of Rosewood Drive near Rosewood Elementary School).

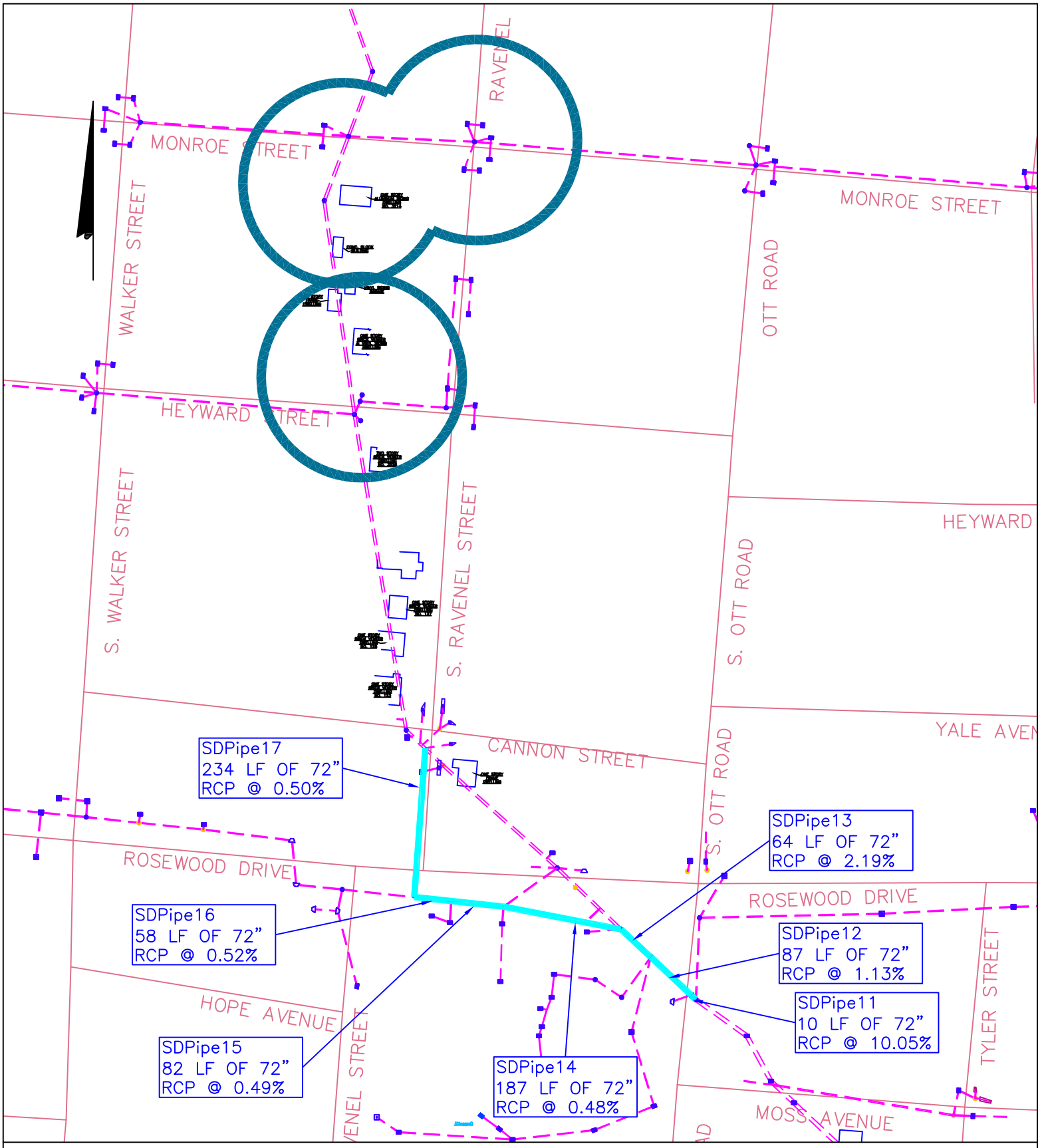
Observations for Parallel Drainage Improvement Scenario 1 (EAST) (south of Rosewood Drive)

- No additional 2-year event surcharge or ponding indicated
- Notice given to additional 10-year event surcharge from Harvard Avenue downstream to north end of Tempo Court (NODES 1701-1578)

Summary Observations for Parallel Drainage Improvement Scenario 1 (EAST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

EAST	Problem Area 2 (NODE 5397) Surcharge	Problem Area 2 (NODE 5397) Ponding	Problem Area 3 (NODE 5382) Surcharge	Problem Area 3 (NODE 5382) Ponding	Problem Area 4 (NODE 5306) Surcharge	Problem Area 4 (NODE 5306) Ponding
Original Model 2-year	YES	YES	YES	NO	YES	NO
Scenario 1 2-year	YES	YES	YES	NO	YES	NO
Original Model 10-year	YES	YES	YES	YES	YES	YES
Scenario 1 10-year	YES	YES	YES	YES	YES	NO



EAST BRANCH - 1 IMPROVEMENTS

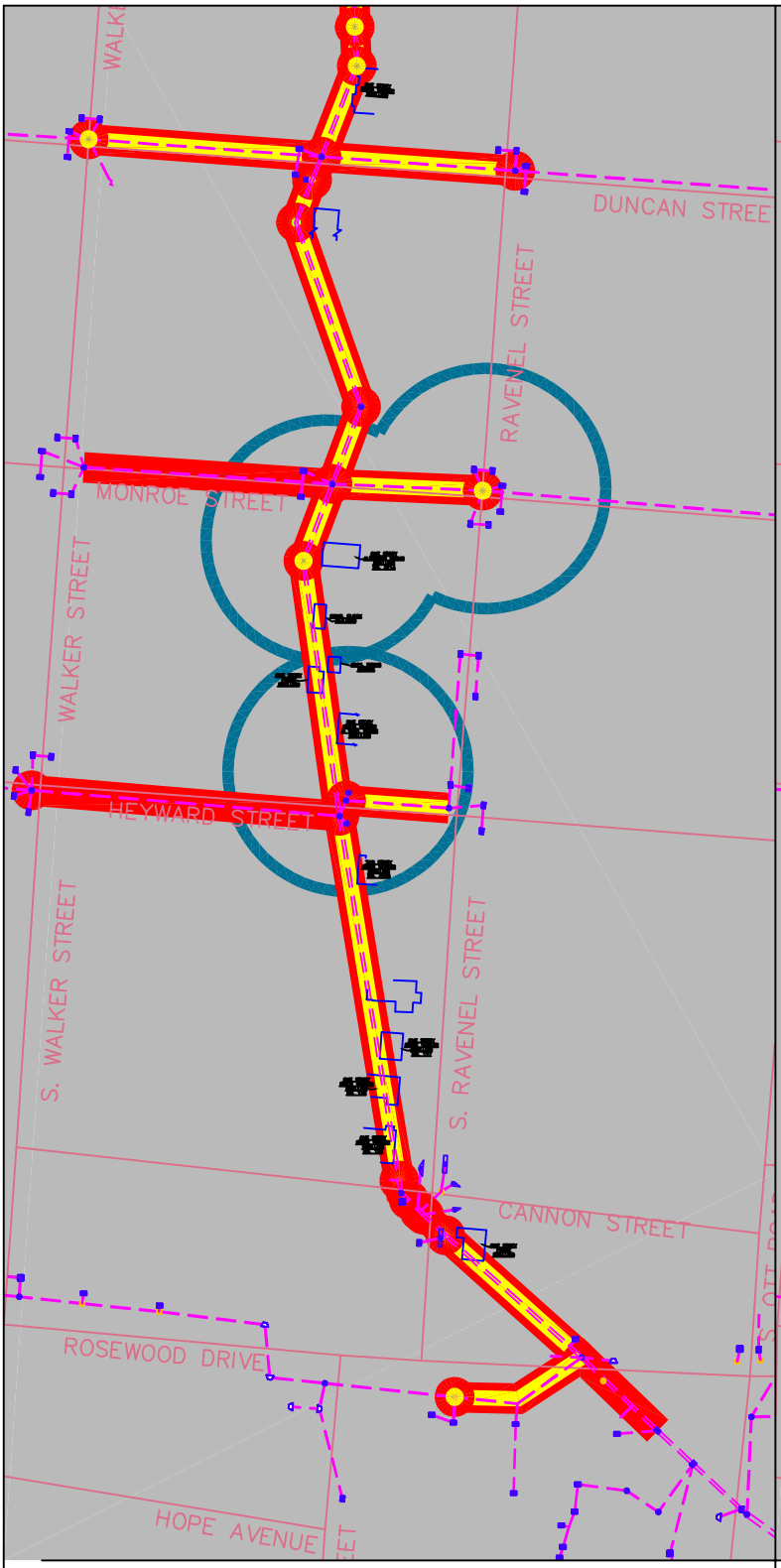
PROJECT:

SHANDON-ROSEWOOD WATERSHED

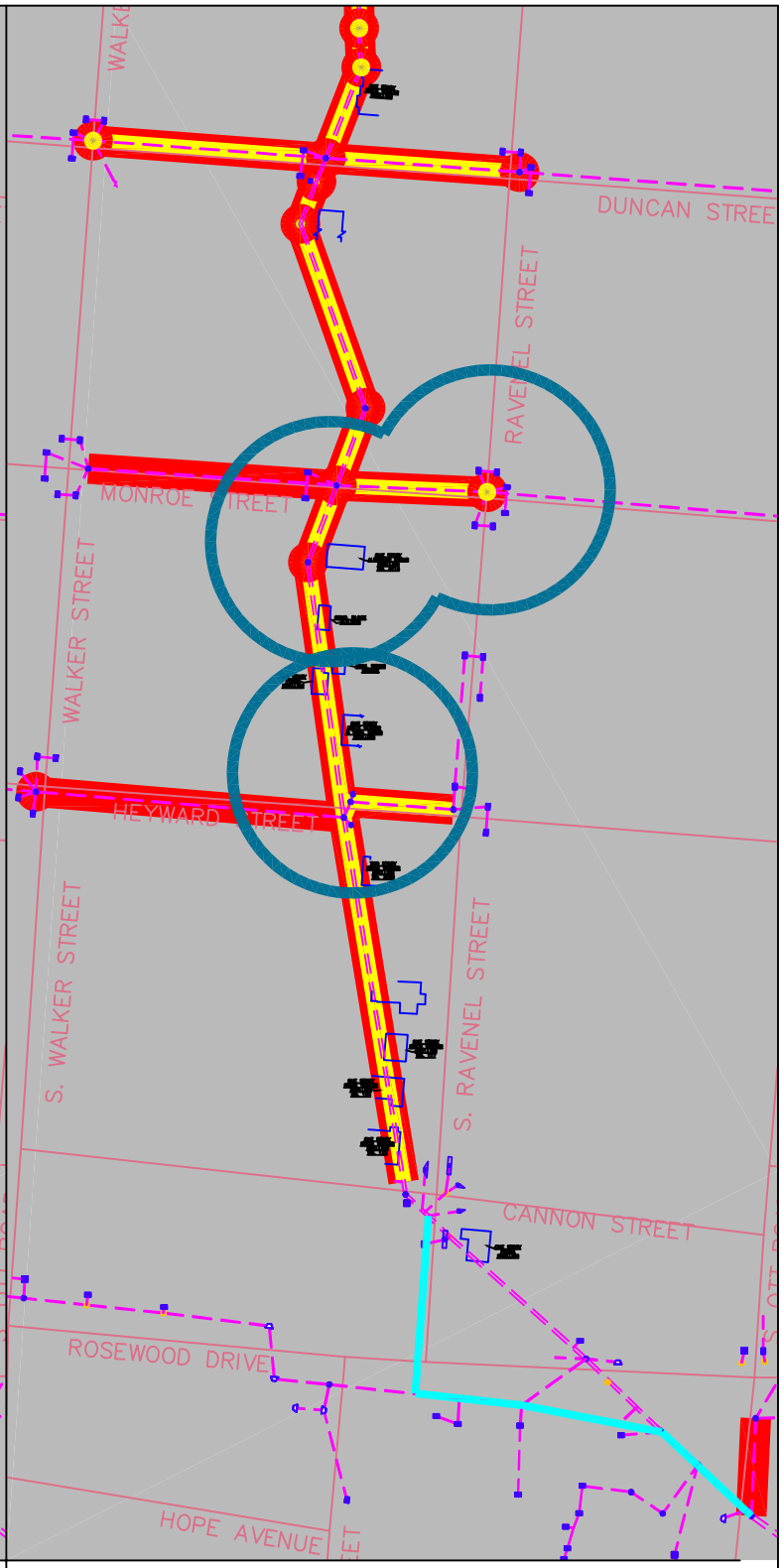
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

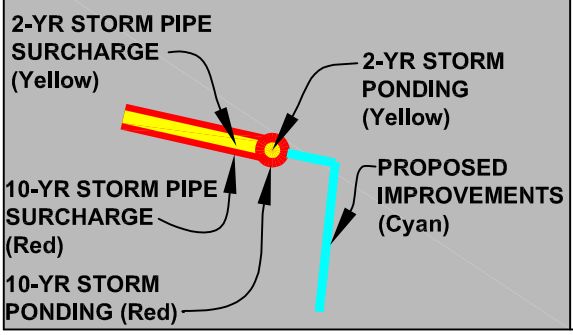


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 1

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED EAST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

Parallel Drainage Improvement Scenario 2 (EAST)

This scenario is based on the continuation of the 72" diameter pipe from **Scenario 1**, continuing north along Ravenel Street (from south of Cannon Street) to Heyward Street, then west along Heyward Street to intercept the "backbone" along Heyward Street, west of Ravenel Street.

Critical Area Observations for Parallel Drainage Improvement Scenario 2 (EAST) (north of Rosewood Drive)

- 2-year and 10-year event ponding remains at the Monroe Street / Ravenel Street intersection (NODE 5397). The original model indicated the same 2-year and 10-year event ponding.

- No 2-year or 10-year event ponding at low point along Monroe Street (between Ravenel Street and Walker Street @ NODE 5382). The original model indicated 10-year event ponding at this location.

- No 2-year or 10-year event ponding at low point along Heyward Street (between Ravenel Street and Walker Street @ NODE 5306). The original model indicated 10-year event ponding at this location.

Additional Observations for Parallel Drainage Improvement Scenario 2 (EAST) (north of Rosewood Drive)

- Notice given to increased relief effects on "backbone" with decrease in maximum water elevation (HGL) beginning at Wilmot Avenue (NODE 5547) but ponding effects remain on "backbone" downstream to Duncan Street (NODE 5942) as with the original model. The exception is at Wilmot Avenue (NODE 5547) where the 2-year event ponding is eliminated as in Scenario 1.

- No 2-year or 10-year event ponding from south of Duncan Street (NODE 5909) downstream to Rosewood Drive with the exceptions being the Heyward Street / Walker Street intersection (NODE 5342) and the Monroe Street / Ravenel Street intersection (NODE 5397). The original model indicated 10-year event ponding from north of Duncan Street (NODE 5492) to the intersection of Cannon Street and Ravenel Street (NODE 5898). The original model also indicated 2-year event ponding at the intersection of Monroe Street and Ravenel Street (NODE 5397) and 2-year event ponding along the "backbone" just south of Monroe Street (NODE 5930).

- 10-year event ponding remains at the Heyward Street / Walker Street intersection (NODE 5342) although there is a decrease in the maximum water elevation (HGL). The original model indicated 10-year event ponding but no 2-year event ponding at that location.

- No 2-year or 10-year event surcharge is indicated in pipes from Heyward Street (NODE 5306) downstream to Rosewood Drive. The original model indicated 2-year and 10-year event surcharge at Heyward Street and continuing downstream to the intersection of Cannon Street and Ravenel Street, with 10-year event surcharge continuing downstream and across Rosewood Drive to NODE 5919.

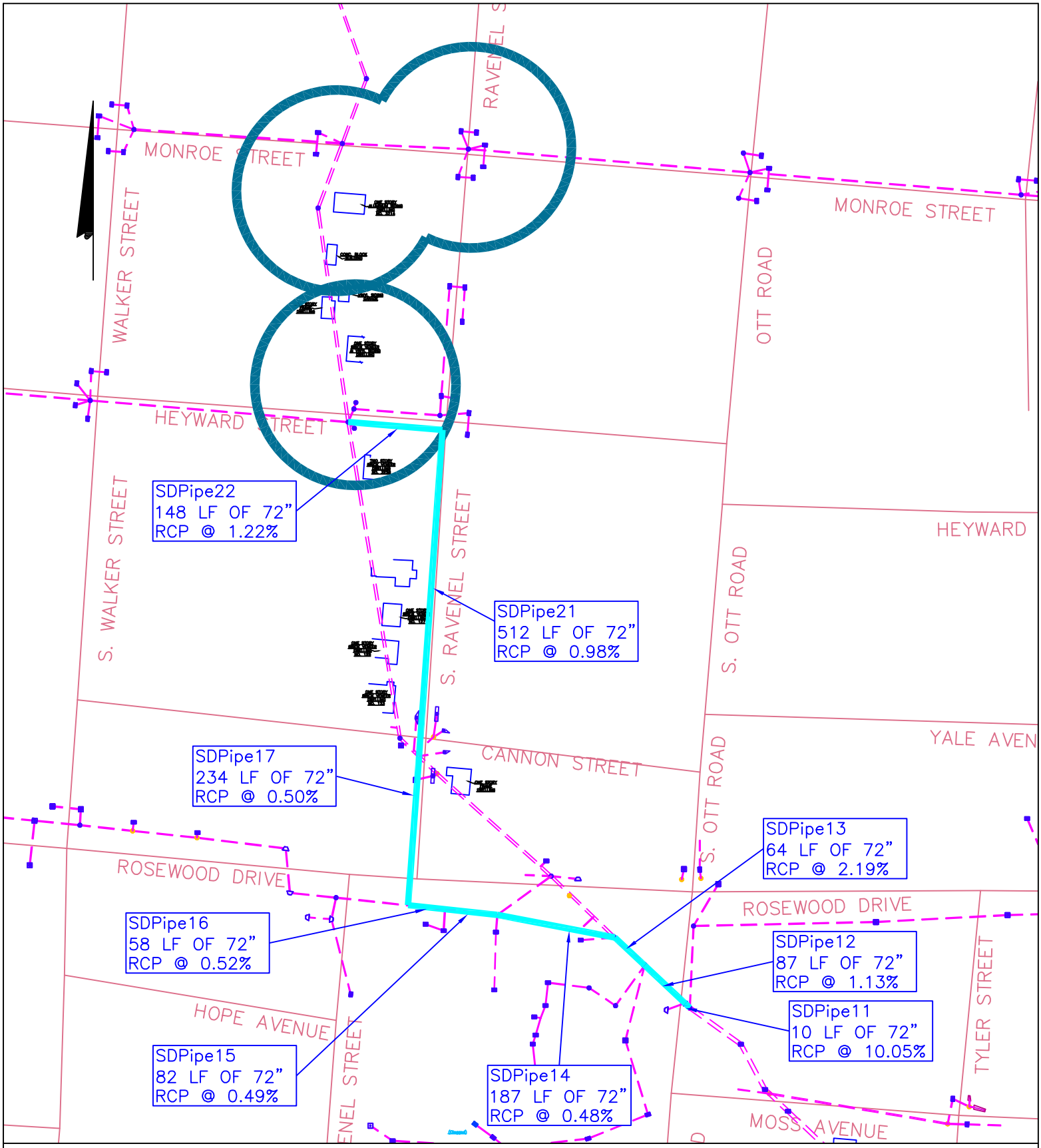
Observations for Parallel Drainage Improvement Scenario 2 (EAST) (south of Rosewood Drive)

- No additional 2-year event surcharge or ponding indicated
- Notice given to additional 10-year event surcharge from Harvard Avenue downstream to Tempo Court (NODES 1701-1576)
- Notice given to additional 10-year event ponding from Harvard Avenue downstream to Bonham Road (NODES 1700 -1589)

Summary Observations for Parallel Drainage Improvement Scenario 2 (EAST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

EAST	Problem Area 2 (NODE 5397) Surcharge	Problem Area 2 (NODE 5397) Ponding	Problem Area 3 (NODE 5382) Surcharge	Problem Area 3 (NODE 5382) Ponding	Problem Area 4 (NODE 5306) Surcharge	Problem Area 4 (NODE 5306) Ponding
Original Model 2-year	YES	YES	YES	NO	YES	NO
Scenario 2 2-year	YES	YES	YES	NO	NO	NO
Original Model 10-year	YES	YES	YES	YES	YES	YES
Scenario 2 10-year	YES	YES	YES	NO	NO	NO



EAST BRANCH - 2 IMPROVEMENTS

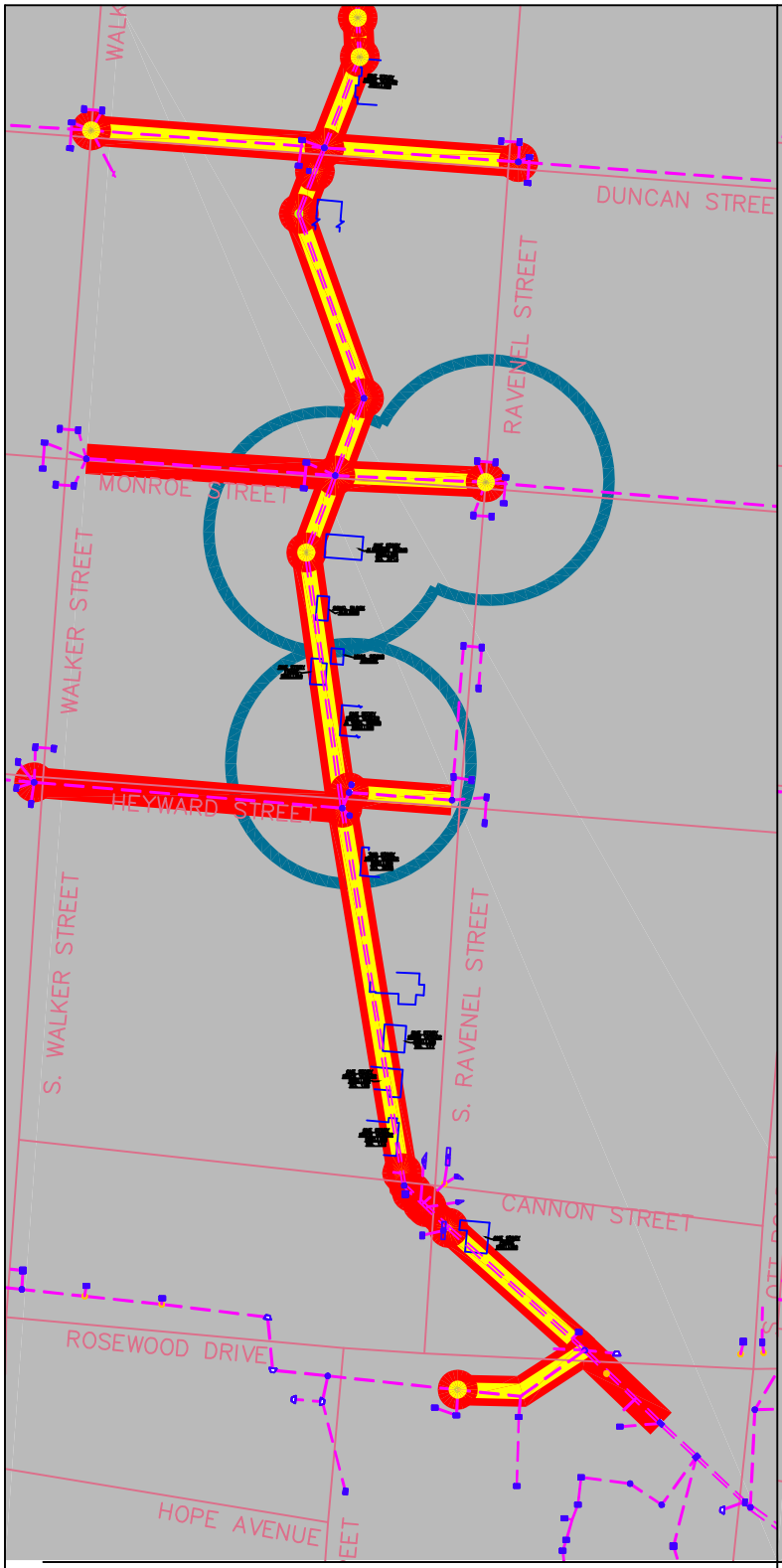
PROJECT:

SHANDON-ROSEWOOD WATERSHED

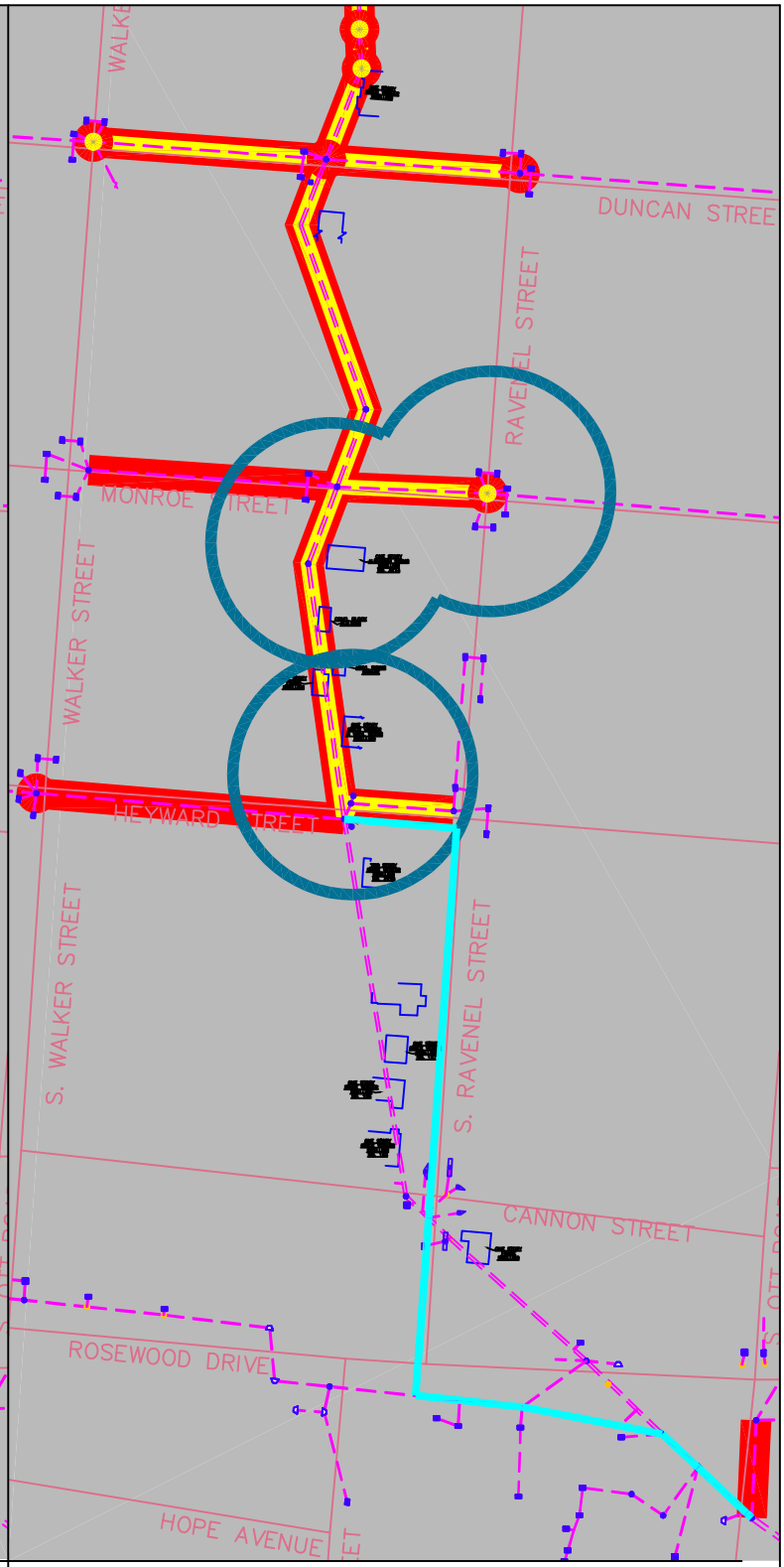
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

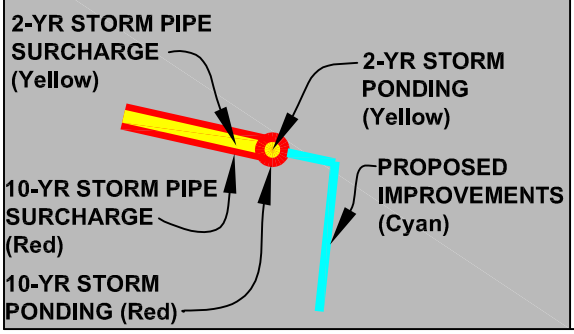


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 2

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED EAST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

Parallel Drainage Improvement Scenario 2A (EAST)

Scenario 2 indicated relief from 2-year and 10-year event ponding at Monroe Street but no relief from 2-year or 10-year event ponding was indicated just upstream and to the east at the Monroe Street / Ravenel Street intersection. **Scenario 2A** was explored as an alternative to determine if ponding relief could be achieved at the Monroe Street / Ravenel Street intersection. In lieu of the 72" pipe intercepting the "backbone" at Heyward Street, **Scenario 2A** represents the continuation of the 72" diameter pipe from the intersection of Heyward Street and Ravenel Street, continuing north along Ravenel Street to Monroe Street, then west along Monroe Street to intercept the "backbone" along Monroe Street, west of Ravenel Street. Feasibility issues exist with this scenario due to depth required to install 72" pipe. Compared to the existing "backbone" at Monroe Street, extension of 72" pipe to this location would require the 72" pipe invert to be approximately 10' below the ground surface, approximately 5' lower than the existing "backbone".

Critical Area Observations for Parallel Drainage Improvement Scenario 2A (EAST) (north of Rosewood Drive)

- No 2-year or 10-year event surcharge or ponding at the Monroe Street / Ravenel Street intersection (NODE 5397). The original model indicated 2-year and 10-year event ponding at this location.

- No 2-year or 10-year event surcharge or ponding at the low point along Monroe Street (NODE 5382). The original model indicated 10-year event ponding at this location.

- No 2-year or 10-year event surcharge or ponding at the low point along Heyward Street (NODE 5306). The original model indicated 2-year and 10-year event surcharge and 10-year event ponding at this location.

Additional Observations for Parallel Drainage Improvement Scenario 2A (EAST) (north of Rosewood Drive)

- Notice given to significant relief on "backbone" with decrease in maximum water elevation (HGL) beginning at Wilmot Avenue (NODE 5547) combined with elimination of 2-year event ponding at Wilmot Avenue (NODES 5547 and 5546) and between Wilmot Avenue and Duncan Street. The original model indicated 2-year and 10-year event ponding from Wilmot Avenue (NODE 5547) downstream to NODE 5929 (on "backbone", just upstream of Duncan Street).

- No 2-year or 10-year event ponding from Duncan Street (NODE 5492) downstream to Rosewood Drive, the exception being the Heyward Street / Walker Street intersection (NODE 5342). The original model indicated 10-year event ponding from Duncan Street (NODE 5492) to the intersection of Cannon Street and Ravenel Street (NODE 5898) along with 2-year event ponding at the intersection of Monroe Street and Ravenel Street (NODE 5397) and along the "backbone" just south of Monroe Street (NODE 5930).

- 10-year event ponding remains at the Heyward Street / Walker Street intersection (NODE 5342). The original model indicated 10-year event ponding but no 2-year event ponding at this location. This ponding is considered primarily an indication of inadequate capacity of existing sideline piping downstream of that intersection.

- No 2-year or 10-year event surcharge indicated in pipes from Monroe Street (NODE 5382) and adjacent intersections east and west (NODES 5397 and 5376 respectively) downstream to Rosewood Drive, with the exception being the Heyward Street / Walker Street intersection (NODE 5342). The original model indicated 2-year and 10-year event surcharge from Monroe Street continuing to the intersection of Cannon Street and Ravenel Street, with 10-year event surcharge continuing downstream across Rosewood Drive to NODE 5919 (in Rosewood Drive near Rosewood Elementary School).

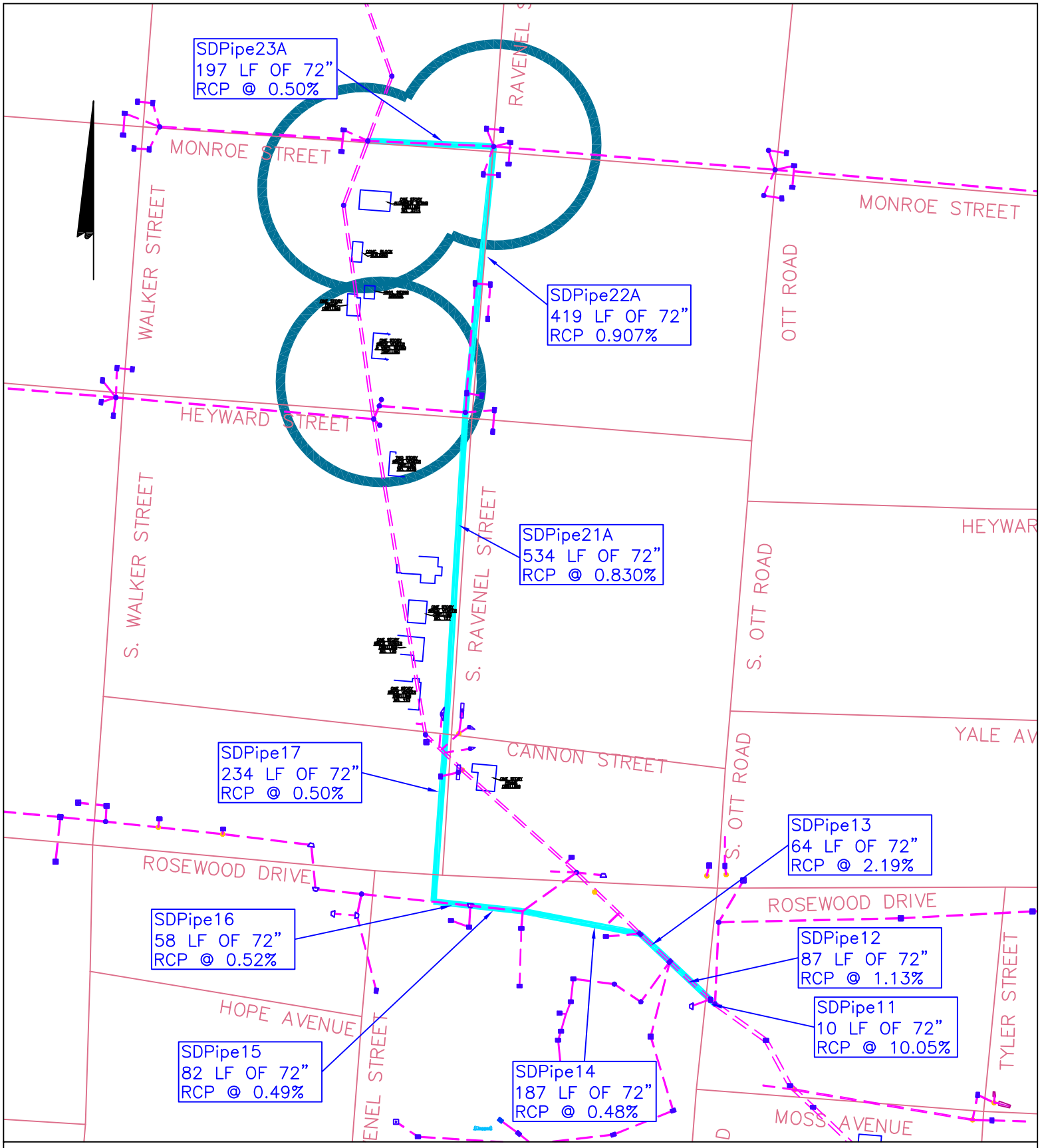
Observations for Parallel Drainage Improvement Scenario 2A (EAST) (south of Rosewood Drive)

- No additional 2-year event surcharge indicated
- Notice given to additional 10-year event surcharge from Capers Avenue downstream to Tempo Court (NODES 1805-1576).
- Notice given to additional 10-year event ponding from Harvard Avenue downstream to Bonham Road (NODES 1701-1589).

Summary Observations for Parallel Drainage Improvement Scenario 2A (EAST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

EAST	Problem Area 2 (NODE 5397) Surcharge	Problem Area 2 (NODE 5397) Ponding	Problem Area 3 (NODE 5382) Surcharge	Problem Area 3 (NODE 5382) Ponding	Problem Area 4 (NODE 5306) Surcharge	Problem Area 4 (NODE 5306) Ponding
Original Model 2-year	YES	YES	YES	NO	YES	NO
Scenario 2A 2-year	NO	NO	NO	NO	NO	NO
Original Model 10-year	YES	YES	YES	YES	YES	YES
Scenario 2A 10-year	NO	NO	NO	NO	NO	NO



EAST BRANCH - 2A IMPROVEMENTS

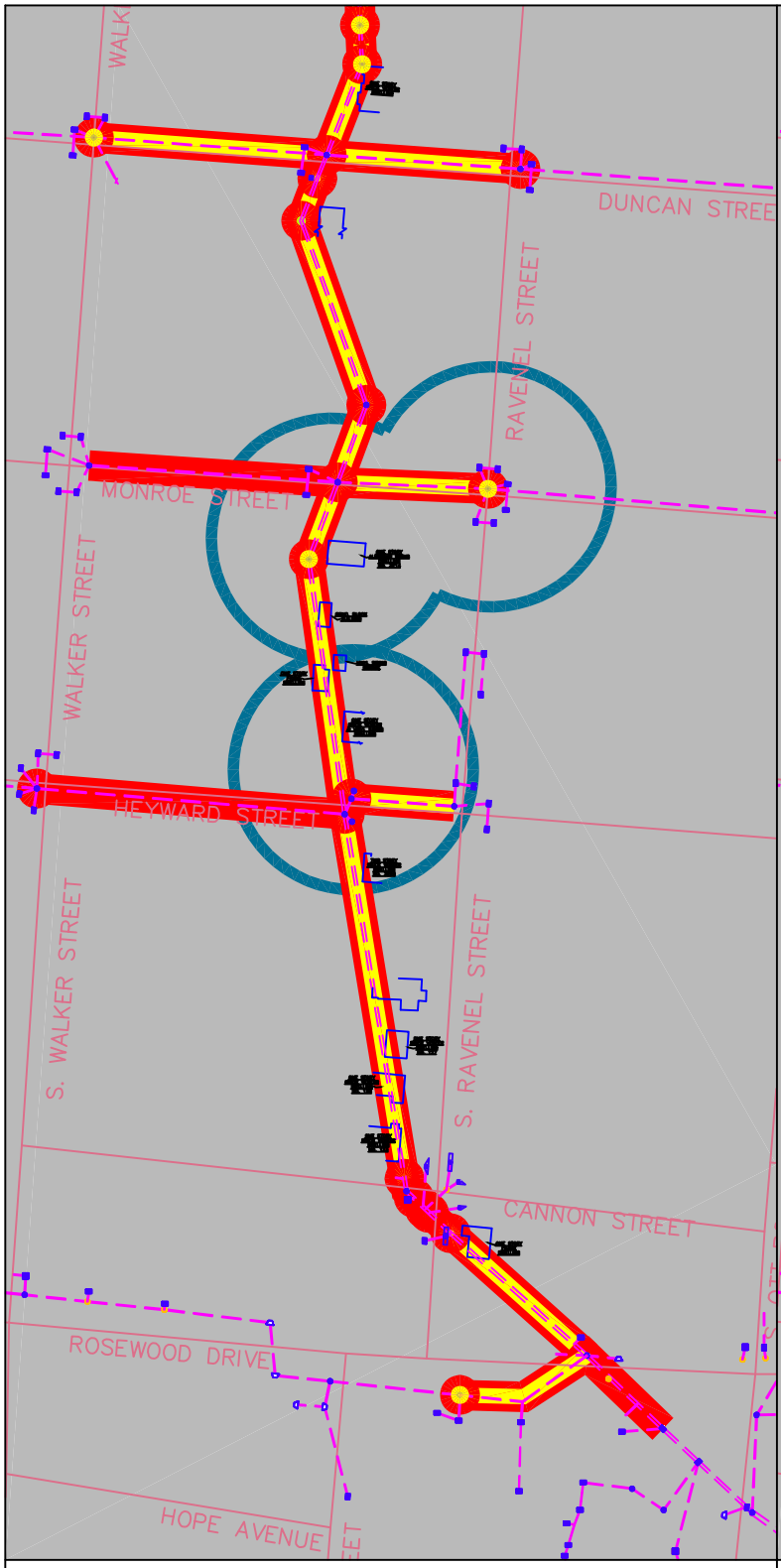
PROJECT:

SHANDON-ROSEWOOD WATERSHED

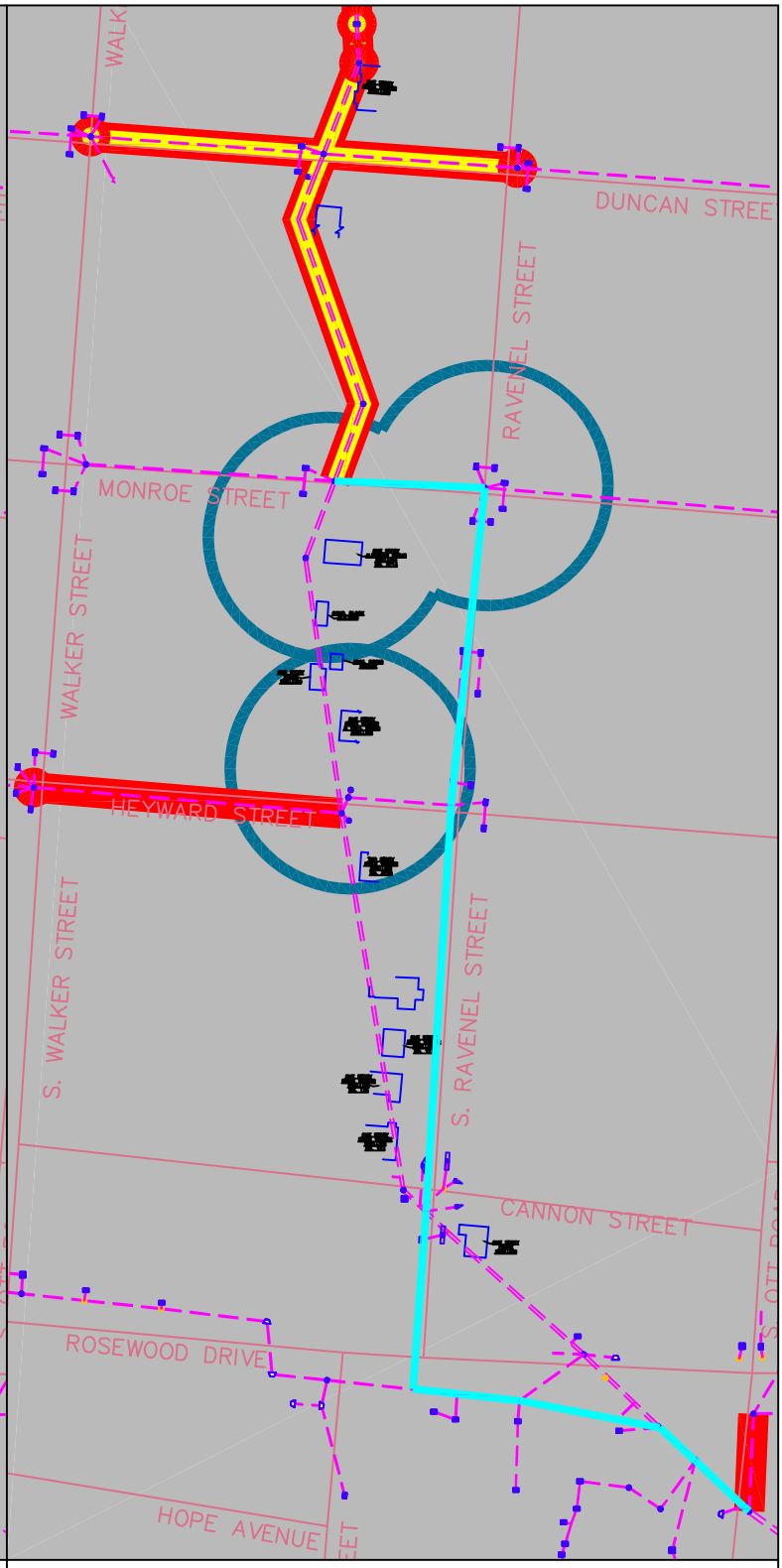
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

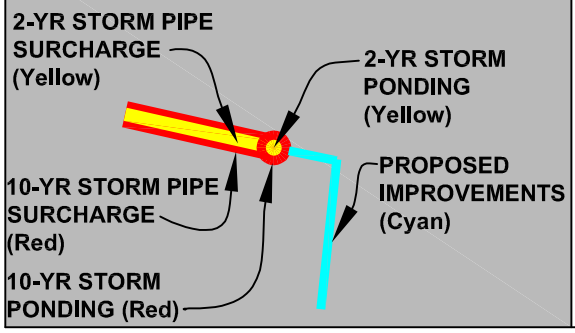


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 2A

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED EAST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

SECTION 3

EAST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS COMPARED TO E4 ALTERNATIVE FROM ORIGINAL MODEL

Comparison to Original Project's E4 Alternative Model (EAST)

During the original project, the E4 Alternative model was developed to predict effects on the storm drainage system downstream of Rosewood Drive, if/when improvements were made north of Rosewood Drive sufficient to eliminate ponding. In the original model, pipe diameters along the existing "backbone" north of Rosewood Drive were systematically upsized until ponding was eliminated along the "backbone" north of Rosewood Drive. However, unlike the E4 Alternative model, the Scenario 2A model still shows ponding at nodes along and upstream of Duncan Street. From that comparison alone it is anticipated that in Scenario 2A peak flows in pipes and ponding at nodes in the backbone downstream of Rosewood Drive should be less than shown in the E4 Alternative model.

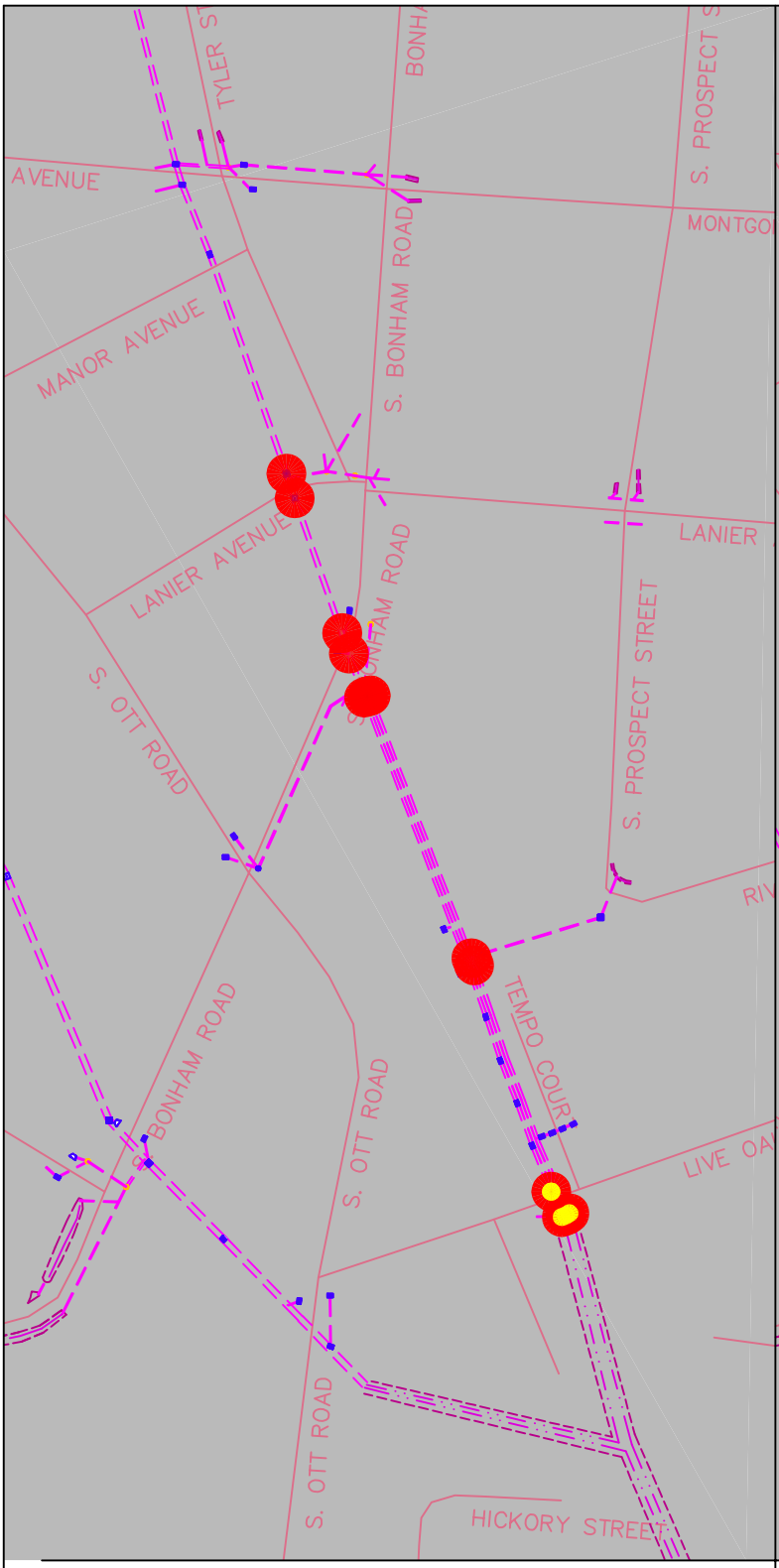
As a means of further comparison, pipe peak flow and node data of the system downstream of Rosewood Drive from the Scenario 2A model and the E4 Alternative model have been compared. That comparison has confirmed that in Scenario 2A the system downstream of Rosewood Drive is not getting the full 2-year and 10-year peak flows as in the E4 Alternative model.

Additional observations:

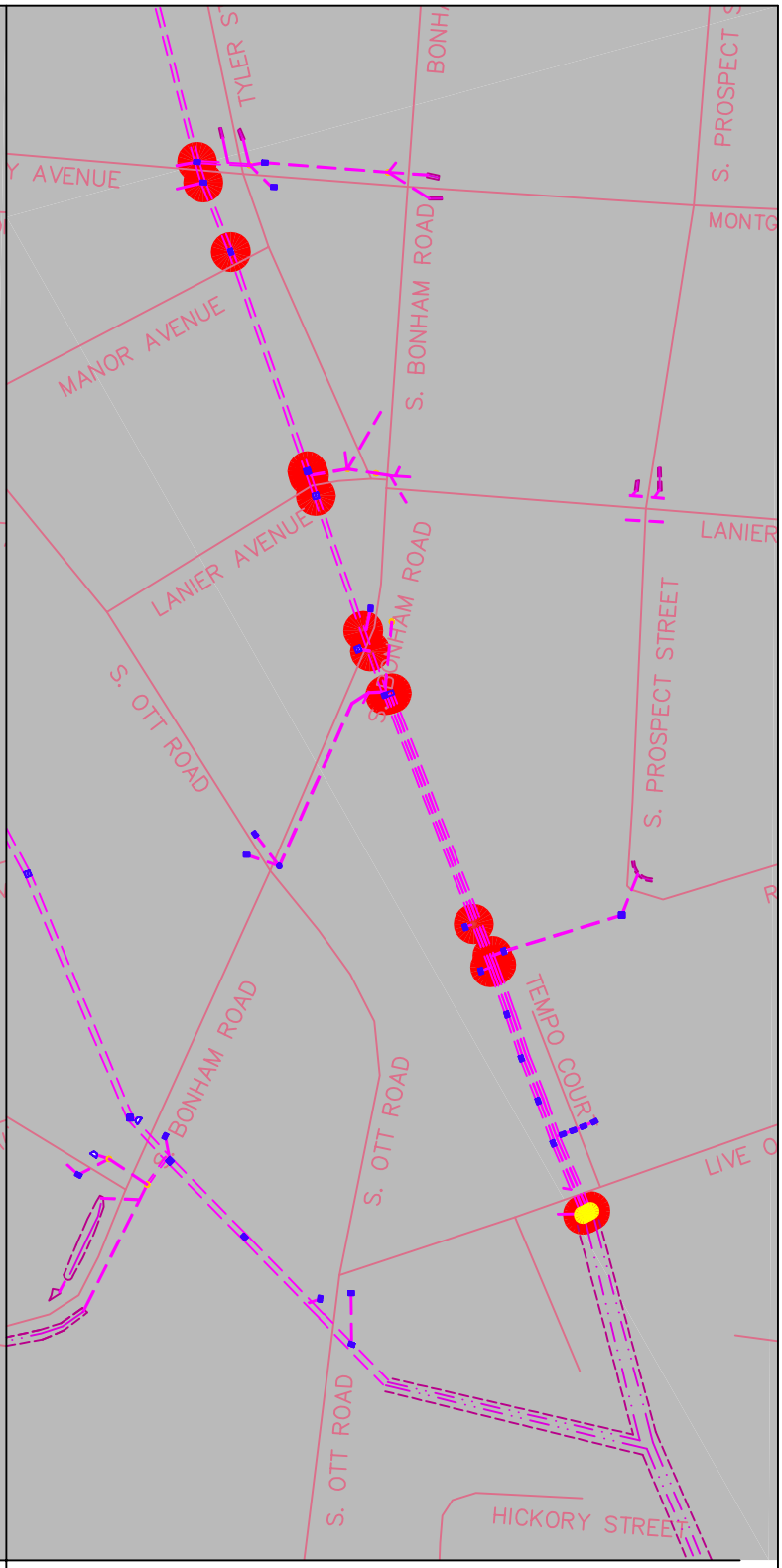
- From the low point in Ott Road next to Rosewood Elementary School (NODE 1999) and continuing downstream, the maximum peak flow in the Scenario 2A model is less than the E4 Alternative model, typically in the 90 percentile range.

- Nodes indicating 2-year and 10-year event ponding in the Scenario 2A model did not exceed the number and area of nodes indicating 2-year and 10-year event ponding in the E4 Alternative model.

- The observed Scenario 2A model results are as expected in comparison to the E4 Alternative model results.



NEW ANALYZED NETWORK SCENARIO 2A



ANALYZED NETWORK ALT E4

LEGEND

2-YR STORM PONDING (Yellow)

10-YR STORM PONDING (Red)

PROJECT:

SHANDON-ROSEWOOD WATERSHED EAST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

COX AND DINKINS
ENGINEERS · SURVEYORS

SECTION 4

EAST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS OPINIONS OF PROBABLE COST

East Branch (Drainage Improvement Scenarios & Opinion of Probable Costs)

The following is a general outline of the scopes of work anticipated in conjunction with the direct remedies described in **Scenarios 1, 2 and 2A**.

- Installation of new drainage collection/conveyance system from the beginning junction (east side of S. Ott Road, south of Rosewood Drive and north of Moss Avenue @ NODE 1999) and continuing to the northwest across the Rosewood Elementary School site, then west along the south side of Rosewood Drive to the Ravenel Street intersection, then crossing Rosewood Drive to proceed north along Ravenel Street and ultimately intercepting the existing "backbone" along various points upstream, with the most upstream location being along Monroe Street, west of Ravenel Street. [approximately 1,900 feet]

- Installation of replacement water mains and appurtenances along the route of the installation of new drainage collection/conveyance system

- Installation of replacement sanitary sewer mains and appurtenances along the route of the parallel installation of new drainage collection/conveyance system

- Repairs associated with natural gas mains and services, telephone lines and services and CATV lines and services along the route of the parallel installation of new drainage collection/conveyance system

- Landscape repairs in construction areas

- In place remedies for portions of the “backbone” drainage collection/conveyance system between Walker Street and Ravenel Street, including replacement of certain existing pipes and drainage structures and rerouting existing pipes that conflict with existing building structures

For the purposes of budgeting the contemplated remedies described previously have been expanded to include further detailed descriptions of work, including anticipated/projected costs, with the end result being an approximate cost per foot. These detailed descriptions are open for further discussion and comparison to comparable City of Columbia project costs. Those discussions and comparisons may result in significant modifications to the approximated costs.

See the descriptions on the following pages for further information and basis for the budget costs.

Work Scope, Material Description	Unit Cost	Cost Per Foot of Drainage Corridor
New 72” diameter RCP	$120 per foot	$120
Installation of New 72” diameter RCP; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$120 per foot	$120
New drainage structures; estimate five (5) per 400’ of pipe or per City block	$7500 each	$94
Traffic Control	Allowance	$12
Estimate ten (10) foot wide trench with average depth of ten (10) feet for flowable fill quantity (minus pipe cross section based on OD)	$100 per cubic yard	$220
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over ten (10) foot wide trench	$70 per square yard	$78
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	$15 per square yard	$45
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	$17 per foot	$17
Allowance for water service disconnects/reconnects (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
*Allowance for sanitary sewer service disconnects/reconnects (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
Allowance for landscape repairs (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
Approximate cost per foot of drainage installation corridor (beginning along Ott Road, then west along Rosewood Drive, then north along Ravenel Street, then north along Ravenel Street to Monroe Street; (Rosewood Drive crossing not included)	**$805**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
New 8” diameter water line	$15 per foot	$15
Installation of new 8” diameter water line; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$15 per foot	$15
New fire hydrants, valves & fittings; per 400’ of pipe or per City block	$8,000	$20
Traffic Control	Allowance	$6
Estimate four (4) foot wide trench with average depth of four (4) feet for flowable fill quantity	$100 per cubic yard	$60
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over four (4) foot wide trench	$70 per square yard	$31
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	Covered by storm drainage install	$0
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	$17 per foot	$17
Allowance for water service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
*Allowance for sanitary sewer service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
Allowance for landscape repairs (equates to $4,000.00 per City block using 400’ block)	$10 per foot	$10
Approximate cost of water main installation per foot of drainage installation corridor (Rosewood Drive crossing not included) It is assumed that water main replacement will be required for approximately ½ of the drainage parallel installation route.	**$186**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
New 8” diameter sanitary sewer line	$15 per foot	$15
Installation of new 8” diameter sanitary sewer line; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$25 per foot	$25
New manholes; estimate three (3) per 400’ of pipe or per City block	$9,000	$22
Traffic Control	Allowance	$6
Estimate six (6) foot wide trench with average depth of eight (8) feet for flowable fill quantity	$100 per cubic yard	$178
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over six (6) foot wide trench	$70 per square yard	$47
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	Covered by storm drainage install	$0
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	Covered by water & storm drainage install	$0
Allowance for water service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
*Allowance for sanitary sewer service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
Allowance for landscape repairs (equates to $4,000.00 per City block using 400’ block)	$10 per foot	$10
Approximate cost of sanitary sewer main installation per foot of drainage installation corridor (Rosewood Drive crossing not included) It is assumed that water main replacement will be required for approximately ½ of the drainage parallel installation route.	**$315**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
Natural gas, electric, telephone and CATV service impacts	$150,000.00 Allowance	$79
Approximate cost of natural gas, electric, telephone and CATV service repairs per foot of drainage installation corridor (Rosewood Drive crossing not included)	**$79**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
Rosewood Drive crossing	$600,000.00 Allowance	$NA
Approximate cost of 100' long Rosewood Drive crossing (allowance)	**$600,000**	

Based on the work scopes, projected unit costs and allowances as described in the preceding outline, the anticipated/projected cost per foot for installation of the drainage installation corridor (Rosewood Drive crossing not included) is approximately $805 + ($186 x ½) + ($315 x ½) + $79 = $1,134 per foot. Applying this cost per foot to the 1,900 foot long projected route, minus the 100' Rosewood Drive crossing, the anticipated/projected cost to install the described drainage improvements is approximately $2 million. Adding the $600,000 allowance for crossing Rosewood Drive increases that total to $2.6 million. It is also recommended that an additional 10% be added to the anticipated/projected cost to pay for remedial work for portions of the backbone drainage system situated in the corridor between Walker Street and Ravenel Street. Including that additional 10% brings the anticipated/projected cost of remedies for the **east branch watershed** Scenario 2A to approximately $2.8 million. The costs for the other two scenarios described herein (Scenario 1, and Scenario 2) have been based accordingly and the costs of all three scenarios are summarized below.

DRAINAGE IMPROVEMENT SCENARIO EAST	Opinion of Probable Construction Costs (OPCC)
Scenario 1	$1.5M
Scenario 2	$2.2M
Scenario 2A	$2.8M

The preceding costs are Opinions of Probable Construction Costs (OPCC) only and these OPCC's were developed without control of the costs or the price of labor, equipment or materials, or the ultimate bidder's (contractor's) methods of pricing. In addition, these OPCC's were developed without the benefit of final construction documents. As a result of these considerations, proposals based on final design and received through the competitive bidding process may vary significantly from these OPCC's.

Certain items are not included in these OPCC's. Some of the items not included are:

1. The cost of permanent and/or construction easements;

2. The cost of remedies for system issues north or south of Rosewood Drive for portions of the system that were not part of the active analysis;

3. The cost of remedies for system issues downstream of Rosewood Drive, whether existing or caused by north of Rosewood Improvements;

4. The cost of remedies in the event of negative impact on the open channel downstream of the piped outfall.

COX AND DINKINS
ENGINEERS · SURVEYORS

SECTION 5

EAST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS SUMMARY

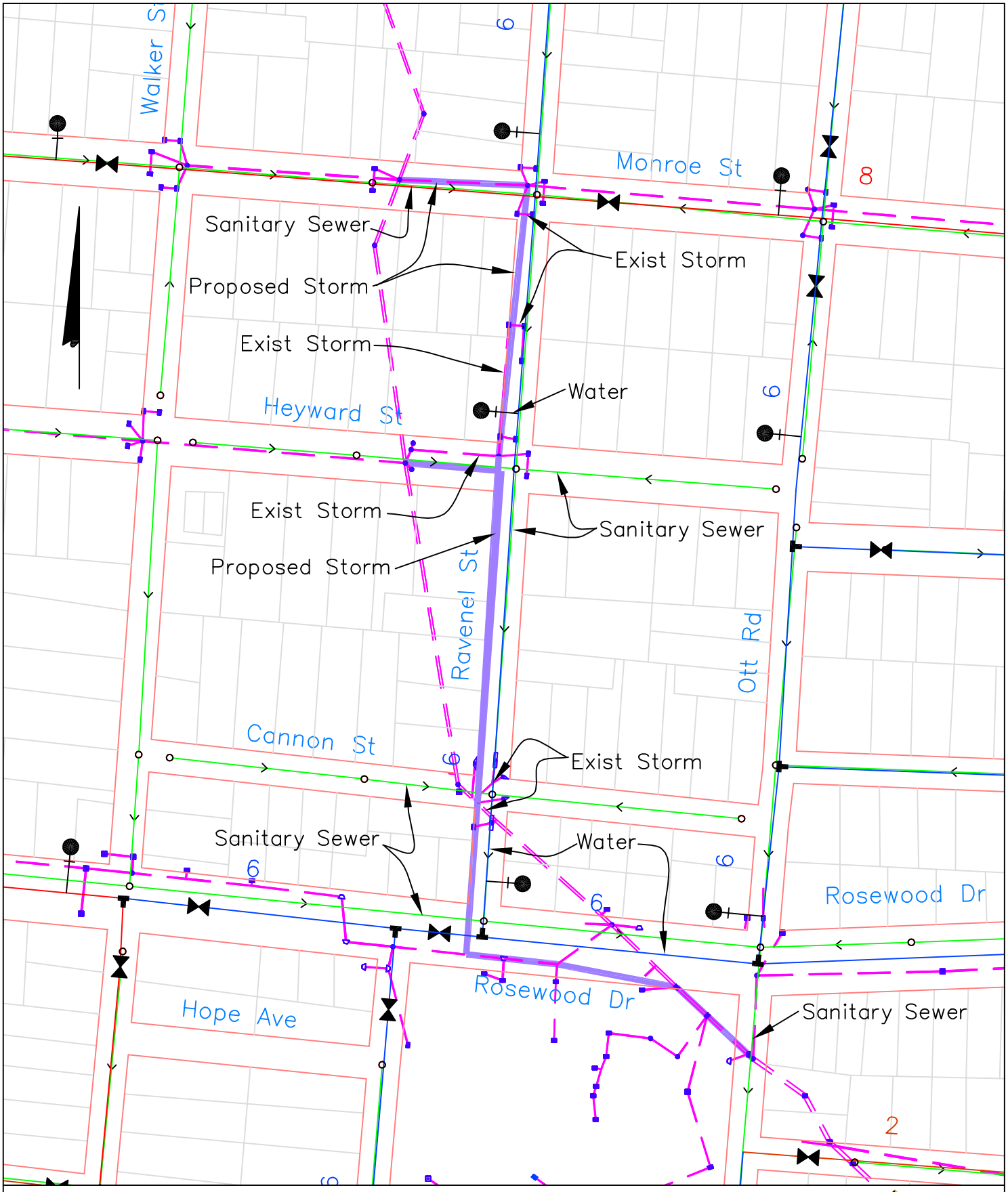
East Branch Drainage Improvement Scenarios Summary

In the preceding sections certain recommendations have been made for conceptual improvements for the **east branch watershed**, all of which have focused on intercepting runoff prior to its entry into the drainage system "backbone". Scenarios 1, 2A and 2B have a common downstream point of commencement being the pipe junction located along the east side of Ott Road, south of Rosewood Drive and north of Moss Avenue. Each of the scenarios considered also have in common the need to cross Rosewood Drive. For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination. The various improvements associated with each scenario, as measured by remedy to surcharge and ponding, are summarized on the following page. Without regard for costs, Scenario 2A clearly produces the better results as measured by remedy to surcharge and ponding.

The Opinion of Probable Construction Cost (OPCC) for each of the considered scenarios are summarized below. Each OPCC exceeds the $1,000,000.00 target that was defined in the criteria for this study. The anticipated costs associated with the Rosewood Drive crossing are a major contributor to that overage. In order to reduce those anticipated costs it is recommended that future design of the Rosewood Drive crossing focus on a means of supplementing the pipe that presently crosses Rosewood Drive and the pipe that presently crosses the Rosewood Elementary School site. If supplemental drainage pipes can parallel these existing pipes the cost associated with crossing Rosewood drive can be reduced, but in order to achieve that savings the intercept of the "backbone" on the north side of Rosewood Drive (along Ravenel Street) will be the critical component. That intercept will need to include a diversion that will proportionately "split" drainage between the new pipe that runs along Ravenel Street and the existing pipe in that runs through the block east of Ravenel Street, between Cannon Street and Rosewood Drive. However, in order to achieve this savings the existing pipe that runs through the through the block east of Ravenel Street, between Cannon Street and Rosewood Drive will have to remain in service. Additional savings may also be achieved if drainage routes can be arranged so as to eliminate or reduce the impacts upon existing utilities (water, sanitary sewer, natural gas, electric and telephone lines, CATV lines, etc.)

DRAINAGE IMPROVEMENT SCENARIO EAST	Opinion of Probable Construction Costs (OPCC)
Scenario 1	$1.5M
Scenario 2	$2.2M
Scenario 2A	$2.8M

EAST SUMMARY	Problem Area 2 (NODE 5397) Surcharge	Problem Area 2 (NODE 5397) Ponding	Problem Area 3 (NODE 5382) Surcharge	Problem Area 3 (NODE 5382) Ponding	Problem Area 4 (NODE 5306) Surcharge	Problem Area 4 (NODE 5306) Ponding
Original Model 2-year	YES	YES	YES	NO	YES	NO
Original Model 10-year	YES	YES	YES	YES	YES	YES
Scenario 1 2-year	YES	YES	YES	NO	YES	NO
Scenario 1 10-year	YES	YES	YES	YES	YES	NO
Scenario 2 2-year	YES	YES	YES	NO	NO	NO
Scenario 2 10-year	YES	YES	YES	NO	NO	NO
Scenario 2A 2-year	NO	NO	NO	NO	NO	NO
Scenario 2A 10-year	NO	NO	NO	NO	NO	NO



UTILITY LOCATIONS PER CITY OF COLUMBIA GIS

PROJECT:

SHANDON-ROSEWOOD WATERSHED

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400

GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

SECTION 6

WEST BRANCH

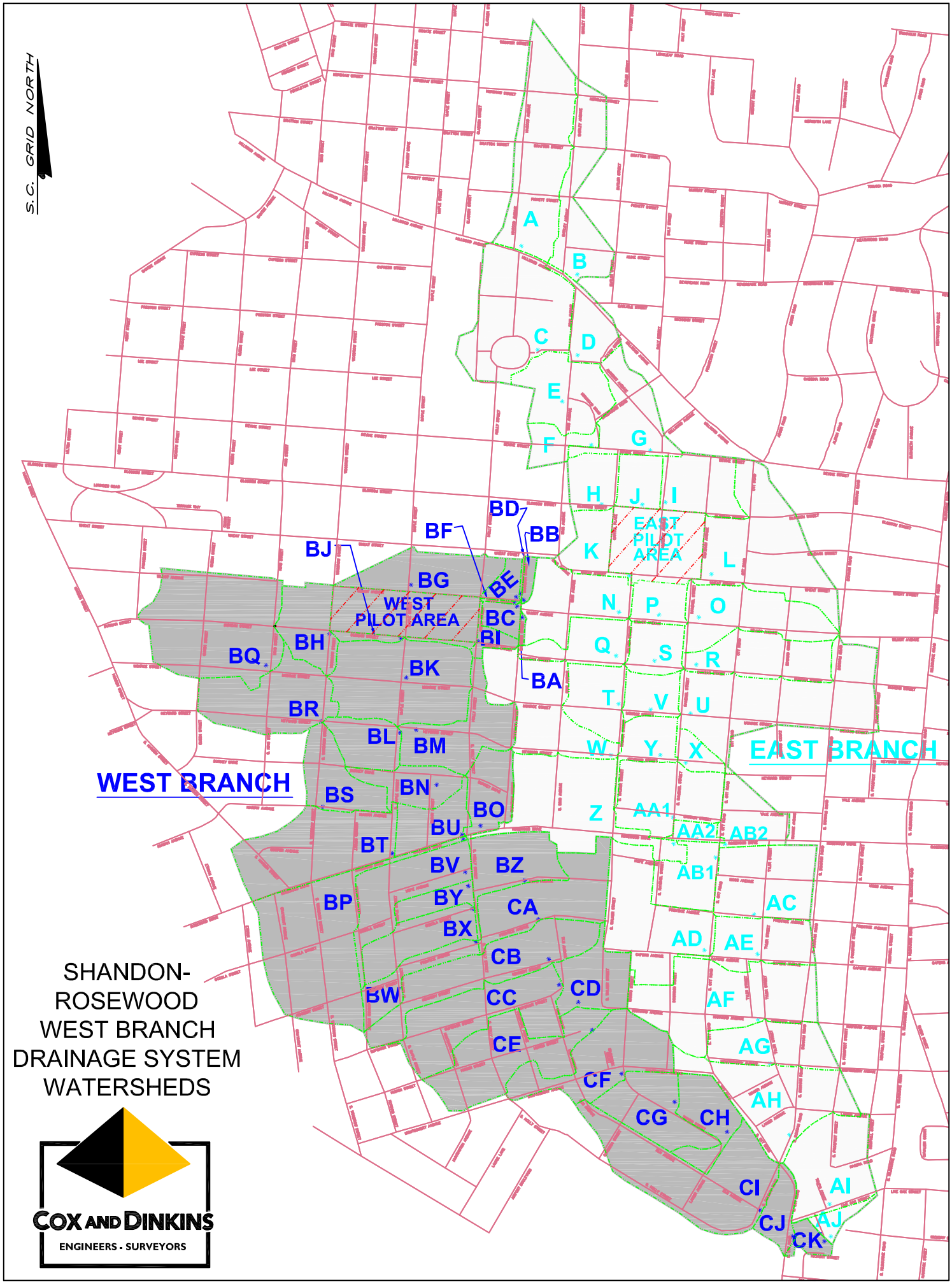
ORIGINAL MODEL WITH GREEN INFRASTRUCTURE PILOT AREAS INCORPORATED

West Branch Watershed (Original Model Revised to Incorporate Green Infrastructure Pilot Areas)

As originally modeled by Cox and Dinkins, Inc., the **west branch watershed** contained approximately 351 acres and was divided into thirty-seven (37) subwatersheds ranging in size from 0.2 acres to 25.6 acres. Since the time of the original project the City of Columbia has contracted for a drainage pilot study within the **west branch watershed** and that pilot study was based on green infrastructure, namely infiltration. For the **west branch watershed** the pilot study identified two problem intersections, namely Shandon Street/Wilmot Avenue and Monroe Street/Maple Street. Those intersections were also identified by the City of Columbia as problem areas in advance of the original project. The pilot study focused on the **west pilot area**, a 12.8± acre area consisting of the two blocks bound by Wilmot Avenue (N), Holly Street (E), Duncan Street (S) and Woodrow Street (W), being nearby both of the referenced problem intersections.

Cox and Dinkins, Inc. modeling for the current project began by incorporating the **west pilot area** (approximately 12.8 acres as identified by the green infrastructure pilot project) into the original Cox and Dinkins, Inc. model for the **west branch watershed**. Incorporating the **west pilot area** resulted in the removal of portions of certain subwatersheds from the original Cox and Dinkins, Inc. model. More specifically, portions of watersheds **BG**, **BH**, **BI** and **BJ** were also removed from the original **west branch watershed** model.

The following graphic shows the original arrangement of the **west branch watershed,** along with the locations of the referenced problem intersections and the **west pilot area**. That graphic is followed by the original **west branch** subwatershed data.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EAST PILOT AREA
WEST PILOT AREA
EAST BRANCH
WEST BRANCH
SHANDON-
ROSEWOOD
WEST BRANCH
DRAINAGE SYSTEM
WATERSHEDS
COX AND DINKINS
ENGINEERS - SURVEYORS

ROSEWOOD-SHANDON STORM DRAINAGE EVALUATION WEST BRANCH WATERSHED

WATERSHED ID	NODE	AREA (ACRES)	IMPERVIOUS %	OVERLAND SLOPE, %	TIME OF CONCENTRATION (MINUTES)	PERVIOUS AREA CURVE NO	2-YR PEAK FLOW AREA (CFS)	2-YR TOTAL SURFACE RUNOFF (INCHES)	10-YR PEAK FLOW AREA (CFS)	10-YR TOTAL SURFACE RUNOFF (INCHES)
BA	5211	0.32	48	0.59	16.20	79	0.62	1.57	1.16	2.99
BB	5210	0.91	45	1.29	15.50	78	1.64	1.45	3.16	2.80
BC	5209	2.15	46	0.48	28.40	78	2.87	1.48	5.57	2.86
BD	5205	0.22	100	1.47	5.70	98	0.99	3.23	1.47	4.91
BE	5206	2.04	50	0.72	23.90	80	3.34	1.63	6.26	3.06
BF	5208	0.20	100	0.46	9.50	98	0.82	3.26	1.22	4.96
BG (old)	5177	14.76	46	0.58	47.80	78	13.86	1.48	27.19	2.85
BG (new)	**5177**	**9.98**	**46**	**0.58**	**47.80**	**78**	**9.37**	**1.48**	**18.38**	**2.85**
BH (old)	5219	8.50	34	0.72	33.70	74	8.17	1.23	17.21	2.51
BH (new)	**5219**	**7.82**	**34**	**0.72**	**33.70**	**74**	**7.51**	**1.23**	**15.83**	**2.51**
BI (old)	5168	2.04	39	0.85	20.80	75	2.79	1.29	5.71	2.60
BI (new)	**5168**	**1.73**	**39**	**0.85**	**20.20**	**76**	**2.54**	**1.35**	**5.07**	**2.67**
BJ (old)	5157	8.54	45	0.98	27.90	78	11.59	1.48	22.54	2.86
BJ (new)	**5157**	**1.52**	**38**	**1.07**	**27.10**	**75**	**1.78**	**1.29**	**3.65**	**2.59**
BK	5128	20.55	38	0.83	36.70	75	19.72	1.29	40.73	2.59
BL	5073	6.13	46	1.42	30.00	78	7.92	1.49	15.43	2.86
BM	5077	11.53	47	1.01	38.00	79	13.40	1.55	25.71	2.95
BN	5027	6.20	47	1.97	23.00	78	9.40	1.49	18.24	2.88
BO	2155	6.64	53	1.49	24.90	81	11.09	1.71	20.50	3.16
BP	10409	25.57	57	0.77	79.90	82	20.02	1.75	36.78	3.20
BQ	5850	25.22	39	1.17	56.40	75	17.79	1.28	37.08	2.57
BR	5783	14.43	48	0.78	51.70	79	13.47	1.54	25.96	2.94
BS	5759	8.11	43	1.40	28.30	77	10.36	1.42	20.48	2.77
BT	5920	18.60	60	1.17	40.00	83	25.13	1.84	45.10	3.33
BU	2259	6.16	72	2.20	15.00	87	16.76	2.18	28.04	3.75
BV	1903	11.68	70	1.31	35.50	87	20.13	2.17	34.10	3.73
BW	2136	5.42	53	1.04	44.20	81	6.27	1.70	11.67	3.15
BX	1907	8.33	54	1.28	35.70	81	11.08	1.69	20.54	3.13
BY	1240	3.25	56	2.18	15.90	82	7.05	1.77	12.69	3.23
BZ	1226	9.16	62	3.49	14.00	84	22.82	1.94	39.85	3.46
CA	1214	13.78	45	2.13	29.80	78	17.92	1.50	34.92	2.88
CB	10410	16.64	46	2.32	39.40	78	17.92	1.48	35.06	2.85
CC	1547	16.28	47	2.85	32.20	79	21.05	1.55	40.34	2.95
CD	10413	7.96	46	2.86	20.20	78	12.91	1.48	24.88	2.85
CE	1130	16.38	48	3.50	27.70	79	23.44	1.56	44.76	2.96

All Hydrographic Shapes are Curvilinear.

All Shape Factors are 484.

ROSEWOOD-SHANDON STORM DRAINAGE EVALUATION WEST BRANCH WATERSHED

WATERSHED ID	NODE	AREA (ACRES)	IMPERVIOUS %	OVERLAND SLOPE, %	TIME OF CONCENTRATION (MINUTES)	PERVIOUS AREA CURVE NO	2-YR PEAK FLOW AREA (CFS)	2-YR TOTAL SURFACE RUNOFF (INCHES)	10-YR PEAK FLOW AREA (CFS)	10-YR TOTAL SURFACE RUNOFF (INCHES)
CF	1084	14.21	49	4.89	17.80	79	25.68	1.56	48.54	2.96
CG	1052	10.07	42	5.47	14.00	77	18.38	1.43	35.86	2.79
CH	1031	7.19	28	3.07	20.70	71	7.74	1.05	17.30	2.25
CI	1006	22.47	41	3.22	35.50	76	23.34	1.35	47.24	2.68
CJ	1001	4.11	26	2.79	20.10	71	4.52	1.05	10.08	2.25
CK	10440	1.90	45	2.75	11.90	78	3.87	1.50	7.38	2.90

All Hydrographic Shapes are Curvilinear.

All Shape Factors are 484.

Following removal of the **west pilot area** from the original **west branch watershed** model the downstream remainder of the **west branch watershed** was studied for areas in which conventional drainage system improvements may have application. The focus of that study area was further influenced by the following:

(1) the green infrastructure pilot study extrapolated pilot results to determine that green infrastructure management is required on 35.3 acres within the **west branch watershed;**

(2) the green infrastructure pilot study contemplates application of infiltration practices in the areas of the intersections of Shandon Street/Wilmot Avenue and Monroe Street/Maple Street;

(3) the original model by Cox and Dinkins, Inc. indicated underperformance of the stormwater collection system in the **west branch watershed** occurred primarily north of Rosewood Drive.

As a result of these influences, the primary study area for application of conventional drainage system improvements in the **west branch watershed** has been focused on the area downstream of the intersection of Monroe Street / Maple Street and north of Rosewood Drive.

SECTION 7

WEST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS (SCENARIOS 1, 2, 2A & 2B)

Background for West Branch Drainage Improvement Scenarios

As identified during the original project, the **west branch watershed** does not have a single, central "backbone" drainage collection/conveyance system. Instead, the **west branch watershed** has two primary drainage collection/conveyance systems north of Rosewood Drive. The **first primary** system is the drainage collection/conveyance system associated with Maple Street, from the Maple Street / Wilmot Avenue intersection south to Burney Drive, then east along Burney Drive to Sloan Street where it turns southeasterly through the block and extends to Rosewood Drive, east of the S. Holly Street intersection. Surveying and mapping data from the original project identifies this location as NODE 2155, the junction of a 42" diameter inlet pipe and 54" diameter outlet pipe located along the north side of Rosewood Drive, between S. Holly Street and S. Shandon Street. The **second primary** system is the drainage collection/conveyance system associated with Woodrow Street, from the Woodrow Street / Monroe Street intersection south to Rosewood Drive, then east along the north side of Rosewood Drive to the west side of the S. Holly Street intersection. NODE 2259, identified by surveying and mapping data from the original project identifies this location as a junction on a 54" diameter pipe located near the S. Holly Street / Rosewood Drive intersection. The **first primary** and the **second primary** systems then converge along Hope Avenue, south of Rosewood Drive and east of S. Holly Street. Surveying and mapping data from the original project identifies the convergence of the **first primary** and the **second primary** systems as NODE 1226.

Due to the configuration of the **west branch watershed**, the original project did not identify a single, central corridor for parallel installation and intercept. Instead, the original project included iterative analyses whereby existing pipes within the analyzed collection/conveyance system were systematically upsized until such time that **ponding** was eliminated north of Rosewood Drive. The most common downstream point of commencement for the original project models was NODE 2155, situated on the **first primary** collection/conveyance system described above. Consideration for downstream point of commencement was also given to NODE 2259, situated on the **second primary** collection/conveyance system described above.

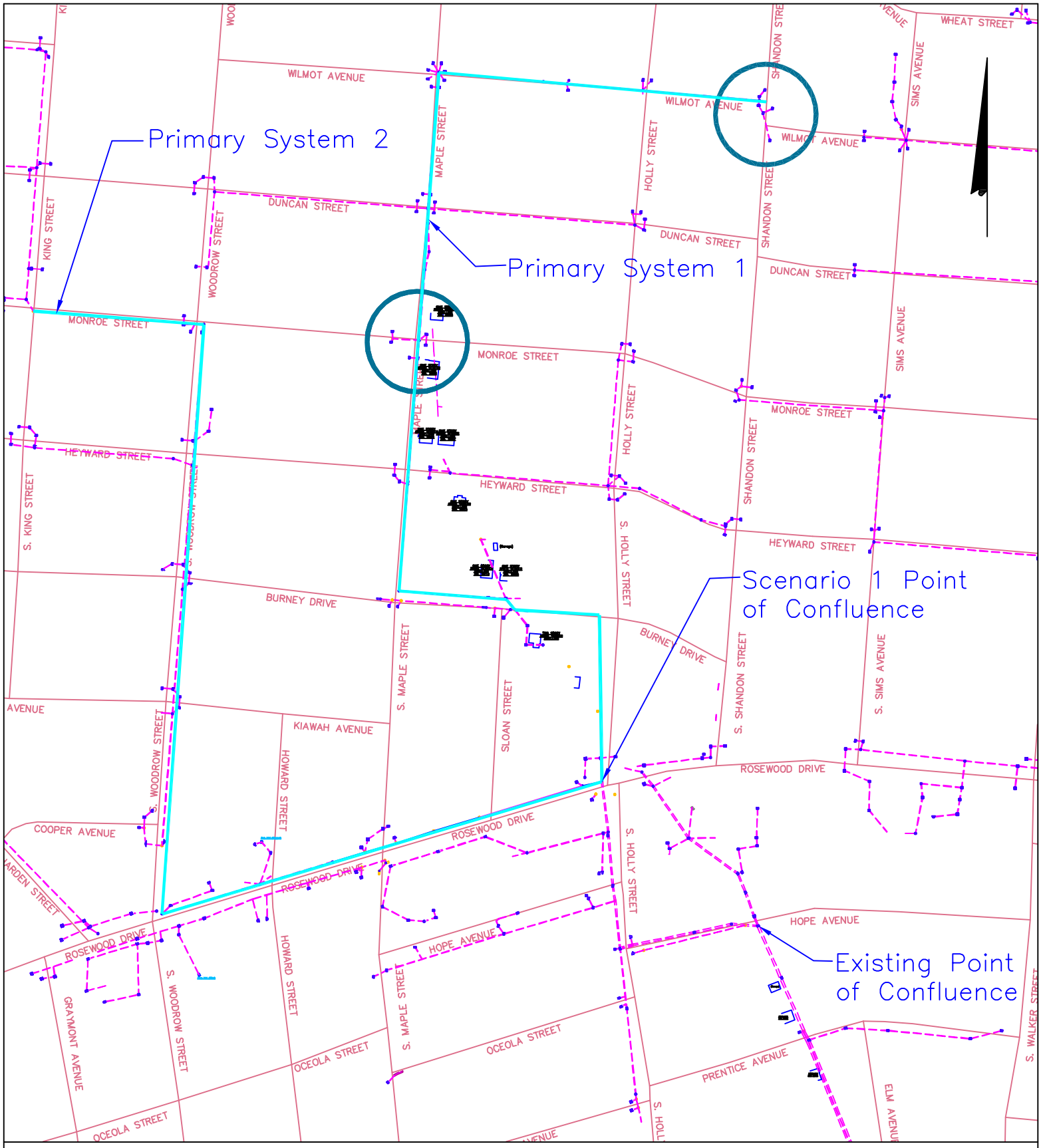
A number of scenarios for parallel drainage collection/conveyance systems were considered for this portion of the **west branch watershed** area. One scenario that was considered has a downstream point of commencement at the junction described above as NODE 2259, situated on the **second primary** collection/conveyance system. The other three scenarios that were considered have a common downstream point of commencement at the junction described above as NODE 2155, situated on the **first primary** collection/conveyance system. For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination.

Descriptions of the four primary parallel drainage improvement scenarios follow. The descriptions include summary observations resulting from comparison of model data from the current project as compared to the original project, especially for the following **critical area**:

- The Monroe Street / Maple Street intersection (NODE 5130; Problem Area 6 in this study; also referred to as Problem Area 6 in original model)

*The Shandon Street / Wilmot Avenue area was referred to as Problem Area 5 in the original model. That location is upstream of the subject area for the green infrastructure pilot and is therefore excluded from comparison.

As with the original project, observations pertaining to both **surcharge** [indicated when the hydraulic grade line (HGL) exceeds the pipe crown for a particular reach] and **ponding** [indicated when the hydraulic grade line (HGL) exceeds the ground elevation or top elevation at a particular structure] are included for areas north of Rosewood Drive. Similar observations are also included for areas of Rosewood Drive since improvements to the system north of Rosewood Drive must consider negative impacts upon the system downstream of Rosewood Drive. Since increased **surcharge** is not typically considered a nuisance or cause for public complaint, for the purposes of this project **surcharge** is not considered a negative impact. Increased **ponding**, to the extent that it becomes a nuisance or a public complaint, is considered a negative impact.



WEST BRANCH - 1 (NEW POINT OF CONFLUENCE)

PROJECT:

SHANDON-ROSEWOOD WATERSHED

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 400 800
GRAPHIC SCALE IN FEET
SCALE: 1"=400'

COX AND DINKINS
ENGINEERS - SURVEYORS

Parallel Drainage Improvement Scenario 1 (WEST)

This scenario is based on the installation of a 48" diameter pipe, beginning on the **second primary** system at the junction of the 54" diameter pipe at the Rosewood Drive / S. Holly Street intersection (NODE 2259) and continuing north along S. Holly Street to Burney Drive, then west along Burney Drive to intercept existing drainage at the low point along Burney Drive, east of the Sloan Street intersection. The connection to NODE 2259 as described would create a connection between the **first primary** system and the **second primary** system within the **west branch watershed** and would divert runoff from the **first primary** system into the **second primary** system.

Critical Area Observations for Parallel Drainage Improvement Scenario 1 (WEST) (north of Rosewood Drive)

- There is a decrease in water surface elevation (HGL) for the 2-year and 10-year event at the Monroe Street / Maple Street intersection (NODE 5130), but ponding remains. The original model also indicated 2-year and 10-year event ponding at this location.

- Notice given to relief of 2-year and 10-year event ponding at the Maple Street / Monroe Street intersection (NODE 5130), with the calculated 2-year event ponding volume being reduced by 95% and the calculated 10-year event ponding volume being reduced by 50%. At 50' downstream (NODE 5128), the calculated 2-year event ponding volume was reduced by 51% and the calculated 10-year event ponding volume was reduced by 37%.

Additional Observations for Parallel Drainage Improvement Scenario 1 (WEST) (north of Rosewood Drive)

- Notice given to significant decrease in water surface elevation (HGL) beginning at the Duncan Street / Woodrow Street intersection (NODE 5219) and the Duncan Street / Holly Street intersection (NODE 5168) and continuing downstream to Rosewood Drive.

- Notice given to relief of 2-year event surcharge at approximately 190' south of the intersection of the Duncan Street / Maple Street (NODE 5145) and continuing upstream to the intersection of Duncan Street / Maple Street (NODE 5869). The original model indicated 2-year event surcharge in this area. As with the original model, 10-year event surcharge remains for Scenario 1.

- No 2-year or 10-year event ponding from the intersection of Heyward Street / Maple Street (NODE 5073) to Rosewood Drive (NODE 2259). The original model indicated 10-year event ponding at the intersection of Heyward Street / Maple Street (NODE 5073).

- No 2-year or 10-year event surcharge from the intersection of Burney Drive / Sloan Street (NODE 5883) to Rosewood Drive (NODE 2259) including the line of pipe through the block between Heyward Street and Burney Drive (NODE 5077 to 5883), the exception being the section from NODE 5013 to 5883 which still indicates 10-year event surcharge. The original model indicated 2-year and 10-year surcharge from the intersection of Burney Drive / Sloan Street (NODE 2259) to the **first primary** crossing at Holly Street (Node 5874) and 10-year event surcharge extending through the block between Heyward Street and Burney Drive to NODE 5077.

- Although the connection to NODE 2259 diverted runoff from the **first primary** system into the **second primary** system, no significant adverse effect was noticed on the **second primary** system. The water surface elevation (HGL) was noted to rise upstream and downstream of NODE 2259, but not enough to cause additional instances of surcharge or ponding.

Observations for Parallel Drainage Improvement Scenario 1 (WEST) (south of Rosewood Drive)

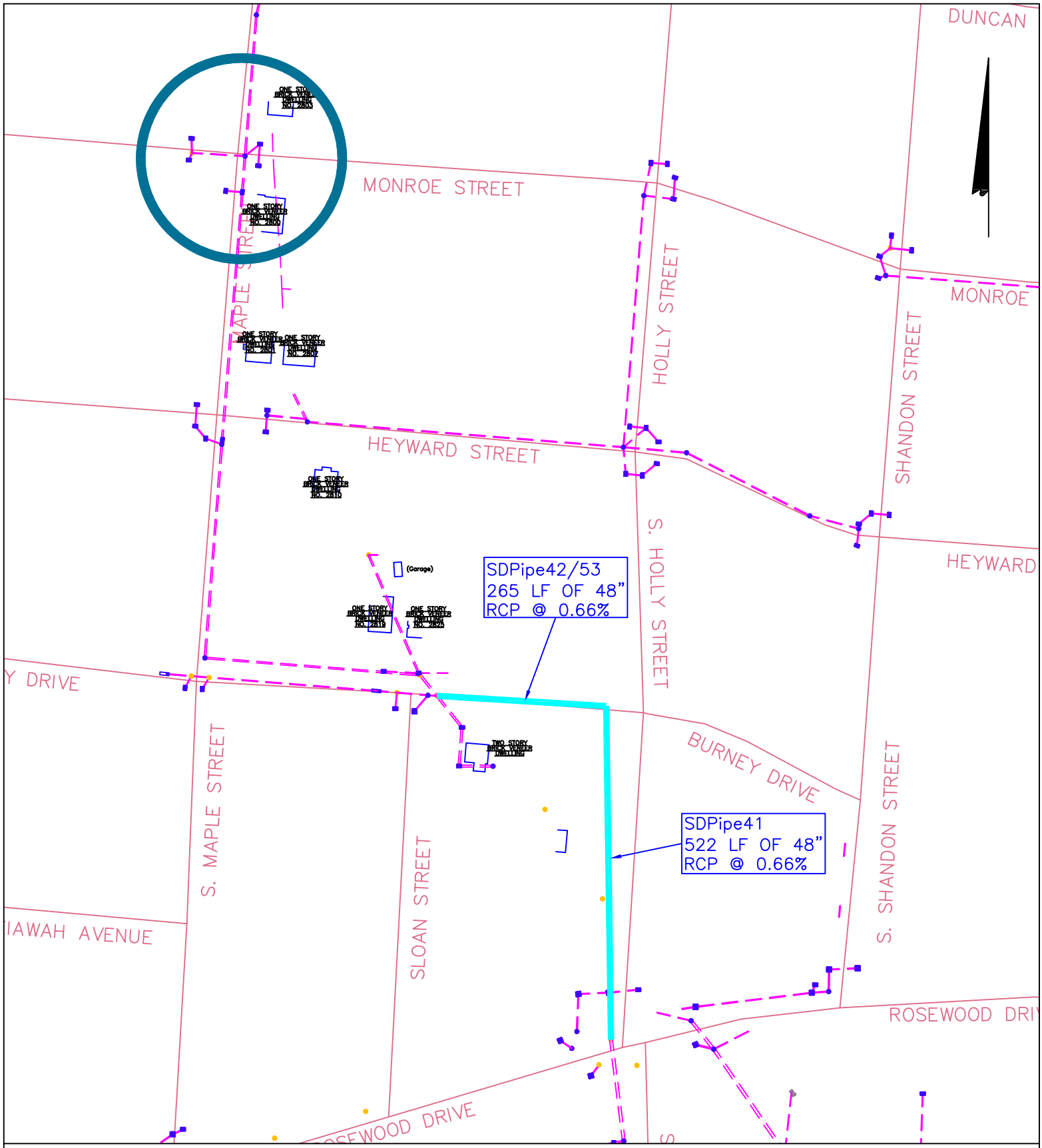
- Peak flows nearly double original model peaks at NODE 2259, where the **first primary** system is diverted into the **second primary** system. From NODE 2259 to NODE 1226, where the first primary and **second primary** converge, the peak slowly decreases from nearly double original model peaks to approximately 150% or original model peaks. However, no 2-year or 10-year event surcharge or ponding occurs.

- Downstream of NODE 1226, there is no significant change in the downstream system compared to what was seen in the original model. A slight increase in peak flows was observed but with the existing 84" diameter pipe the change in water surface elevation (HGL) is not significant.

Summary Observations for Parallel Drainage Improvement Scenario 1 (WEST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

WEST	Problem Area 6 (NODE 5130) Surcharge	Problem Area 6 (NODE 5130) Ponding
Original Model 2-year	YES	YES
Scenario 1 2-year	YES	YES
Original Model 10-year	YES	YES
Scenario 1 10-year	YES	YES



WEST BRANCH - 1 IMPROVEMENTS

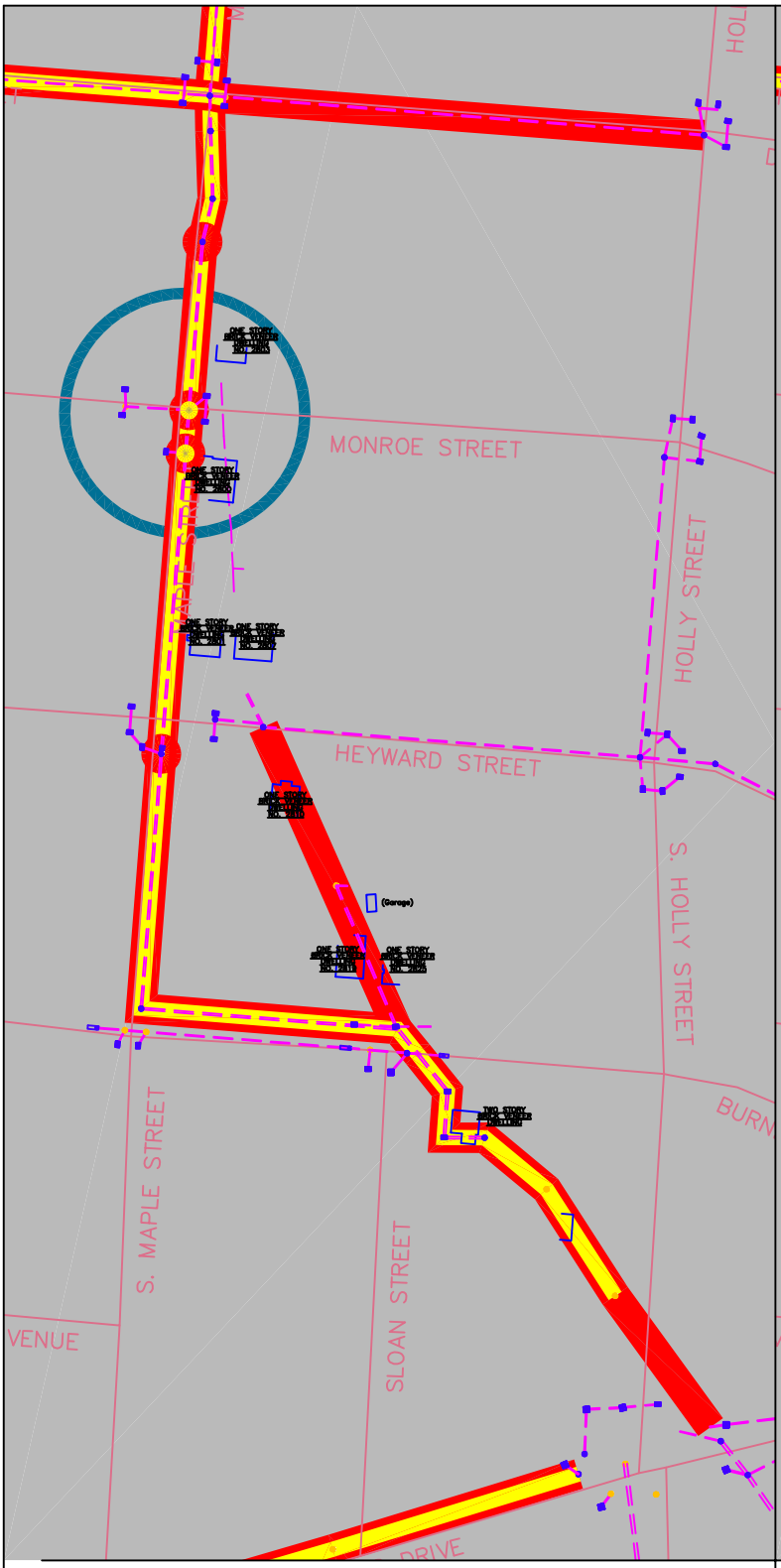
PROJECT:

SHANDON-ROSEWOOD WATERSHED

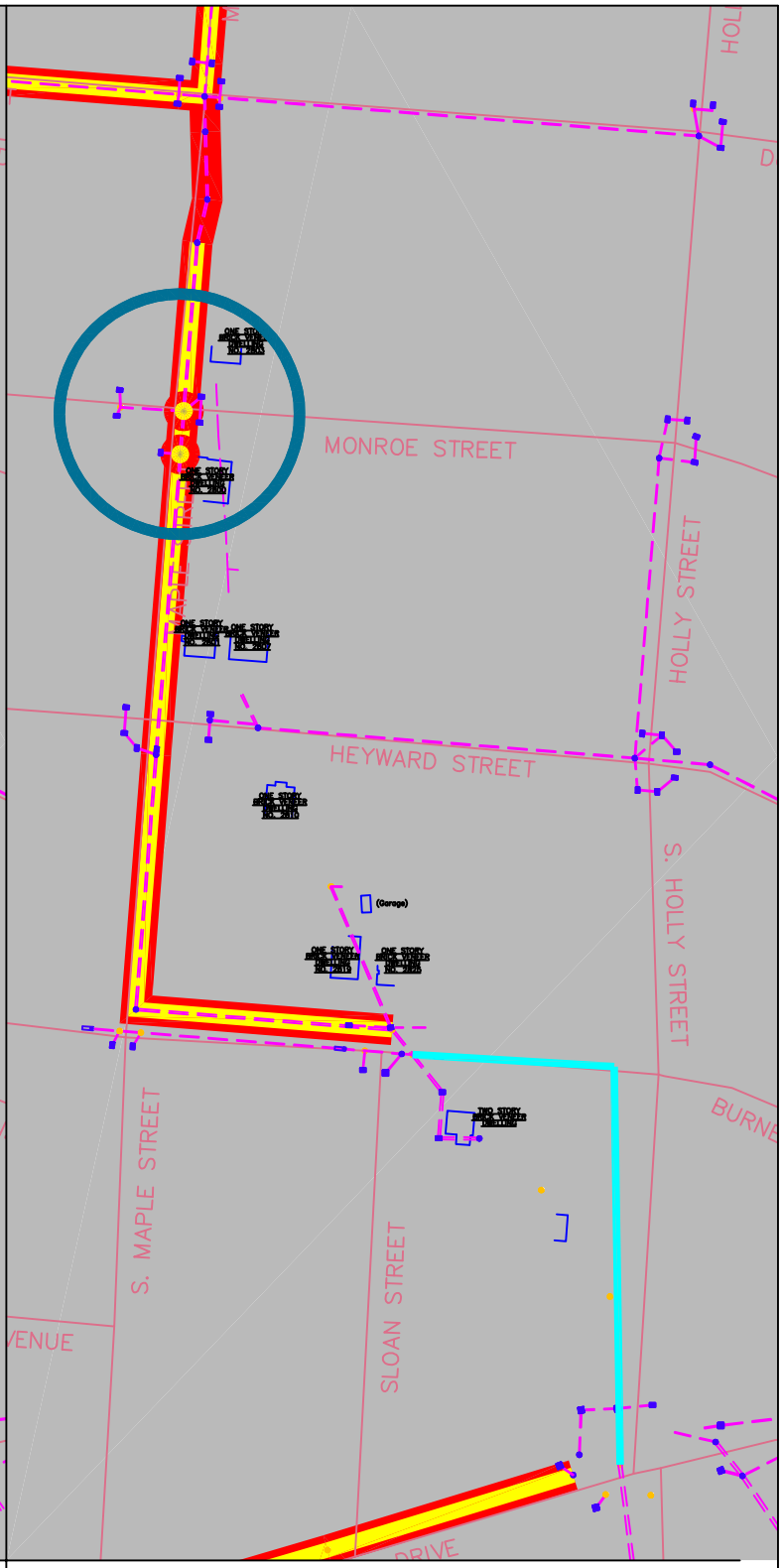
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

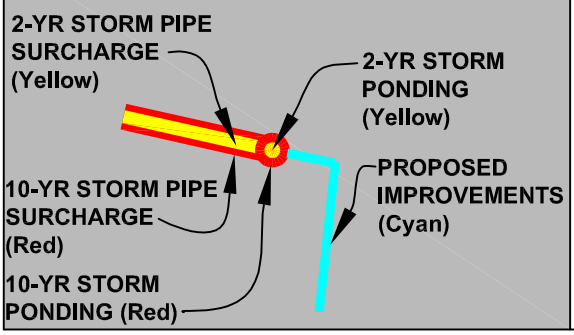


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 1

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED WEST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

Parallel Drainage Improvement Scenario 2 (WEST)

This scenario is based on the installation of a 48" diameter pipe, beginning on the **first primary** system at the junction of a 42" diameter inlet pipe and 54" diameter outlet pipe located along the north side of Rosewood Drive, between S. Holly Street and S. Shandon Street (NODE 2215), and continuing north along S. Holly Street to Burney Drive, then west along Burney Drive to intercept existing drainage at the low point along Burney Drive, east of the Sloan Street intersection.

Critical Area Observations for Parallel Drainage Improvement Scenario 2 (WEST) (north of Rosewood Drive)

- There is a decrease in the water surface elevation (HGL) for the 2-year and 10-year event at the Monroe Street / Maple Street intersection (NODE 5130), but 2-year and 10-year event ponding remains. The original model also indicated 2-year and 10-year event ponding at this location.

- Notice given to relief of 2-year and 10-year event ponding at the Maple Street / Monroe Street intersection (NODE 5130), with the calculated 2-year event ponding volume reduced by 95% and the calculated 10-year event ponding volume reduced by 50%, both at NODE 5130. At 50' downstream (NODE 5128), the calculated 2-year event ponding volume was reduced by 51% and the calculated 10-year event ponding volume was reduced by 37%.

Additional Observations for Parallel Drainage Improvement Scenario 2 (WEST) (north of Rosewood Drive)

- Notice given to significant decrease in water surface elevation (HGL) beginning at the Duncan Street / Woodrow Street intersection (NODE 5219) and the Duncan Street / Holly Street intersection (NODE 5168) and continuing downstream to Rosewood Drive.

- Notice given to relief of 2-year event surcharge at approximately 190' south of the intersection of the Duncan Street / Maple Street intersection (NODE 5145) and continuing upstream to the Duncan Street / Maple Street intersection (NODE 5869). The original model indicated 2-year event surcharge in this area. As with the original model, 10-year event surcharge remains for Scenario 2.

- No 2-year or 10-year event ponding from Heyward Street / Maple Street intersection (NODE 5073) to Rosewood Drive (NODE 2155). The original model indicated 10-year event ponding at the Heyward Street / Maple Street intersection (NODE 5073).

- No 2-year or 10-year event surcharge from the Burney Drive / Sloan Street intersection (NODE 5883) to Rosewood Drive (NODE 2155), including the line of pipe through the block between Heyward Street and Burney Drive (NODE 5077 to 5883), the exception being a section from NODE 5013 to 5883 which still indicates 10-year event surcharge. The original model indicated 2-year and 10-year surcharge from the Burney Drive / Sloan Street intersection to **first primary** crossing at Holly Street (NODE 5874) and 10-year event surcharge extending through the block between Heyward Street and Burney Drive to NODE 5077.

- Results upstream of the Burney Drive / Sloan Street intersection essentially match Scenario 1. That suggests that other system restrictions in the **first primary** system may be located further upstream of the Burney Drive / Sloan Street intersection.

Observations for Parallel Drainage Improvement Scenario 2 (WEST) (south of Rosewood Drive)

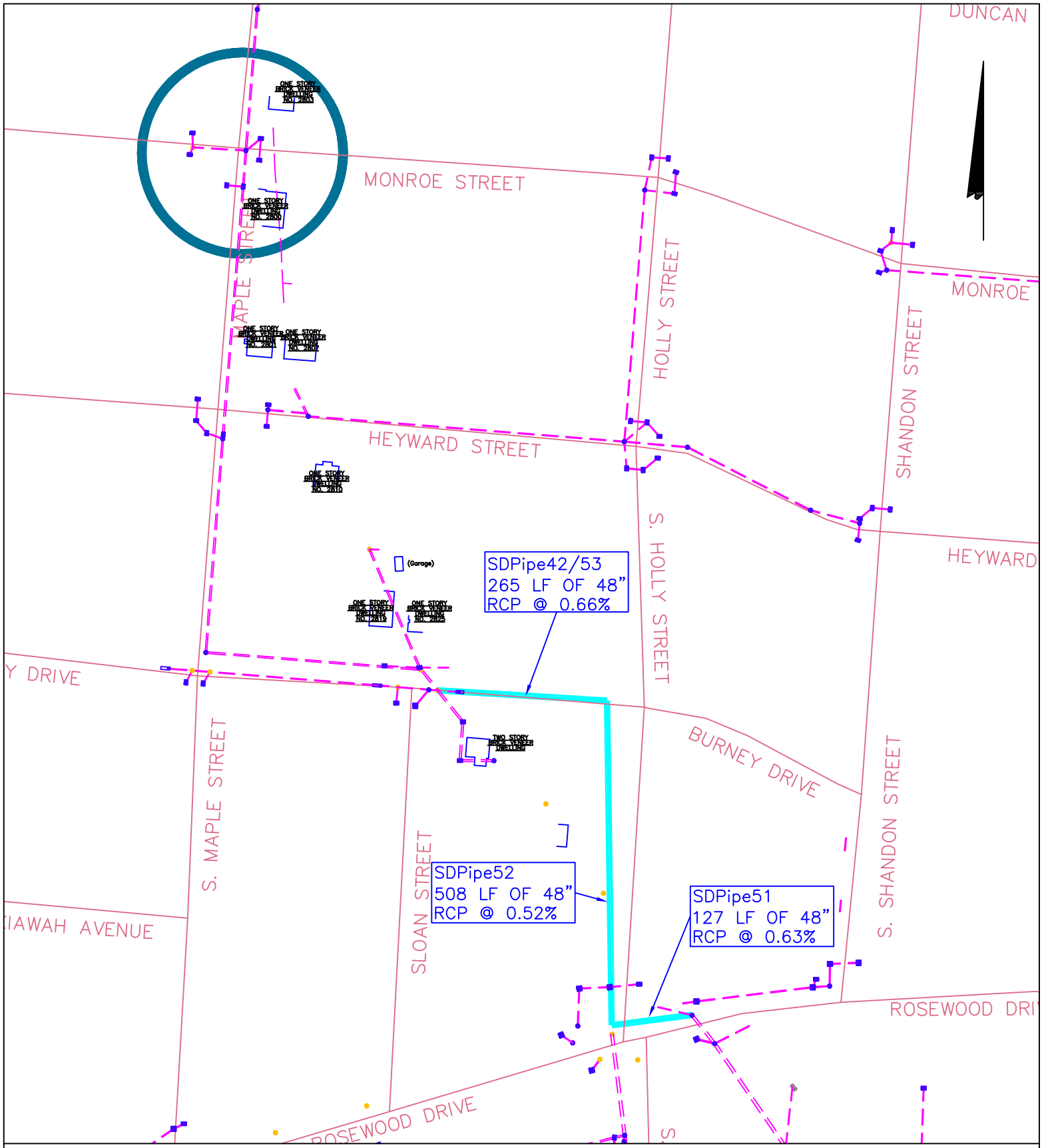
- No additional 2-year or 10-year event surcharge or ponding indicated

- At NODE 1226, where the **first primary** and **second primary** systems converge into an 84" diameter pipe, results are very similar to Scenario 1. Although there is a slight increase in peak flows, the increase in water surface elevation (HGL) compared the original model is insignificant.

Summary Observations for Parallel Drainage Improvement Scenario 2 (WEST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

WEST	Problem Area 6 (NODE 5130) Surcharge	Problem Area 6 (NODE 5130) Ponding
Original Model 2-year	YES	YES
Scenario 2 2-year	YES	YES
Original Model 10-year	YES	YES
Scenario 2 10-year	YES	YES



WEST BRANCH - 2 IMPROVEMENTS

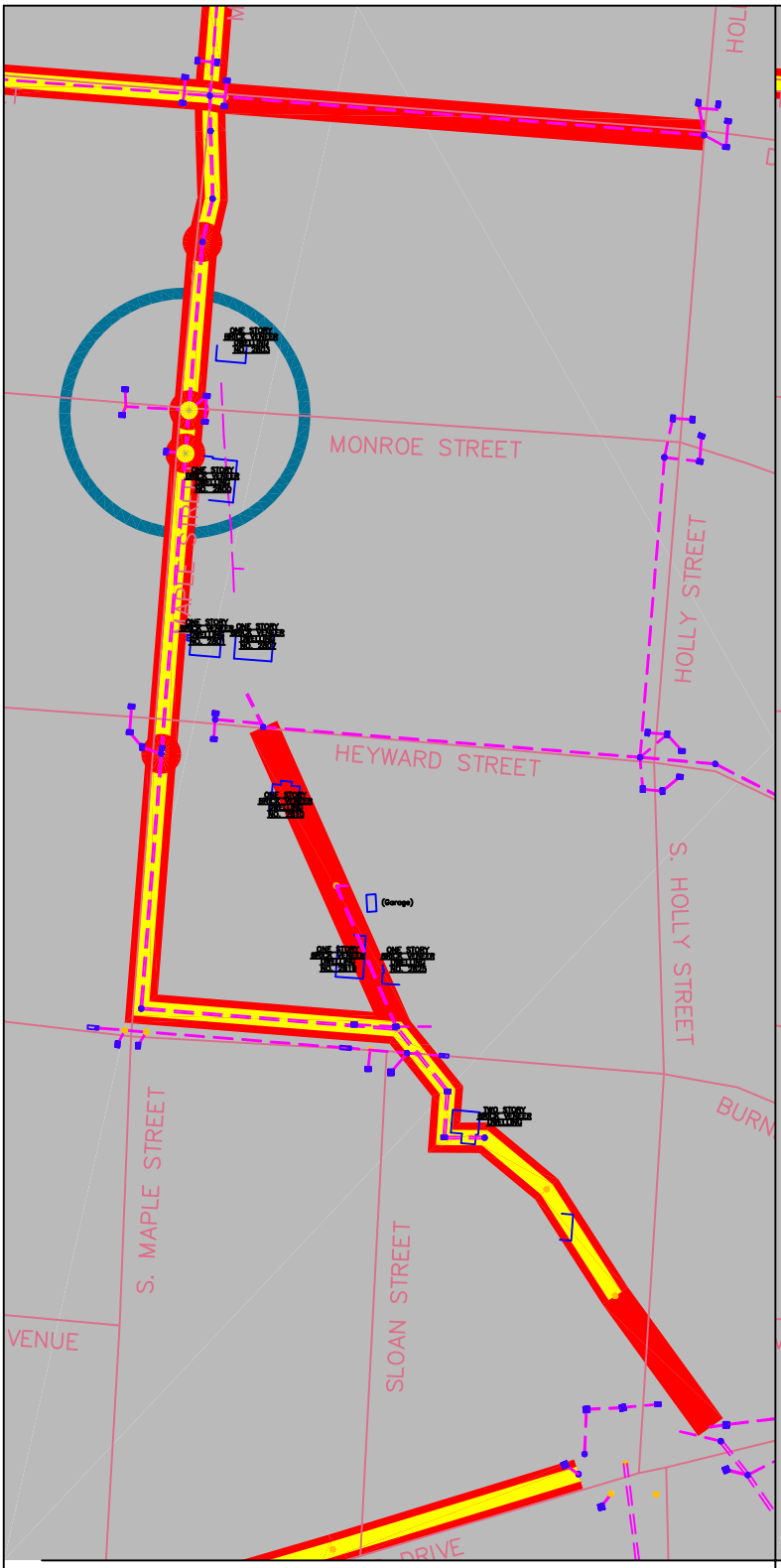
PROJECT:

SHANDON-ROSEWOOD WATERSHED

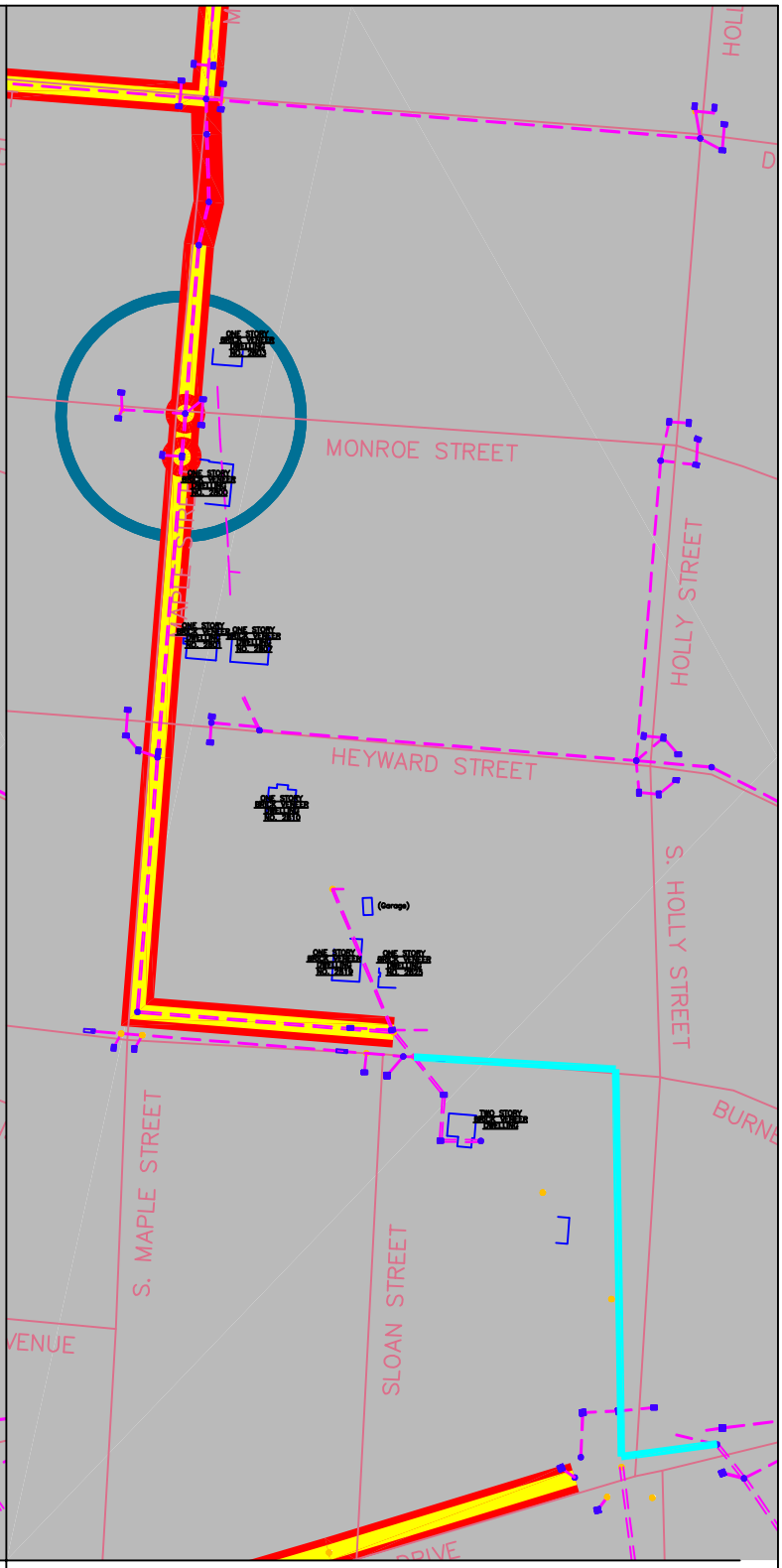
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

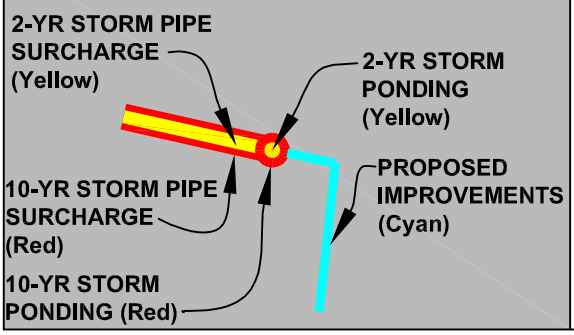


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 2

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED WEST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

Parallel Drainage Improvement Scenario 2A (WEST)

This scenario is based on **Scenario 2**, with the installation of a 48” diameter pipe beginning on the **first primary** system at the junction of a 42" diameter inlet pipe and 54" diameter outlet pipe located along the north side of Rosewood Drive, between S. Holly Street and S. Shandon Street (NODE 2155), and continuing north along S. Holly Street to Burney Drive, then west along Burney Drive to Maple Street, then north along Maple Street to the Maple Street / Monroe Street intersection to NODE 5130.

Critical Area Observations for Parallel Drainage Improvement Scenario 2A (WEST) (north of Rosewood Drive)

- No 2-year or 10-year event surcharge or ponding at the Maple Street / Monroe Street intersection (NODES 5130 and 5128). The original model indicated 2-year and 10-year event surcharge and ponding at this intersection.

Additional Observations for Parallel Drainage Improvement Scenario 2A (WEST) (north of Rosewood Drive)

- 10-year event surcharge remains at the Burney Drive / Holly Street intersection (NODE 5882) and continues upstream in the system to the Maple Street / Heyward Street intersection (NODE 5073). The original model also indicated 2-year and 10-year event surcharge through this portion of the system.

- No 2-year or 10-year event surcharge in the line of pipe through the block between Heyward Street and Burney Drive (NODE 5077 to 5883), the exception being a section from NODE 5013 to 5883 which still indicates 10-year event surcharge. The original model indicated 10-year surcharge extending through the block between Heyward Street and Burney Drive to NODE 5077.

Observations for Parallel Drainage Improvement Scenario 2A (WEST) (south of Rosewood Drive)

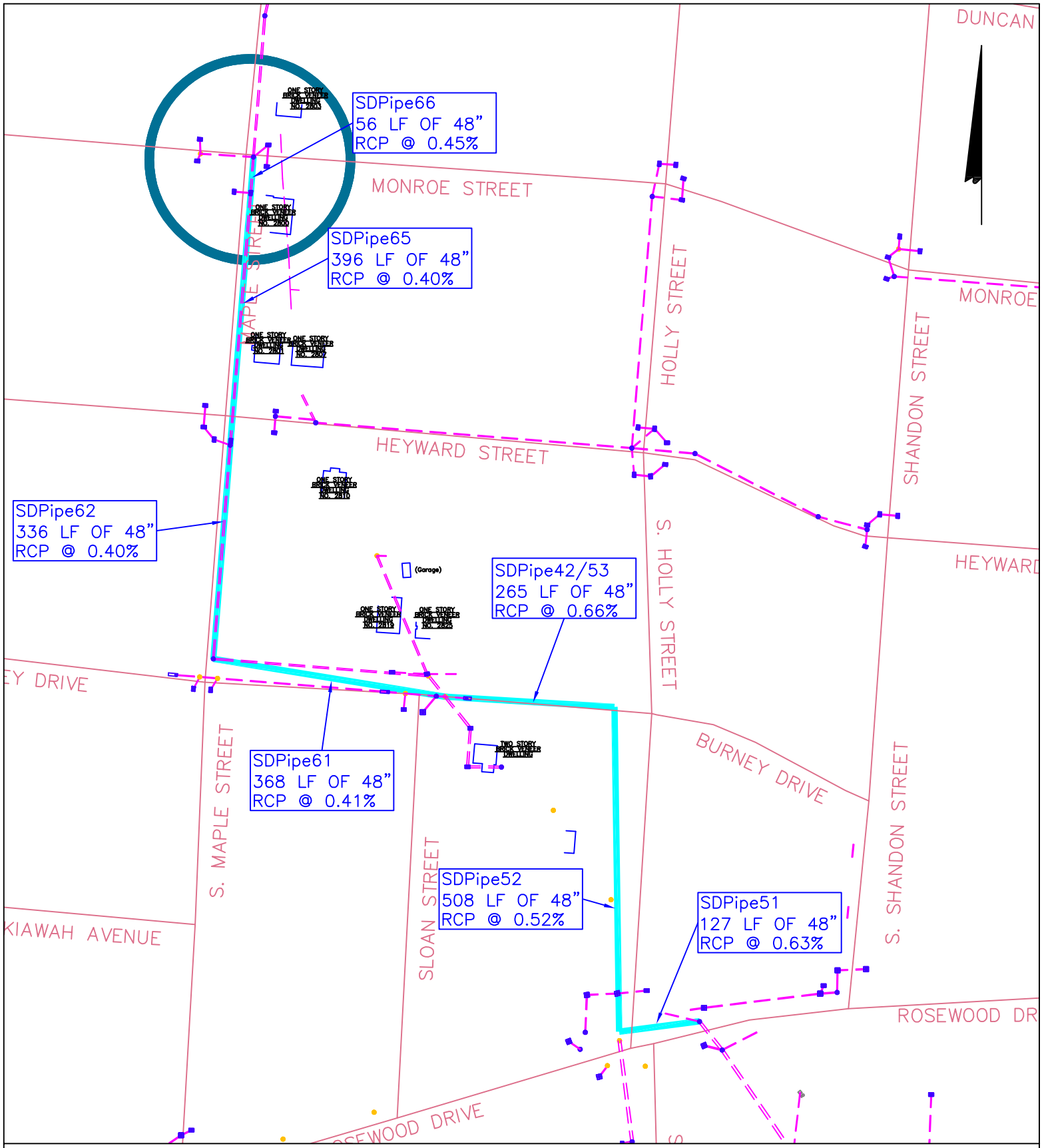
- Notice given to slight increase in water surface elevation (HGL) from beginning point (NODE 2215) downstream through remainder of system but no additional ponding indicated.

- Notice given to additional 10-year event surcharge beginning at the twin 60” diameter pipe length from NODE 10412 at Prentice Avenue to NODE 1188 along Elm Avenue, between Kennedy Street and Superior Street.

Summary Observations for Parallel Drainage Improvement Scenario 2A (WEST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

WEST	Problem Area 6 (NODE 5130) Surcharge	Problem Area 6 (NODE 5130) Ponding
Original Model 2-year	YES	YES
Scenario 2A 2-year	NO	NO
Original Model 10-year	YES	YES
Scenario 2A 10-year	NO	NO



WEST BRANCH - 2A IMPROVEMENTS

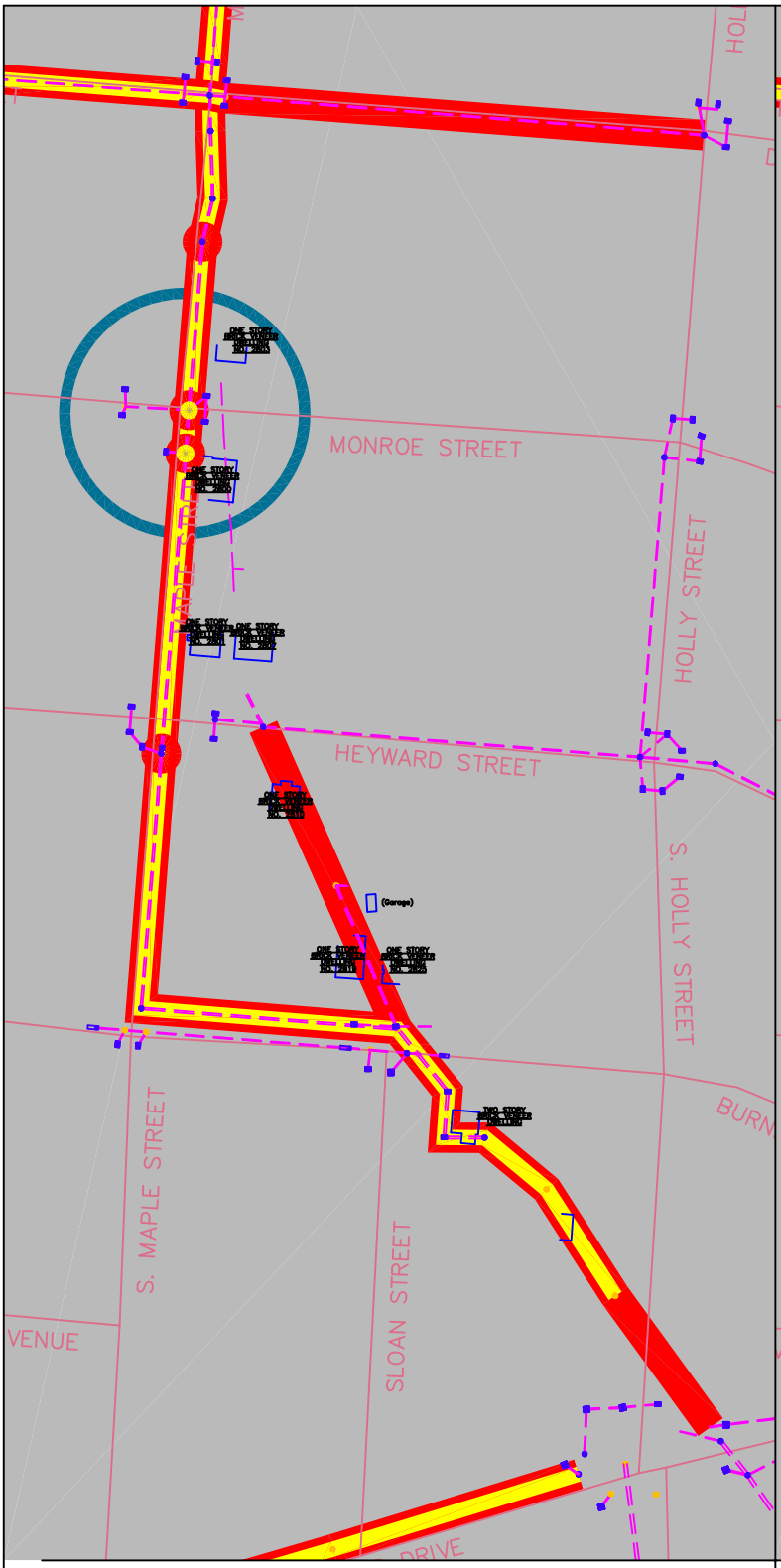
PROJECT:

SHANDON-ROSEWOOD WATERSHED

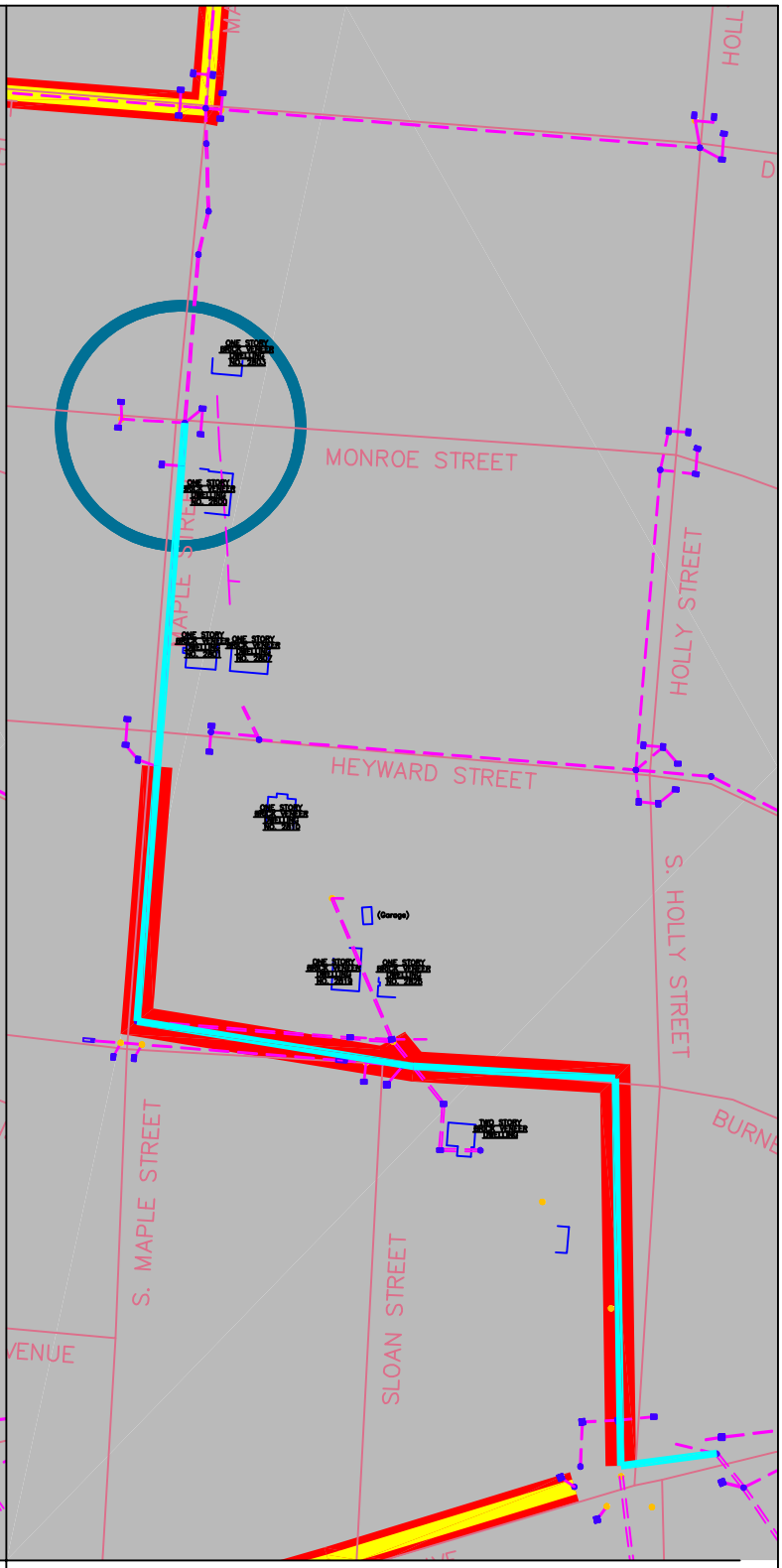
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

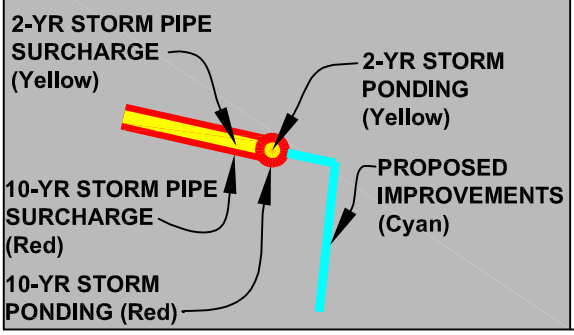


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 2A

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED WEST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
ENGINEERS - SURVEYORS

Parallel Drainage Improvement Scenario 2B (WEST)

This scenario is based on **Scenario 2A** but this scenario also routes 30" diameter pipe from NODE 5077 (east of the Maple Street / Heyward Street intersection) to NODE 5073 near the Maple Street / Heyward Street intersection. The described 30" diameter pipe routing (NODE 5073 to NODE 5077) essentially intercepts the drainage going through the block between Heyward Street and Burney Drive, east of Maple Street and west of S. Holly Street.

Critical Area Observations for Parallel Drainage Improvement Scenario 2B (WEST) (north of Rosewood Drive)

- No additional 2-year event surcharge noted
- 10-year event surcharge noted from Monroe Street (NODE 5128) and approximately half-way up the block (to NODE 5144) but not reaching upstream to Duncan Street.
- 10-year event ponding is noted at the Maple Street / Monroe Street intersection (NODE 5128). The original model indicated both 2-year event and 10-year event ponding.

Additional Observations for Parallel Drainage Improvement Scenario 2B (WEST) (north of Rosewood Drive)

- Notice given to 10-year event surcharge from the Burney Drive / S. Holly Street intersection (NODE 12001) and approximately half-way up the block (to NODE 5144) but not reaching upstream to Duncan Street.
- Rerouting storm drainage from Heyward Street (NODE 5077) to the Heyward Street / Maple Street intersection (NODE 5073) reintroduced surcharge in the system that Scenario 2A did not indicate. 10-year event ponding was also reintroduced at the Heyward Street / Maple Street intersection. Since larger diameter pipe cannot be used for added capacity due to elevation drop available to connect to the Rosewood Drive crossing (NODE 2155), the required capacity to eliminate ponding and surcharge will have to be achieved using multiple pipes.

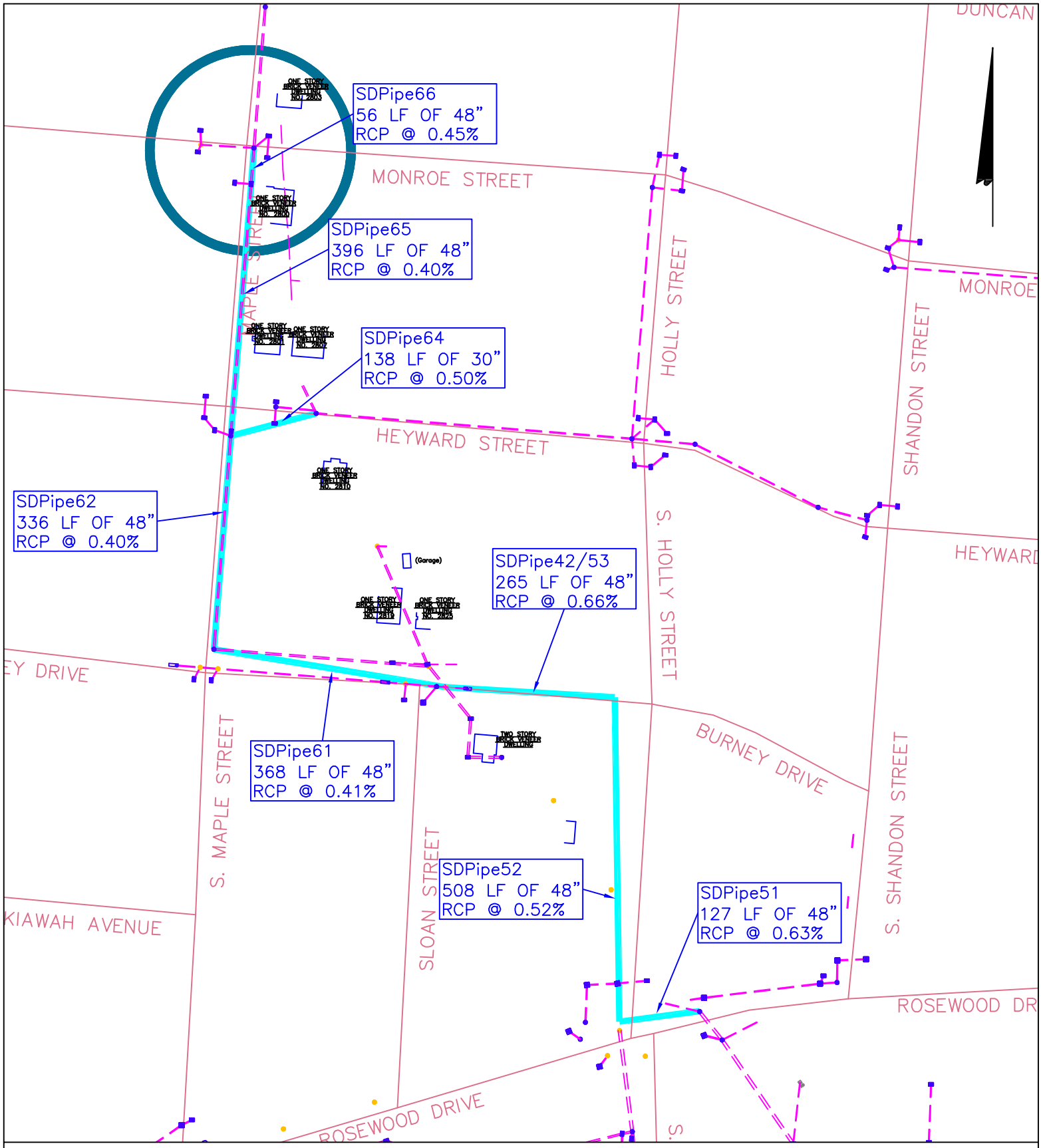
Observations for Parallel Drainage Improvement Scenario 2B (WEST) (south of Rosewood Drive)

- Notice given to slight increase in water surface elevation (HGL) from beginning point (NODE 2215) downstream through remainder of system but no additional ponding indicated.
- As in Scenario 2 there is additional surcharge in the twin 60" diameter pipe length from NODE 10412 at Prentice Avenue to NODE 1188 along Elm Avenue, between Kennedy Street and Superior Street.
- Notice also given to some 10-year event ponding upstream of the intersection of Elm Avenue and Bohnam Road (NODE 1009).

Summary Observations for Parallel Drainage Improvement Scenario 2B (WEST)

Benefits associated with this improvement increment, as measured by remedy to surcharge and ponding, are summarized below.

WEST	Problem Area 6 (NODE 5130) Surcharge	Problem Area 6 (NODE 5130) Ponding
Original Model 2-year	YES	YES
Scenario 2B 2-year	NO	NO
Original Model 10-year	YES	YES
Scenario 2B 10-year	YES	NO



WEST BRANCH - 2B IMPROVEMENTS

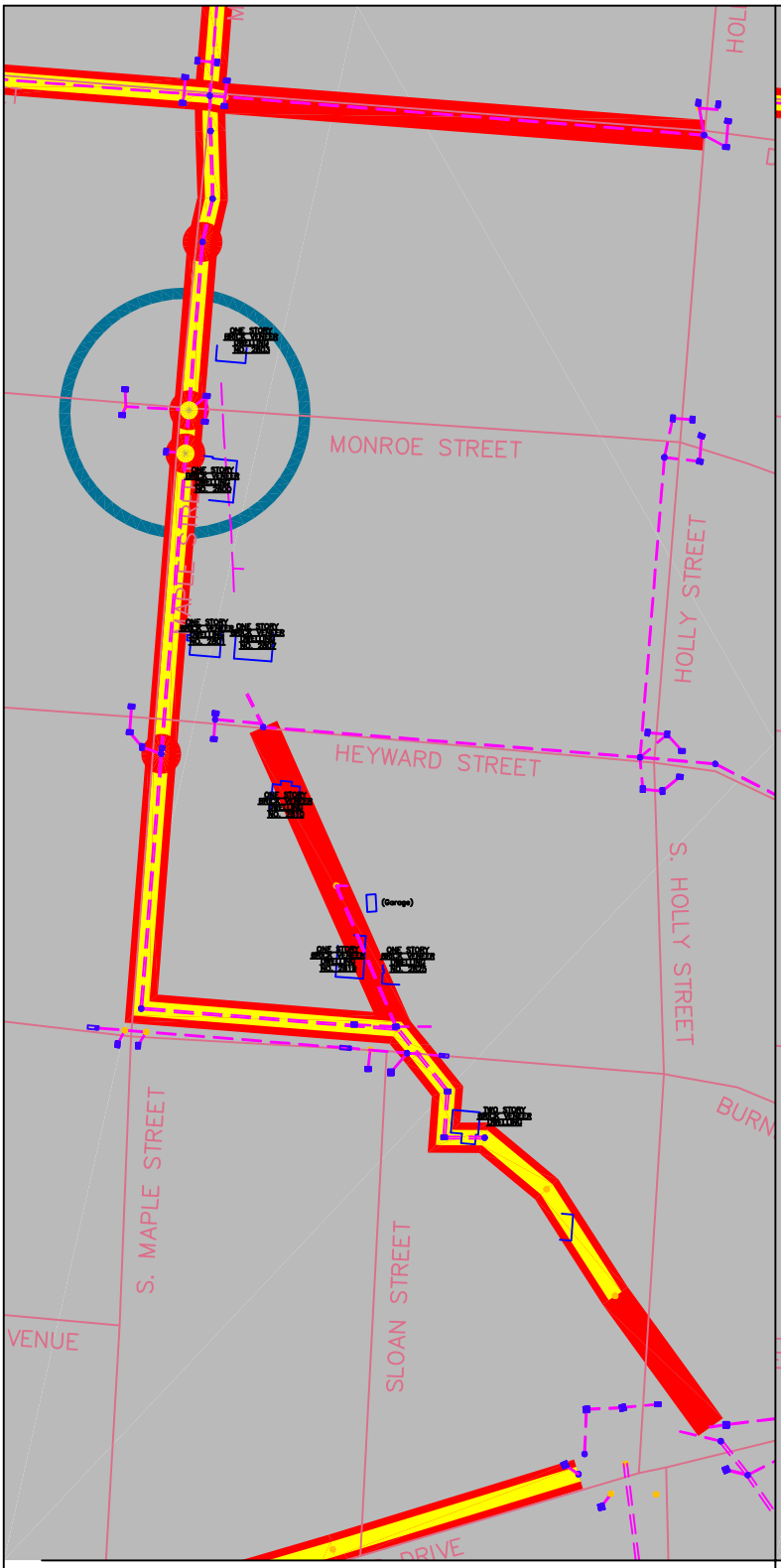
PROJECT:

SHANDON-ROSEWOOD WATERSHED

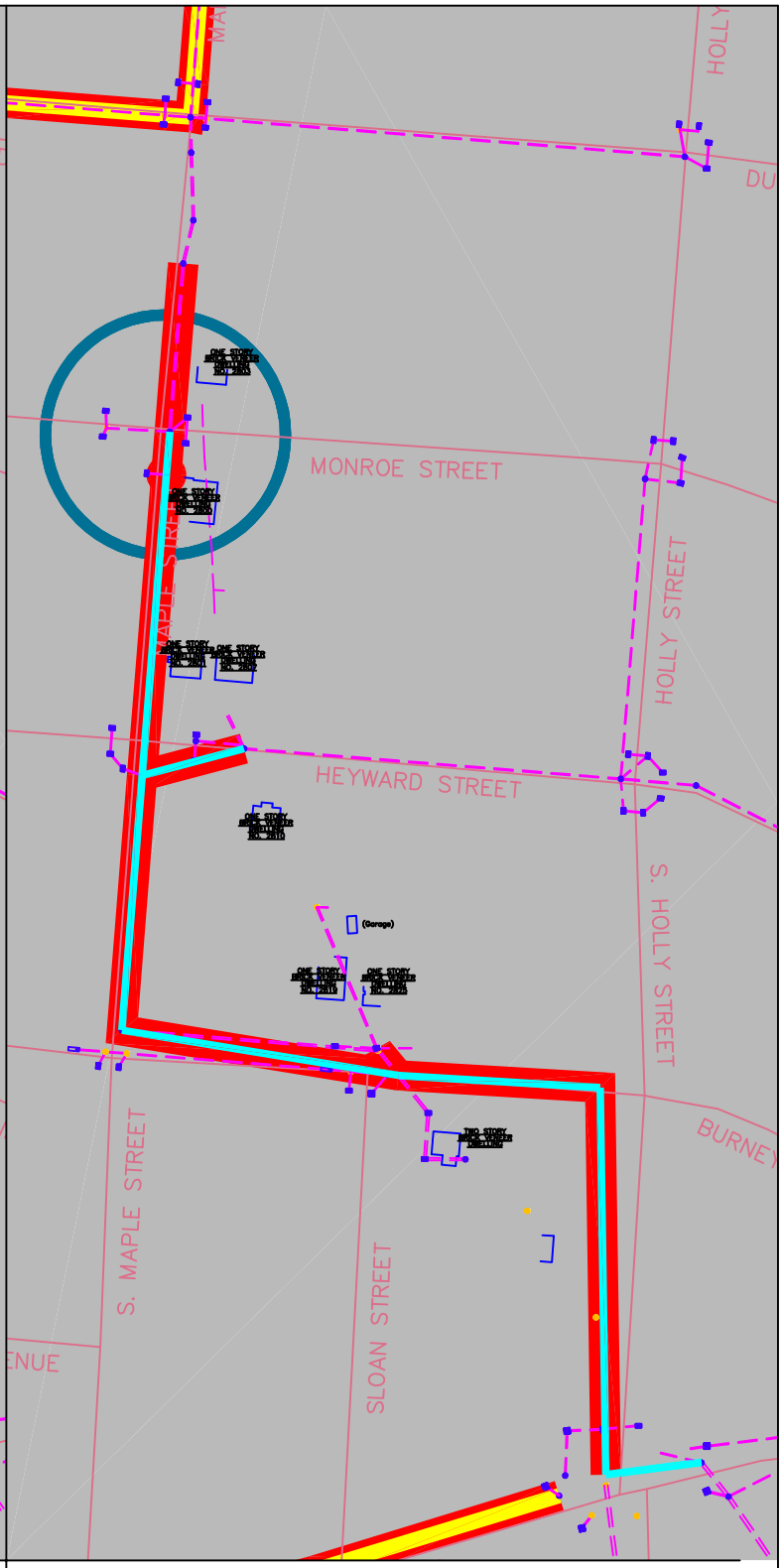
LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400
GRAPHIC SCALE IN FEET
SCALE: 1"=200'

COX AND DINKINS
ENGINEERS - SURVEYORS

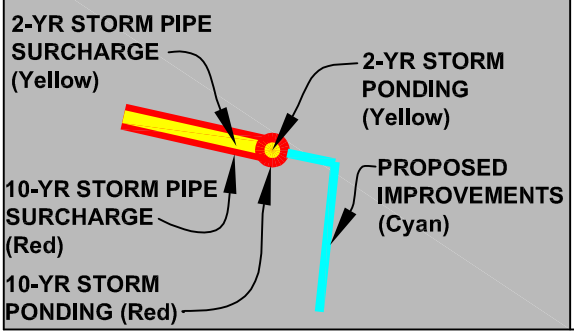


ORIGINAL ANALYZED NETWORK



NEW ANALYZED NETWORK SCENARIO 2B

LEGEND



PROJECT:

SHANDON-ROSEWOOD WATERSHED WEST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

COX AND DINKINS
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SECTION 8

WEST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS COMPARED TO W4 ALTERNATIVE FROM ORIGINAL MODEL

Comparison to Original Project's W4 Alternative Model (WEST)

During the original project, the W4 Alternative Model was developed to predict effects on the storm drainage system downstream of Rosewood Drive, if/when improvements were made north of Rosewood Drive sufficient to eliminate ponding. In the original model, pipe diameters north of Rosewood Drive were systematically upsized until ponding was eliminated north of Rosewood Drive. However, unlike the W4 Alternative model, the Scenario 2B model still shows ponding at nodes along and upstream of Rosewood Drive. From that comparison alone it is anticipated that in Scenario 2B peak flows in pipes and ponding at nodes downstream of Rosewood Drive should be less than shown in the W4 Alternative model.

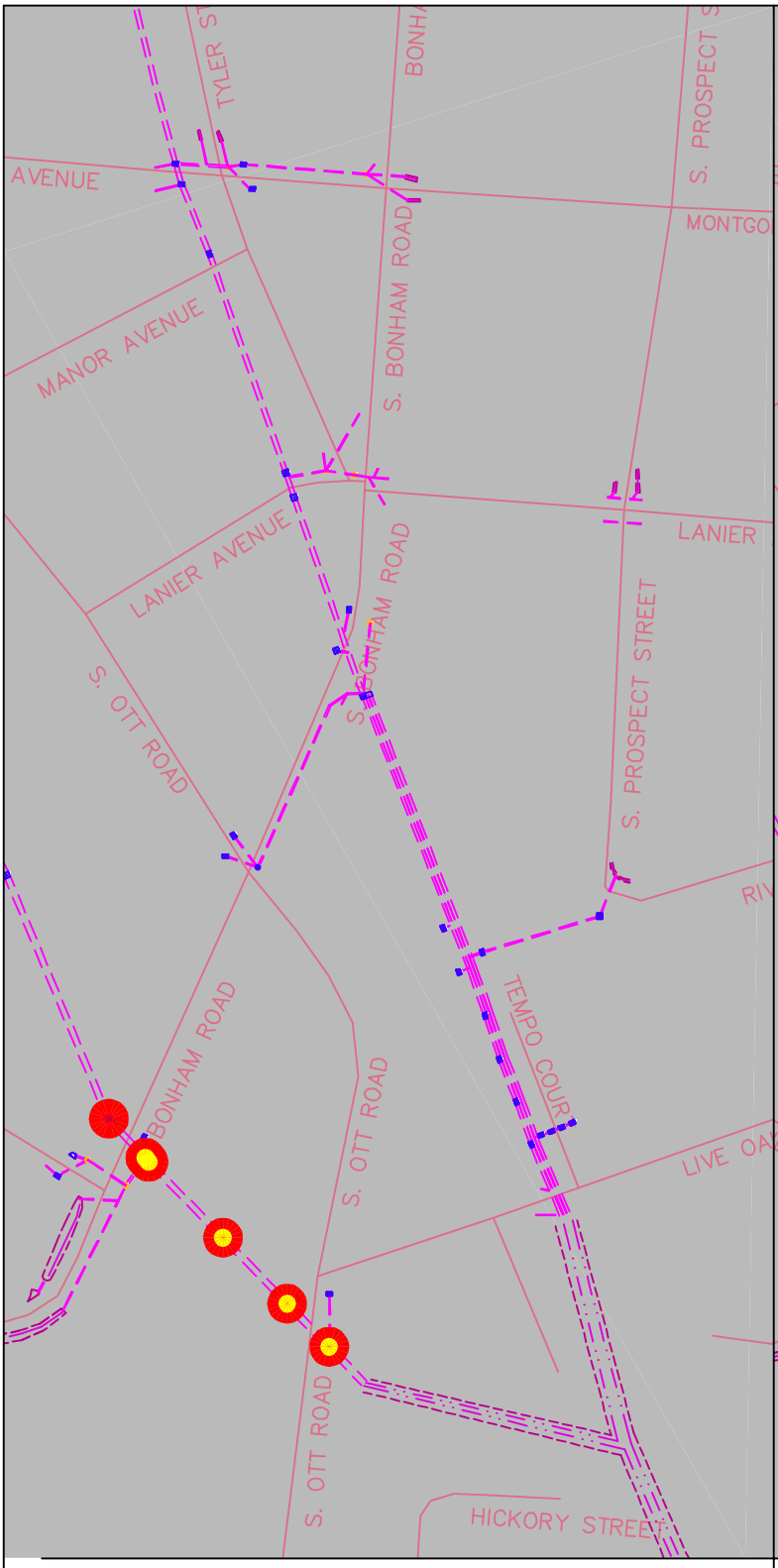
As a means of further comparison, pipe peak flow and node data of the system downstream of Rosewood Drive from the Scenario 2B model and the W4 Alternative model have been compared. That comparison has confirmed that in Scenario 2B the system downstream of Rosewood Drive is not getting the full 2-year and 10-year peak flows as in the W4 Alternative model.

Observations:

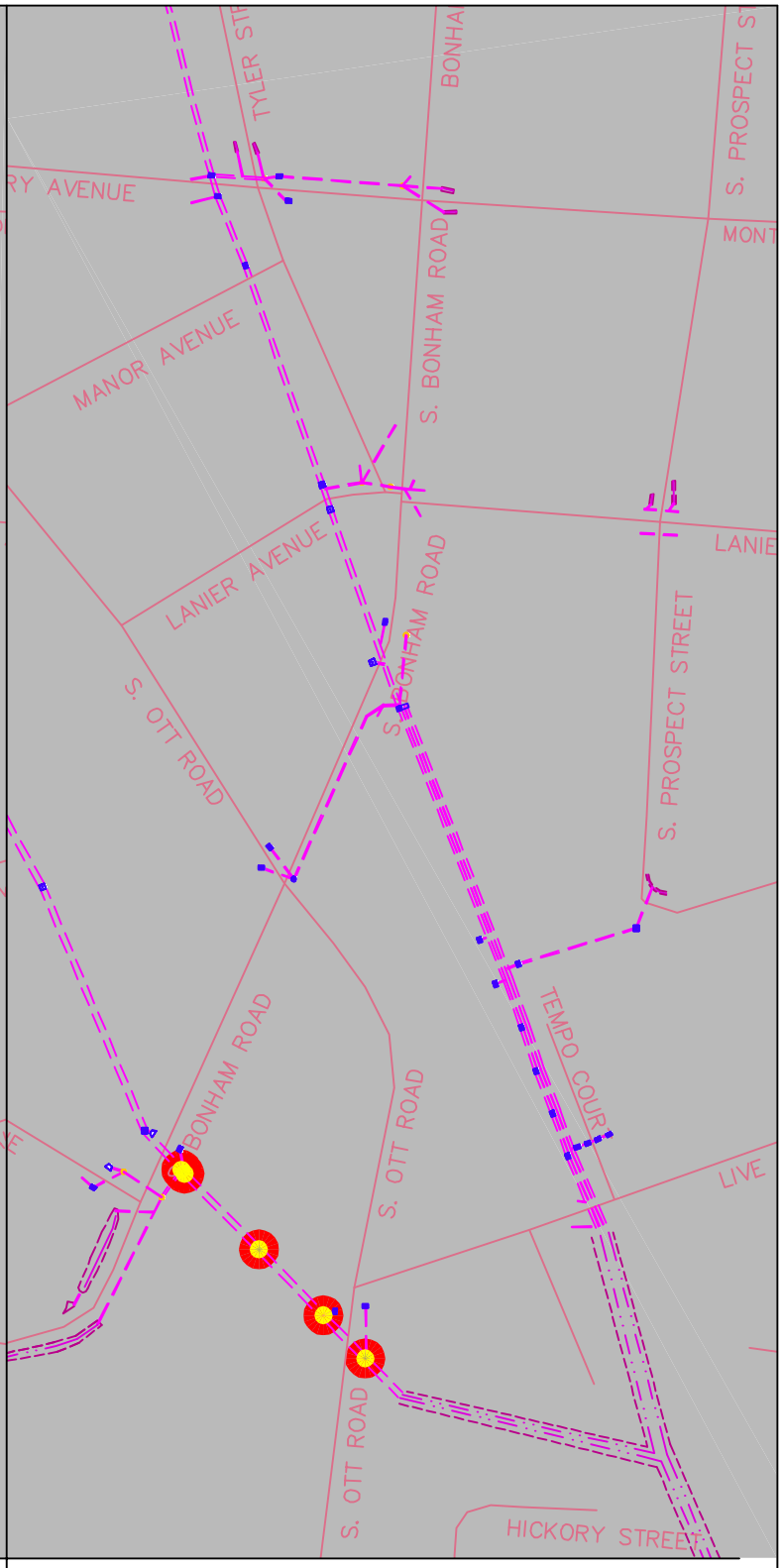
- From the junction point of the **first primary** and **second primary** (NODE 1226), on Hope Ave between Holly Street and Walker Street, to the end of the system at Ott Road (NODE 1001) the max peak flow is less than the W4 Alternative model, typically in the 60-75 percentile range but increasing to 90 percentile range towards the downstream end of the system.

- Nodes indicating ponding in the Scenario 2B model did not exceed the area of nodes indicating ponding in the W4 Alternative model, the exception being NODE 1188, which shows slight ponding.

- The observed Scenario 2B model results are as expected in comparison to the W4 Alternative model results.



NEW ANALYZED NETWORK SCENARIO 2B



ANALYZED NETWORK ALT W4

LEGEND

2-YR STORM PONDING (Yellow)

10-YR STORM PONDING (Red)

PROJECT:

SHANDON-ROSEWOOD WATERSHED WEST BRANCH

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 250 500

GRAPHIC SCALE IN FEET
SCALE: 1"=250'

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SECTION 9

WEST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS OPINIONS OF PROBABLE COST

West Branch (Drainage Improvement Scenarios & Opinion of Probable Costs)

The following is a general outline of the scopes of work anticipated in conjunction with the direct remedies described in **Scenarios 1, 2, 2A and 2B**.

- Scenario 1: Installation of a 48" diameter pipe, beginning on the **second primary** system at the junction of the 54" diameter pipe at the Rosewood Drive / S. Holly Street intersection (NODE 2259) and continuing north along S. Holly Street to Burney Drive, then west along Burney Drive to intercept existing drainage at the low point along Burney Drive, east of the Sloan Street intersection. [approximately 800 feet of 48" pipe]

- Scenario 2: Installation of a 48" diameter pipe, beginning on the **first primary** system at the junction of a 42" diameter inlet pipe and 54" diameter outlet pipe located along the north side of Rosewood Drive, between S. Holly Street and S. Shandon Street (NODE 2215), and continuing north along S. Holly Street to Burney Drive, then west along Burney Drive to intercept existing drainage at the low point along Burney Drive, east of the Sloan Street intersection. [approximately 900 feet of 48" pipe]

- Scenario 2A: Installation of a 48" diameter pipe beginning on the **first primary** system at the junction of a 42" diameter inlet pipe and 54" diameter outlet pipe located along the north side of Rosewood Drive, between S. Holly Street and S. Shandon Street (NODE 2155), and continuing north along S. Holly Street to Burney Drive, then west along Burney Drive to Maple Street, then north along Maple Street to the Maple Street / Monroe Street intersection to NODE 5130. [approximately 2,050 feet of 48" pipe]

- Scenario 2B: Same as Scenario 2A but also includes 30" diameter pipe from NODE 5077 (east of the Maple Street / Heyward Street intersection) to NODE 5073 near the Maple Street / Heyward Street intersection. [approximately 2,050 feet of 48" pipe plus approximately 140' of 30" pipe]

- Installation of replacement water mains and appurtenances along the route of the installation of new drainage collection/conveyance system

- Installation of replacement sanitary sewer mains and appurtenances along the route of the parallel installation of new drainage collection/conveyance system

- Repairs associated with natural gas mains and services, telephone lines and services and CATV lines and services along the route of the parallel installation of new drainage collection/conveyance system

- Landscape repairs in construction areas

For the purposes of budgeting the contemplated remedies described previously have been expanded to include further detailed descriptions of work, including anticipated/projected costs, with the end result being an approximate cost per foot. These detailed descriptions are open for further discussion and comparison to comparable City of Columbia project costs. Those discussions and comparisons may result in significant modifications to the approximated costs.

See the descriptions on the following pages for further information and basis for the budget costs.

Work Scope, Material Description	Unit Cost	Cost Per Foot of Drainage Corridor
New 48” diameter RCP	$55 per foot	$55
Installation of New 48” diameter RCP; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$55 per foot	$55
New drainage structures; estimate five (5) per 400’ of pipe or per City block	$7500 each	$94
Traffic Control	Allowance	$12
Estimate eight (8) foot wide trench with average depth of eight (8) feet for flowable fill quantity (minus pipe cross section based on OD)	$100 per cubic yard	$163
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over eight (8) foot wide trench	$70 per square yard	$62
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	$15 per square yard	$45
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	$17 per foot	$17
Allowance for water service disconnects/reconnects (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
*Allowance for sanitary sewer service disconnects/reconnects (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
Allowance for landscape repairs (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
Approximate cost per foot of drainage installation corridor	**$602**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Drainage Corridor
New 30” diameter RCP	$45 per foot	$45
Installation of New 48” diameter RCP; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$45 per foot	$45
New drainage structures; estimate five (5) per 400’ of pipe or per City block	$6500 each	$81
Traffic Control	Allowance	$12
Estimate six (6) foot wide trench with average depth of xsix (6) feet for flowable fill quantity (minus pipe cross section based on OD)	$100 per cubic yard	$107
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over six (6) foot wide trench	$70 per square yard	$47
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	$15 per square yard	$45
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	$17 per foot	$17
Allowance for water service disconnects/reconnects (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
*Allowance for sanitary sewer service disconnects/reconnects (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
Allowance for landscape repairs (equates to $11,500.00 per City block using 400’ block)	$29 per foot	$29
Approximate cost per foot of drainage installation corridor	**$498**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
New 8” diameter water line	$15 per foot	$15
Installation of new 8” diameter water line; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$15 per foot	$15
New fire hydrants, valves & fittings; per 400’ of pipe or per City block	$8,000	$20
Traffic Control	Allowance	$6
Estimate four (4) foot wide trench with average depth of four (4) feet for flowable fill quantity	$100 per cubic yard	$60
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over four (4) foot wide trench	$70 per square yard	$31
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	Covered by storm drainage install	$0
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	$17 per foot	$17
Allowance for water service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
*Allowance for sanitary sewer service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
Allowance for landscape repairs (equates to $4,000.00 per City block using 400’ block)	$10 per foot	$10
Approximate cost of water main installation per foot of drainage installation corridor. **It is assumed that water main replacement will be required for approximately ½ of the drainage parallel installation route.**	**$186**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
New 8” diameter sanitary sewer line	$15 per foot	$15
Installation of new 8” diameter sanitary sewer line; includes haul off of excavated material since flowable fill will be required by SCDOT; also includes steel traffic plates 100’ in advance of pavement patch	$25 per foot	$25
New manholes; estimate three (3) per 400’ of pipe or per City block	$9,000	$22
Traffic Control	Allowance	$6
Estimate six (6) foot wide trench with average depth of eight (8) feet for flowable fill quantity	$100 per cubic yard	$178
Saw cut of existing pavement and removal of pavement (saw cut along both sides of installation)	$6 per foot	$12
Assume SCDOT will require 8” full depth asphalt patch over six (6) foot wide trench	$70 per square yard	$47
Assume SCDOT will require 1-1/2” asphalt overlay over patched streets	Covered by storm drainage install	$0
Assume removal and replacement of curb and gutter along one side of street for every foot of pipe	Covered by water & storm drainage install	$0
Allowance for water service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
*Allowance for sanitary sewer service disconnects/reconnects (equates to $10,000.00 per City block using 400’ block)	Covered by storm drainage install	$0
Allowance for landscape repairs (equates to $4,000.00 per City block using 400’ block)	$10 per foot	$10
Approximate cost of sanitary sewer main installation per foot of drainage installation corridor. **It is assumed that water main replacement will be required for approximately ½ of the drainage parallel installation route.**	**$315**	

Work Scope, Material Description	Unit Cost	Cost Per Foot of Parallel Corridor
Natural gas, electric, telephone and CATV service impacts	$175,000.00 Allowance	$79
Approximate cost of natural gas, electric, telephone and CATV service repairs per foot of drainage installation corridor.	**$79**	

Based on the work scopes, projected unit costs and allowances as described in the preceding outline, the anticipated/projected cost per foot for installation of the drainage installation corridor is approximately $602 + ($186 x ½) + ($315 x ½) + $79 = $932 per foot. Applying this cost per foot to the 2,050 foot long projected route for Scenario 2A, the anticipated/projected cost to install the described drainage improvements is approximately $1.9 million. It is also recommended that an additional 10% be added to the anticipated/projected cost to pay for remedial work for auxiliary portions of the system not included in the described improvement scenarios. Including that additional 10% brings the anticipated/projected cost of remedies for the **west branch watershed** Scenario 2A to approximately $2.1 million. The costs for the other three scenarios described herein (Scenario 1, Scenario 2 and Scenario 2B) have been based accordingly and the costs of all three scenarios are summarized below.

DRAINAGE IMPROVEMENT SCENARIO WEST	Opinion of Probable Construction Costs (OPCC)
Scenario 1	$0.8M
Scenario 2	$0.9M
Scenario 2A	$2.1M
Scenario 2B	$2.2M

The preceding costs are Opinions of Probable Construction Costs (OPCC) only and these OPCC's were developed without control of the costs or the price of labor, equipment or materials, or the ultimate bidder's (contractor's) methods of pricing. In addition, these OPCC's were developed without the benefit of final construction documents. As a result of these considerations, proposals based on final design and received through the competitive bidding process may vary significantly from these OPCC's.

Certain items are not included in these OPCC's. Some of the items not included are:

1. The cost of permanent and/or construction easements;

2. The cost of remedies for system issues north or south of Rosewood Drive for portions of the system that were not part of the active analysis;

3. The cost of remedies for system issues downstream of Rosewood Drive, whether existing or caused by north of Rosewood Improvements;

4. The cost of remedies in the event of negative impact on the open channel downstream of the piped outfall.

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SECTION 10

WEST BRANCH

DRAINAGE IMPROVEMENT SCENARIOS SUMMARY

West Branch Drainage Improvement Scenarios Summary

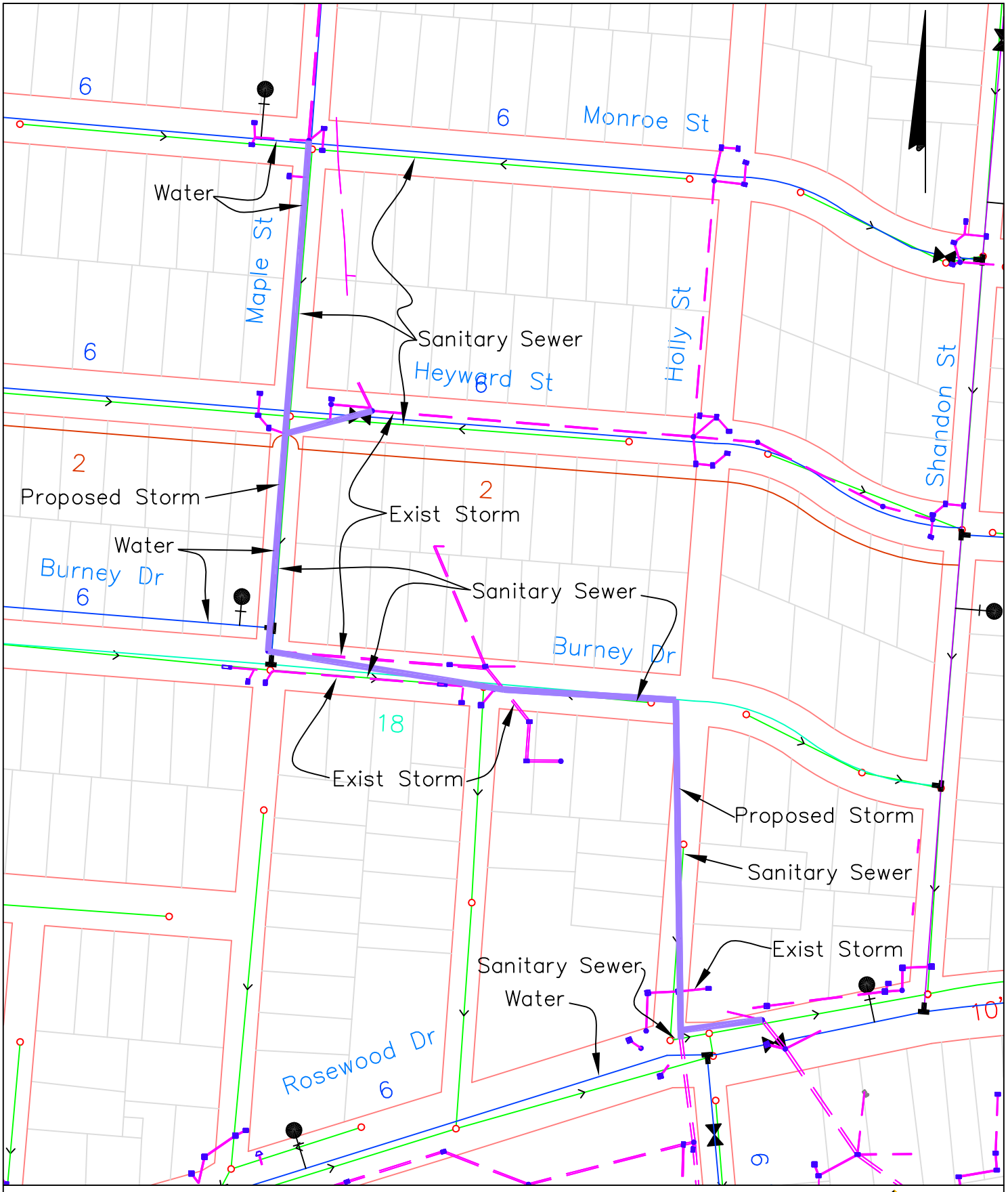
In the preceding sections certain recommendations have been made for conceptual improvements for the **west branch watershed**. Scenario 1 that was considered has a downstream point of commencement at a junction situated on the **second primary** collection/conveyance system. Scenarios 2, 2A and 2B have a common downstream point of commencement at a junction situated on the **first primary** collection/conveyance system. For the purpose of incremental evaluation, each of the scenarios has an alternate upstream point of termination, with Monroe Street being the most upstream point of termination. The various improvements associated with each scenario, as measured by remedy to surcharge and ponding, are summarized on the following page. Without regard for costs, Scenario 2A clearly produces the better results as measured by remedy to surcharge and ponding.

The Opinion of Probable Construction Cost (OPCC) for each of the considered scenarios are summarized below. Two of the scenarios considered exceed the $1,000,000.00 target that was defined in the criteria for this study. Those two scenarios produce more desirable results when measured by remedy to surcharge and ponding.

The length of the system impacts anticipated costs due to length of improvements and increased potential for impacts upon other utilities. In order to reduce those anticipated costs it is recommended that future design focus on drainage routes that can be arranged so as to eliminate or reduce the impacts upon existing utilities (water, sanitary sewer, natural gas, electric and telephone lines, CATV lines, etc.). Consideration can also be given to parallel drainage routes that will leave certain “through the block” pipes in place, while “splitting” drainage amongst existing pipes and new pipes. However, some of the “through the block” drainage in the **west branch watershed** may prove to be problematic if left in service.

DRAINAGE IMPROVEMENT SCENARIO WEST	Opinion of Probable Construction Costs (OPCC)
Scenario 1	$0.8M
Scenario 2	$0.9M
Scenario 2A	$2.1M
Scenario 2B	$2.2M

WEST SUMMARY	Problem Area 6 (NODE 5130) Surcharge	Problem Area 6 (NODE 5130) Ponding
Original Model 2-year	YES	YES
Original Model 10-year	YES	YES
Scenario 1 2-year	YES	YES
Scenario 1 10-year	YES	YES
Scenario 2 2-year	YES	YES
Scenario 2 10-year	YES	YES
Scenario 2A 2-year	NO	NO
Scenario 2A 10-year	NO	NO
Scenario 2B 2-year	NO	NO
Scenario 2B 10-year	YES	NO



UTILITY LOCATIONS PER CITY OF COLUMBIA GIS

PROJECT:

SHANDON-ROSEWOOD WATERSHED

LOCATED IN THE CITY OF COLUMBIA
RICHLAND COUNTY, SOUTH CAROLINA

0 200 400

GRAPHIC SCALE IN FEET
SCALE: 1"=200'

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ENGINEERS - SURVEYORS


COX AND DINKINS
ENGINEERS · SURVEYORS
724 Beltline Boulevard
Columbia, SC 29205
803-254-0518— Fax 803-765-0993
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