SOUTH BROADWAY IMPACT ANALYSIS

FINAL DESIGN MEMORANDUM

PREPARED FOR THE CITY OF ALBUQUERQUE

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Smith Project No.: 117106-10

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The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal as a professional engineer licensed to practice in the state of New Mexico, is affixed below.

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March, 2019

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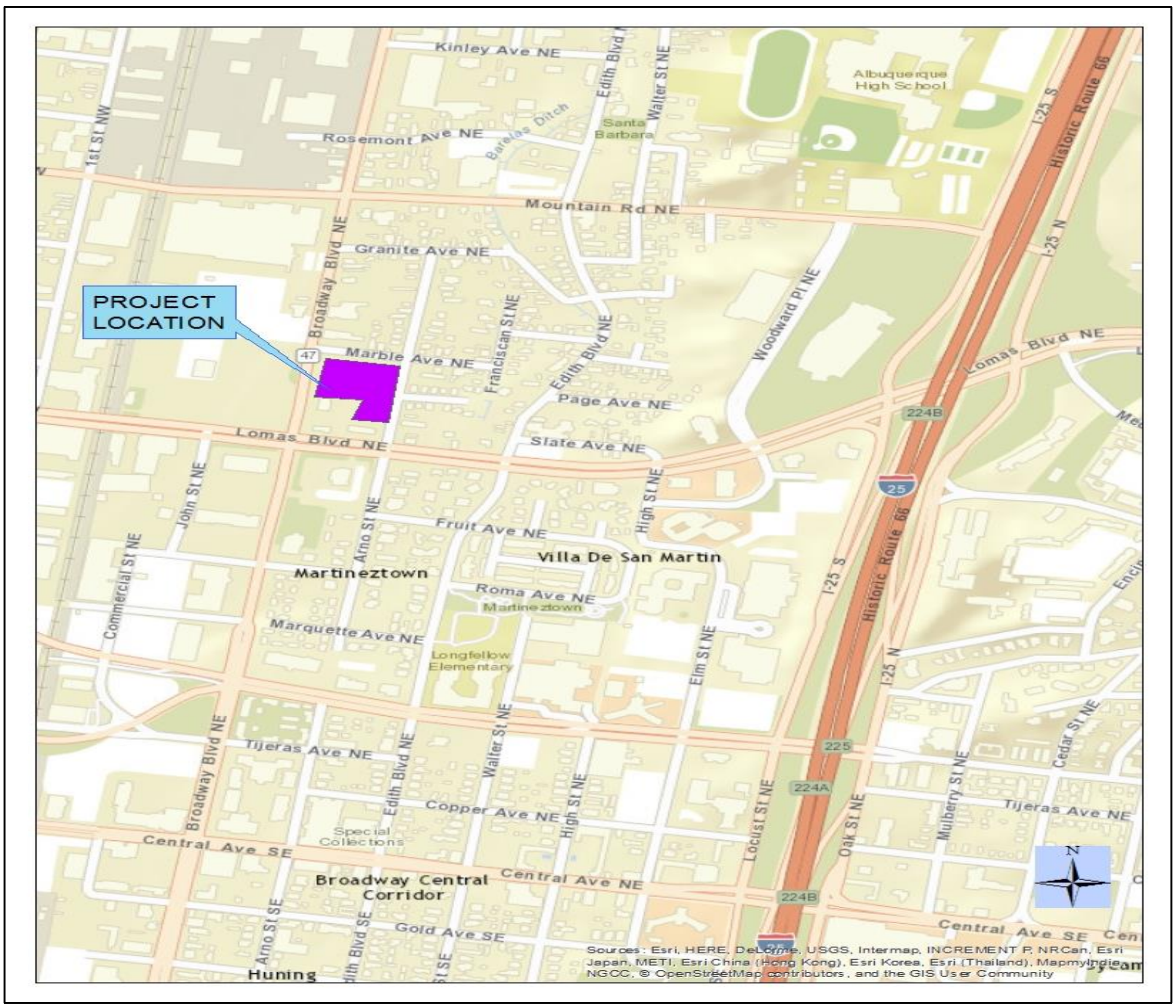
1.1 DESCRIPTION AND PURPOSE OF PROJECT

Smith Engineering Company, (Smith) is currently designing the Marble-Arno storm water pump station, detention pond and adjoining storm drain improvements for the City of Albuquerque, (COA). The Marble-Arno facility was originally proposed in the Mid-Valley Drainage Master Plan Addendum 1 in 2012 by Smith. The facility improvements will be located in the north east corner of Lomas Blvd and Broadway Blvd as shown on **Figure 1**. Once fully operational the Marble-Arno pump station will replace the existing Broadway Pump Station which was originally constructed in 1956. Upon completion of the Mid-Valley DMP in July 2012, an addendum was required to address findings from the South Broadway Drainage and Storm Water Quality Plan completed in April 2012 by URS which will be referred to hereon as the original South Broadway Study.

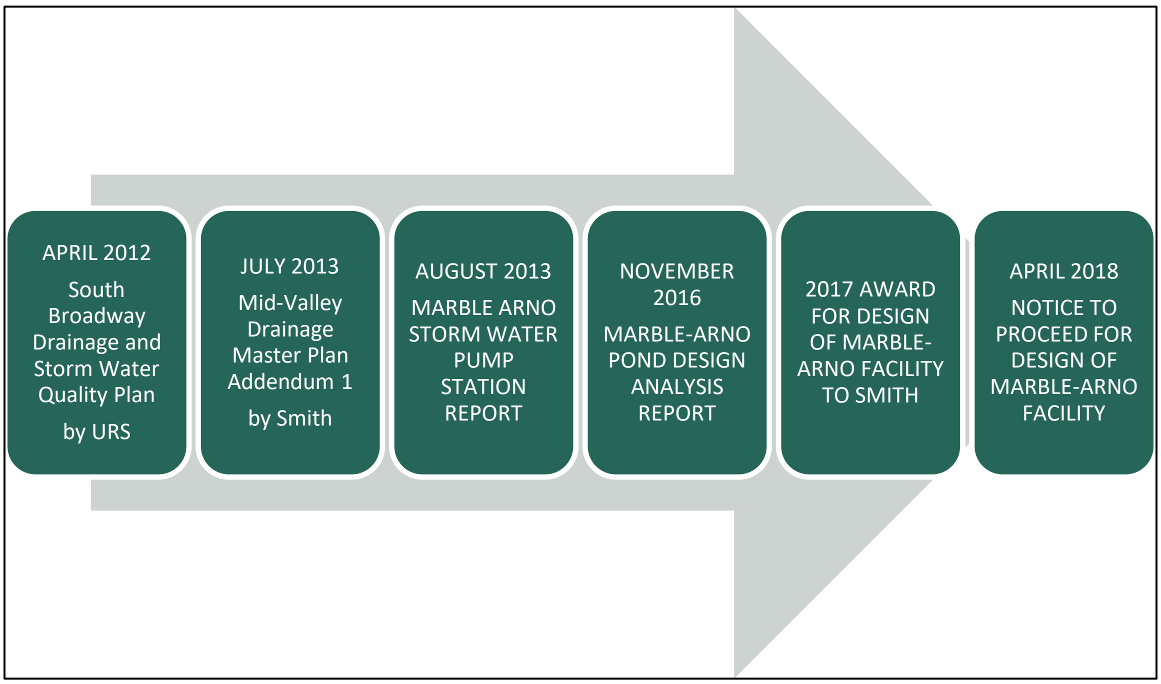
Figure 1: Vicinity Map



The South Broadway study predicted that there would be approximately 228 cubic feet per second (cfs)/ 11 acre-ft (AF) of surface flow that would flow north overland from the intersection of Broadway Blvd and Martin Luther King Blvd (MLK) to the intersection of Broadway Blvd and Lomas Blvd. As such, the footprint of the Marble-Arno Pond and several other facilities had to be modified in the Mid-Valley DMP Addendum 1 in order to accommodate this excess flow based on direction given by the COA.

Two subsequent studies were performed to determine the feasibility of replacing the existing Broadway Pump Station and to evaluate the potential footprint of the proposed Marble-Arno Pond. Both feasibility studies incorporated the predicted South Broadway flows as part of the analysis and therefore the magnitude of the pump station and wet well was very large. At Smith's recommendation, COA authorized Smith to conduct this study to analyze the impact of the original South Broadway flows to potentially downsize the Marble-Arno Facility.

The timeline of the various studies is shown below.



The purpose of this study was:

- To analyze the subbasins that would potentially contribute flows to the intersection of Broadway and Lomas Blvd and verify the validity of the subbasin boundaries from the original South Broadway Study
- Determine if the existing storm drains in the South Broadway subbasins would provide capture of surface flows that may have been omitted in the original study
- Evaluate the parameters used in the computation of hydrographs in the original South Broadway Study and adjust these parameters as necessary
- Run the hydraulic analysis of the storm drain network in the South Broadway subbasins
- Quantify total runoff at the intersection of MLK and Broadway Blvd

- Determine the surface flow direction of these overland hydrographs
- Determine the impact these hydrographs will have on the design capacity and function of the Marble-Arno Facility

1.2 FIELD OBSERVATION

Smith conducted field observations in December 2018. The purpose of the field work was to observe the physical characteristics of the subbasins that form the adjoining basin boundaries between the Mid-Valley and South Broadway watersheds. The presence of storm drain infrastructure, particularly inlets was noted. **Figure 2** shows the shared boundaries between the Mid-Valley and South Broadway study.

SECTION 2. HYDROLOGIC ANALYSES

2.1 Previous StudiesThe following reports were reviewed before performing any analysis.

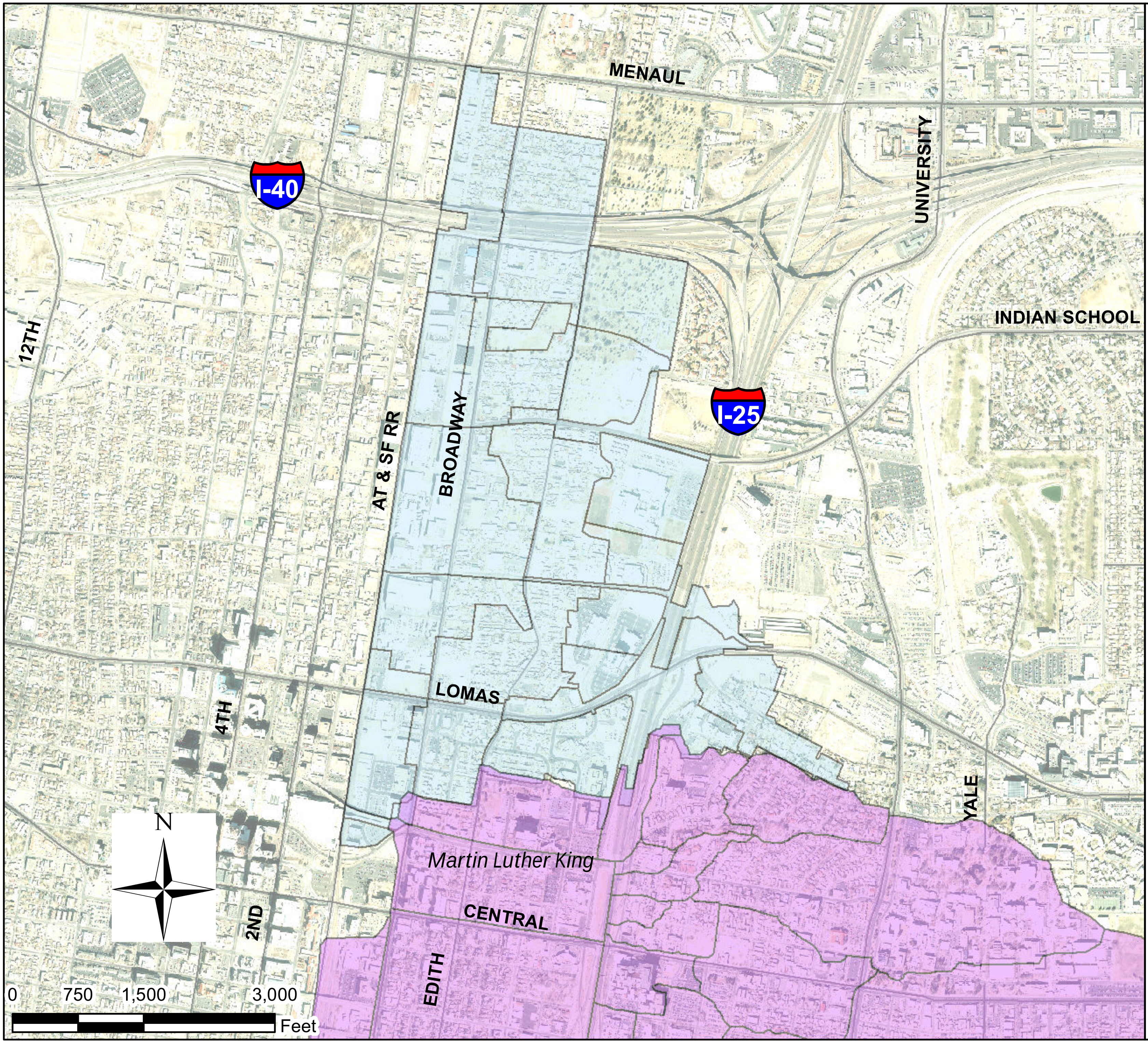
- South Broadway Drainage and Storm Water Quality Plan by URS completed in April 2012
- Mid-Valley Drainage Master Plan Addendum 1 by Smith, completed in July 2012
- Marble-Arno Feasibility Report by Smith, completed November 2016

2.2 SUBBASIN ANALYSIS

The original subbasin boundaries from the South Broadway study area that were deemed to contribute surface flows to the intersection of Broadway and MLK Blvd. were evaluated and field verified. The original boundaries are shown on **Figure 3.** The following subbasin boundaries were modified to better represent topographic and urban features identified in the field and to make sure that there were no gaps between the Mid-Valley and South Broadway subbasin boundaries:

- SJH-100_1A
- SJH-100_2A
- SJH-100_3A
- SJH-100_4A
- SJH-100_5A
- SJH-100_6A

Subbasin SJH-100_3A was originally routed overland to drain to Central. This was revised after field work was performed since MLK acts as the divide and will prevent any flows from draining south. Subbasin SJH-100_3A was subdivided so that the northern portion drained west on MLK. The remaining portion of the area was merged with Subbasin SJH-100_4A as these areas drain to the same outlet location. The areas were adjusted in the SWMM model. The modified subbasin boundaries are shown on **Figure 4.**



Legend

- Original South Broadway Basins
- Mid-Valley Basins

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FIGURE 2 SHARED SUBBASIN BOUNDARY

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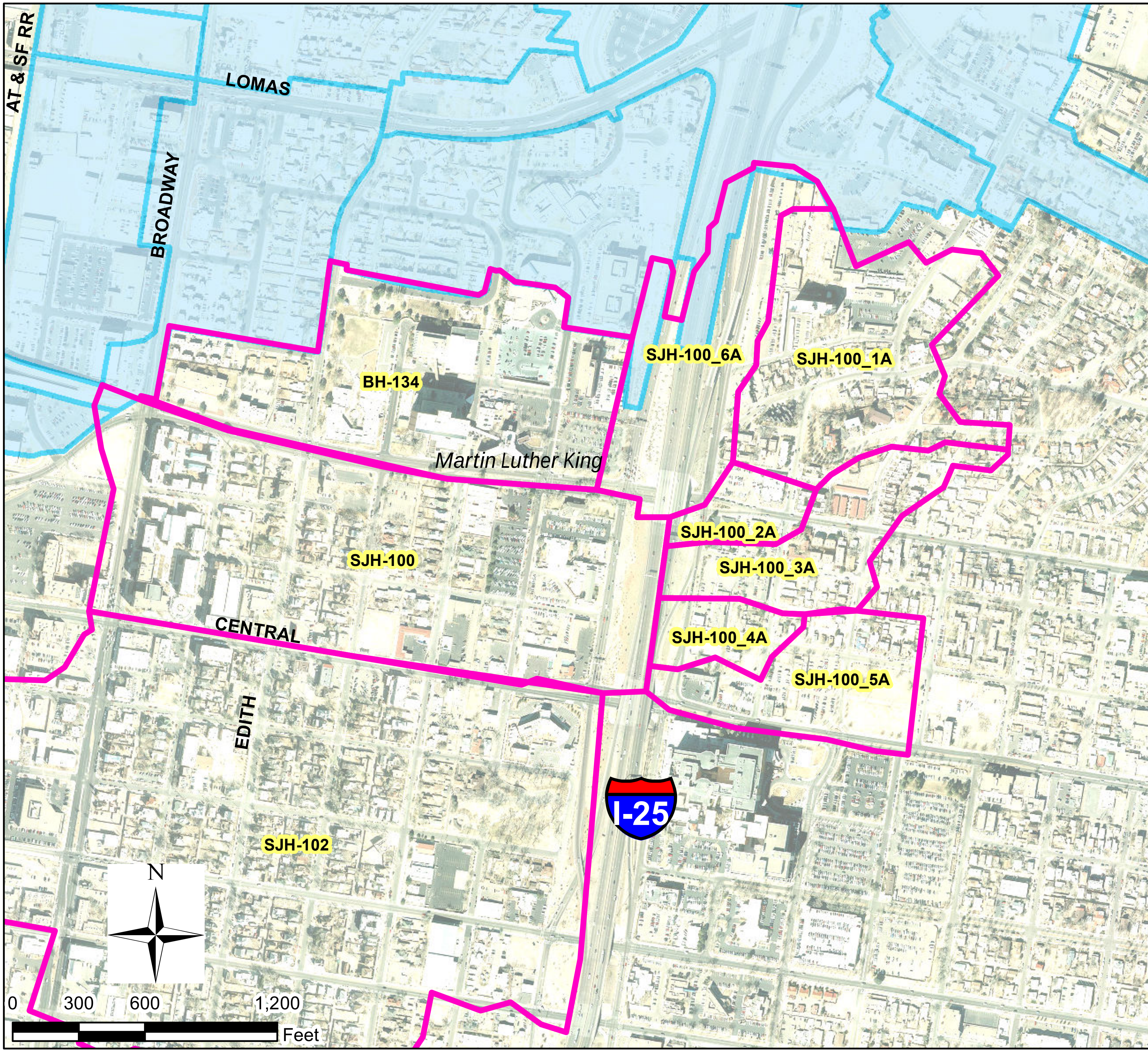

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Mid-Valley Basins

Original South Broadway Subbasins

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FIGURE 3 ORIGINAL SOUTH BROADWAY BASIN BOUNDARY

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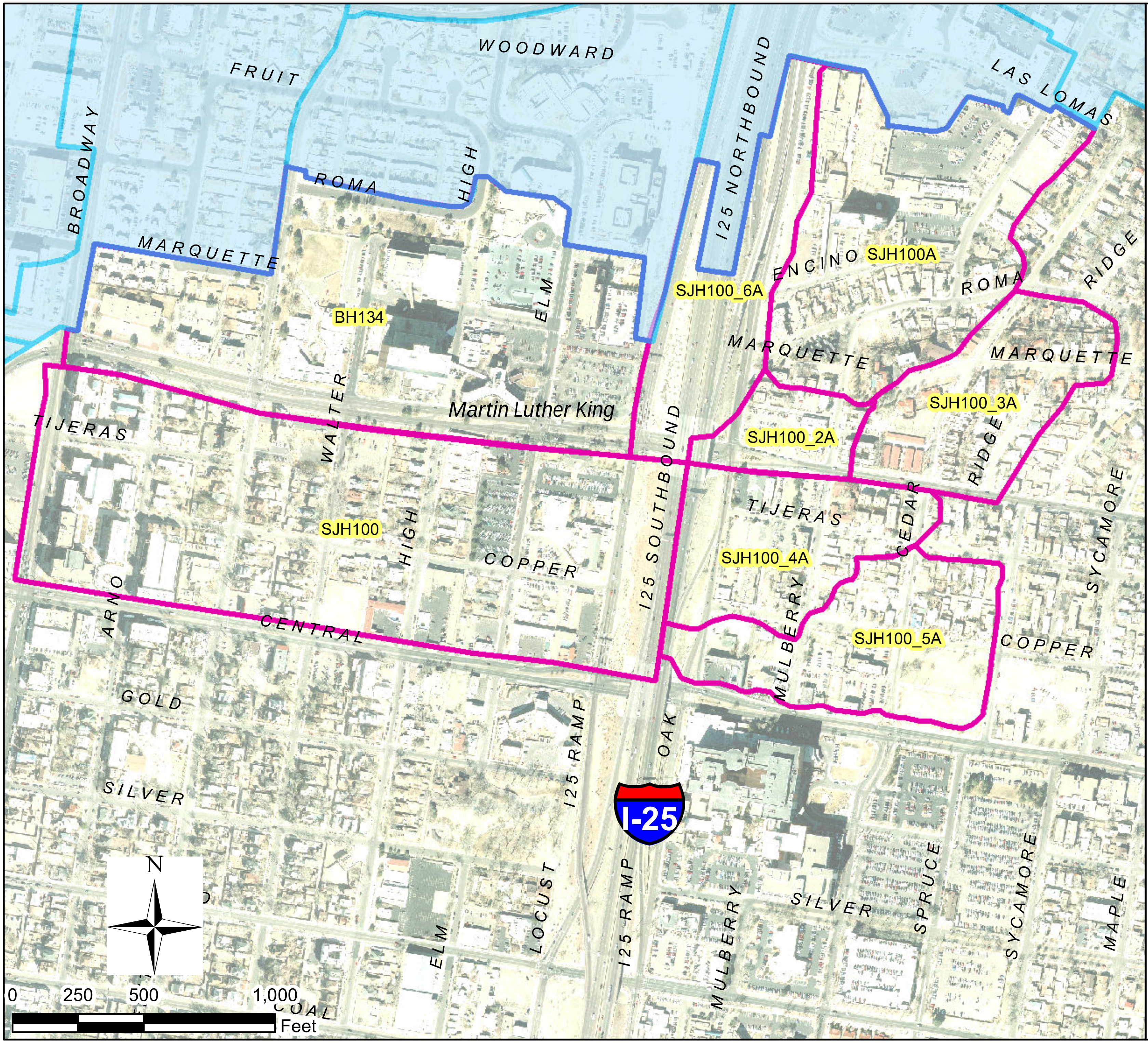

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Mid-Valley Basins

Modified South Broadway Basins

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FIGURE 4 MODIFIED SOUTH BROADWAY BASIN BOUNDARY

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2.3 EXISTING STORM DRAIN INFRASTRUCTURE

One of the benefits of using SWMM is that it will allow the user to do a combined hydrologic and hydraulic analysis of an urban watershed. The user can define subbasin characteristics to generate a hydrograph which can then be added directly into a hydraulic conveyance network in the form of either storm drains or open channels. The program is then able to dynamically route the hydrographs inside the hydraulic network using the Saint Venant's one dimensional partial differential equation. This method allows the network to be analyzed dynamically based on continuity and momentum for conduits while analyzing volume continuity at nodes. In this analysis the conduits represent the storm drains while the nodes represent the manholes. This method allows a hydraulic network (in this study, storm drains) to pressurize such that flows can exceed the normal flow values and surcharge out of the pipes at the nodes. The flooding that occurs at nodes can be allowed to pond on the node by assigning a storage value. This ponded volume of water will then be returned into the storm drain system once the hydraulic grade line (HGL) recedes and capacity becomes available in the storm drain system. The ponding condition should only be used if the roads are very flat and will act as a means of secondary conveyance and or storage when the storm drains surcharge. The existing conditions South Broadway SWMM model was reviewed to determine the locations where hydrographs were added into the existing storm drain networks east of Broadway. **Figure 5** shows the location and sizes of the existing storm drain infrastructure in the South Broadway subbasins that contributes to the Mid-Valley subbasins.

Photo 1

There are a considerable number of inlets in the various subbasins. However, the original model assumed none of the subbasin hydrographs were captured by the inlets and storm drains in the respective subbasins shown on Figure 5. Instead all hydrographs were routed overland and added into the storm drains at the intersection of Broadway and MLK and at Copper and MLK. Based on field observation and topography, some of the overland flow paths assigned are not possible due to significant buildings acting as flow obstructions or due to the flow path going uphill. Particularly at Broadway and Copper, the large buildings as shown on **Photo 1** will prevent any surface flows to traverse the facility.

Photo 2 shows that inside the compound there are depressed areas that will impound the water on site in the event the flows overtopped the curb shown in **Photo 1.** Copper does not connect directly to Broadway due to the buildings shown in Photos 1 and 2. **Figure 6** shows the overland flow paths used in the original study. Subbasins SJH-100_1A and BH-134 were presumed to drain to the intersection of MLK and Broadway. All other subbasins were routed to Copper and Broadway Blvd. Smith reanalyzed the available capacity of the storm drains and inlets in the South Broadway subbasins from the original study and compared this to the peak discharges from the various subbasins.

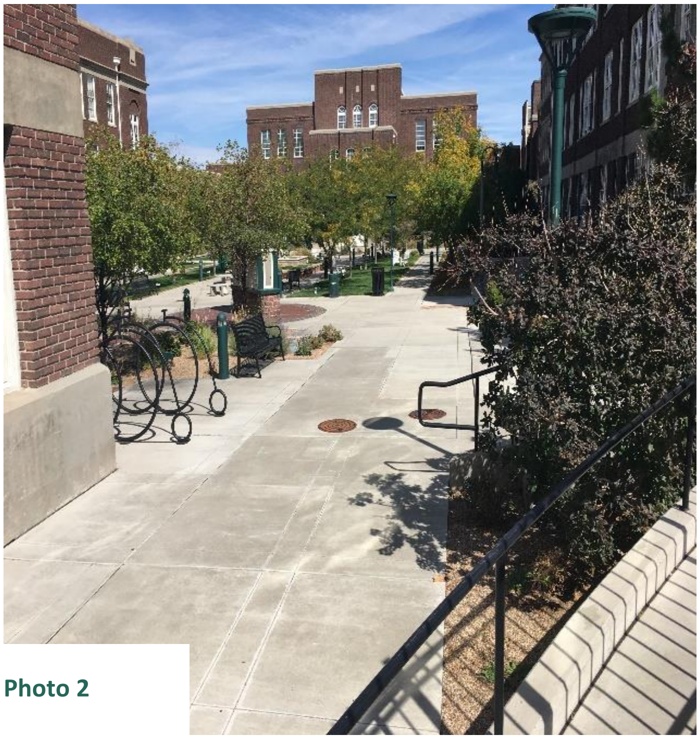
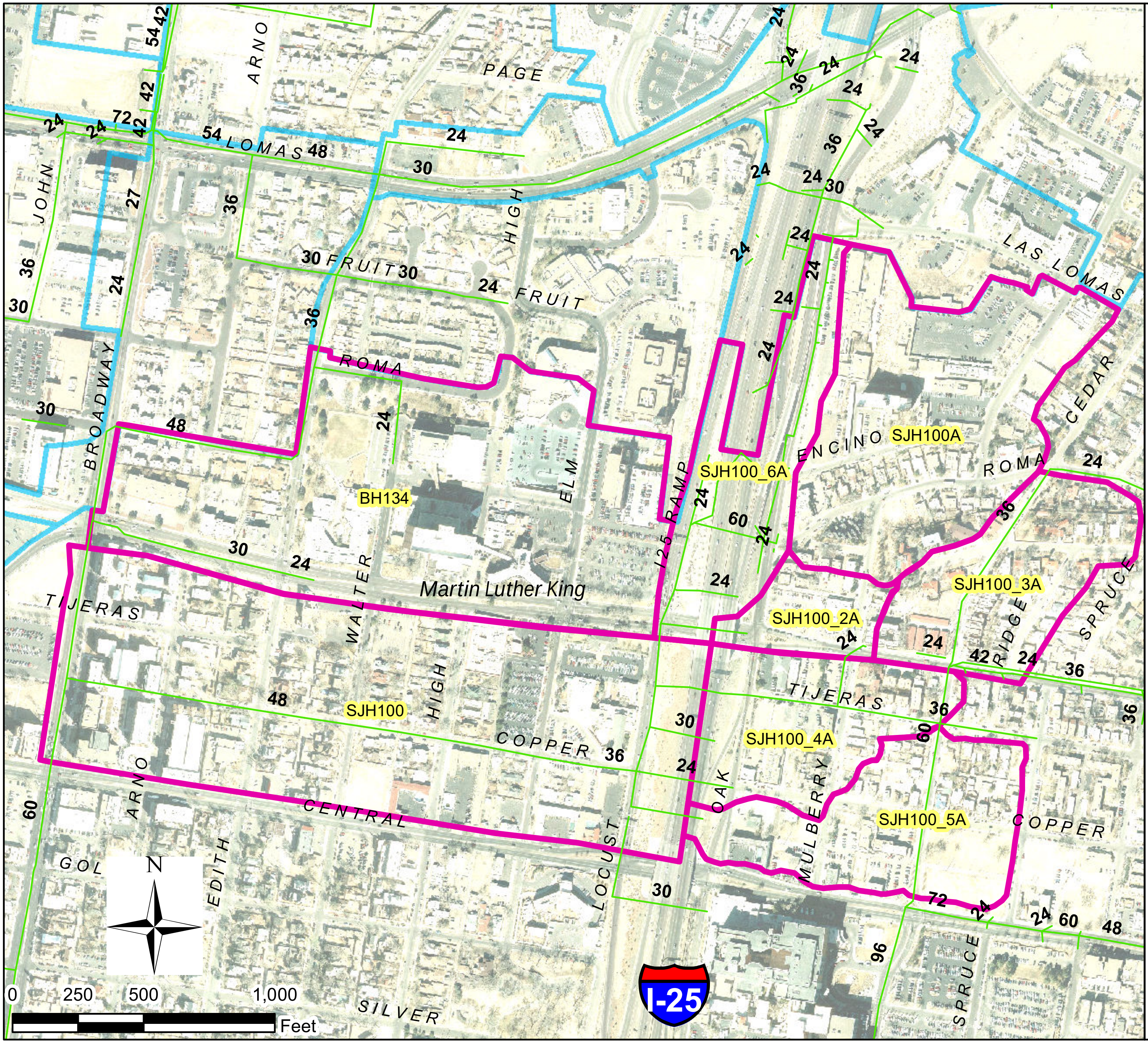


Photo 2

A typical capture value of 5 cfs per inlet has been deemed acceptable based on inlet analysis performed in previous drainage analyses for COA and AMAFCA. This was the value assumed for all inlets in the South Broadway subbasins. Peak flows were compared against the maximum capture capability of the inlets and storm drains. The capacity of the storm drains and inlets were compared against each other to ensure that full capture was not prevented by the lack of either inlet or storm drain capacity. Based on this comparison, hydrographs from the respective subbasins were added into appropriate storm drain systems until all storm drains were at full capacity at the peak of the 100 Year-24 Hour storm. No other hydraulic parameters were modified for the storm drain network that was created in the original South Broadway Study. With the exception of subbasin SJH-100_1A, the existing storm drains have the capacity to intercept runoff from all other subbasins contributing to Broadway and MLK Blvd. **Figure 7** shows the modified flow patterns. Subbasins SJH-100_6A, SJH-100_3A, SJH-100_4A and SJH-100_5A were initially routed overland on Central and then to Copper, however this flow path is topographically not possible. The absence of inlets at Central and Oak St mean that any overland flows will continue west on Central to Broadway where major flow splits occur due to topography and crowned street sections. This overland flow was approximately 86 cfs. The hydrographs from these subbasins were evaluated using a 2D surface water model which will be discussed later. The total runoff from subbasin SJH-100_1A, which would flow overland to MLK and Broadway Blvd was determined to be approximately 60 cfs and 4.1 AF. This was significantly lower than the initially predicted 228 cfs and 11 AF.

This large discrepancy occurred because the capture capacity of all the storm drain infrastructure in the subbasins shown on Figure 5 and 6 were not accounted for in the original South Broadway Study.



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Existing Storm Drains

Modified South Broadway Basins

Mid-Valley Basins

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FIGURE 5 EXISTING STORM DRAINS IN STUDY AREA

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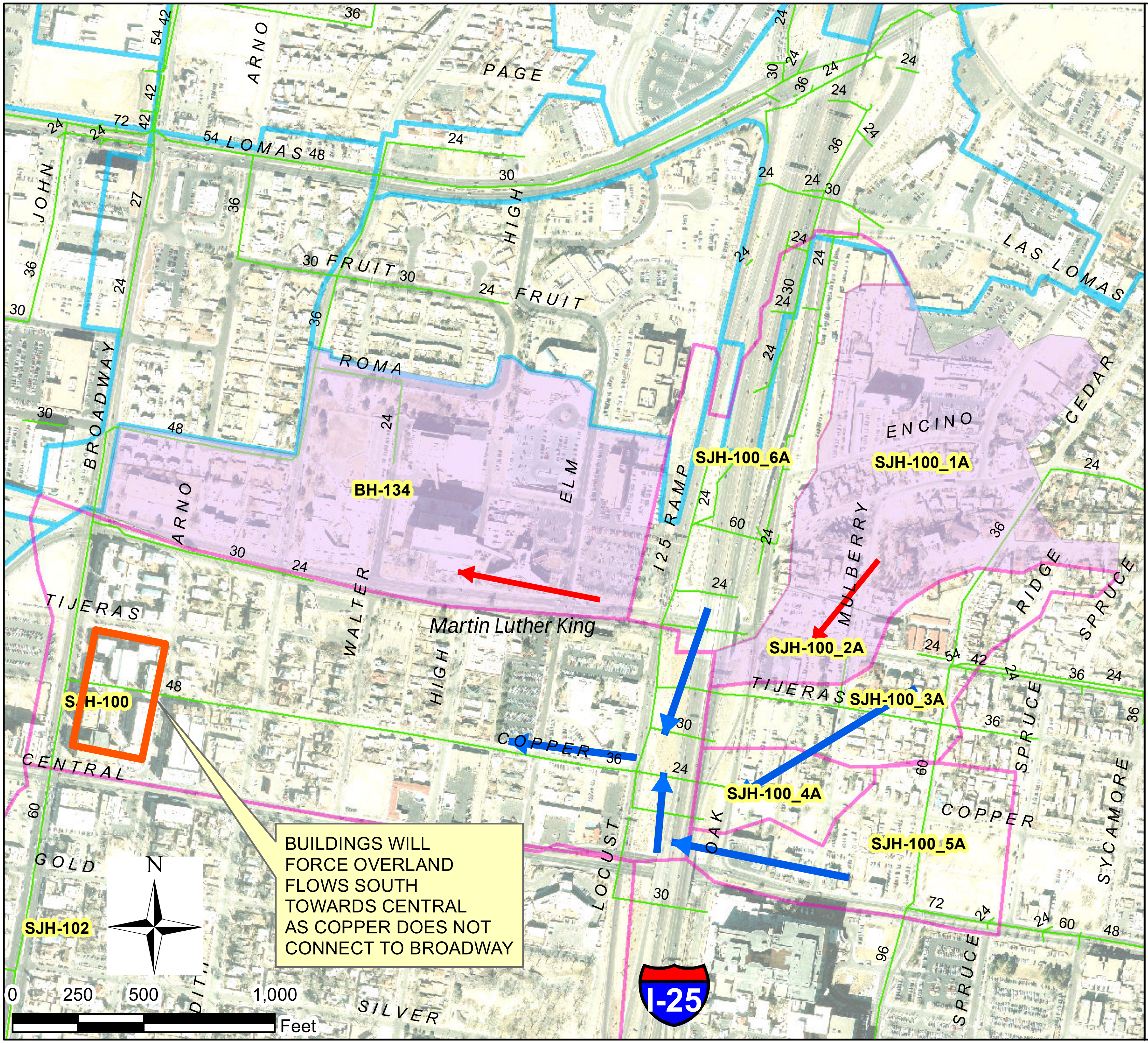

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Overland Flows to MLK and Broadway

Overland Flows to Copper and Broadway

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FIGURE 6 OVERLAND FLOW PATHS USED IN ORIGINAL STUDY

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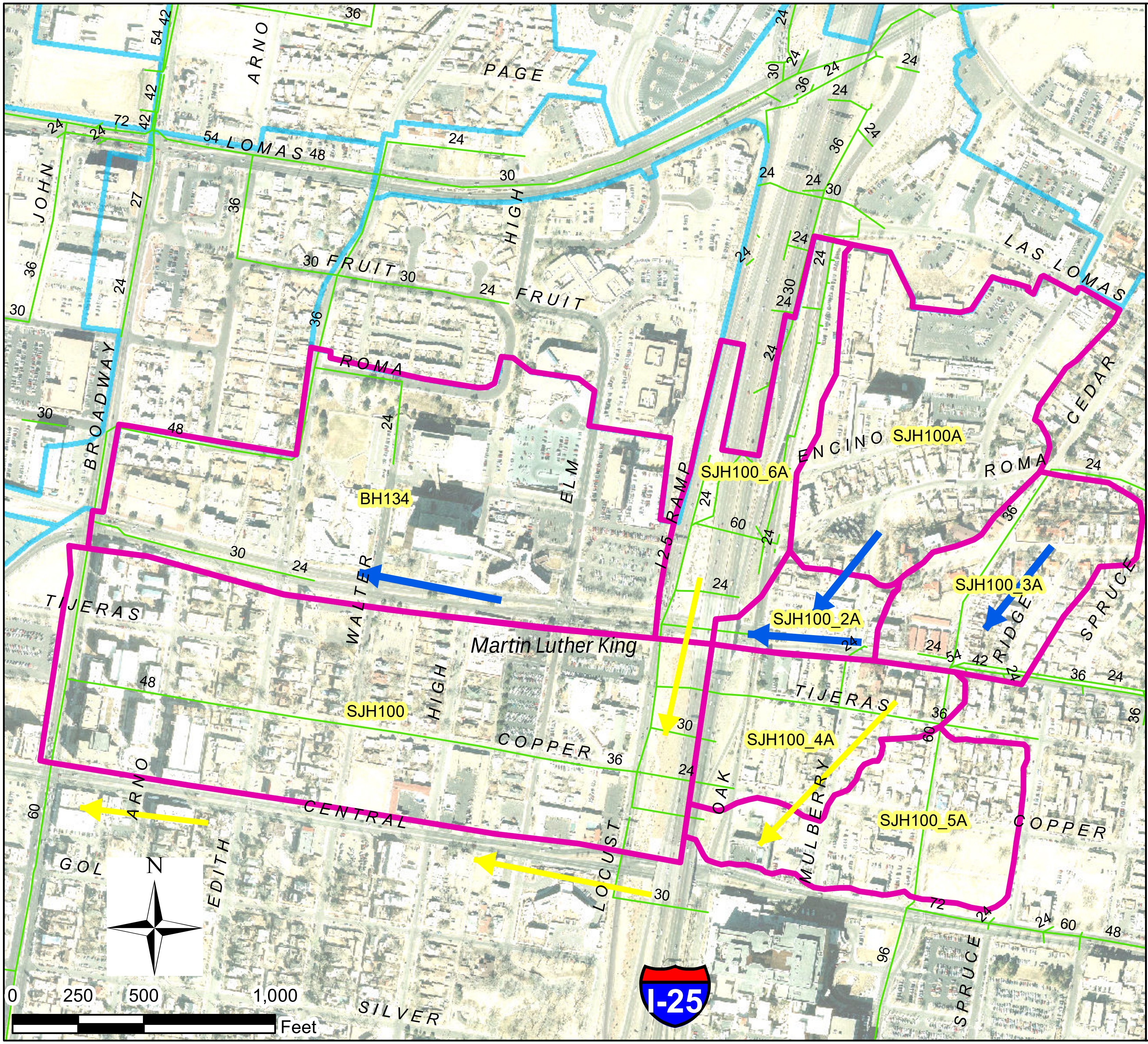

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Overland Flows to Central and Broadway

Overland Flows to MLK and Broadway

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FIGURE 7 MODIFIED OVERLAND FLOW PATHS USED IN IMPACT ANALYSIS STUDY

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2.4 ANALYSIS OF INPUT PARAMETERS

The hydrologic analysis methods available in SWMM provide an effective tool for the analysis of subbasins that are depressed and characterized as valley watersheds. This is due to the fact that initial abstractions for these depressed subbasins can be increased to reflect the added onsite ponding, infiltration and volume losses that occurs in areas that do not drain. SWMM essentially treats each dendritic subbasin as a rectangular sub-catchment polygon that a hydrograph is generated from. There are several parameters that have a significant bearing on the shape of the polygon which in turn directly correlates to the runoff of rates and runoff volumes.

- **Sub-catchment**: The terminology used to describe the equivalent of a subbasin
- **Area:** Every sub-catchment requires an area to be specified based on appropriate topographical and urban boundaries.
- **Hydrologic Area Width:** This is the characteristic width of overland flow path for sheet flow runoff. The appropriate width for the upland part of any subbasin is difficult to predict, especially in a heavily urbanized subbasin that is convoluted with buildings, parking lots etc. SWMM recommends approximating the width by delineating the longest flow path for the Time of Concentration (Tc). The characteristic hydrologic width can then be computed as a ratio of the sub-catchment area to the sub-catchment's Tc flow path length. The Tc flow path is easily delineated based on topographic data for most sub-catchments. This procedure of using the ratio of area to length minimizes the subjectivity in the computation of this parameter. For instance, the original model assigned a value of 59,448 ft to subbasin SJH-100_6A. for its overland flow width based on an equation that was developed internally for this project. This value is very unreasonable especially when the entire basin area is only 12 acres.
- **% Impervious:** Percentage of the sub-catchment that is impervious. This is determined primarily by measurements based on ortho-imagery and field observation. If an impervious sub-area routing method is chosen, the percentage impervious value drives the infiltration computations as opposed to the curve number.
- **Curve Number:** Based on NRCS curve numbers. It is very important to note that the curve number is only applied to the pervious part of the sub-catchment if an impervious subarea routing is chosen. If a pervious sub-area routing method is used and a composite curve number is assigned, then the % impervious value should be set to 0 to avoid runoff errors as the software will rely predominantly on the composite curve number to perform its infiltration calculations.
- **Sub-Area Routing:** Determines how runoff from the upper part of the subbasin is routed through the rest of the subbasin and how much infiltration occurs in the process. There are two choices, impervious sub-area routing or pervious sub-area routing. Impervious sub-area routing assumes that the pervious, upland part of the runoff is routed internally over the directly connected impervious part.

If an impervious subarea routing method is chosen, it is crucial to define the percent imperviousness in the subbasin as accurately as possible because the software relies on this parameter exclusively to compute infiltration losses which affects runoff volumes.

The original South Broadway model used the impervious sub-area routing method but assumed that only the roads would contribute towards the impervious portion of the subbasins.

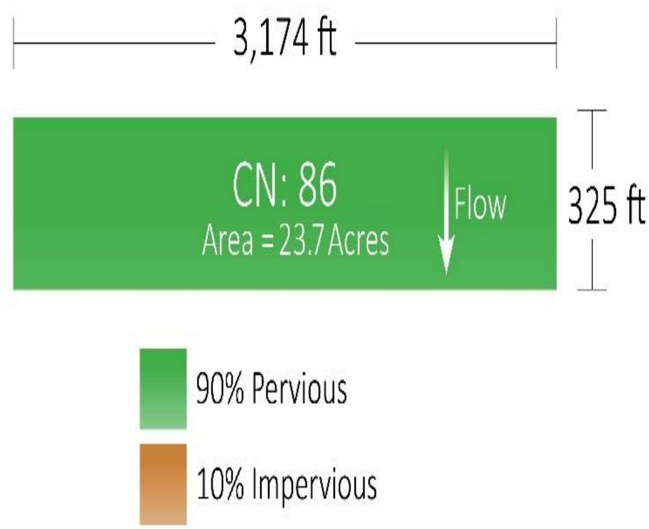
As such a standard value between 10-15 % imperviousness was allocated per subbasin. It appears that a composite curve number was used with the understanding that losses and imperviousness for the entire subbasin would be computed based on the composite curve number. However as discussed earlier, when an impervious sub-area routing is chosen, the curve number is only applied to infiltration losses assigned to the pervious part of the subbasin. The impervious losses are a direct function of the percentage imperviousness assigned to the sub-catchment polygon

Table 1 provides a comparison of key parameters for subbasin SJH-100_1A as delineated in the original study versus that which was subsequently modified by Smith.

Table 1: Comparison of Parameters for Subbasin SJH-100_1A

SWMM Parameter	Definition	Original South Broadway Study Assumptions	Smith Modified Model Assumptions
Area	Subbasin Area	23.7 acres	23.7 acres
Length of Longest Flow Path	Flow path that would be used to compute the Time of Concentration	Not Computed	1700 ft
Hydrologic Area Width	Characteristic width of overland flow path for sheet flow runoff.	Computed based on Consultant Equation = 3174 ft	Computed Area / Tc Flow Path = 564 ft
%Impervious	Percent of land area that is impervious	10%	80%
Curve Number	CN	86	77
Sub-area Routing	**Internal routing methods**	**Impervious**	**Impervious**

Figure 8: SWMM Sub-Catchment Polygon based on Original Parameters of the South Broadway Study

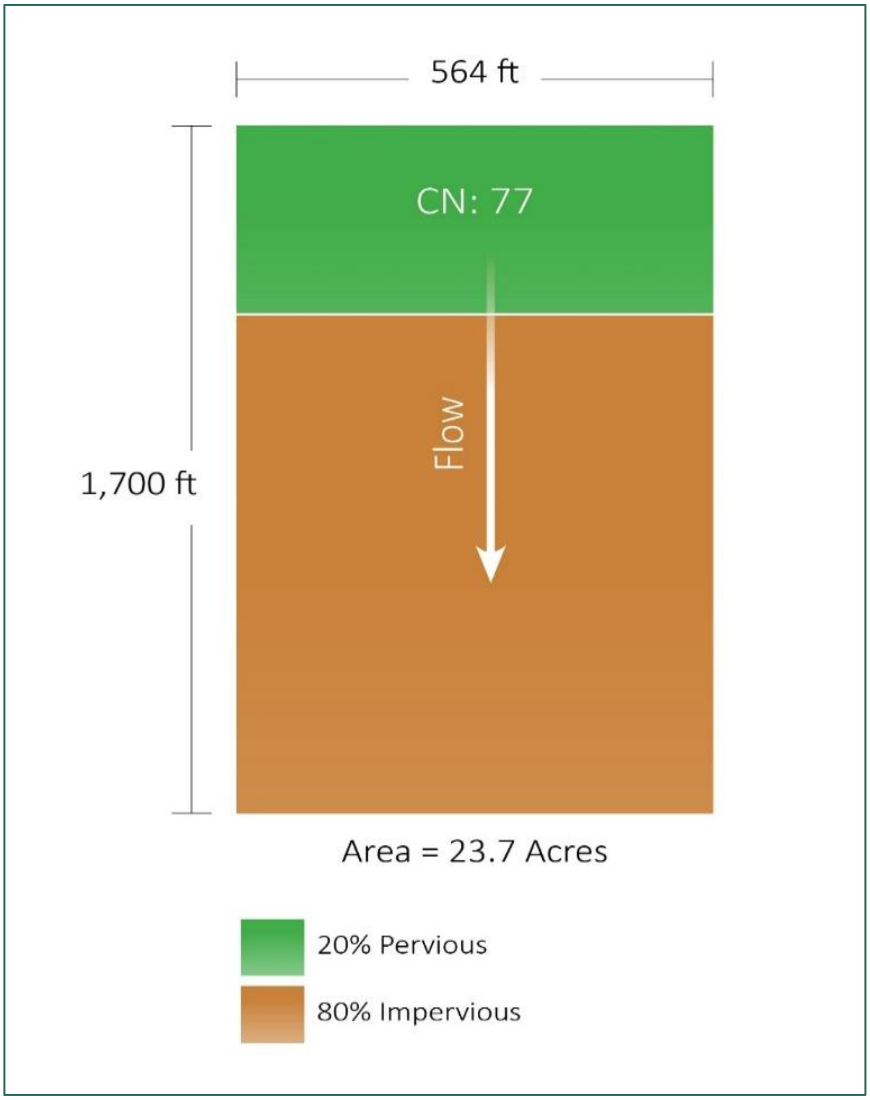


Based on the parameterization shown in **Table 1,** the SWMM sub-catchment polygon used by the software in the original study is shown in **Figure 8.** As shown on **Figure 8,** the sub-catchments for the original vs the modified models are vastly different in manner the impervious areas are allocated based on the area, width and length computations. The original model shows a wide polygon which is almost completely pervious and because only 10% of the area was allocated as impervious. The polygon does not show the impervious area when compared to the Smith Modified sub-catchment polygon because it was only allocated approximately 10% of the whole sub-catchment. While a composite curve number of 86 is used, the curve number is only allocated to the pervious part of the sub-catchment since an impervious subarea routing method was chosen. In this case, most of the polygon is pervious therefore the composite curve number has very little impact on the direct runoff volume. There is a significant amount of infiltration losses that occur which is highly inaccurate and incorrect. As a result, the volumes predicted in the initial study will be approximately 29% lower. The results are shown in the conclusion section.

Smith proceeded to correct the parameters discussed in all the subbasins that affect the Mid-Valley study area and recomputed the models to derive new discharges in this modified study. Once the percent imperviousness of the subbasins were redefined based on ortho imagery and the width and length parameters rectified, the SWMM sub-catchment polygon appear as shown on **Figure 9**. Since the subarea routing method is impervious a more accurate estimate of the impervious area has been specified. SWMM then computes the infiltration and direct runoff volumes more appropriately.

It is important to note that while in both models the subbasin areas are exactly the same, the shape of the sub-catchment polygon derived from the allocation of width and percent imperviousness is vastly different. This has a tremendous bearing on the runoff volume and peak discharge.

Figure 9: SWMM Sub-Catchment Polygon based on Modified Study by Smith



SECTION 3. RESULTS FROM SMITHS MODIFIED SOUTH BROADWAY ANALYSIS

3.1 RESULTS OF MODIFIED SWMM MODEL AND 2D SURFACE WATER MODEL

The modified South Broadway model was carefully checked for continuity and surcharging. Based on the dynamic HGL analysis, no surcharging was observed in the storm drain systems that were shown on **Figure 5.** However, the main storm drain trunk line in Broadway Blvd that drains south from Marquette St reaches maximum capacity. As such, the flows from subbasin SJ-100_1A cannot be added into the storm drain system. This overland flow of 60 cfs and 4.1 AF will most likely be the tributary flow to the intersection of Broadway and Lomas Blvd. West bound Central Blvd continues to steeply drop in elevation until it hits the low point underneath the railroad bridge.

Figure 10: Location of Overland Hydrographs in 2D Model

The total flow from Subbasins SJH-102_1A, SJH-100_4A and SJH-100_5A was approximately 86 cfs that drains to the intersection of Central and Broadway Blvd as shown on **Figure 10**. There is also a topographical drainage divide just north of Central and Broadway Blvd so any surface flows reaching this location will follow the existing terrain and flow west and south as opposed to north. Since the terrain is flat on Broadway north of Central, overland flow directions are very difficult to predict based on contour data. Therefore, a 2Dimensional surface water model was developed using HEC-RAS 2D using the available digital elevation models (DEM). The overland hydrographs at Central and Oak and MLK and Broadway were added at the locations shown on **Figure 10.** As anticipated, the hydrograph from Central and Oak flows west and south. The hydrograph from MLK and Broadway Blvd showed a series of complex flow splits from MLK onto Marquette and Roma and then north towards John St. The flow splits are shown in **Figure 11.** The results show that while the 60 cfs will flow overland north towards Lomas Blvd, the bulk of the flows drain north west from Broadway onto Marquette and Roma Ave towards John St which is the lowest point in this area. Coincidently, there is a storm drain system that is designed to convey a maximum of 37 cfs under full flow conditions. The storm drain, that starts as 30-inch and increases to a 36-inch diameter ties into the 72-inch Lomas storm drain that flows west on Lomas Blvd. and John St. 18 inlets were also observed on John St, many of which will act as sump inlets.

As such the existing system is capable of conveying the 28 cfs that reaches this location. The flow that does drain to the intersection of Broadway and Lomas Blvd only amounts to 9 cfs and approximately 0.6 AF.

To fully verify that these flows could be intercepted by the storm drains in John St and Broadway and Lomas Blvd, the latest Mid-Valley SWMM model which is being used to design the Marble-Arno facility was updated to include the storm drain system on John St. The actual hydrographs were then added into the storm drain network. No surcharging was observed. The existing storm drains drain west towards the Barelas and Alcalde pump stations. Since all Mid-Valley subbasins to east of Lomas and Broadway are being diverted into the new pump station/pond facility, the Lomas system west of Lomas and Broadway will have additional capacity.

Figure 11: Overland Flow Splits Based on 2D Modeling

3.2 CONCLUSION

After carefully reevaluating the subbasin boundaries, existing storm drain capacity and hydrologic modeling parameters the South Broadway Impact analysis provides the following conclusions:

The initial prediction made in the original report is not accurate. The 228 cfs and 11 AF of overland flow resulted largely due to discounting the existing storm drain infrastructure that is present in the subbasins east of I-25. Topography and urban development were also not accounted for when making assumptions for overland flow paths. The 2D surface water model also predicts that overland flows on Broadway Blvd will drain north west towards John St instead of Broadway and Lomas. The total flow that does get to the intersection of Broadway and Lomas Blvd. is only around 9 cfs and the existing storm drains have the capacity to convey this flow west. Based on the results from this analysis, the flows from the South Broadway subbasin will have no impact on the design capacity of the Marble-Arno Pump Station and detention pond.

Major modeling discrepancies were discovered that affect the runoff volumes in the South Broadway system as a whole **Table 2** presents a summary of volumetric differences from the subbasins based on the original South Broadway Study and modified South Broadway Impact Analysis. Overall, the subbasins from the original study that were analyzed as part of the Impact Analysis predict approximately 29% less volume. The reasons for the lower volumes are due to the higher infiltration rates discussed in section 2.1. Since the South Broadway Drainage Master Plan serves as a major planning document for the COA, Smith recommends that the overall analysis be reviewed, and modeling discrepancies resolved.

Table 2: Volume Difference Between Original South Broadway Study and Modified Study

Original South Broadway Draiange Master Plan					Modified South Broadway Impact Analysis		
Subbasin Name	Subbasin Area (acres)	Volume (Acre Feet)	Flow (cfs)		Subbasin Area (acres)	Volume (Acre Feet)	Flow (cfs)
SJH-100_6A	12.01	2.3	50		11	2.2	39
SJH-100_5A	12.29	1.5	36		12	1.8	29
SJH-100_4A	4.49	0.7	17		10	1.9	32
SJH-100_3A	11.71	1.5	35		11	1.8	29
SJH-100_2A	3.92	0.7	15		4	0.8	16
SJH-100_1A	23.73	3.1	47		22	4.1	60
SJH-100	53.26	7.8	175		53	10.2	155
BH-134	34.31	4.8	106		37	6.1	96
Total Voume		22.4				28.9	
Percent Difference In Volume Between Original and Modified Study Approximately 29%							