Section 3
Hydrology and Hydraulics

3.1 Introduction

This section summarizes the methodology used to modify the hydrologic and hydraulic models used for this study. The models used for this study were developed by modifying previously completed models of Salt Creek. The following sections summarize the modifications made to the existing models.

3.2 Hydrology

Hydrologic modeling was performed using the U. S. Army Corps of Engineer's (USACE) Hydrologic Engineering Center's Hydrologic Modeling System program (HEC-HMS) Version 2.2.2. Existing HEC-HMS models for each major subwatershed that drains into Salt Creek between Saltillo Road and downstream of North 98th Street were updated for this study.

3.2.1 Subarea Modification

Modifications to the existing hydrologic models were completed for this study to more fully understand local drainage at the offline storage sites. This effort consisted of modifying the subarea delineation and updating subarea hydrologic parameters in a manner consistent with the methodology used previously to model Salt Creek. Subarea delineations completed for the Oak Creek and Middle Creek models are shown in Table 3-1 and Figure 3-1.

Table 3-1 Subarea Updates

	DFIRM Subarea	Split into:
Oak Creek	R3320W3320	OAK-N1
		OAK-S1
		OAK-S2
		OAK-S2a
Middle Creek	R3590W3590	MID-TO SALT[1]
		MID-S1
		MID-S2
		MID-S3
		MID-S4
		MID-S5

[1]Subarea "MID-TO SALT" was loaded directly onto Salt Creek

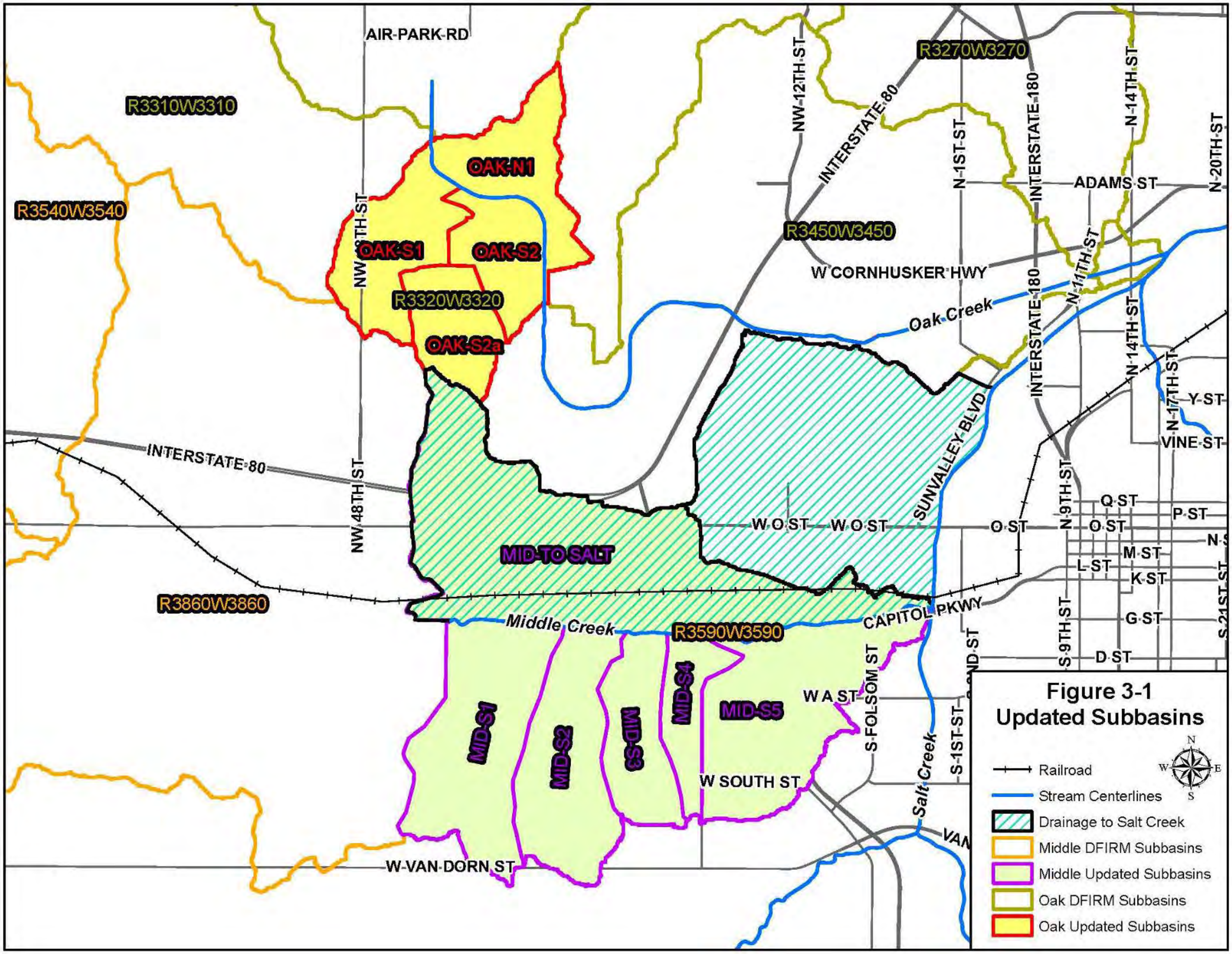

Figure 3-1
Updated Subbasins
Railroad
Stream Centerlines
Drainage to Salt Creek
Middle DFIRM Subbasins
Middle Updated Subbasins
Oak DFIRM Subbasins
Oak Updated Subbasins
OAK-N1
OAK-S1
OAK-S2
OAK-S2a
R3320W3320
R3310W3310
R3540W3540
R3270W3270
R3450W3450
R3860W3860
R3590W3590
MID-TO SALT
MID-S1
MID-S2
MID-S3
MID-S4
MID-S5
Oak Creek
Middle Creek
Salt Creek
AIR PARK RD
INTERSTATE 80
NW 48TH ST
NW 12TH ST
N 1ST ST
INTERSTATE 180
N 14TH ST
N 20TH ST
ADAMS ST
W CORNHUSKER HWY
SUNVALLEY BLVD
W O ST
O ST
CAPITOL PKWY
W A ST
S FOLSOM ST
W SOUTH ST
W VAN DORN ST
VINE ST
Y ST

3.2.2 Rainfall

The HEC-HMS models were used to simulate the runoff volumes and hydrographs resulting from 10-, 50-, 100-, and 500-year return period events. Precipitation depth quantiles used previously were used for this project as well. The precipitation depths were originally derived from TP-40, and depths not included in TP-40 were extrapolated from the available TP-40 depths. The HEC-HMS "frequency storm" option was employed for distributing the rainfall and reducing point rainfalls to reflect the watershed area. The rainfall input is listed in Table 3-2. The non-shaded data was taken from TP-40, while the shaded data was extrapolated. Duration extrapolations were performed by constructing a linear form between the precipitation depth and the log of duration. Extrapolations to the 500-year storm were conducted using the Gumbel distribution.

Table 3-2 HEC-HMS Precipitation Input

Duration	Storm depths in inches			
(hours)	10-year	50-year	100-year	500-year
0.08	0.72	0.94	1.05	1.31
0.25	1.40	1.84	2.04	2.54
0.50	1.95	2.55	2.83	3.53
1	2.50	3.27	3.63	4.34
2	2.87	3.75	4.25	5.04
3	3.13	4.00	4.50	5.41
6	3.50	4.75	5.25	6.33
12	4.17	5.33	6.00	7.16
24	4.67	6.00	6.67	8.05
48	5.08	6.55	7.31	8.81
96	5.56	7.16	7.98	9.62

In the HEC-HMS input, a central (50 percent) rainfall peak similar to SCS Type II was used. For this study, no changes in the precipitation input data were made.

3.2.3 Runoff Volume (SCS CN)

The same runoff volume method used for the Salt Creek DFIRM model, the SCS Curve Numbers Loss Rate, was used for this study to generate runoff volumes for new subareas. The SCS option uses an initial abstraction value and composite curve number (CN) to estimate runoff volumes from each subarea for a particular design rainfall event.

Initial abstraction is defined as losses from rainfall before runoff begins. Initial abstraction is a function of the composite CN and is commonly calculated using Equation 1.

$$Ia = 0.2(1000/CN - 10) \qquad \text{Equation 1}$$

The CN is a function of the land use condition and hydrologic soil group (HSG). For each new subarea developed for this study, a new composite CN was developed. These are shown in Table 3-3.

Table 3-3 Curve Numbers for New Subareas

	Subarea	Previous Composite Curve Number	Subarea	Area (square miles)	Curve Number
Oak Creek	R3320W3320	76.5	N1	0.43	88.4
			S1	0.49	80.7
			S2	0.33	80.0
			S2a	0.33	77.1
Middle Creek	R3590W3590	83.5	TO SALT	1.89	87.5
			S1	0.86	78.7
			S2	0.67	77.2
			S3	0.40	85.5
			S4	0.25	88.7
			S5	0.93	90.2

3.2.4 Existing Land Use

The existing land use conditions for Lancaster County were supplied by the City of Lincoln. The land use data were used to determine a CN using the values in the *Drainage Criteria Manual* as a guideline. Table 3-4 shows the land use categories and the assigned CN. Several land use categories did not correspond directly with CN cover types located in the *Drainage Criteria Manual*. CNs for these land uses were assigned by determining an average percent impervious and calculating a composite CN.

As shown in Table 3-4, all agricultural land use was designated a cover description of contour/crop residue in good hydrologic condition. Streams/Creeks, lakes, and wetlands were given a CN of 98. Land uses that did not correspond directly with a cover type were assigned a CN based on approximate average percent impervious and generally accepted engineering practices.

Table 3-4 Curve Numbers for Salt Creek Watershed Study

Lincoln/Lancaster County Land Use	Cover Type (Percent Impervious)	Hydrologic Soil Group			
		A	B	C	D
Agricultural Production: Crops/Tree Farm	Row Crops – Straight Row Good Condition	67	78	85	89
Airport	Compacted Soil	72	82	87	89
Apartments (w/number of units)	Residential 1/8 acre or less (65%)	77*	85*	90*	92*
Attached Single Family (Townhouses)	Residential 1/8 acre or less (65%)	77	85	90	92
Church, Synagogue, or Temple	Churches/Schools (75%)	84*	89*	92*	94*
Commercial NEC	Commercial and business (85%)	89	92	94	95
Duplex	Residential 1/8 acre or less (65%)	77*	85*	90*	92*
Educational Institution	Churches/Schools (75%)	84*	89*	92*	94*
Forest/Woodland	Woods - Fair Condition	36	60	73	79
Golf Course	Open Space - Good Condition	39	61	74	80
Heavy Industrial	Industrial (72%)	81	88	91	93
Lake	Water	98	98	98	98
Light Industrial	Industrial (72%)	81	88	91	93
Mobile Home including parks, courts (w/number of unit)	Residential 1/8 acre or less (65%)	77*	85*	90*	92*
Open Space	Open Space - Fair Condition	49	69	79	84
Park Land	Open Space - Fair Condition	49	69	79	84
Parking Lot (PL)/Street	Impervious (100%)	98	98	98	98
Pasture/Grassland	Pasture - Fair Condition	49	69	79	84
Public & Semi-Public NEC (e.g., cemetery)	Open Space - Fair Condition	49	69	79	84
Railroad	Gravel Covered Surface	76	85	89	91
Single Family (detached)**	Residential 1/3 acre (30%)	57	72	81	86
Stream/Creek	Water	98	98	98	98
Utility Facility (e.g., communication tower)	Commercial and business (85%)	89	92	94	95
VACANT (UNDEVELOPED) LAND	Open Space - Fair Condition	49	69	79	84
Vacated ROW (retained by public entity)	Open Space - Fair Condition	49	69	79	84
Wetland	Water	98	98	98	98

CN was assigned based on average 1/3-acre lot size.
* CN may be adjusted based on actual percent impervious versus reported standard percent impervious
**Single Family (detached) land use includes large and small lots.

The single family (detached) category includes residential lots of varying sizes; however, the *Drainage Criteria Manual* CN tables have lot sizes broken into 1/8 acre, 1/4 acre, 1/3 acre, 1/2 acre, 1 acre, and 2 acres. Single family (detached) land use was assigned to the 1/3 acre average lot size.

3.2.5 Hydrologic Soil Groups (HSG)

HSGs by soil types were determined from the Nebraska DNR Spatial GIS database website. The HSG was used to assign an appropriate CN for each subarea. Table 3-5 shows the soil types and their associated HSG for soils within the Salt Creek watershed.

Table 3-5 Hydrologic Soil Groups

Soil Type	HSG	Soil Type	HSG	Soil Type	HSG	Soil Type	HSG
Aksarben	B	Fillmore	D	Nodaway	B	Urban Land	D
Burchard	B	Geary	B	Pawnee	D	Wabash	D
Butler	D	Judson	B	Salmo	C/D	Water	D
Colo	B/D	Kennebec	B	Sharpsburg	B	Wymore	D
Crete	C	Mayberry	D	Shelby	B	Yutan	B
Crete Variant	D	Morrill	B	Steinauer	B	Zook	C/D

3.2.6 Runoff Hydrographs (Lag Time)

The SCS Dimensionless Unit Hydrograph was used to distribute the runoff volume to a unit hydrograph. The determination of an SCS lag time was required for this method. Consistent with the methodology of the SCS's *Technical Release-55 Urban Hydrology for Small Watersheds* published June 1986, the lag time for a subarea was assumed to equal 0.6 times the time of concentration. The time of concentration, in turn, was defined as the time required for water to travel to the subarea outlet from the most hydraulically distant point in the subarea. The updated lag times used for the new subareas are provided in Table 3-6.

Table 3-6 New Subarea Lag Times

	Subarea	Lag Time (min)
Oak Creek	OAK-N1	33.9
	OAK-S1	15.0
	OAK-S2	21.3
	OAK-S2a	8.0
Middle Creek	MID-TO SALT	36.5
	MID-S1	20
	MID-S2	21.8
	MID-S3	20.7
	MID-S4	25.6
	MID-S5	16.5

The time of concentration for each subarea was calculated using the methodology outlined in TR-55 (SCS 1986). For each subarea, the longest flow path to the subarea outlet was determined using a digital elevation model (DEM) developed from the LiDAR data and ArcView/ArcInfo tools that divided the flow path into four elements:

- Sheet flow
- Shallow concentrated flow
- Secondary channel
- Primary channel

The travel times associated with each of the four elements were added to calculate the time of concentration for each subarea. The methodology described below was used to evaluate existing conditions in the flow elements for each new subarea.

3.2.7 Sheet Flow

Sheet flow was assumed to occur at the most hydraulically distant portion of the flow path. TR-55 recommends a maximum sheet flow length of 300 feet, and best professional judgment indicates that a length more than 100 feet may not be appropriate for some subareas. Consequently, a subarea sheet flow length of 100 feet was used for this study.

Physical data were required to calculate the travel time associated with sheet flow using the TR-55 methodology, including flow length, slope, and overland flow roughness coefficient. An overland flow roughness value was estimated using typical literature values for each surface condition. The surface condition was determined from the aerial photos. Table 3-7 (from TR-55) shows Manning's n values for sheet flow for various surface conditions.

Table 3-7 Roughness Coefficients (Manning's n) for Sheet Flow

Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils: Residue cover #20 percent Residue cover >20 percent	 0.06 0.17
Grass: Short grass prairie Dense grasses Bermuda grass	 0.15 0.24 0.41
Range (natural)	0.13
Woods: Light underbrush Dense underbrush	 0.40 0.80

3.2.8 Shallow Concentrated Flow

Shallow concentrated flow occurs between the areas of sheet flow and open channel flow. To find shallow concentrated flow length, ArcMap was used to connect the end of sheet flow to the beginning of a defined value, as indicated by 2-foot contours. To calculate the travel time associated with shallow concentrated flow by the TR-55 methodology, physical data including the shallow concentrated flow length, slope, and surface conditions along the path were required. The average velocity was determined using Equation 2.

$$\text{Unpaved } v = 16.1345\,(s)^{0.5} \qquad \text{Equation 2}$$

The travel time for the shallow concentrated flow was calculated based on the segment length and velocity.

3.2.9 Secondary Channel Flow and Primary Channel Flow

Secondary and primary channel flow occurs between the end of shallow concentrated flow and the subarea outlet. Secondary channel flow occurs between the end of shallow concentrated flow and the flow path intersection with the primary stream. The primary streams in this project were the main channels of Middle Creek and Oak Creek. Middle Creek and Oak Creek were evaluated with the HEC-RAS model. Depending on location, a subarea may have one or both of these channel flow features. For example, as shown in Figure 3-2, subbasin OAK-S2a has only the secondary stream network associated with it, while OAK-N1 contains both secondary and primary channel flow.

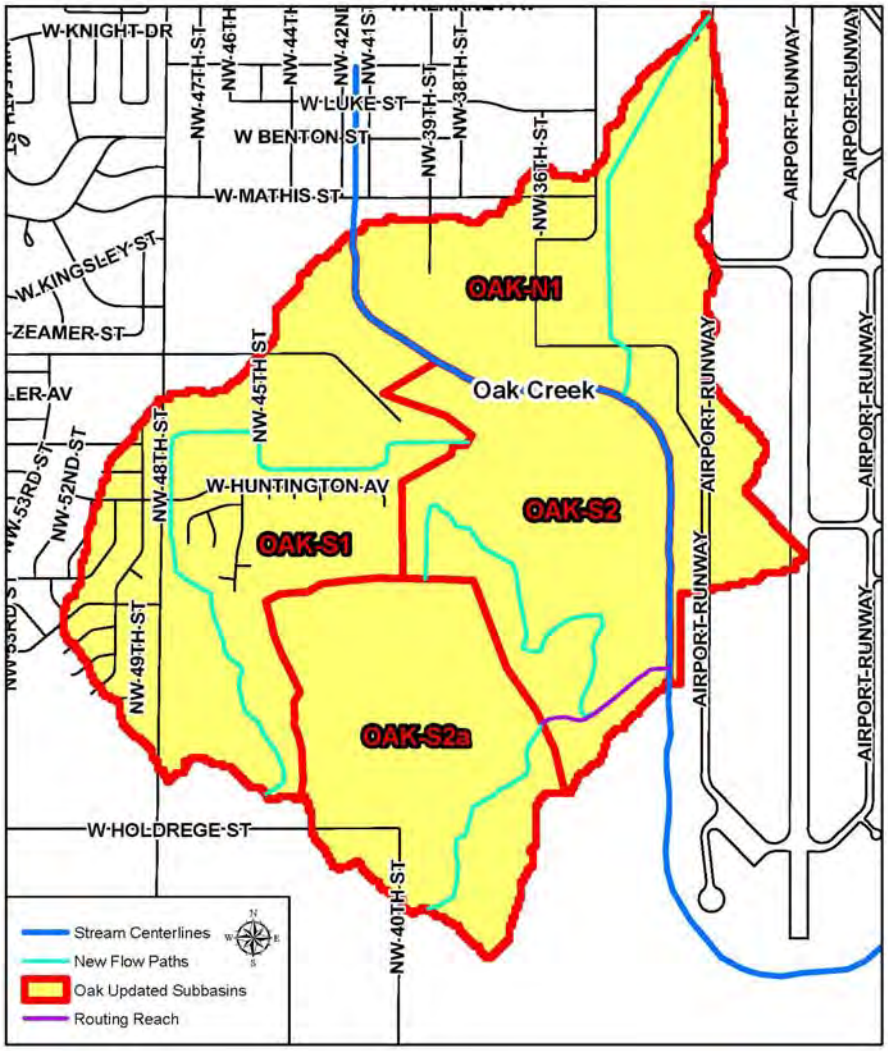

Figure 3-2 Channel Routing Reach

Travel time was calculated based on channel length and velocity for the 2-year storm. The velocity, in turn, was estimated based on channel slope and assumed flow depth and cross-sectional geometry. All of these data were developed in ArcMap. Slope data were calculated using the upstream and downstream elevations and the stream length in GIS. Cross section geometries were assigned based on review of stream geometry data developed by using GIS tools and the DEM.

3.2.10 Routing (Muskingum-Cunge)

The Muskingum-Cunge Routing method was the option used to route runoff through the subareas. Only one new routed reach was added to the model to route flow from OAK-S2a through OAK-S2. A representative trapezoidal channel cross section was developed using available contour data. The channel length and slope was determined using ArcMap and the existing topography TIN. The new routing reach is shown in Figure 3-2 and Muskingum-Cunge Routing parameters are shown in Table 3-8.

Table 3-8 Muskingum-Cunge Routing Parameters

Oak S2 Reach	Value
Reach Length (ft)	1,260
Energy Slope (ft/ft)	0.001
Bottom Width (ft)	40
Side Slope	10:01
Manning's n	0.15

3.2.11 Modeling Results

The updated HEC-HMS model was used to estimate flows for the 10-, 50-, 100-, and 500-year design events. The updated model results were then compared to previous studies. Table 3-9 presents the HEC-HMS modeling results under existing land use conditions, the results are within 5 percent of the flow values estimated during the Salt Creek DFIRM Update Project.

Table 3-9 HEC-HMS Modeling Results

Description	Source	10-Year	50-Year	100-Year	500-Year
Middle Creek					
Confluence with Salt Creek	Study Results	5,746	9,084	10,978	14,752
	Salt Creek DFIRM Update	5,690	9,002	10,890	14,630
Oak Creek					
Confluence with Salt Creek	Study Results	7,807	12,881	15,587	21,336
	Salt Creek DFIRM Update	7,807	12,881	15,587	21,336

The Oak Creek model experienced no change in peak flows because the subarea modified was of an inconsequential size. The Middle Creek subarea which was modified accounted for 5 percent of the total Middle Creek subwatershed area, while the modified Oak Creek subarea comprised only 0.6 percent of the total subwatershed area. Appendix C contains the hydrologic models in electronic format.

3.2.12 HEC-HMS Hydrograph Loading

The outlet hydrographs showing flow from each subarea developed in the HEC-HMS model were recorded to a USACE Hydrologic Engineering Center's Data Storage System (HEC-DSS) database file. This file is readable by HEC-RAS. Specifically, a HEC-RAS unsteady model "reads" hydrographs from the HEC-DSS file and uses it as input into the model. These hydrographs are specified at appropriate load points along the reach in a manner similar to flow loading in steady HEC-RAS. Table 3-10 lists all load points for the new Oak Creek and Middle Creek stream reaches.

The flows associated with a design event in the HEC-HMS model are modeled in an unsteady HEC-RAS simulation run. In addition to modeling the range of flows, the timing of the hydrographs is taken into account. Steady HEC-RAS modeling typically loads peak flows from hydrographs, which makes the assumption that peak flow occurs across all reaches at the same time in the design event. Unsteady HEC-RAS modeling is able to model the time to peak of all loaded hydrographs, and therefore produces more refined results than the steady HEC-RAS option.

Table 3-10 HEC-HMS Hydrograph Load Points for New Oak Creek and Middle Creek Reaches

	HEC-HMS Hydrologic Element	HEC-RAS Cross Section Station
Oak Creek	JR3320	34062.37
	S1	30990.72
	N1	28653.35
	JUNCTION-2	27133.61
	R3420W3420	25828.36
	R3450W3450	13068.5
	R3270W3270	2195.176
	R3390W3390	2185.176
Middle Creek	USERPOINT6	13336.84
	S1	12016.73
	S2	7900.38
	S3	6865.266
	S4	6273.604
	S5	3513.296

3.3 Hydraulics

The open channel hydraulics of Salt Creek and its major tributaries through Lincoln, NE were modeled with HEC-RAS version 3.1.3. The project team started with the unsteady HEC-RAS model of Salt Creek developed by CDM, under a separate contract. This study extended the hydraulic model through the proposed offline storage locations. This effort included updating the HEC-RAS geometry of Middle Creek and the addition of a new hydraulic model for Oak Creek, as shown in Figure 3-3.

This study used the unsteady option as well to be consistent with the previous methodology. An unsteady HEC-RAS model accounts for channel and overbank storage. It can also model offline storage, which made it the tool of choice for this study. As previously described, an unsteady HEC-RAS model "reads" hydrographs directly from the hydrologic HEC-HMS model and uses it as input at appropriate load points along the reach.

3.3.1 Base Map Development

The LiDAR data collected in November 2003 by USGS for the Salt Creek DFIRM update was used in this project. Two new TINs were created to supplement the existing TINS from the Salt Creek DFIRM update. The TIN is a three-dimensional representation of the ground topography that was used to automate the development of input data for the hydraulic computer models. The TIN was also used in conjunction with other GIS tools to automate the floodplain delineation process.

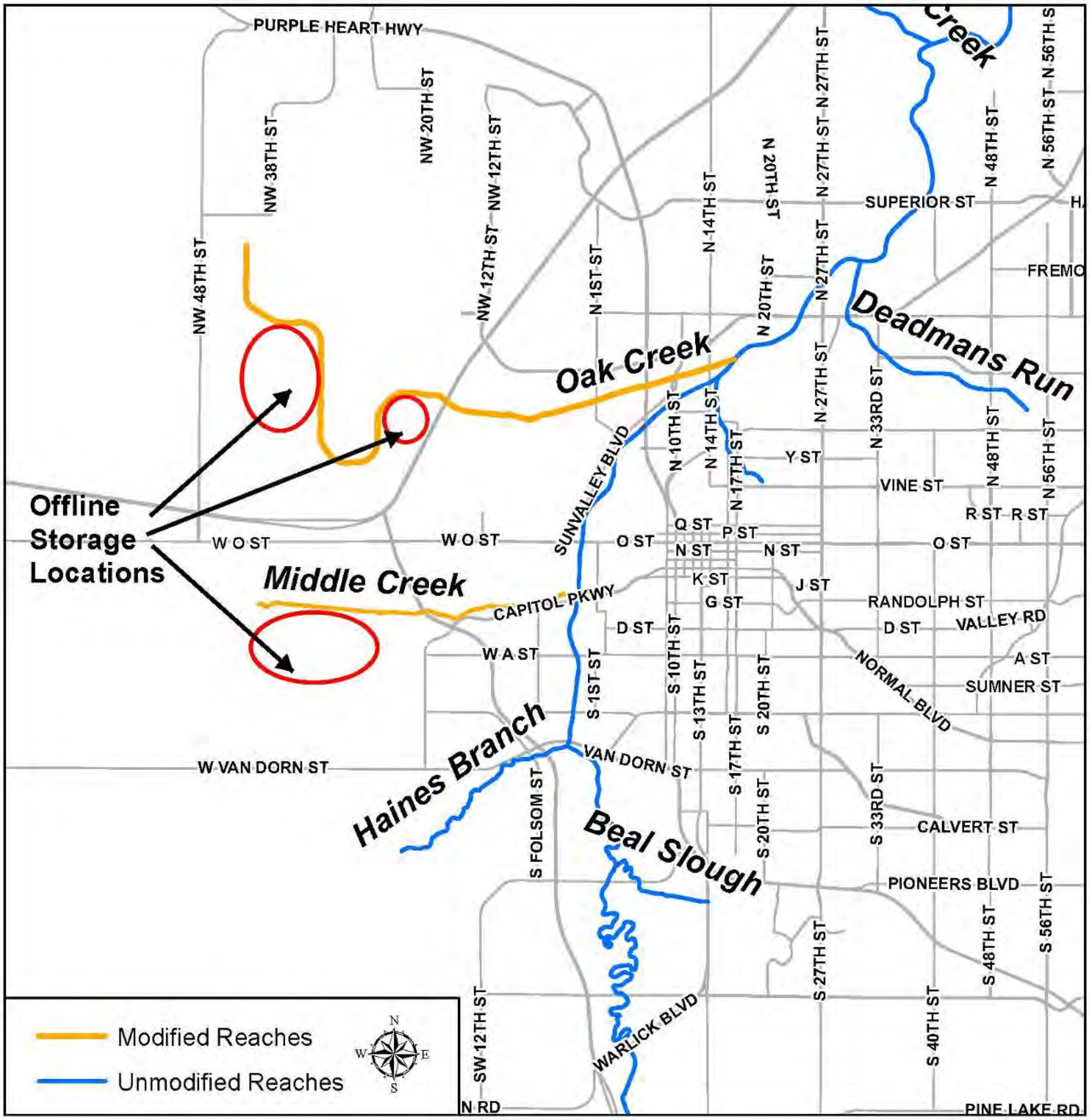

Figure 3-3 Updated HEC-RAS Reaches

3.3.2 HEC-RAS Geometry File Development

The methodology used to create HEC-RAS geometry files for the Salt Creek DFIRM Update project was also utilized to develop geometry files for both Oak Creek and Middle Creek. These geometry files took into special consideration the locations of the potential offline storage areas and because of this, the distance between cross sections was shorter in these locations. Cross section locations were created as a GIS layer that identified the location and extent of each cross section. The cross section layer was generated in ArcMap 9.2 as shown in Figure 3-4 and 3-5. Cross section cut lines were located along the stream centerline at points that represent the average geometry of the stream reach and at changes in geometry, slope, channel, overbank roughness, and discharge. Available aerial photographs and contour information were used to lay out the cross section locations.

The development of cross sections, Manning's "n" values, interpolated cross sections, ineffective areas, and structure input followed the same methodology of the previous studies. This was necessary to produce consistent results and minimize any impact the updates might have on model output.

3.3.2.1 Oak Creek Updates

In the Salt Creek *DFIRM Floodplain Model*, the Oak Creek watershed was modeled only in HEC-HMS (2.2.2) and the outlet hydrograph was loaded at the appropriate station on Salt Creek. However, for this project, a hydraulic model of Oak Creek was created which extended to upstream of Mathis Street. The outlet hydrograph from this model was then loaded to the Salt Creek Model.

The new HEC-RAS reach of Oak Creek, as shown in Figure 3-4, included seven hydraulic structures. The data source for each of these structures is summarized in Table 3-11.

Table 3-11 Oak Creek Structures

Structure Location	Source of Information
West Mathis Street	As-builts from LAA
South of Lincoln Airport	As-builts from LAA
I-80	As-builts from the City
1st Street	As-builts from the City
I-180	As-builts from the City
10th Street	Salt Creek DFIRM Update Model
14th Street	Salt Creek DFIRM Update Model

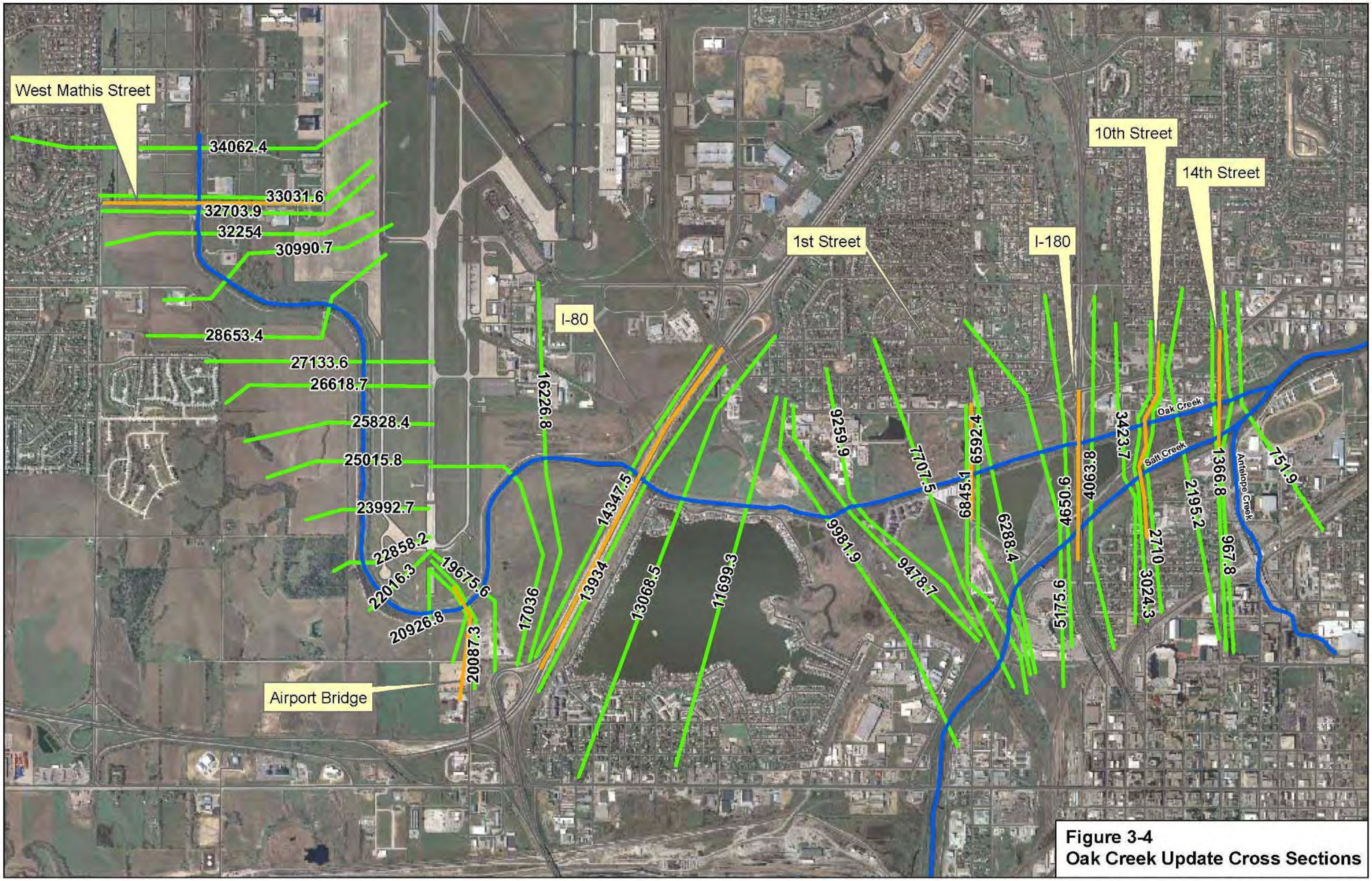

Figure 3-4
Oak Creek Update Cross Sections

The Oak Creek project area is mostly characterized by open space with some wooded areas, and some developed urban areas. The study reach extends from West Mathis Street to the confluence with Salt Creek, and is approximately 7 river miles, conveying over 260 square miles of drainage.

3.3.2.2 Middle Creek Updates

The Middle Creek geometry was updated using the same reach extents as was used in the Salt Creek DFIRM Floodplain Model. This update included the creation of new HEC-RAS cross sections and the addition of hydraulic structure data for the Homestead Expressway Bridge. Data for input of the bridge was obtained from as-builts provided by the City. The new HEC-RAS reach of Middle Creek is shown in Figure 3-5.

The project area is mostly undeveloped, and is characterized by open space with some wooded areas. The study reach extends from Southwest 40th Street to the confluence with Salt Creek, and is approximately 3 river miles, conveying over 100 square miles of drainage.

3.3.2.3 Blocked Areas

A detailed approach was used to determine areas that could effectively be "blocked" along modeled cross sections. The estimated water surface elevations (WSE) on both Middle Creek and Oak Creek were evaluated to determine the location of these areas. For example, several cross sections on Middle Creek were cut through a rail yard located north of Middle Creek. Based on the contours in this area, it was clear that water from Middle Creek does not flow through the low point on the north side of the rail yard. A modeled cross section with a blocked obstruction from this area is shown in Figure 3-6. By applying this approach, a conservative estimate of both storage and conveyance along Middle Creek and Oak Creek was achieve, which made determining the benefits of the proposed storage areas more appropriate for this study.

The HEC-RAS levee option was utilized on Oak Creek, though the levee located here is not certified. This option in HEC-RAS keeps the area behind the levee from being used as storage or conveyance. Using this option was necessary to accurately simulate conveyance through this reach.

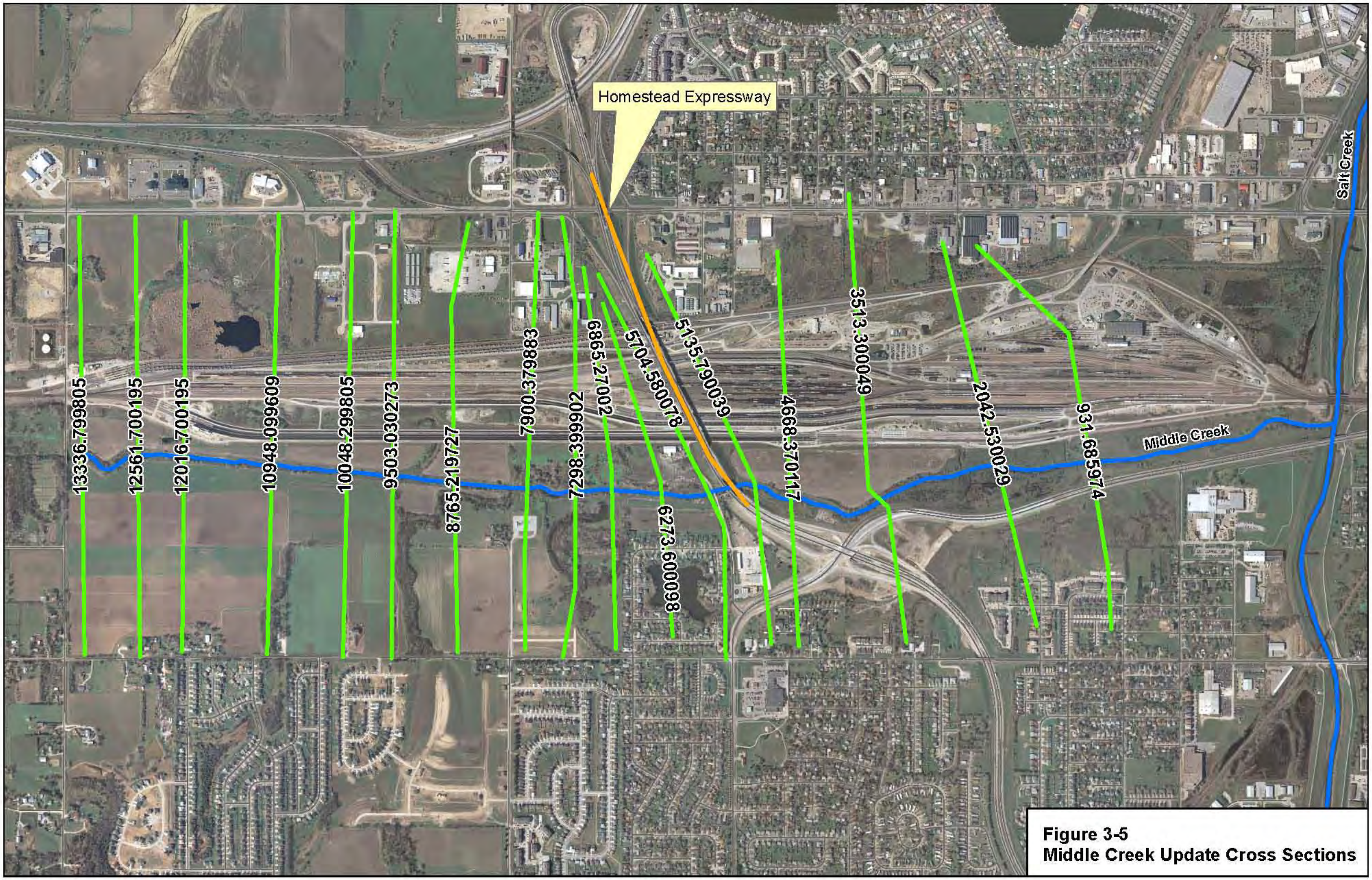

Figure 3-5
Middle Creek Update Cross Sections

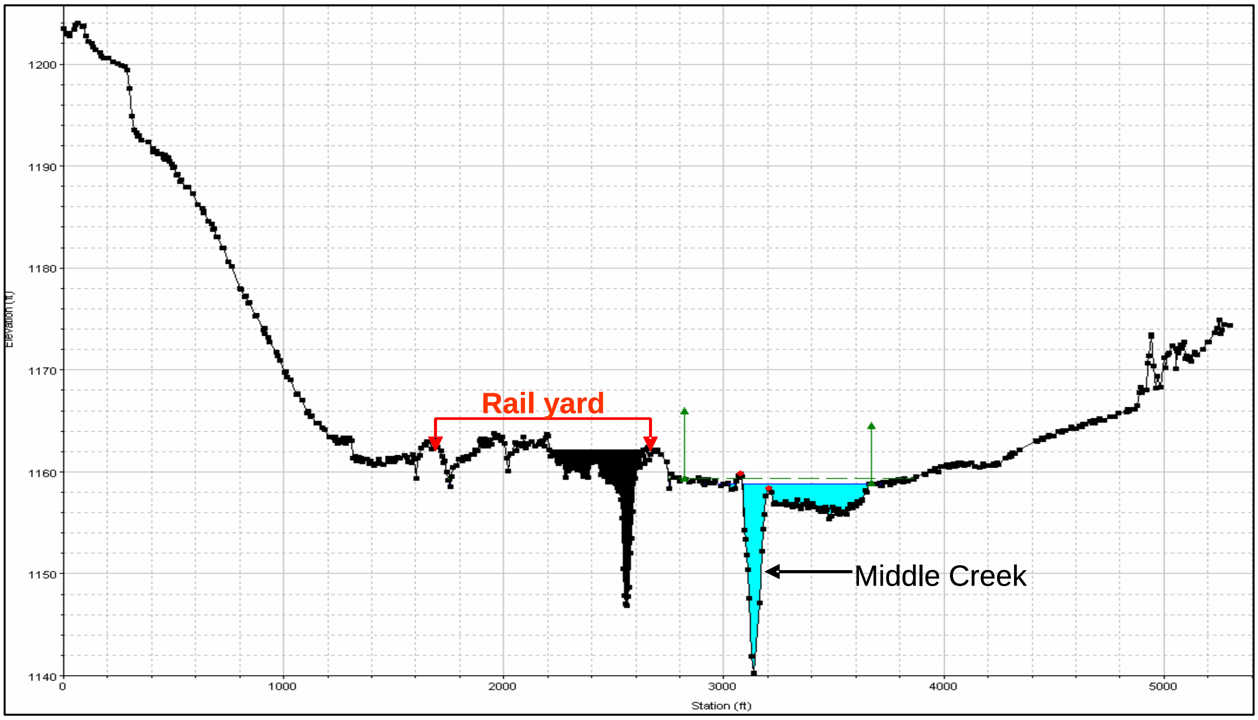

Figure 3-6 Modeled Cross Section with Blocked Obstruction

3.3.3 Unsteady Flow File Development

Inflow hydrographs for the unsteady flow file were obtained from DSS files created from the modified HEC-HMS models previously described. Initial flow conditions were developed for the updated reaches based on the starting values on the inflow hydrographs. The new downstream boundary condition for the Oak Creek model was set at normal depth and the friction slope was calculated to be 0.0005. No boundary condition for Middle Creek was necessary because it was connected to the Salt Creek model by a junction.

3.3.3.1 Comparison of Peak Discharges

After the new Oak Creek and Middle Creek reaches had been incorporated, peak discharges calculated by unsteady HEC-RAS at specified locations along Salt Creek were compared to the original Salt Creek DFIRM model results. The goal was to ensure that the change in peak discharge was less than 5 percent and the water surface elevation did not change by more than 0.5 feet. Table 3-12 presents a summary of peak discharges and corresponding peak water surface elevations along the Salt Creek study reach.

Table 3-12 Comparison of Peak Flows and Peak Water Surface Elevations

Existing DFIRM versus Study Results							
	Max WSE (ft)			Peak Flow (cfs)			
Station	DFIRM	Study Results	Difference	DFIRM	Study Results	Percent Difference	Crossing
266998.5	1,199.5	1,199.5	0	14,375	14,375	0.0	U/S end of model
186130	1,155.7	1,155.9	0.25	20,791	20,581	1.0	W South Street
173811.8	1,150.8	1,151.1	0.3	23,516	24,034	-2.2	Line Drive
162396.4	1,148.2	1,148.4	0.24	34,102	34,505	-1.2	Cornhusker Hwy
160516.7	1,147.6	1,147.8	0.22	34,149	34,467	-0.9	N 27th Avenue
154006.5	1,141.3	1,141.5	0.23	34,561	34,992	-1.2	Superior Street
137617.4	1,136.2	1,136.3	0.18	40,412	41,409	-2.5	Hwy 77/N 56th Street
132237	1,134.2	1,134.5	0.24	40,714	41,713	-2.5	70th Street

3.3.4 Methodology for Modeling Offline Storage

Since unsteady HEC-RAS was utilized in this analysis, offline storage was modeled using the HEC-RAS storage area feature. HEC-RAS storage areas require either an area and minimum elevation or an elevation volume curve. For this analysis, 3D Analyst was used to convert contours from the preliminary offline storage layout into a TIN, which was used to find the elevation volume curve. The offline storage was connected to the adjacent stream using lateral structures. These lateral structures were placed in locations that made the most sense based on water surfaces and potential inflow and outflow locations. The position of these lateral structures was refined as design was completed. Lateral structures that were used as inlets were connected to the storage area itself, while those lateral structures used only for outlets were connected to the most appropriate HEC-RAS cross section for drainage.

In order to avoid overestimating storage and conveyance, HEC RAS blocked obstructions were used to remove overbank storage and conveyance from any cross section that was located within an offline storage site, as shown in Figure 3-7.

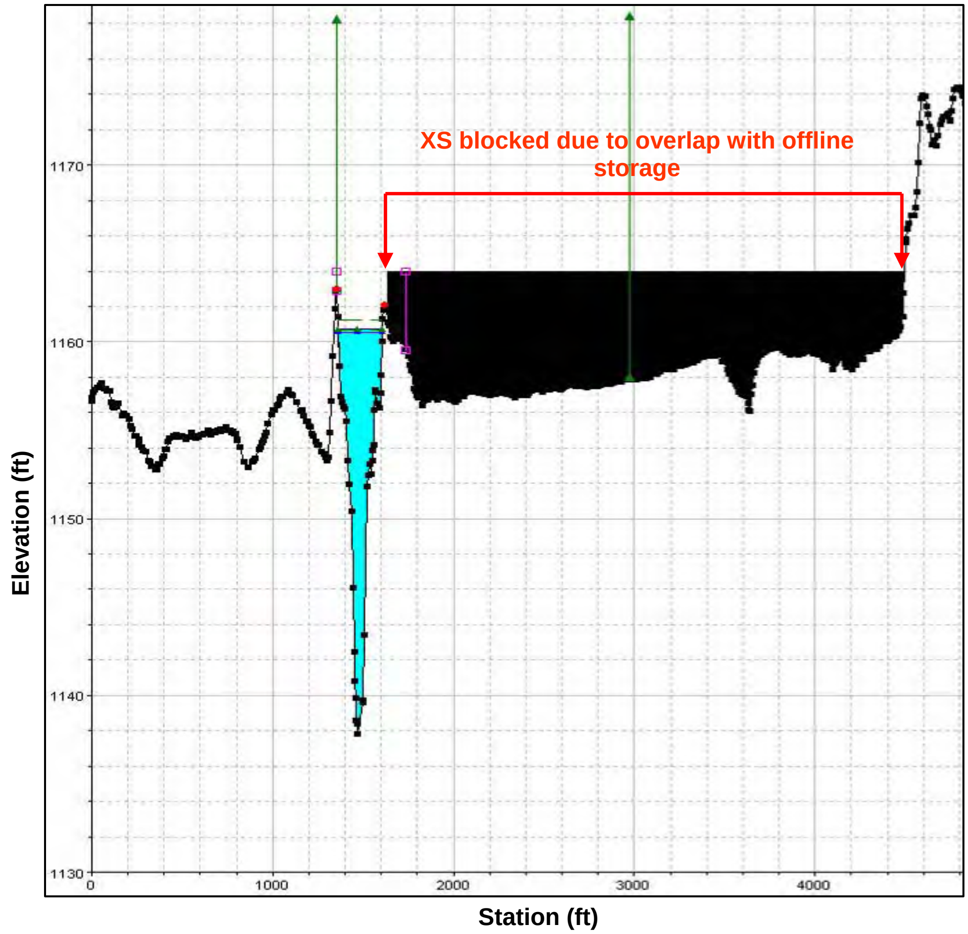

Figure 3-7 Cross Section of HEC RAS Blocked Obstruction

3.4 Analysis of Wilderness Park Flood Attenuation

Flood attenuation due to overbank storage currently provided by Wilderness Park was evaluated. This was accomplished by removing overbank storage in cross sections within Wilderness Park using the "Unsteady Encroach" option. Two scenarios were run and compared:

- Scenario 1: FEMA floodway encroachment stations developed for the Salt Creek DFIRM project were applied at all HEC-RAS cross sections in Wilderness Park. These stations are represented by the color blue on Figure 3-8.
- Scenario 2: Encroachment stations were set 50 feet from the left and right channel bank stations. This resulted in an average top width of approximately 210 feet, and a maximum top width no greater than 300 feet. These encroachment stations are represented by the color green on Figure 3-8.

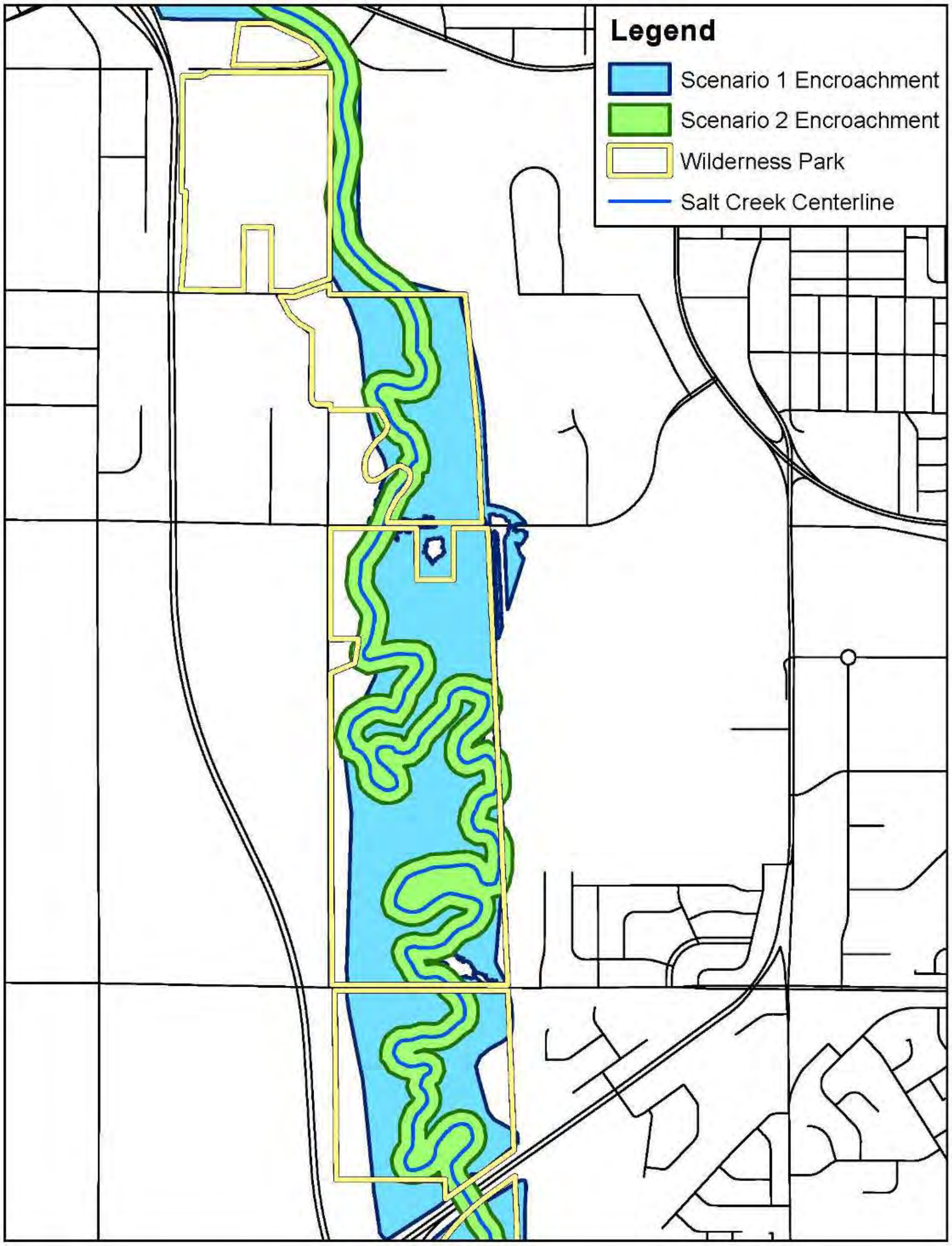

Figure 3-8 Wilderness Park Flood Attenuation Scenarios

The analysis of the output from these models included a comparison to the Salt Creek DFIRM Update model and the USACE Section 22 Report, "Salt Creek at Wilderness Park Hydrologic Study". The Section 22 report assumed a top with of no greater than 300 feet.

As shown in Tables 3-13 and 3-14 and Figure 3-9, Wilderness Park overbank storage provides a large reduction in water surface elevation in the Park and downstream to the confluence with Haines Branch, with a diminished reduction downstream. High peak flow attenuation is also seen immediately downstream of Beal Slough to the confluence with Middle Creek. This analysis shows that flood attenuation provided by Wilderness Park greatly reduces flooding in heavily urban areas of Lincoln, NE, along Salt Creek, especially downstream of the Park and upstream of Middle Creek.

The complete results of this analysis are provided in Appendix B.

Table 3-13 Wilderness Park Analysis – 100-Year Peak Flow Comparison

	Salt Creek Storage Area Analysis					Section 22 Analysis		
Location Description	Salt Creek DFIRM Maximum Water Surface Elevation (ft)	Scenario 1 Maximum Water Surface Elevation (ft)	Elevation Difference between Scenario 1 & DFIRM (ft)	Scenario 2 Maximum Water Surface Elevation (ft)	Elevation Difference between Scenario 2 & DFIRM (ft)	Section 22 Exist Model Maximum Water Surface Elevation (ft)	Section 22 Encroach Model Maximum Water Surface Elevation (ft)	Elevation Difference between Section 22 exist and encroach (ft)
US of Railroad - Model Begins	1,200	1,200	0.7	1,208	8.7	1,205	1,209	3.6
US of Saltillo Rd	1,199	1,199	0.2	1,205	5.8	1,198	1,200	2.7
DS of 14th St	1,184	1,184	0.6	1,190	6.8	1,184	1,187	3.1
DS of Cardwell Branch	1,175	1,175	0.0	1,178	3.2	1,174	1,177	2.3
US of Old Cheney	1,166	1,166	0.5	1,172	5.5	1,167	1,171	4.0
DS of Beal Slough	1,159	1,159	0.2	1,161	1.9	1,159	1,162	2.8
DS of Haines Branch	1,156	1,156	0.0	1,156	0.2	1,157	1,159	2.6
DS of Middle Creek	1,153	1,153	0.0	1,153	0.3	1,153	1,154	1.0
US of Railroad Bridge	1,152	1,152	0.0	1,152	0.3	1,151	1,151	0.6
DS of Oak Creek	1,139	1,139	0.0	1,139	0.2	1,148	1,148	0.5

Table 3-14 Wilderness Park Analysis – 100-Year Maximum Water Surface Comparison

	Salt Creek Storage Area Analysis					Section 22 Analysis		
Location Description	**Salt Creek DFIRM Peak Flow (cfs)**	**Scenario 2 Peak Flow (cfs)**	**Percent Difference between Scenario 1 & DFIRM**	**Scenario 2 Peak Flow (cfs)**	**Percent Difference between Scenario 2 & DFIRM**	**Section 22 Exist Model Peak Flow (cfs)**	**Section 22 Encroach Model Peak Flow (cfs)**	**Percent Difference between Section 22 exist and encroach**
US of Railroad - Model Begins	14,375	14,375	0.0%	14,375	0.0%	10,093	11,233	11.3%
US of Saltillo Rd	14,401	14,321	-0.6%	14,394	-0.1%	9,915	11,128	12.2%
DS of 14th St	14,486	14,350	-0.9%	14,555	0.5%	9,900	11,292	14.1%
DS of Cardwell Branch	14,723	14,637	-0.6%	14,645	-0.5%	9,414	12,841	36.4%
US of Old Cheney	14,697	14,623	-0.5%	14,689	-0.1%	9,390	12,856	36.9%
DS of Beal Slough	14,880	15,571	4.6%	17,491	17.5%	9,434	13,153	39.4%
DS of Haines Branch	21,031	21,025	0.0%	23,576	12.1%	17,037	21,960	28.9%
DS of Middle Creek	28,005	28,028	0.1%	27,767	-0.8%	26,537	31,028	16.9%
US of Railroad Bridge	24,658	24,760	0.4%	25,034	1.5%	26,557	30,459	14.7%
DS of Oak Creek	40,410	40,514	0.3%	40,951	1.3%	38,861	42,272	8.8%

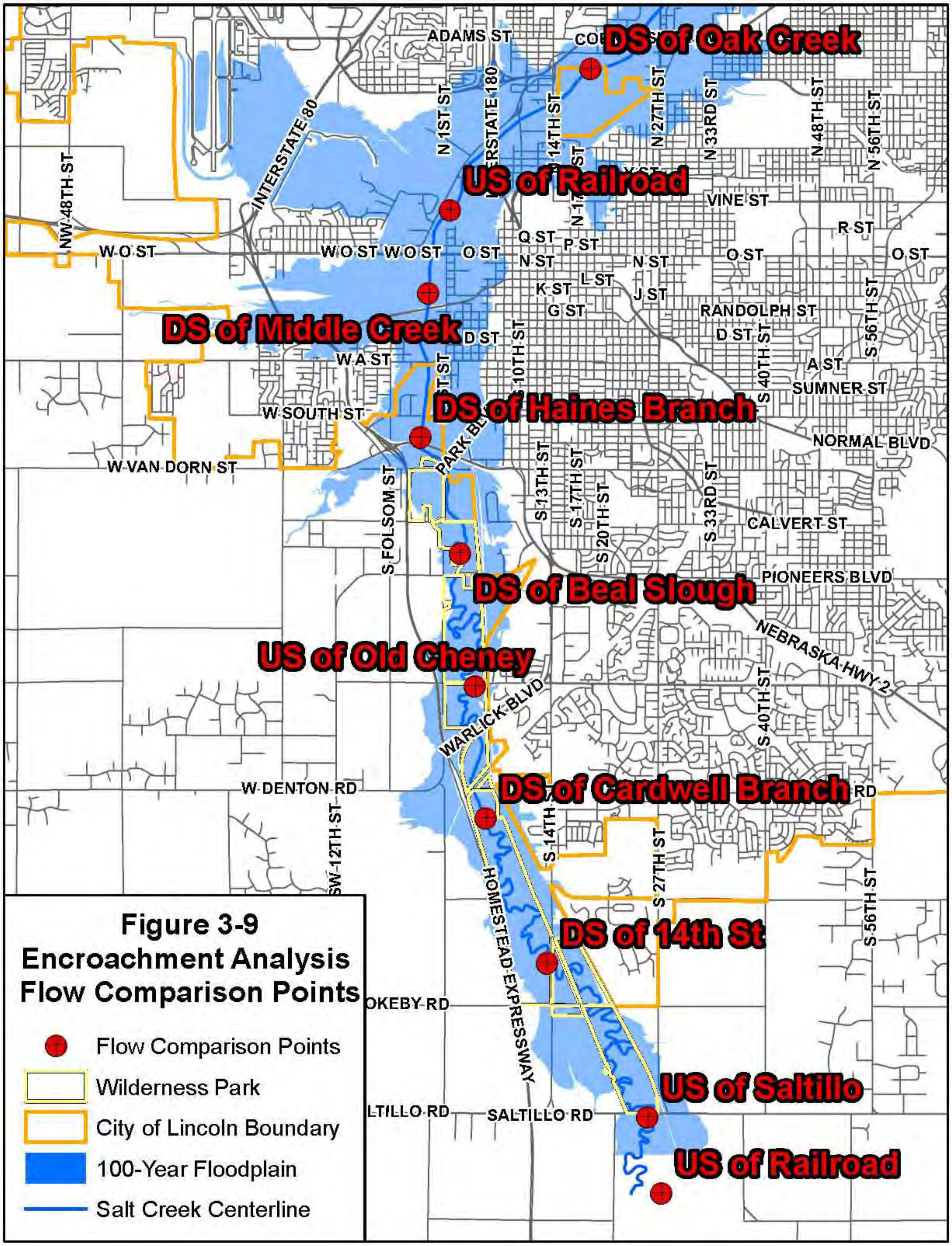

Figure 3-9
Encroachment Analysis Flow Comparison Points