Section 3
Hydrologic Model Development

3.1 Introduction

This section summarizes the methodology used to develop the hydrologic model for the Stevens Creek Watershed. The modeling was performed using the USACE's Hydrologic Engineering Center's Hydrologic Modeling System program (HEC-HMS) Version 2.2.2. Both an existing conditions model and a future conditions model were developed. The hydrologic methods used to develop the HEC-HMS models are described below. The following appendix sections, located in Volume II of this report, provide detailed information on the hydrologic and hydraulic model data input and results:

- Appendix C - Hydrologic Model Input Data and Results
- Appendix D - Hydraulic Model Input Data and Results
- Appendix E - Stream Profiles
- Appendix J - Drainage Structure Design Data

3.2 Hydrology Methodology

The HEC-HMS model was used to simulate the runoff volumes and hydrographs resulting from 2-, 5-, 10-, 50-, 100-, and 500-year return periods using the design storms outlined in the City's Drainage Criteria Manual dated February 22, 2000. The hydrology methodology contains six primary components including the subarea delineation, rainfall, runoff volume, runoff hydrographs, routing, watershed storage, and flow diversions.

3.2.1 Subarea Delineation

The Stevens Creek Watershed was delineated into 241 subareas with an average area of 146 acres. A map showing the subarea boundaries are shown on Figure 3-1. The subarea delineation was performed using ArcView, HEC-GeoHMS, and the digital elevation model (DEM) developed from the contour data provided by the City. The HEC-GeoHMS tool runs within ArcView and uses the DEM to delineate subareas and to determine the overland flow path for each subarea. Another major advantage of using the HEC-GeoHMS tool was that it automated the HEC-HMS model development.

Using the HEC-GeoHMS tool, the approximate locations for subarea outlets such as stream crossings, tributaries, and major lakes/ponds were located using ArcView and available GIS data. The HEC-GeoHMS tool uses these points to automatically delineate the subarea boundaries based on the DEM. The automation process was then checked against contours and drainage structure locations.

Subareas draining to Stevens Creek were given a unique alphanumeric name with the format SC-BBB. "SC" is the two-letter code for the Stevens Creek Watershed. "BBB" is a three-digit subarea number. Generally, the subarea numbers were assigned in increments of four to allow for future subdivision (e.g., SC-004, SC-008, SC-012). The subareas draining to the Stevens Creek Overflow were named in a similar manner using a prefix of "SCO."

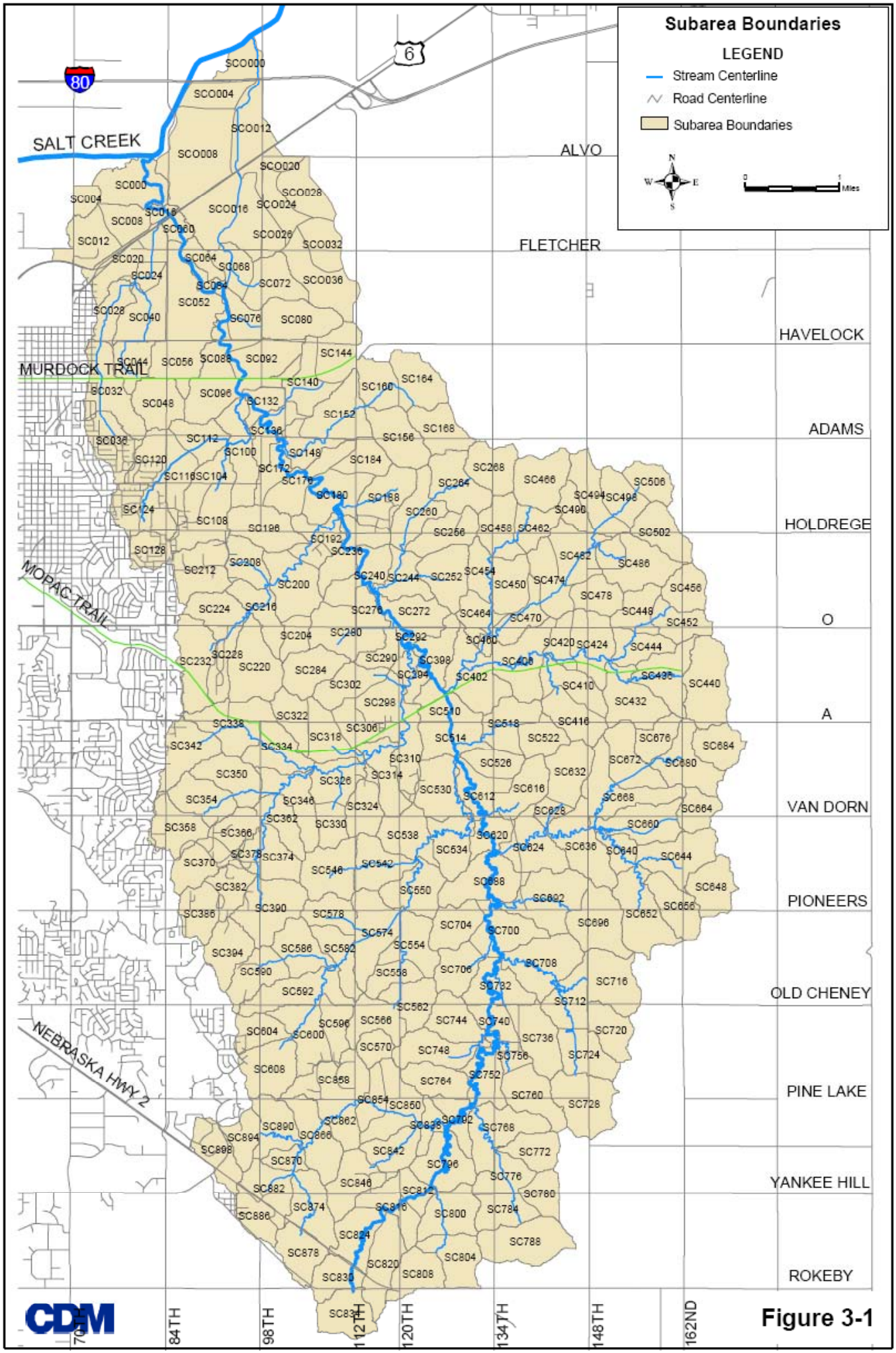

Subarea Boundaries
LEGEND
Stream Centerline
Road Centerline
Subarea Boundaries
N
W
E
S
0
1
Miles
80
6
SALT CREEK
ALVO
FLETCHER
HAVELOCK
MURDOCK TRAIL
ADAMS
HOLDREGE
MOPAC TRAIL
O
A
VAN DORN
PIONEERS
OLD CHENEY
NEBRASKA HWY 2
PINE LAKE
YANKEE HILL
ROKEBY
70TH
84TH
98TH
112TH
120TH
134TH
148TH
162ND
CDM

Figure 3-1

3.2.2 Rainfall

The Soil Conservation Service (SCS), now called the Natural Resources Conservation Service (NRCS), Type II storm distribution was used to simulate rainfall events for each return interval. This method requires the rainfall depth for a storm duration of 24 hours as input data. Table 3-1 summarizes the design rainfall depths for 24-hour events from the City's Drainage Criteria Manual that were used in the HEC-HMS model. The peak intensity was derived by distributing the rainfall depth over a 24-hour period using the Type II distribution and 15-minute increments. The peak intensity in inches per hour was calculated by multiplying the peak 15-minute intensity by 4. The 500-year rainfall depth was determined by extrapolating along a logarithmic curve fit to the data. Figure 3-2 shows the plotted data points and the logarithmic curve.

Table 3-1
Rainfall-Duration Depths

Return Interval	Rainfall Depth (inches)	Peak Intensity (in/hr)
2-Year	3.00	3.31
5-Year	3.93	4.34
10-Year	4.69	5.18
50-Year	6.00	6.62
100-Year	6.68	7.37
500-Year	8.18	9.03

3.2.3 Runoff Volume (SCS CN)

The SCS Curve Number Loss Rate option in the HEC-HMS model was used to generate runoff volumes for each subarea. 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 3-1.

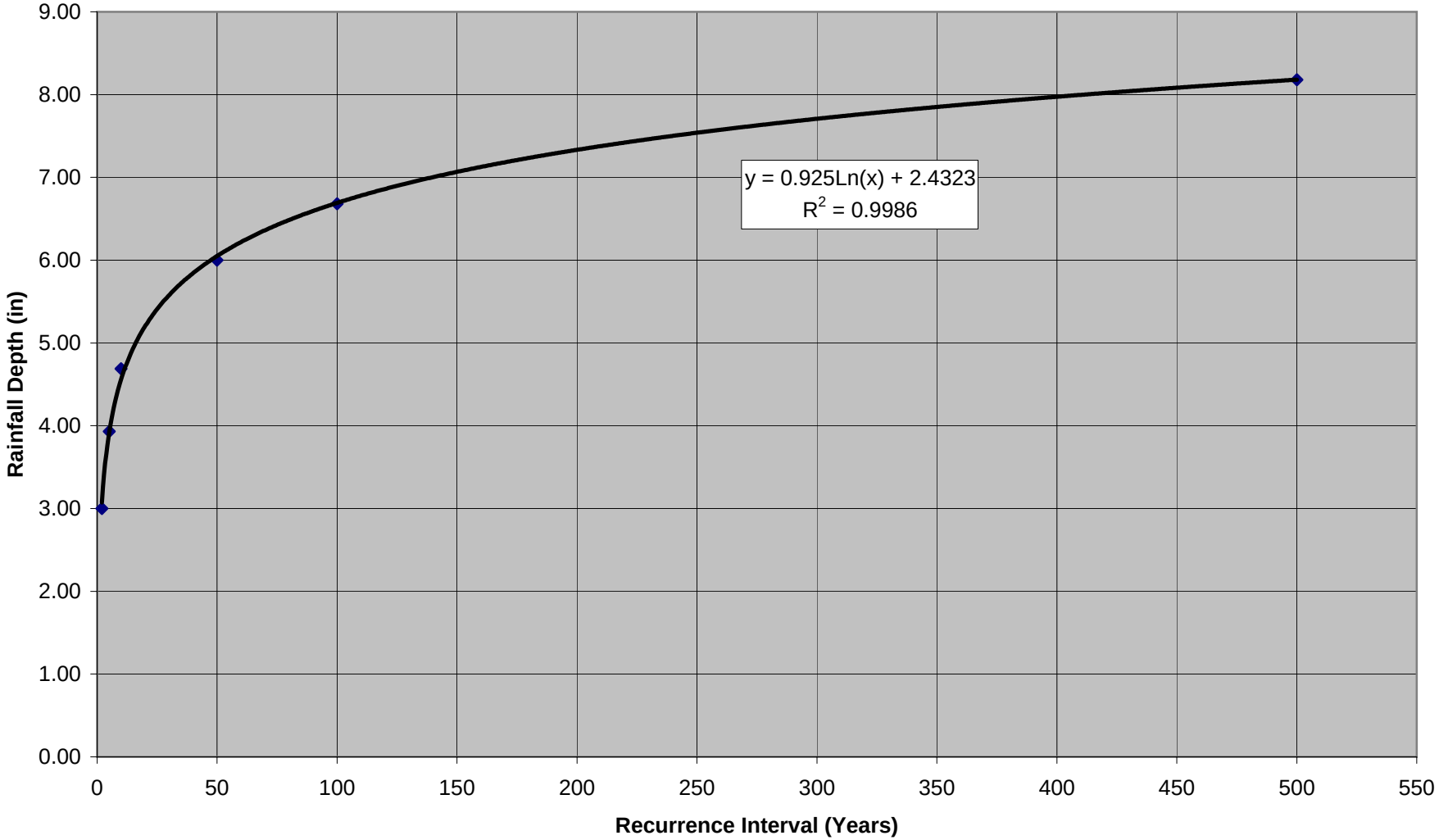
$$Ia = 0.2(1000/CN - 10) \qquad \text{Equation 3-1}$$

The CN is a function of the land use condition and hydrologic soil group (HSG). For each subarea, a composite CN was developed using the GIS by overlaying the soils and land use coverages and spatially analyzing the percent of each land use and soil condition in each subarea. Runoff CN tables from the Drainage Criteria Manual were used to assign a CN to each soil and land use combination. The runoff CN tables are provided in Appendix C, located in Volume II of this report. The CNs listed represent average antecedent moisture conditions (AMC II conditions).

Existing Land Use

For existing land use conditions, the digital land use data supplied by the City were used to determine a CN using the values in the Drainage Criteria Manual as a guideline. Figure 3-3 shows the existing land uses and Table 3-2 lists the percentage of watershed area for each existing land use category. Table 3-3 shows the land use

Figure 3-2
Recurrence Interval Versus Rainfall Depth



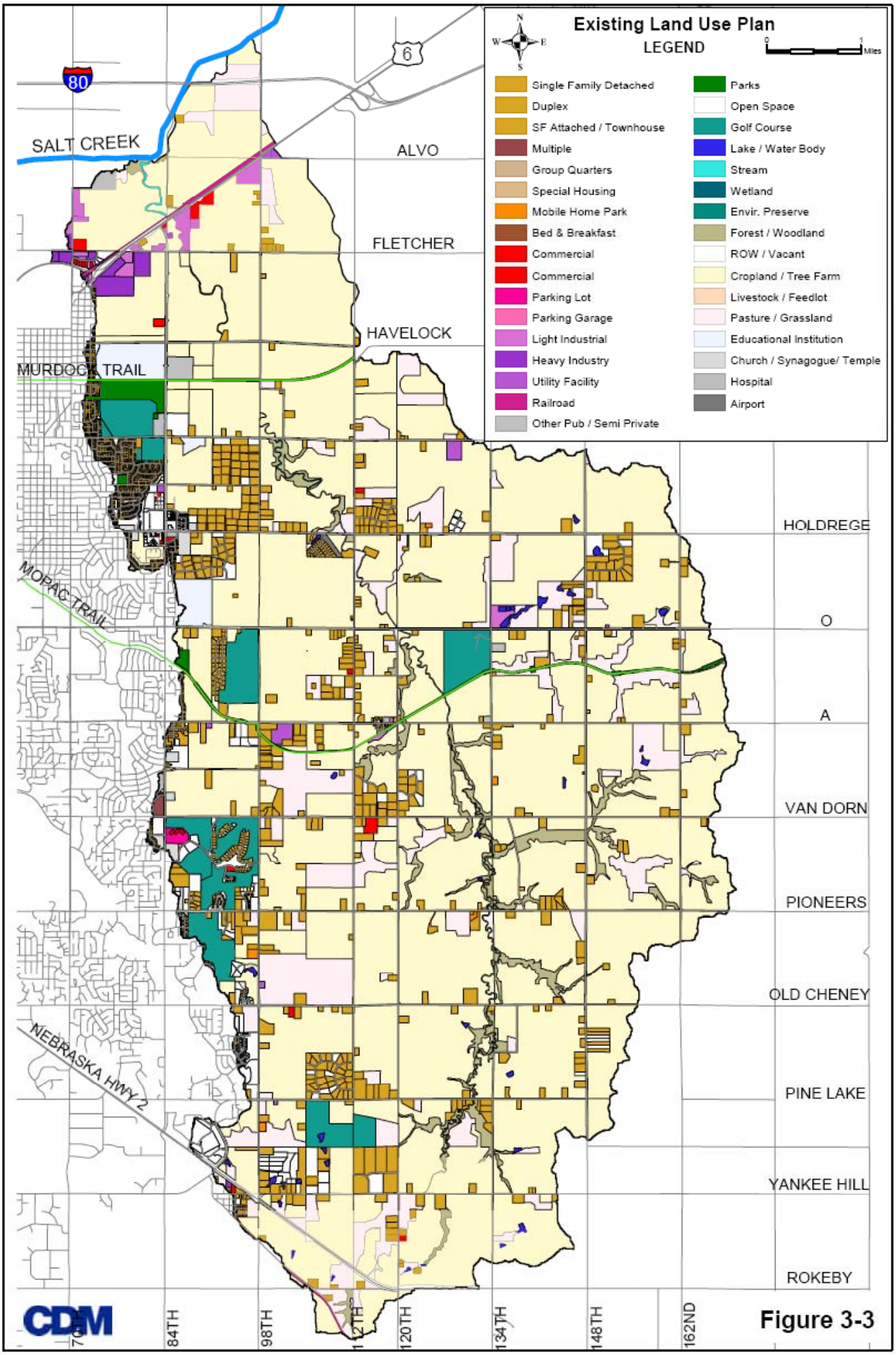

Existing Land Use Plan
LEGEND
Single Family Detached
Duplex
SF Attached / Townhouse
Multiple
Group Quarters
Special Housing
Mobile Home Park
Bed & Breakfast
Commercial
Commercial
Parking Lot
Parking Garage
Light Industrial
Heavy Industry
Utility Facility
Railroad
Other Pub / Semi Private
Parks
Open Space
Golf Course
Lake / Water Body
Stream
Wetland
Envir. Preserve
Forest / Woodland
ROW / Vacant
Cropland / Tree Farm
Livestock / Feedlot
Pasture / Grassland
Educational Institution
Church / Synagogue/ Temple
Hospital
Airport
SALT CREEK
ALVO
FLETCHER
HAVELOCK
MURDOCK TRAIL
MOPAC TRAIL
NEBRASKA HWY 2
HOLDREGE
O
A
VAN DORN
PIONEERS
OLD CHENEY
PINE LAKE
YANKEE HILL
ROKEBY
84TH
98TH
112TH
120TH
134TH
148TH
162ND
CDM

Figure 3-3

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.

Table 3-2
Existing Land Use Percentages

Land Use Category	*Watershed Area (%)*
Agricultural Production: Crops/Tree Farm	69.2
Airport	<0.1
Apartments (w/number of units)	<0.1
Attached Single Family (Townhouses)	<0.1
Church, Synagogue, or Temple	0.2
Commercial NEC	0.3
Duplex	<0.1
Educational Institution	0.9
Forest/Woodland	2.4
Golf Course	3.4
Heavy Industrial	0.4
Lake	0.2
Light Industrial	0.5
Mobile Home including parks, courts (w/number of unit)	0.1
Open Space	0.6
Park Land	0.7
Parking Lot (PL)	0.1
Pasture/Grassland	8.5
Public & Semi-Public NEC (e.g., cemetery)	0.3
Railroad	0.2
Single Family (detached)	9.2
Stream / Creek	0.2
Utility Facility (e.g., communication tower)	0.2
VACANT (UNDEVELOPED) LAND	2.4
Vacated ROW (retained by public entity)	<0.1
Total	**100**

As shown in Table 3-3, all agricultural land uses were 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 do not correspond directly with a cover type were assigned a CN based on approximate average percent impervious and generally accepted engineering practices.

The category Single Family (detached) 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 one of these six land use CN categories based on the actual lot size. The lot size was calculated using GIS. For example, if a single family (detached) land use parcel has an area of 1 acre, it was assigned a CN for 1-acre residential.

Table 3-3
Curve Numbers for Stevens Creek Watershed Study

Lincoln/Lancaster County Land Use	*Cover Type (% Imp)*	*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
Rural Residential	Residential 2 acres (12%)	51	68	79	84
Single Family (detached)+	Residential 1/4 acre (38%)	61	75	83	87
	Residential 1/3 acre (30%)	57	72	81	86
	Residential 1/2 acre (25%)	54	70	80	85
	Residential 1 acre (20%)	51	68	79	84
Stream/Creek	Water	98	98	98	98
Urban Residential	Residential 1/3 acre (30%)	57	72	81	86
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

+ Single Family (detached) land use includes large and small lots.
CN will be assigned based on lot size calculated using GIS.
* CN may be adjusted based on actual percent impervious versus reported standard percent impervious.

Future Land Use

For the purpose of this study, full buildout of the watershed was assumed to provide a conservative estimate of future flows. The future land use plan for the watershed is based on a 2025 planning horizon, which is illustrated on Figure 3-4. Under the 2025 planning horizon, more than 55 percent (Table 3-4) of the watershed is defined as agricultural. Therefore, to simulate full buildout conditions, a prediction of future land use conditions was required for this category.

Table 3-4
2025 Land Use Percentages

Land Use Category	*Watershed Area (%)*
Agricultural	55.7
Commercial	0.9
Industrial	4.3
Green Space	8.2
Public/Semi-Public	2.7
Residential, Low Density	3.5
Residential, Urban	17.3
Lakes and Streams	0.6
Environmental Resources	5.8
Agricultural Stream Corridor	1.0

Using data provided by the Lincoln-Lancaster County Planning Department, a surrogate future land use category was developed based on a typical square mile area of development. Table 3-5 summarizes the land use category percentages used for the surrogate future land use, which was applied to agricultural land use categories.

Table 3-5
Breakdown of Surrogate Future Land Use

Land Use Category	*Percentage (%)*
Commercial/Business	11
Parks/Open Space	11
Public/Semi-Public	3
Urban Residential	75

Using this surrogate land use breakdown, a composite CN was calculated by multiplying the fraction of each land use category by its corresponding CN and then summing the values. Using this technique, the CNs for the surrogate future land use are 69, 80, 87, and 90 for hydrologic soil groups A, B, C, and D, respectively. These surrogate future land use CNs were applied over the agricultural areas to simulate the full buildout conditions.

Hydrologic Soil Groups

HSGs by soil types were determined from the NRCS Lancaster County Soil Survey. Figure 3-5 shows the HSGs for Stevens Creek Watershed. The HSG was used to assign an appropriate CN for each subarea. Table 3-6 shows the soil types and their associated HSG for soils within the Stevens Creek Watershed. For soil types where HSGs are provided for drained and undrained conditions, the undrained HSG was used. For example, Colo soil type has an HSG designation of B/D where B is for drained conditions and D is for undrained. All Colo soils were categorized as having an HSG of D, unless available data shows that the water table was lowered in a particular area.

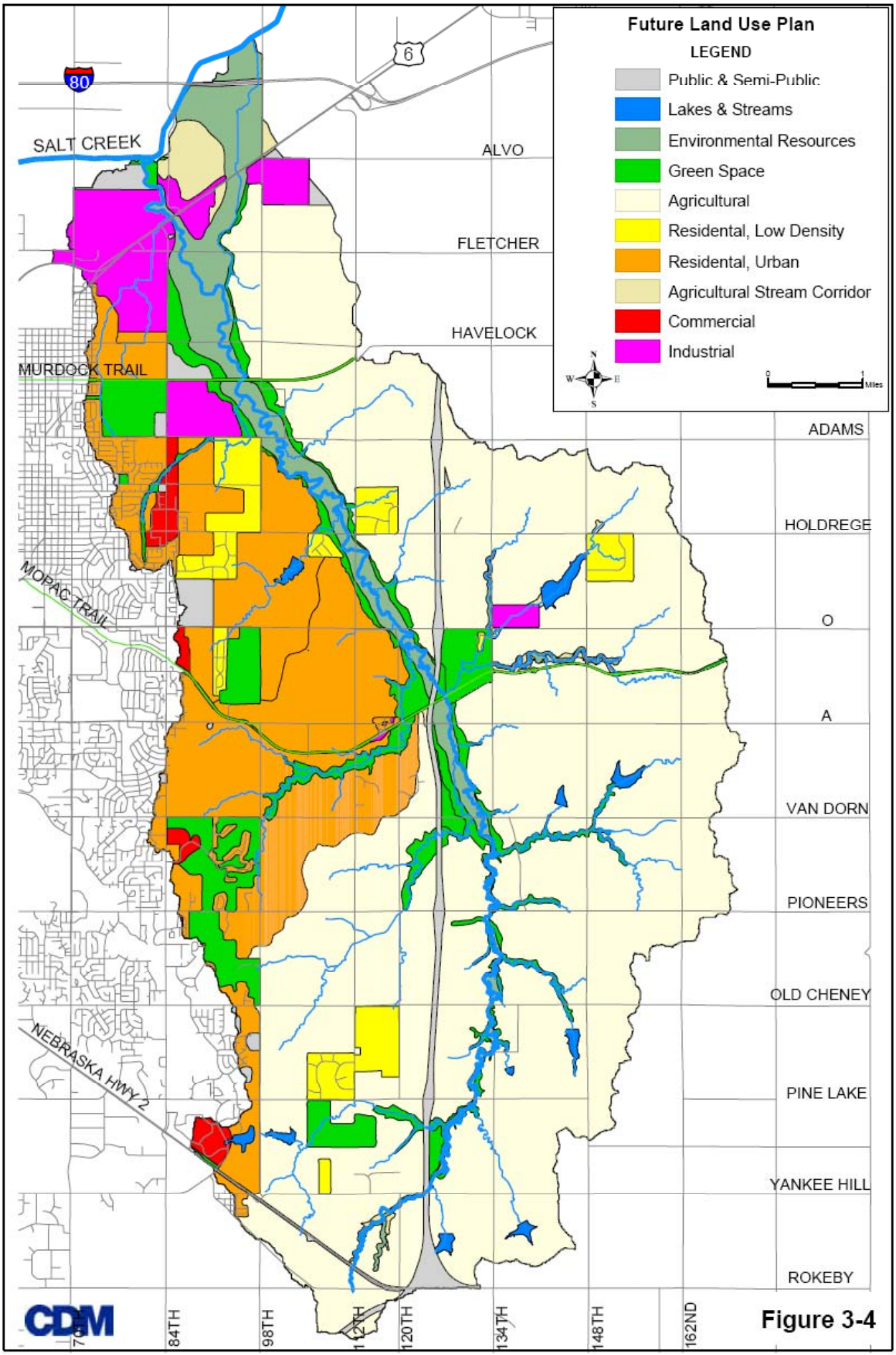

Future Land Use Plan
LEGEND
Public & Semi-Public
Lakes & Streams
Environmental Resources
Green Space
Agricultural
Residental, Low Density
Residental, Urban
Agricultural Stream Corridor
Commercial
Industrial
N
W
E
S
0
1
Miles
80
6
SALT CREEK
ALVO
FLETCHER
HAVELOCK
MURDOCK TRAIL
ADAMS
HOLDREGE
MOPAC TRAIL
O
A
VAN DORN
PIONEERS
OLD CHENEY
NEBRASKA HWY 2
PINE LAKE
YANKEE HILL
ROKEBY
84TH
98TH
112TH
120TH
134TH
148TH
162ND
CDM

Figure 3-4

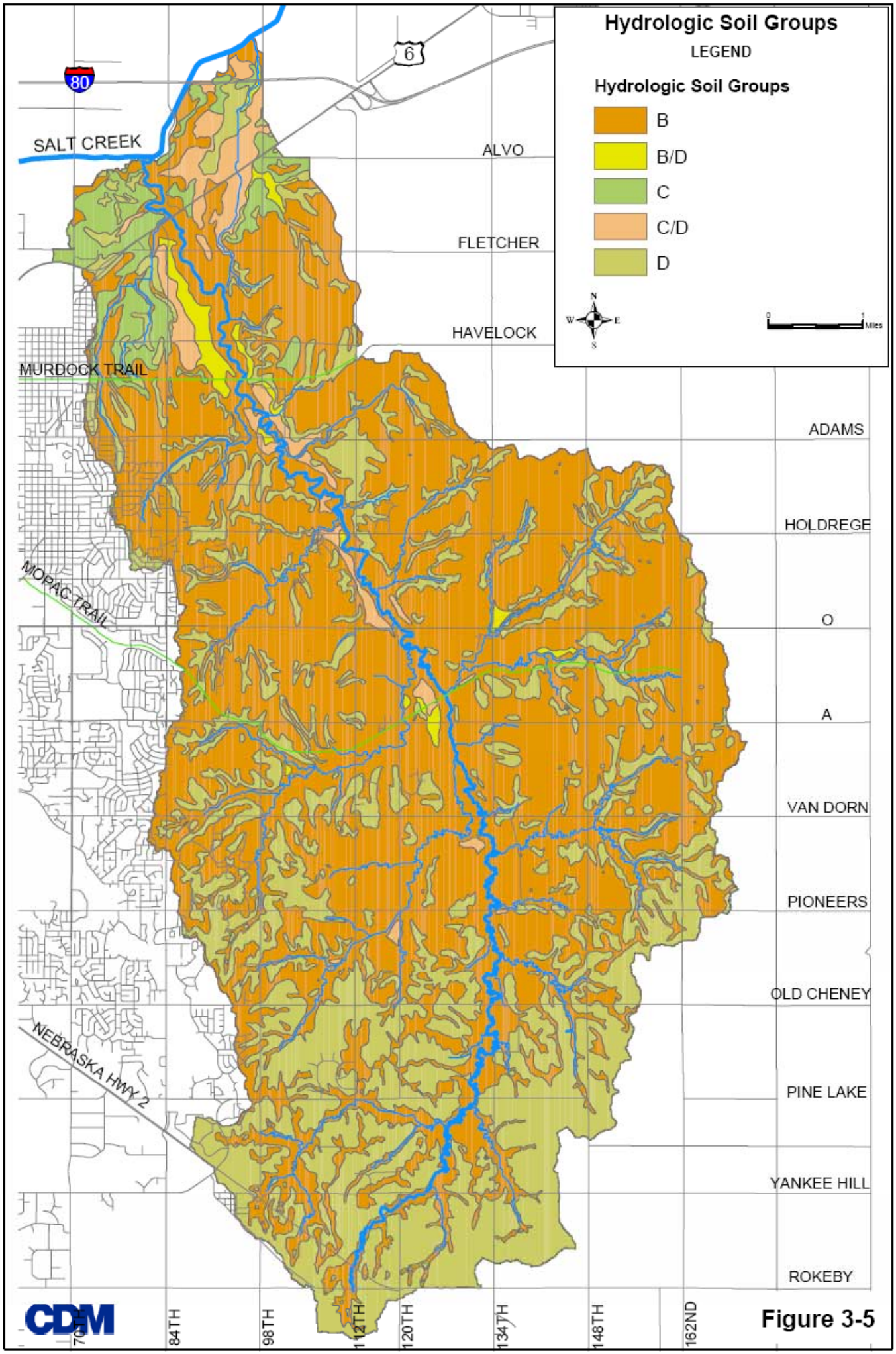

Hydrologic Soil Groups
LEGEND
Hydrologic Soil Groups
B
B/D
C
C/D
D
N
W
E
S
0
1
Miles
80
6
SALT CREEK
ALVO
FLETCHER
HAVELOCK
MURDOCK TRAIL
ADAMS
HOLDREGE
MOPAC TRAIL
O
A
VAN DORN
PIONEERS
OLD CHENEY
NEBRASKA HWY 2
PINE LAKE
YANKEE HILL
ROKEBY
70TH
84TH
98TH
112TH
120TH
134TH
148TH
162ND
CDM

Figure 3-5

Table 3-6
Lancaster County Hydrologic Soil Groups

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

3.2.4 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 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 the DEM 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 both existing and future surface conditions in the watershed. In the case of sheet flow and shallow concentrated flow, the methodology accounted for reduced travel time as undeveloped surface conditions (existing) are converted to developed surface conditions (future). Secondary and primary channels were assumed to be the same for both existing and future conditions.

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 of 100 feet or less may not be appropriate for some subareas. Consequently, subarea sheet flow lengths will typically fall within the range of 100 to 300 feet. The sheet flow length was estimated using ArcView with aerial photographs and contour data.

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. The sheet flow length was calculated using GIS. A composite overland flow roughness value was estimated by calculating a weighted roughness value using typical

literature values for each surface condition and the length of sheet flow associated with each surface condition. The surface condition was determined from the aerial photos. Table 3-7 lists the overland flow roughness coefficients used for sheet flow.

Table 3-7
Sheet Flow and Shallow Concentrated Flow Values

Surface Conditions	*Overland Flow Roughness Coefficient*	*Shallow Flow Paved/Unpaved*
Business-Heavy Commercial	0.06	Paved
Business-Light Commercial	0.08	Paved
Single Family I	0.23	Unpaved
Single Family II	0.17	Paved
Multi-Family Areas	0.13	Paved
Churches and Schools	0.10	Paved
Industrial-Light Areas	0.13	Paved
Industrial-Heavy Areas	0.09	Paved
Industrial-Parks, Cemeteries	0.22	Unpaved
Industrial-Railroad Yard	0.19	Paved
Undeveloped Areas (Permanent)	0.40	Unpaved
Impervious: Asphalt, Concrete, Roofs, etc.	0.011	Paved
Turfed	0.15	Unpaved
Wet Detention Basins	0.05	NA
Unknown Developed	0.17	Paved
Cultivated Soils	0.11	Unpaved

Shallow Concentrated Flow

Shallow concentrated flow occurs between the areas of sheet flow and open channel flow. Open channel flow is commonly assumed to begin at a point where blue lines (solid or intermittent) appear on U. S. Geological Survey (USGS) quadrangle maps. USGS maps were reviewed to estimate the tributary area at which blue lines begin to occur. The results indicated that, on average, blue lines typically were shown for tributary areas of approximately 20 acres. Therefore, travel times are based on shallow concentrated flow occurring from the end of sheet flow to 20 acres along the subarea's flow path.

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 process for calculating the time of concentration for shallow concentrated flow was the same as performed for sheet flow.

Secondary Channel Flow and Primary Channel Flow

Secondary and primary channel flow occur 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 network, while primary channel flow occurs along the primary stream network to the subarea outlet. The primary stream network is defined as the main channel of Stevens Creek and it's tributaries that receive runoff from areas approximately 150 acres in size and greater. This network was evaluated with the HEC-RAS model. Depending upon location, a subarea may have one or both of these channel flow features. For example, a headwater subarea will probably include only flow length associated with the secondary stream network and none associated with the primary stream network.

For both types of channel flow, 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 from the GIS. Slope data were calculated by 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 DEM.

3.2.5 Routing (Muskingum-Cunge)

The Muskingum-Cunge Routing method was used to route runoff through the watershed. An eight-point channel cross section was developed for each routed reach using the ArcView profiler tool and the elevation contours. The channel length and slope was also determined using ArcView and DEM.

3.2.6 Watershed Storage

Areas of significant storage were simulated in HEC-HMS as a reservoir hydrologic element. In general, storage areas were simulated if the storage volume to runoff volume ratio was greater than 0.20 for the 100-year design event. Under existing land use conditions, the hydrologic model includes five small high-hazard flood control structures designed by the NRD. The model also includes two additional ponds, the first (Magee Dam) located at the intersection of Yankee Hill Road and 120th Street and the second (Korver Dam) located between Pine Lake Road and Highway 2 west of 98th Street. In addition, channel storage affects along the main channel of Stevens Creek was simulated, including the area between Highway 6 and Havelock Avenue and directly upstream of Murdock Trail.

Under future land conditions, the model includes the seven ponds and channel storage locations from the existing conditions model as well as five additional ponds designed by the NRD, which will be constructed over the next few years. The storage areas that were simulated under existing and future land use conditions are depicted on Figure 3-6.

3.2.7 Flow Diversions

The Stevens Creek main channel diverts flow at two locations during flooding conditions as depicted on Figure 3-7. During high flows, a portion of the main channel flow is diverted in the easterly direction to the Stevens Creek Overflow channel. The overflow channel was included in both the hydrologic and hydraulic models to accurately define the Stevens Creek floodplain and floodway.

Flow diversion also occurs near the confluence of Tributary 5 and the Stevens Creek main channel (Figure 3-7). A portion of the flow from Tributary 5 enters the Stevens Creek main channel between Fletcher and Highway 6. The Tributary 5 flow diversion was also included in both the hydrologic and hydraulic models.

Diversion nodes in HEC-HMS were used to simulate the diverted flow. The diversion node required defining a relationship between the primary channel flow and the diverted flow. The procedure included using the HEC-RAS models to determine the flow rate that the primary channel and the diversion channel could convey that resulted in the same water surface elevation. To develop the peak flow diversion table, a range of flow rates were

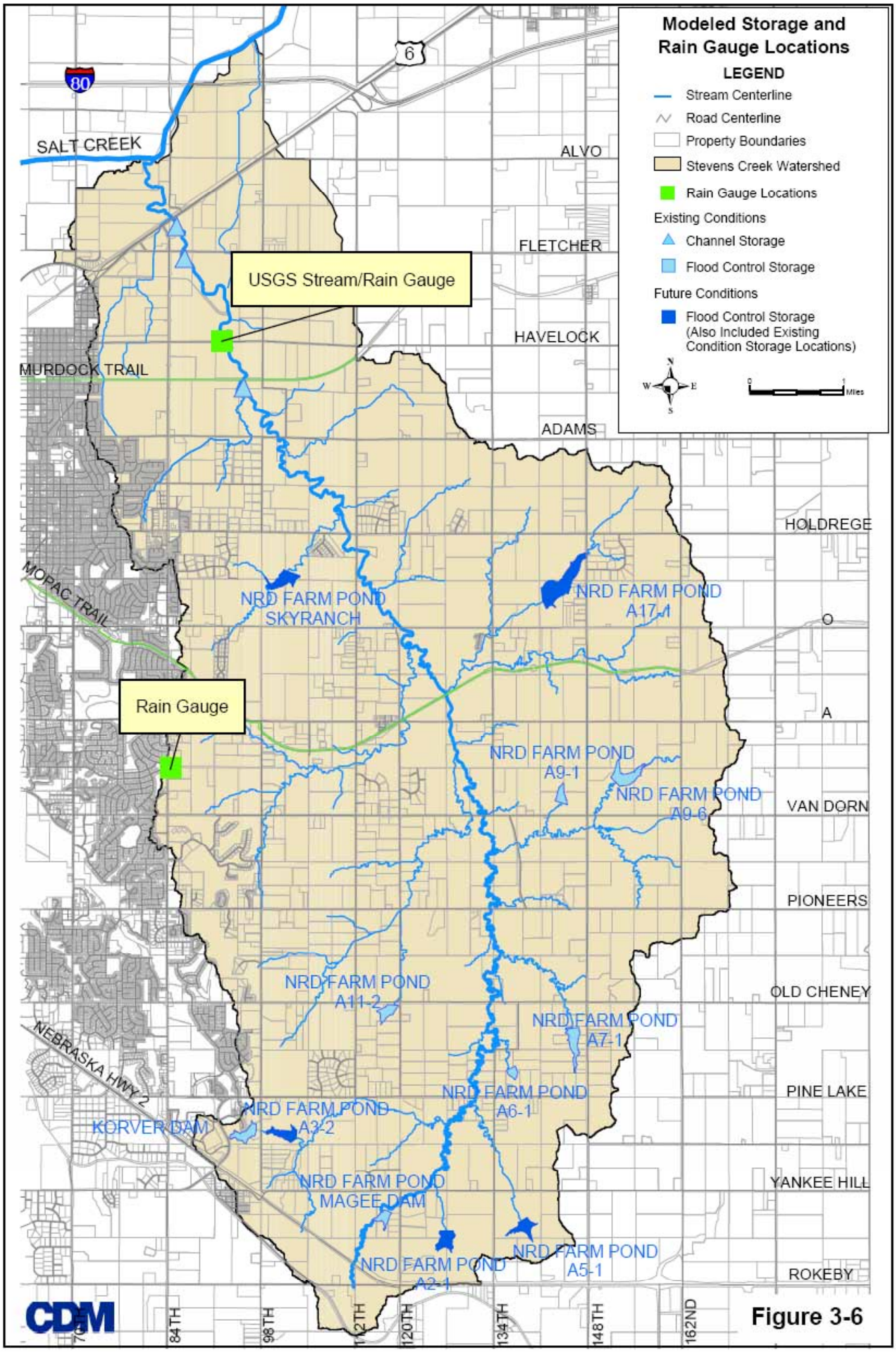

Modeled Storage and Rain Gauge Locations
LEGEND
Stream Centerline
Road Centerline
Property Boundaries
Stevens Creek Watershed
Rain Gauge Locations
Existing Conditions
Channel Storage
Flood Control Storage
Future Conditions
Flood Control Storage (Also Included Existing Condition Storage Locations)
N
W
E
S
0
1
Miles
80
6
SALT CREEK
ALVO
FLETCHER
HAVELOCK
ADAMS
HOLDREGE
O
A
VAN DORN
PIONEERS
OLD CHENEY
PINE LAKE
YANKEE HILL
ROKEBY
USGS Stream/Rain Gauge
Rain Gauge
MURDOCK TRAIL
MOPAC TRAIL
NEBRASKA HWY 2
NRD FARM POND SKYRANCH
NRD FARM POND A17-1
NRD FARM POND A9-1
NRD FARM POND A9-6
NRD FARM POND A11-2
NRD FARM POND A7-1
NRD FARM POND A6-1
NRD FARM POND A3-2
KORVER DAM
NRD FARM POND MAGEE DAM
NRD FARM POND A2-1
NRD FARM POND A5-1
84TH
98TH
112TH
120TH
134TH
148TH
162ND
CDM

Figure 3-6

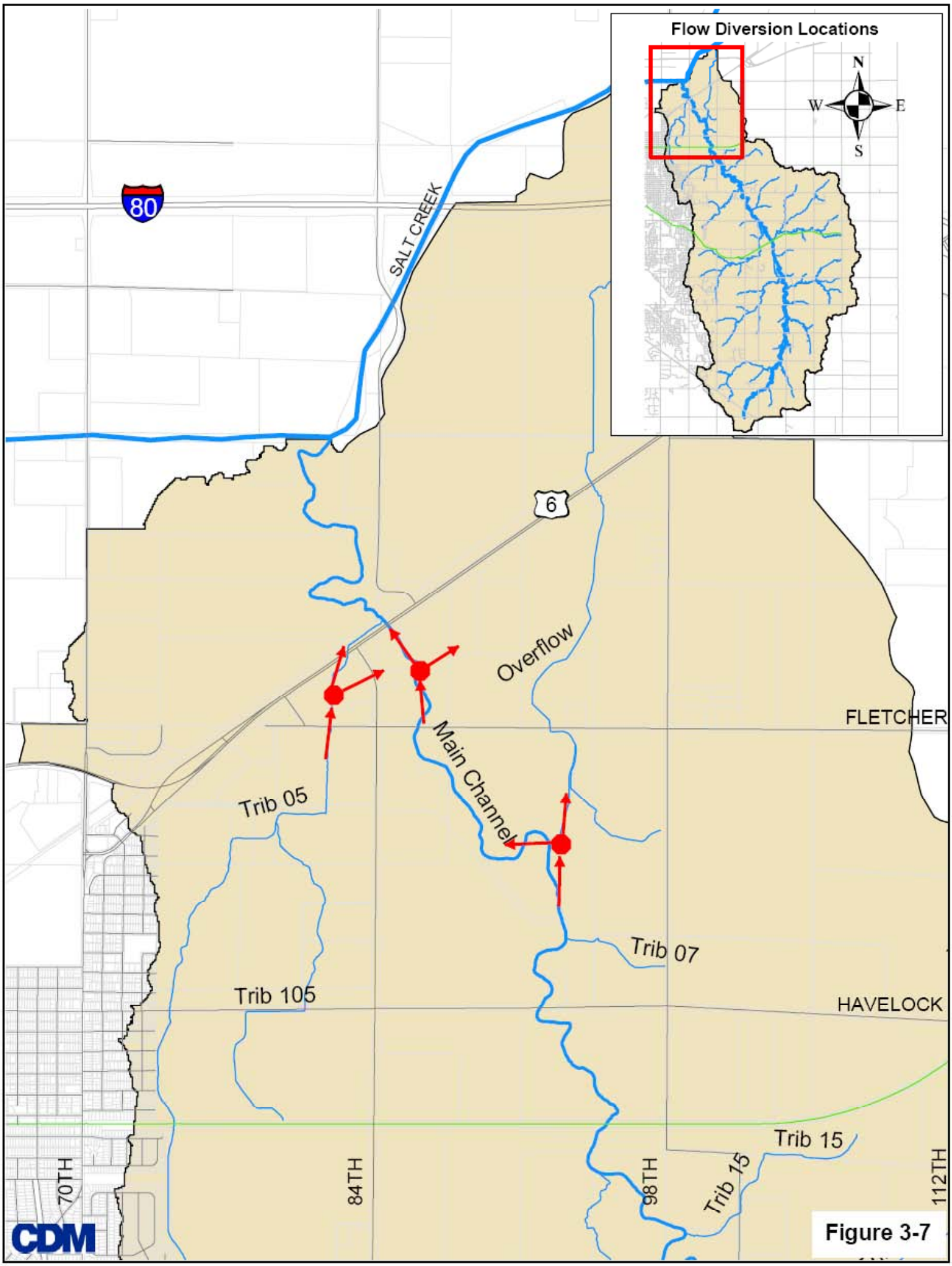

Flow Diversion Locations
N
W
E
S
80
SALT CREEK
6
Overflow
Main Channel
FLETCHER
Trib 05
Trib 07
Trib 105
HAVELOCK
Trib 15
Trib 15
70TH
84TH
98TH
112TH
CDM

Figure 3-7

inputted into both HEC-RAS models. The HEC-RAS models were then run to simulate the water surface elevation (WSE) through this area. The WSEs were then matched to determine the flow rate that the primary channel and overflow channel could convey for various WSEs. The same general procedure was used for the three flow diversion locations.

3.3 Model Calibration

The calibration process included two components, including historical storm event calibration and peak flow verification, using FEMA published flows and regression equation flow estimates.

3.3.1 Historical Storm Event Calibration

Historical storm event calibration requires stream gauge data and a distribution of rain gauges located in the watershed. Figure 3-6 shows the location of one stream gauge and two rain gauges within the watershed.

A USGS gauge (06803520) is located on the main channel of Stevens Creek at Havelock Avenue and contains both hourly stream flow and rainfall data. This gauge has available information from October 1, 1968, through December 2002. A review of data identified the September 8, 1989 storm event with the highest recorded peak discharge for the period of record, which was approximately 12,900 cubic feet per second (cfs). The existing FEMA Lancaster County Flood Insurance Study (FIS), dated September 21, 2001, 10-year flow rate is 9,400 cfs.

The other rain gauge is located along 84th Street between Van Dorn and A Street. This gauge contains hourly rainfall data from 1992 to 2003, which does not correspond to the September 8, 1989 flood event.

The HEC-HMS model was used to estimate a runoff hydrograph for the September 8, 1989 rain storm using only the recorded precipitation data from the Havelock gauge. Figure 3-8 shows the hydrographs from both the HMS model and the stream flow data recorded at the USGS gauge.

Typically, for a watershed of this size, six or more rain gauges distributed throughout the watershed are needed to properly calibrate the model. As shown in the Figure 3-8, the HEC-HMS peak flow estimate is approximately 30 percent lower than the recorded value. Due to insufficient rainfall data distributed across the watershed, it was concluded the HEC-HMS model could not be properly calibrated using historical data.

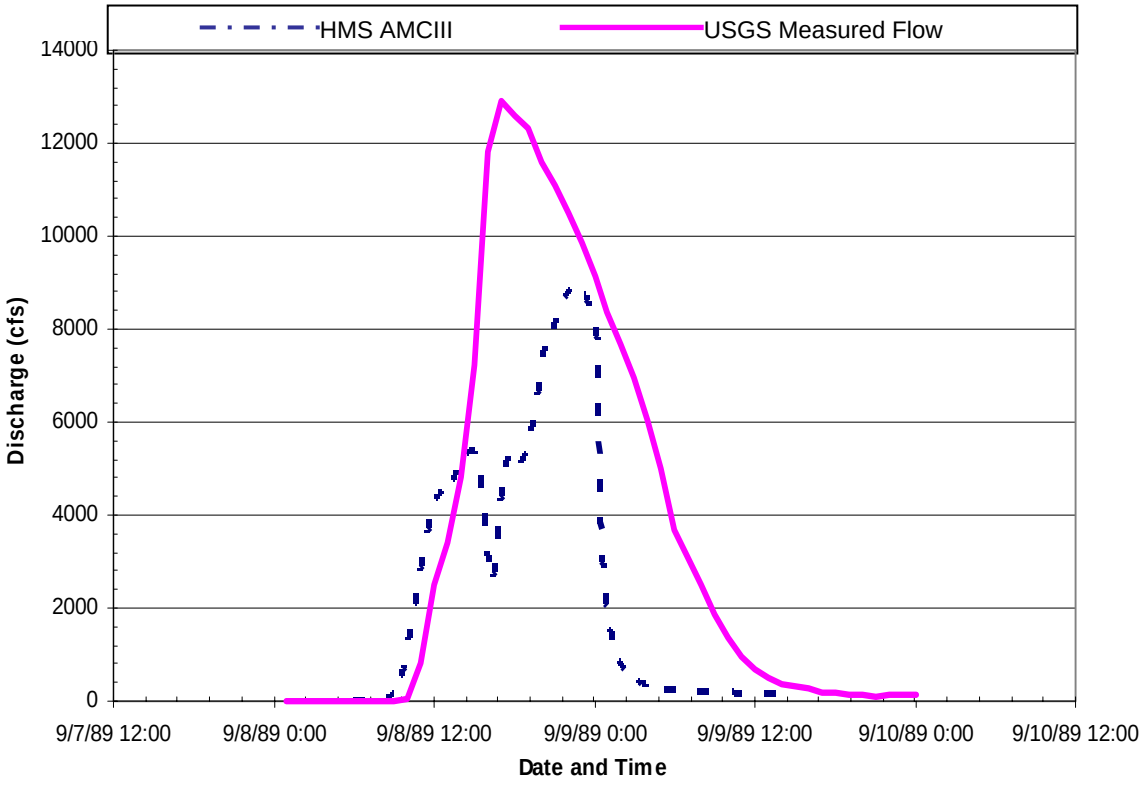


Figure 3-8
Stevens Creek - Havelock Street
9-8-89 Calibration Event

3.3.2 Peak Flow Verification

The HEC-HMS model results were compared to the Lancaster County FIS and peak flows derived using the Nebraska USGS regression equations. Table 3-8 illustrates the flow rates used in the verification process, while Figure 3-9 illustrates the location.

Other data were used in the verification process, including historical photos and eyewitness accounts of flooding during storm events. The project team used a questionnaire mailer and public meetings to facilitate the gathering of this information.

On average, the peak runoff rates estimated by the HEC-HMS model under existing land use conditions are 2 percent higher than the flow rates published by FEMA. At the Havelock Avenue location, the HEC-HMS is within 5 percent of both the FEMA published flows and the minimum regression equation estimate.

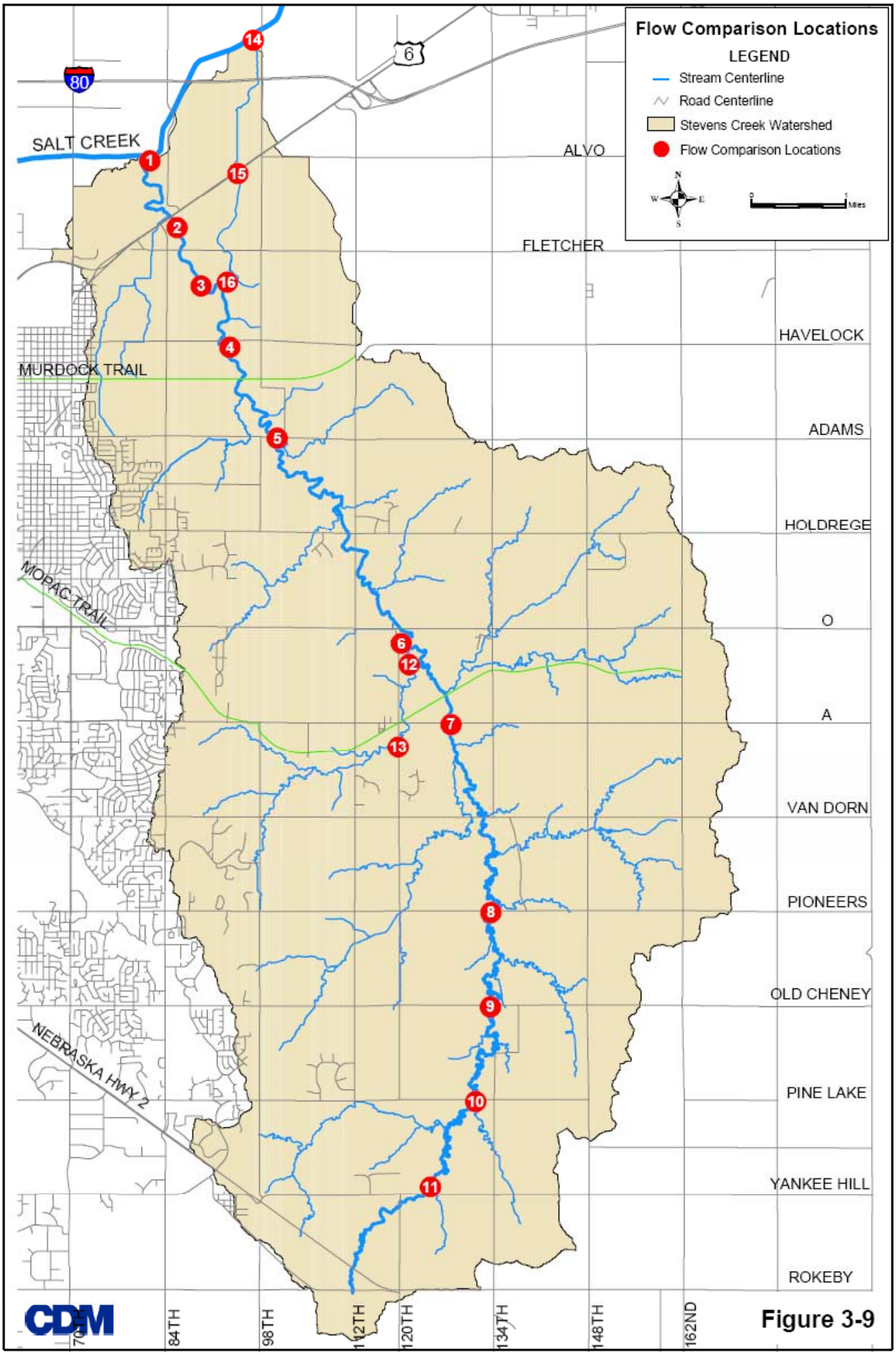

Flow Comparison Locations
LEGEND
Stream Centerline
Road Centerline
Stevens Creek Watershed
Flow Comparison Locations
Miles
SALT CREEK
80
6
ALVO
FLETCHER
HAVELOCK
ADAMS
HOLDREGE
O
A
VAN DORN
PIONEERS
OLD CHENEY
PINE LAKE
YANKEE HILL
ROKEBY
MURDOCK TRAIL
MOPAC TRAIL
NEBRASKA HWY 2
70TH
84TH
98TH
112TH
120TH
134TH
148TH
162ND
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
CDM

Figure 3-9

Table 3-8
100-Year Flow Comparisons

Location Number	Description	FEMA	HMS Model[1]	Regression Minimum	Regression Maximum
Stevens Creek Locations					
1	At mouth	8,100	9,730	NA[2]	NA[2]
2	Upstream of Hwy 6	8,000	9,687	NA[2]	NA[2]
3	D/S of Stevens Creek Overflow	13,100	11,482	NA[2]	NA[2]
4	Havelock Avenue	17,400	18,331	19,570	34,191
5	Adams Street	17,700	19,372	NC	NC
6	D/S of Trib 45	19,800	20,407	NC	NC
7	A Street	14,000	13,298	NA[3]	NA[3]
8	Pioneers Boulevard	7,660	6,769	NC	NC
9	At Old Cheney	6,050	6,259	NA[3]	NA[2]
10	Pine Lake Road	5,790	6,266	NC	NC
11	At Yankee Hill	2,090	2,443	NA[3]	NA[3]
12	Trib45 - at Mouth	3,900	4,134	6,760	11,810
13	Trib45 - U/S of 120th Street	4,000	4,918	6,270	10,950
Stevens Creek Overflow Channel Locations					
14	At mouth	8,300	7,367	NA[2]	NA[2]
15	Upstream of Hwy 6	8,300	7,430	NA[2]	NA[2]
16	D/S of Stevens Creek	6,500	6,310	NA[2]	NA[2]

1 Peak flow rates based on existing land use conditions.
2 Regression equations are not applicable due to the reduction in peak flow caused by flow diversions at these locations.
3 Regression equations not applicable for A Street, Old Cheney, and Yankee Hill. Basin slope variable outside of applicable range.

NC: Not calculated.

3.4 Stream Gauge Statistical Analysis

In addition to the calibration and verification process described above, the feasibility of performing a flood flow frequency analysis using the historical stream data at the USGS Havelock gauge was evaluated. The review of the gauge data found that the two highest recorded flow rates (12,900 and 9,760 cfs) were approximately a 10-year event. In addition, an examination of the yearly recorded peak discharges found that over 87 percent was less than 5,000 cfs and 71 percent less than 3,000 cfs.

The stream gauge is located within very mild terrain with significant overbank conveyance capacity that may have affected the historical gauge data. This was confirmed with historical photos of this area during a flood event. Therefore, this gauge was found to lack the necessary extreme events (>10 year event) and quality of data to perform a flood flow frequency analysis.

3.5 Modeling Results

Table 3-9 presents the HEC-HMS modeling results under existing and future land use conditions. The stormwater peak flow rates are provided at the same major locations as reported in the Lancaster County FIS. The 100-year peak flow rates under existing conditions were used to delineate the floodplain/floodprone areas as depicted in Section 5. Model input data and results are included in Appendix C, located in Volume II. Peak flow rates for each structure included in the hydraulic model are presented in Appendix J, located in Volume II.

Table 3-9
Peak Flow Modeling Results

Location No.	Description	2-year		5-year		10-year	
		Exist	Future	Exist	Future	Exist	Future
1	At mouth	4,507	5,456	6,695	6,975	7,388	7,548
2	Upstream of Hwy 6	4,493	5,450	6,668	6,948	7,354	7,512
3	D/S of Stevens Creek Overflow	4,464	5,454	6,829	7,061	7,539	7,852
4	Havelock Avenue	4,529	5,570	7,645	8,099	9,337	10,250
5	Adams Street	4,602	5,846	8,086	9,109	10,927	12,197
6	D/S of Trib 45	5,046	6,626	8,331	10,111	11,314	12,974
7	A Street	3,460	4,541	5,698	7,209	7,760	9,385
8	Pioneers Boulevard	2,233	2,106	3,192	3,134	4,032	4,298
9	At Old Cheney	2,030	1,860	2,934	2,665	3,718	3,671
10	Pine Lake Road	2,105	2,283	3,002	3,138	3,704	3,857
11	At Yankee Hill	727	822	1,111	1,192	1,438	1,445
12	Trib45 - at Mouth	1,063	1,636	1,767	2,397	2,350	3,027
13	Trib45 - U/S of 120th Street	1,096	1,730	1,842	2,716	2,573	3,606
Stevens Creek Overflow Channel Locations							
14	At mouth	893	1,393	1,269	2,174	1,871	2,870
15	Upstream of Hwy 6	700	1,268	1,202	2,001	1,888	2,556
16	D/S of Stevens Creek	0	0	696	1,001	1,737	2,265

Location No.	Description	50-year		100-year		500-year	
		Exist	Future	Exist	Future	Exist	Future
1	At mouth	8,679	9,033	9,730	9,982	11,511	11,567
2	Upstream of Hwy 6	8,641	8,997	9,687	9,942	11,452	11,509
3	D/S of Stevens Creek Overflow	9,896	10,426	11,482	11,950	14,252	14,512
4	Havelock Avenue	15,408	16,480	18,331	19,301	24,678	25,187
5	Adams Street	16,311	17,653	19,372	20,669	26,381	27,288
6	D/S of Trib 45	17,048	19,127	20,407	22,540	28,064	30,009
7	A Street	11,247	13,563	13,298	15,892	17,819	20,565
8	Pioneers Boulevard	5,783	5,961	6,769	6,833	8,633	8,777
9	At Old Cheney	5,348	5,071	6,259	5,855	8,066	7,531
10	Pine Lake Road	5,352	5,093	6,266	5,765	8,245	7,529
11	At Yankee Hill	2,101	1,941	2,443	2,206	3,196	2,801
12	Trib45 - at Mouth	3,441	4,406	4,134	5,170	5,726	7,046
13	Trib45 - U/S of 120th Street	4,046	5,474	4,918	6,477	6,916	8,745
Stevens Creek Overflow Channel Locations							
14	At mouth	5,709	6,299	7,367	7,909	11,787	12,033
15	Upstream of Hwy 6	5,786	6,272	7,430	7,858	11,850	11,942
16	D/S of Stevens Creek	4,962	5,412	6,310	6,707	9,979	10,144