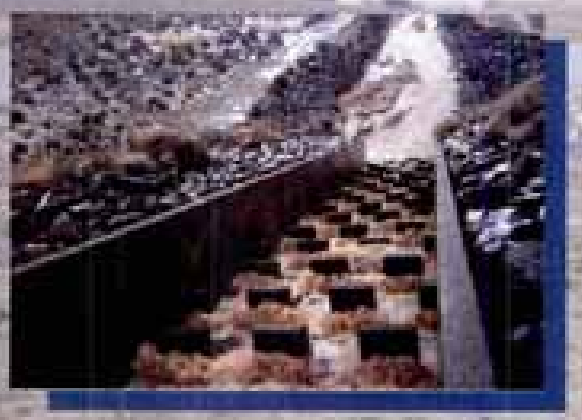
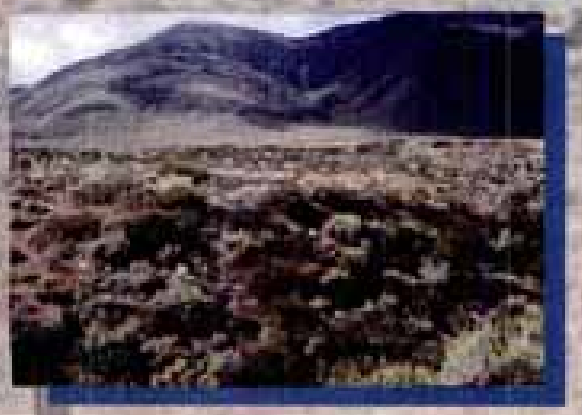
Volume 1 of 4:
Report Text, Figures and Cost Analysis

Drainage Master Plan

for

Stead, Nevada





Prepared for:

RENO

Prepared by:

Stantec

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August 2000

Project No. 80100208

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Stantec

August 16, 2000
Project No. 80100208

Mr. Gary Stockhoff, P.E.
Deputy Public Works Director
CITY OF RENO
P.O. Box 1900
Reno, Nevada 89505

RE: Stead Master Plan

Dear Gary:

Stantec is pleased to present the attached two copies of the final drainage master plan for Stead, Nevada, entitled *Drainage Master Plan Stead, Nevada*, dated August 2000. The master plan is being submitted in four volumes. Volume One is the report text, figures and cost estimates; Volume Two is existing conditions hydrologic analysis; Volume Three is proposed conditions hydrologic analysis; and Volume Four is correspondence, previous studies, existing and proposed conditions hydraulic analysis and back up data, quantities and cost estimates, survey data and references. Diskettes containing all hydrologic HEC-1 models can be found in Volume 1.

If you have any questions regarding the material, please call.

Sincerely,

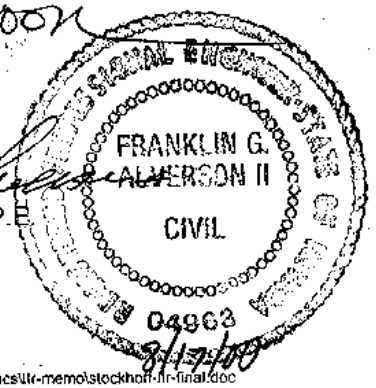
STANTEC CONSULTING INC.

Trina Magoon

Trina Magoon, P.E.
Project Engineer

Franklin G. Alverson II, P.E.
Manager, Reno/Sparks

FGA:mak
Enclosures



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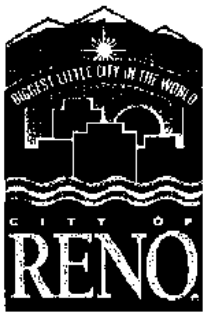
Buildings
Environment
Industrial
Management Systems
Transportation
Urban Land

Drainage Master Plan
Stead, Nevada

Prepared for:



Prepared by:

Stantec

August 2000

Project No. 80100208

TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX 1 – Volume 2 (under a separate cover)

APPENDIX 2 – Volume 3 (under a separate cover)

APPENDIX 3 – Volume 4 (under a separate cover)

CITY OF RENO
STEAD HYDROLOGIC AND DRAINAGE MASTER PLAN

INTRODUCTION

Project Description

The City of Reno Stead Hydrologic and Drainage Master Plan was prepared at the request of the City of Reno. The purpose of the report is to develop a comprehensive drainage document specifically for the Lemmon Valley Basin. The report and associated models identify existing hydrologic drainage patterns in the Lemmon Valley basin, and quantify amounts of storm runoff at specific locations. Results of the analysis provide identification of present condition flooding and problem areas within the region, so that capital flood improvements may be scheduled and undertaken. Projected hydrologic models are intended to provide a strong foundation for planning and future development in the area.

Stead is a small suburb of Reno located approximately 10 miles north of Reno. The focal point of the area is the Stead Airport, which was developed by the U.S. Army, but is now under the jurisdiction of the Airport Authority. Areas in close proximity to the U.S. Highway 395 have become home to a growing population of manufacturing, business, and industry, while the surrounding areas have experienced a steady growth of residential development. Stead lies within Lemmon Valley, one of numerous desert valleys found throughout the region. Lemmon Valley is bounded on the south by Peavine Mountain, and on the west by the Granite Hills range. The northern boundary is defined by Fred's Mountain and the Hungry Mountains, and to the east by the Hungry Ridge, a low range separating Lemmon Valley from Spanish Springs and Sun Valleys.

Scope of Work

The City of Reno Stead Hydrologic and Drainage Master Plan was initiated under contract with the City of Reno in December 1997. The plan was prepared solely for the City of Reno, and is not intended for review by the Federal Emergency Management Agency (FEMA) for use in obtaining a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR). Preparation for the project was broken down into the following tasks:

- Compile and review existing studies
- Analyze and prepare a 100-year hydrologic model for present day conditions
- Analyze and prepare a 5-year hydrologic model for present day conditions
- Develop a 100-year hydrologic model for proposed conditions based upon a 20-year land use plan
- Develop a 5-year hydrologic model for proposed conditions based upon a 20-year land use plan
- Incorporate proposed design improvements from previous studies into the Master Plan
- Analyze localized areas of acute flooding identified by City of Reno maintenance personnel
- Provide scheduling and opinions of probable construction costs for proposed improvements
- Provide conceptual sizing of a regional retention basin for the Silver Lake area.

PREVIOUS STUDIES

Previous studies prepared for the Stead area were complied and reviewed with regard to identifying previous hydrologic criteria, drainage basins, and proposed improvements. Pertinent information was incorporated into the Stead Master Plan project. The following summarizes the previous studies complied and reviewed.

- **Kennedy Jenks**

  Provided the Washoe County Flood Control Master Plan, Concept Level Report under contract with Washoe County, Nevada, April 1991. Provided statistical data and recommendations for Lemmon Valley, Western Part, and Lemmon Valley, Eastern Part, mainly in the form of flow channelization and related structures.

- **Schaaf & Wheeler / CFA**

  Southwest Lemmon Valley Flood Channel Master Plan (revised June 1998)

  On behalf of North Valleys Development Company and Dermody Properties. In December 1996, FEMA conditionally approved a hydrologic model of the Lemmon Lake watershed affected by the proposed development bounded by Military Road on the west, Lemmon Drive on the east, and Lemmon Lake to the north.

- **Schaaf & Wheeler / CFA**

  Peek's Lemmon Valley Property: Hydrologic and Hydraulic Analyses, prepared in March 1996. Provided hydrologic and hydraulic modeling for the Southwest Lemmon Valley Flood Channel Master Plan.

- **Winzler & Kelley**

  Provided the Reno Drainage Study Analysis of the Stead Drainage Deficiency Area under contract with City of Reno, March 1985. Focused on channelization of flows west of Stead Boulevard, as well as storm drain improvements to areas around the Old State complex in Stead.

- **Summit Engineering**

  Hydrologic Analysis of the City of Reno's Major Drainage Basins, October 1985. Provided a general overview of drainage conditions and recommendations for problem areas.

- **Nimbus Engineers**

  Prepared Hydrologic Analysis of Silver Lake and Lemmon Valley Playas, July 1987. Provides water surface elevations for Silver and Lemmon Lakes, adopted by FEMA.

  Prepared Hydrologic and Hydraulic Analysis for Silver Shores #8, April 1993. Provided hydrology for a portion of the Silver Lake runoff area around the Red Rock interchange.

- **Jeff Codega Planning/Design, Inc.**

  Provided Sky Vista Drainage-way Master Plan, August 1994. Provides hydrology for a portion of the Lemmon Lake runoff area affecting development area north of Silver Lake Boulevard between Stead Boulevard and Military Road.

- **FEMA FIRM/ Flood Hazard Designations**

  FEMA Flood Insurance Rate Maps (FIRM) were reviewed in order to prepare an overall comprehensive map of the Stead area showing the floodplain delineations, major drainage basins, and corporate boundaries.

HYDROLOGIC METHODOLOGY

The methodology used for the preparation of the hydrologic models was based upon discussions with the City of Reno staff and current engineering standard practices.

The U.S. Army Corp of Engineer's (COE) Flood Hydrograph package, HEC-1, Version 4.0.1E was used to perform the hydrologic modeling for the study area. The HEC-1 models were prepared based upon the Soil Conservation Service's (SCS) Unit Hydrograph method outlined in the Final Draft Washoe County Hydrologic Criteria and Drainage Design Manual (HCDDM). The following four models were developed for the Master Plan Study:

- 100-year, 24-hour existing conditions hydrologic model
- 5-year, 24-hour existing conditions hydrologic model
- 100-year, 24-hour proposed conditions hydrologic model
- 5-year, 24-hour proposed conditions hydrologic model

Basin Areas

The overall Lemmon Valley watershed was delineated utilizing United States Geological Survey (USGS) 7.5 minute quadrangle maps for the Reno, Reno NE, Reno NW, and Verdi areas. These maps were also used for delineating individual sub-basins in outlying and/or rural areas. The majority of the developed areas within City of Reno boundaries were divided into sub-basins using a 2-foot contour map provided by the city. Additional resources in determining basin boundaries included subdivision site plans, Nevada Department of Transportation highway plans, major roadway profiles, and field investigation supplemented by spot surveys.

The quadrangle maps and the City of Reno 2-foot contour map were both positioned in real orientation within AutoCAD Release 14. Boundaries were then drawn and exported into Geographic Information Systems (GIS) format, where all sub-basin area calculations were performed.

Precipitation

Precipitation within the HEC-1 program was modeled using a balanced storm distribution (PH card). Precipitation values were obtained from the National Weather Service's Precipitation Frequency Study of the United States, NOAA Atlas 14, Volume 1 - Semi-Arid Southwest United States (SSPFS, 1997). After locating individual sub-basin centroids, point rainfall values for 2-year 1-hour, 2-year 6-hour, and 2-year 24-hour storm events were read from the individual maps. Values for basin centroids that fell between rainfall isopluvials were interpolated accordingly. In order to have a

consistent model, all basins were assigned a value using this methodology, including ones from previous studies or references.

The 100-year, 24-hour and 5-year, 24-hour balanced storm distribution card values were calculated using the regional growth factors and conversion ratios described in the Washoe County HCDDM, Section 600. Depth-area reduction factors were utilized within the hydrologic models according to sub-basin areas. Precipitation values are expressed in terms of partial-duration frequencies, with no conversion factors applied within the HEC-1 modeling program.

Curve Numbers

The Soil Conservation Service (SCS), U.S. Department of Agriculture curve number method was used to determine curve number values for use in the hydrologic models. Hydrologic soil groups for each basin were determined using information from the SCS Soil Survey of Washoe County, Nevada, South Part. Land uses were obtained from Washoe County for the entire watershed, and field investigations were performed in order to verify and classify each basin's land use and cover designations, respectively. An Antecedent Moisture Condition II was used per the Washoe County HCDDM. Runoff curve numbers for each applicable land use, according to soil group, were taken from SCS Technical Release 55.

Lag Times

Two methods of computing lag times were used according to the SCS dimensionless unit hydrograph method. The lag parameter is equal to the lag (in hours) between the center of mass of rainfall excess and the peak of the unit hydrograph. For drainage basins less than one square mile and whose slopes are less than ten percent, the lag time parameter equals 60% of the time of concentration for the individual basin. The concentration time is composed of an initial overland flow time plus a travel time. The initial time was calculated according to Equation 702 of the Washoe County HCDDM, while the following travel time was estimated by measuring the travel length and dividing by an estimated flow velocity.

For basins larger than one square mile and whose slopes exceed ten percent, the lag time is influenced more by the concentrated flow time. Equation 710 of the Washoe County HCDDM, based upon analysis by the United States Bureau of Reclamation, was used in computing lag time parameters for applicable basins within the Lemmon Valley watershed.

Hydrograph Routing

The Muskingum-Cunge routing technique was used to route the majority of upstream hydrographs within the HEC-1 models. Channel properties for small natural channels were based upon topographic information and field investigations. For larger channels, including designed ones, field measurements and/or channel design plans served as the basis for input parameters. The remaining hydrographs located in urban areas around Stead Boulevard were routed using the Kinematic Wave method.

Split Flows and Detention

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Split flow calculations for diversion parameters within the HEC-1 models were based upon topographic information and field survey spot elevations. At culvert locations, culvert ratings were performed using Dodson & Associates pipe culvert analysis program, based upon Manning's Equation. Weir flow ratings were calculated using an irregular section analysis program based upon the standard weir flow equation $Q = c\ l\ h^{3/2}$. By balancing the common water surface between the

culvert and weir flow ratings, split flow amounts were determined for use in the hydrologic models. The culvert analysis program was also used to determine outflow ratings at several detention areas within the watershed.

Silver Lake and Lemmon Lake Water Surface Elevations

Storage volume and initial water surface elevations for Silver Lake and Lemmon Lake were taken from Nimbus Engineers Hydrologic Analysis of Silver Lake and Lemmon Valley Playas, dated July 1987. The report was prepared in conjunction with a Federal Emergency Management Agency (FEMA) Flood Insurance Re-study (FIS) for the Reno/Sparks area.

EXISTING CONDITIONS HYDROLOGIC MODEL

The Lemmon Valley watershed covers an area of approximately 96.5 square miles. Elevation ranges from a high of 8766 feet at the top of Peavine Mountain to a low of 4915 feet at the water surface of Lemmon Lake. In the higher elevations of the numerous ranges, ground cover consists of a mixture of pines, juniper, and various other low-growing brush. The lower hills and undeveloped valley areas consist of sagebrush with grass understory, or simply grass. Small pockets of urban areas can be found in the valley communities of Stead, Lemmon Valley, and Golden Valley, but the area is predominantly rural by development standards.

Surface runoff terminates at two distinct locations within the overall watershed. The first location is Silver Lake, situated on the west side of the valley, north and west of Moya Boulevard. The Silver Lake drainage basin covers an area of approximately 56.5 square miles, or 60% of the total watershed. The second collection location is Lemmon Lake, located west of Lemmon Valley Drive. Both are playa lakes whose water volumes fluctuate according to annual precipitation amounts. The physical separation line between the two lakes runs approximately north and south according to natural topography at the ends, and urban development in the vicinity of Stead Boulevard. The following discussion summarizes the existing drainage patterns within the overall region.

SILVER LAKE WATERSHED

Silver Knolls

The Silver Knolls area is located north of Silver Lake and the Stead Airport. The area covers approximately 42 square miles, which represents over 70% of the area draining to Silver Lake. The area is predominantly rural, with scattered residential areas located in the vicinity of Red Rock Road. The area also encompasses the majority of the Stead Airport property.

Storm runoff originates in the Fred's Mountain basins labeled FR1 and FR2. Runoff is conveyed in natural ephemeral streams and channels south towards the north boundary of the airport property. Through the airport, the flow path becomes less defined, and the overall spread increases. Lateral inflow occurs from basins RR1 and Silver Knolls basins 2, 3 and 4 (SK2-SK4) as the area drains towards Silver Lake. Large storm events produce flooding in developed areas at the southwest corner of Osage Road in basin SK2.

Moya Boulevard at Red Rock Road

Flow at this concentration point is predominantly the result of runoff from Peavine Mountain basins PW1-PW6, and Granite Hills basins GR2-GR4. Runoff from Peavine Mountain is collected in a series

of ephemeral streams that bisect Highway 395. Each basin terminates at a culvert, which transmits the flow north beneath the highway. From there, concentrated flows are directed towards Red Rock Boulevard. Any flow in excess of the highway culverts' capacity collects at the south side of the Red Rock Road interchange and is then conveyed north in the roadway.

An improved channel is located along the east side of Red Rock Road that carries flows originating from the south and east (basins PW5, PW6, RRI, SS2) up to Moya Boulevard. Flows from basins PW1-PW4 join with flows from the Granite Hills basins and cross Red Rock Road in concrete box culverts just before reaching Moya Boulevard. The two flows combine at this point, then are conveyed beneath Moya Boulevard in concrete box culverts. Ultimately, flow discharges north into Silver Lake. The improved section of channel along Red Rock Road was designed to carry 347 cfs adjacent to the Silver Shores Subdivision. The concrete box culverts beneath Red Rock Road near Moya Boulevard were designed to accommodate a 100-year storm event of approximately 600 cfs. The grouted riprap channel and concrete box culverts beneath Moya Boulevard were designed to accommodate a 100-year storm event of approximately 750 cfs. However, current precipitation data used in the master plan models yields flow rates (Q100=1324cfs) exceeding the original design value indicating potential occurrence of flooding at the box culverts beneath Moya Boulevard.

Silver Shores

Silver Shores is a residential subdivision located east of Red Rock Road between Moya Boulevard and Highway 395. Basin PA1 south of the highway contributes runoff that flows beneath the highway in a culvert, then north in a large natural channel through basin SS3 until it reaches Moya Boulevard. Channel flow is joined by minor flow from basins SS1a and SS1b. Flooding at the culvert inlet beneath Moya will occur during the 100-year storm event. The remainder of basin SS3 contributes a large amount of runoff due to dense development within the basin, which creates the potential for flooding at Moya Boulevard and Silver Shores Drive. The City of Reno has indicated that the Silver Shores developer was required to convey the 100-year storm event flows beneath Moya Boulevard and out to Silver Lake. Stantec did not analyze the storm drain design for the entire subdivision, but does recommend further review based upon the amount of storm runoff calculated at this location.

Silver Lake Basins 2 and 3

Silver Lake basin 2 is located immediately north of U.S. Highway 395 and east of the Silver Shores development. Runoff begins at the north edge of the highway, with no contributions from areas south of the highway. Flow progresses north through basins SL3a and SL3b, areas scheduled for development adjacent to the west boundary of the Sierra Sage Golf course. Before dropping down to Moya Boulevard, flow is routed in a small man made channel that is susceptible to erosion during large-scale storm events. Upon reaching Moya Boulevard at concentration point GC3, flow is joined by runoff from basin GC3, creating a flooding condition at this low point.

Golf Course Channel

The golf course channel is located on the eastern boundary of the Sierra Sage Golf course basin labeled GC1. The channel runs adjacent to the elevated north-south railroad spur serving the industrial areas of Stead. Areas that discharge into the channel extend into the upper reaches of Peavine Mountain. The channel eventually breaks west and away from the railroad at the JC Penney property. A concrete energy dissipation structure takes flows down to a lower channel terminating at Silver Lake. Flooding occurs at several locations along the length of the channel. The following summarizes the drainage patterns contributing to the channel.

Runoff originating from basins on Peavine Mountain flows north and slightly east as it progresses from the higher elevations. Several man-made flow obstructions are encountered along the flowpath, beginning with the railroad line running across the base of mountain, followed by North Virginia Street, then US Highway 395. Each of these features limits the flow of runoff because of the embankment fill across the natural streamline. While culverts are installed at each embankment location to convey flow, most are undersized in the event of a 100-year storm. Stantec analyzed culvert capacities and diverted flows at overtopping locations based upon field surveys of each individual area.

The first point experiencing problematic flooding is at concentration point AW3, located where the rail spur crosses North Virginia Street. This location is a sag point in the roadway, which collects excess runoff not already conveyed beneath North Virginia. The majority of water crossing the roadway sag point is collected in a low-lying area on the western side of the rail spur. From here, it travels north in a swale along the tracks. The swale also collects excess runoff not already conveyed beneath the new highway from basins to the west. The swale transitions to a defined channel north of the highway, where it is rejoined by culvert flows from beneath the highway, and storm drain flows.

The next problem area in the overall channel is at a large inlet to the Stead Boulevard storm drain system. The inlet is located between Stead Boulevard and the rail spur, north of the highway. Piped flows from basin AW3, as well as surface runoff from basins SI1 and SI2 contribute to the inlet. Once inside the pipe, flow is split into three portions. The first portion outfalls west beneath the rail spur and into the rail-side channel mentioned previously. The second joins the main northbound trunk line in Stead Boulevard, while the third outfalls east behind the school facilities on the east side of Stead Boulevard.

Flooding occurs at the inlet to this system due to several factors. First, the flow is constricted by undersized outfall pipes. Second, are junction losses at manhole locations, where flows are forced into turning 90 degrees several times. Further capacity losses are the result of an elevated invert leading to the third outfall. Finally, problems with sediment and debris reduce the inlet capacity and contribute to flooding of the inlet area.

Returning to the channel along the rail spur, flow continues north to Silver Lake Boulevard. Several hundred cubic feet per second of runoff accumulates at the 24" culvert beneath the roadway before overtopping the street and splitting to the north and east. The excess culvert capacity is also joined by flow from Silver Lake Estates (basin SLE) to the west, and excess flows from basin PA3 south of the highway. Split flow heading east crosses the railroad spur and enters Stead Boulevard, while flow heading north drops back into the channel along the rail and continues north.

The eastern side of the channel is well defined by the elevated rail spur through golf course basin 1 (GC1). Some spreading occurs along the west edge, but flow is ultimately channeled by the large railroad cut as it enters basin GC2. However, due to the large volume of water, overtopping of the rail line occurs through the cut and flows east onto the JC Penney site.

Flow that does not overtop the rail enters a designed channel and energy dissipation structure west of JC Penney's. After dropping down into another designed channel, flow continues northwest towards Silver Lake. Lateral inflow from basin GC2 occurs prior to the channel terminating at Moya Boulevard. Flooding again occurs at Moya Boulevard due to undersized roadway culverts.

Stead Boulevard

Stead Boulevard is a major north-south arterial that provides access from Highway 395 to areas surrounding the Stead Airport. A storm drain trunk line carries minor storm event flows just north of the intersection with Lear Boulevard, then east, where flows eventually end up in Lemmon Lake. The street itself serves as a conduit for runoff exceeding storm drain capacity, which originates from areas in the immediate vicinity of the boulevard itself. Additionally large storm event split flows enter from Silver Lake Boulevard, as mentioned earlier in the golf course channel overview. The natural sag point and collection point for surface flows lies at the intersection with Lear Boulevard. Excess storm drain flows pond at the intersection and eventually overtop the northwest corner, and drop into the Donnelley channel.

Donnelley Channel

RR Donnelley is a large industrial printing plant located on the northwest corner of Stead and Lear Boulevards. The site was built on a natural playa within basin MOY, which required that a channel be designed and built to drain the area and alleviate flooding of the site. Aside from onsite flows, the channel serves as the main drainage-way for overflow from Stead Boulevard (basin ST2) and basin LEA to the south. The channel runs west adjacent to Lear Boulevard until it reaches the rail spur, then is directed north to the Moya detention area. The channel was constructed at minimal slopes (approximately 0.15%), and considerable backwater is developed because of limiting structures at access points to the property.

Moya Detention Basin

The Moya detention area was also a natural playa located within basin MOY. The area is bounded on the west by Moya Boulevard and on the east by the rail spur. Echo Avenue forms the north boundary, with Lear Boulevard enclosing the area. Several industries have located within the boundary, thus further defining the detention area.

In addition to collecting runoff via the Donnelley channel, the detention basin acquires runoff from the airport complex and nearby developed areas. Two outlets exist for the basin, both of them culverts beneath Moya Boulevard. The culverts outlet to a recently constructed channel west of Moya Boulevard, which carries flow south to Silver Lake. Flooding of Moya Boulevard at several locations occurs during 100-year storm events because of low output volume from the two culverts.

LEMMON LAKE WATERSHED

Sky Vista Estates

Sky Vista Estates is a large residential development located north of Highway 395 between Stead Boulevard and Military Road. Areas contributing runoff to the development are located south of the highway and include Peavine basins 1-3, along with basin ESB. Once again, the railroad, North Virginia Street, and Highway 395 form barriers in the natural streamlines, so that numerous split and diverted flows occur. At the highway, several culverts deliver runoff that continues northeast through the Sky Vista development. During large storm events, excess highway culvert capacity will flow east along the highway to a sag point located in basin PE4, where it crosses the highway and bypasses Sky Vista Estates.

Jeff Codega Planning/Design developed a master plan for the Sky Vista residential development. The plan provided hydrologic parameters for the areas affected by the development, as well as offsite

areas studied by Stantec. Onsite drainage paths continue to follow the overall natural drainage patterns for the area, with runoff continuing to flow in a northeasterly direction. Ultimately, all Sky Vista storm runoff drains to a main east-west channel leaving the sanitary treatment plant, located north of Lear Boulevard and east of Military road. The main channel bisects a low point in Military Road just south of the intersection with Lear Boulevard. Three concrete box culverts convey flow beneath the road, after which a channel conveys the flow to Lemmon Lake.

Basin parameters, channel improvements, and detention basins for the overall HEC-1 master plan models were incorporated directly from the Sky Vista Master Plan, with the exception of precipitation values.

Military Road

Military Road is a two-lane roadway connecting Lemmon Drive north of the Lemmon Valley exit of Highway 395 to Echo Avenue near the Stead Airport. The roadway cuts across the natural drainage pattern of areas draining to Lemmon Lake. Improvements in the form of box culverts and roadway channels have been constructed, but the area continues to experience flooding and problems.

Storm runoff contributing to Military Road originates south of the highway in basin PE4. This basin drains north to the highway by way of ephemeral streams and natural channels. Numerous split flows and diversions take place before flow reaches the highway because of the rail, North Virginia, and Highway 395 embankment fills spanning the natural drainage courses. Additionally, diverted flow from basin ESB to the west enters basin PE4. A sag point in Highway 395 located east of the eastern boundary of basin ESB is where any excess highway culvert capacity will cross into basin ML1 to the north.

Once in basin ML1, flow continues north and slightly east in several natural channels cut through the low-lying soils. The waterways eventually converge into a single channel south of Tholl Drive, then continue north to Military Road. The natural channel path is perpendicular to Military Road where the two intersect just south of Charlene Drive. Flow has been channeled to turn 90 degrees and proceed north in a roadside channel for several hundred feet until it reaches a box culvert intended to deliver it across the roadway. Extensive scouring of the roadway embankment at the 90-degree bend has occurred, along with significant sediment deposition. At the box culvert, flow is intended to cross beneath Military Road. However, several culverts beneath a residential access road to the west allow a portion of the channel flow to continue north along the west side of the roadway. The collection of structures at this location is inadequate to convey runoff during large events and backwater creates flooding across Military Road.

Beyond this location, runoff continues to travel north along both sides of Military Road in unlined channels. The west side channel picks up minor amounts of lateral inflow from basin ML3, and continues to overtop the roadway due to backwater effects from another access road to the west, and due to inadequate channel size complicated by soil depositions. The east side roadway channel collects any roadway overtopping, and loses flow to basin ML2 for lack of conveyance capacity. Ultimately, both channels intersect the main east-west channel originating from the treatment plant on either side of the box culverts located south of the intersection with Lear Boulevard. From the box culverts, flow travels northeast to Lemmon Lake. Flows in excess of the east roadside channel capacity meander through basin ML2 and eventually reach Lemmon Lake.

Golden Valley

Golden Valley is a residential community located east of Highway 395 at the southeast corner of the Lemmon Lake watershed. Golden Valley basin GV3 serves as the focal point for flows within the valley, as well as all basins south of Highway 395 and south of basin PE4. Basins south of the

highway drain in a northeasterly direction. Natural drainage-ways are once again impacted by embankment fill from the railroad, North Virginia Street, and Highway 395. In spite of numerous splits and diversions during major storm events, the only location experiencing problematic flooding is the intersection of Golden Valley Road and North Virginia. Minor problems occur at the southwest portion of the Lemmon Valley interchange where surface runoff has caused erosion prior to entering NDOT conveyance structures.

Flow exiting culvert structures beneath the highway travels in a northeasterly direction before entering the main natural channel located in basin GV3. Aside from culvert structures, the only drainage improvement consists of a concrete-lined channel behind the North Hills Shopping Center in basin GV1. Areas around the Golden Valley interchange detain portions of the runoff from the Raleigh Heights area (RH1) south of the highway, but further studies should be performed to quantify the impacts of potentially large storm event runoff.

South Lemmon Drive

Lemmon Valley Drive begins at the Lemmon Valley interchange and proceeds north and around the east side of Lemmon Lake. The south portion of the roadway fronting the shopping center to the east is underlain by a 6 foot diameter corrugated metal pipe. This culvert conveys runoff from south of the interchange to the main natural channel at the outlet to basin GV3. From here, flow proceeds through basin LD2 in a natural channel to a box culvert beneath the northbound lanes.

At the box culvert, Lemmon Valley Drive becomes divided in the center by a large channel. Roadway overtopping occurs at the box culvert entrance, with excess runoff collecting in basin LD3. The ensuing channel remains in the center of roadway for about one mile, where another box culvert conveys the runoff to the west-side of the roadway. The west-side channel continues north for another mile, where it drains to Lemmon Lake.

A second large channel is situated on the east side of the roadway beginning near the end of the center channel. This channel receives lateral inflow from the Bernoulli (BER) and Patrician (PAT) Way basins. Flow travels north in the channel to the northern tip of basin PAT, where it is conveyed beneath Lemmon Drive and out to Lemmon Lake.

North Lemmon Valley

North Lemmon Valley is comprised of five large basins situated north and east of Lemmon Lake. The basins share the same rural characteristics and landscape as those in the Silver Knolls area mentioned earlier. With the exception of drainage improvements related to the subdivision in basin LV2, runoff reaches Lemmon Lake in natural ephemeral streams and channels. The eastern boundary of basin LV1 consists of a cutoff channel and earth berm designed to keep runoff away from entering the adjacent subdivision. The channel terminates at a small detention basin located at the southeast corner of the basin. Culvert and minor channel improvements were made through the subdivision to facilitate the delivery of runoff generated immediately north of the subdivision.

EXISTING CONDITIONS SUMMARY

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The Stead Master Plan hydrologic models include almost 100 separate sub-basins. In outlying areas, basins were kept large due to the lack of development. Within City of Reno boundaries, urban conditions became more dominant, and sub-basin size decreased. The following tables summarizes the hydrologic model peak flow rates and water surface elevations at key locations throughout the Lemmon Valley watershed:

TABLE 1
Stead Master Plan Existing Conditions Hydrologic Summary

Silver Lake Watershed

Location	100-year storm event	5-year storm event
CP GR3	960 cfs	175 cfs
Moya at Red Rock	1249 cfs	226 cfs
CP SS3	467 cfs	140 cfs
SS3 at 48" RCP	219 cfs	23 cfs
CP SL3B	155 cfs	40 cfs
CP GC3	234 cfs	59 cfs
CP AW3	205 cfs	28 cfs
CP SRS	197 cfs	5 cfs
Silver Lake Blvd at RR	80 cfs	35 cfs
CP RSD	281 cfs	62 cfs
CP GC1	463 cfs	86 cfs
CP GC2	769 cfs	138 cfs
CP ST1	270 cfs	53 cfs
DV ST2	614 cfs	109 cfs
CP LEA	738 cfs	126 cfs
Moya Detention Basin	4970.77 ft	4966.83 ft
CP SLK	9688 cfs	2397 cfs

Lemmon Lake Watershed

Location	100-year storm event	5-year storm event
CP ML3 (box inlet)	899 cfs	258 cfs
CP ML3 (box outlet)	1038 cfs	377 cfs
CP LD2	1418 cfs	231 cfs
CP PE4	884 cfs	127 cfs
CP ML1	1161 cfs	178 cfs
CP LLK	5435 cfs	1062 cfs

Lake Elevations

Location	100-year storm event	5-year storm event
Silver Lake	4965.01 ft.	4960.74 ft.
Lemmon Lake	4914.79 ft.	4913.14 ft.

PROPOSED CONDITIONS HYDROLOGIC MODEL

The Lemmon Valley watershed shares many of the same growth increases as those found in the Reno-Sparks area. The Airport Authority of Washoe County has a master plan in place for the Stead Airport that includes new roadway, infrastructure, and industry. Easy access to transportation corridors has spawned the growth of manufacturing and warehousing throughout the area. And the appeal of a rural atmosphere, coupled with the affordability and quality of life accompanying outlying residences, drives housing growth throughout the communities. These factors all point to continued growth in the Lemmon Valley Watershed.

The master plan hydrologic models prepared for the City of Reno are intended to provide a planning level view of the impacts of continued growth throughout the watershed. The models include revisions in several areas that will profoundly affect the existing drainage patterns. The first is the projected land use codes, which will increase the amount of impervious area and runoff in the watershed. The second is Peek's Project, which consists of channelization of flows between Military Road and Lemmon Drive. The golf course channel will be a series of culvert and channel improvements designed to alleviate flooding in the Stead area. Finally, a regional retention basin north of the airport has been incorporated to offset the increases in volume associated with continued growth in the area. Modifications to the existing conditions model are summarized in more detail under the specific improvement plans.

SPECIFIC IMPROVEMENT PLANS

Land Use Codes

The planning analysis was based on a collection of data from numerous sources, including the City of Reno and Washoe County, for approved development. Using the County's adopted land use plan as a base, data from various sources was collected and a new land use GIS based coverage was created. A determination of the potential for development was based on a statistical summary, which included the following data sources:

- Stead District Council Land Use Map dated November 1996
- City of Reno Zoning Map
- Reno-Stead Corridor Joint Plan approved August 1999
- North Valleys Land Use Map, updated October 1999
- Sky Vista Land Use Plan date May 27, 1999

The effects of future development facilitated the need for new runoff curve numbers to be calculated for use in the hydrologic modeling. Increased development comes at the expense of natural ground cover, which results in higher curve numbers, and hence, higher runoff amounts. Stantec revised all basin curve numbers for modeling within the Lemmon Valley watershed based upon projected land use.

Southwest Lemmon Valley Flood Channel Master Plan

The Southwest Lemmon Valley Flood Channel Master Plan was prepared by Schaaf & Wheeler / CFA Engineers. In December 1996, FEMA conditionally approved a hydrologic model of the Lemmon Lake watershed affected by the proposed development bounded by Military Road on the west, Lemmon Drive on the east, and Lemmon Lake to the north. The plan was revised in June 1998 and incorporated into the Stantec hydrologic models in its present form. Changes to existing models consisted of breaking up basins LD3 and ML2 into two basins each. Parameters for the two modified

basins (LD3, MK2) and the two new basins (LVL, NVD) were recalculated and incorporated into the models according to the procedures discussed under the hydrologic methodology section. In addition, Stantec used proposed culvert structures and channel improvements shown on the plans submitted to FEMA as they affected hydrograph routing and combining.

The proposed culvert structures and channel improvements will eliminate flooding problems at Military Road and Lemmon Drive for existing conditions storm events. In spite of different precipitation values, the runoff amounts calculated by Schaaf & Wheeler and Stantec compare favorably at both locations. However, proposed hydrologic modeling indicates the need for upstream detention for any proposed developments to mitigate 100-year peak flow rates.

Golf Course Channel

Drainage patterns for the golf course channel were previously discussed under the existing conditions section Golf Course Channel. Proposed plans for the channel include increasing the cross sectional area where necessary, providing protective lining, and modification of existing structures (See Figure 11C). A brief review of the preliminary design, beginning at North Virginia Street, follows:

Between concentration point AW3 at North Virginia Street and concentration point RSD at Silver Lake Boulevard, the channel reach will require protection from erosion caused by high flow velocities. Although the channel cross section capacity is adequate in this reach, refinements to the section shape should be included as part of the erosion protection.

Improvements are proposed for the storm drain system beginning at concentration point SI2. Flooding at the inlet will be eliminated by plugging and abandoning the 36" line falling east to Stead Boulevard, and by enlarging the pipe reach that outfalls to the rail ditch channel. By abandoning the 36" line, flow will be eliminated from entering the main Stead Boulevard trunk line. This will improve inlet conditions at the top end of the trunk, located just north of the Stead Interchange on the west side of the boulevard, and increase the available capacity of the trunkline. Enlarging the outfall to the rail ditch will relieve choking conditions in the system, thus alleviating flooding and maintenance problems at the 48" inlet.

At Silver Lake Boulevard, a new culvert structure is proposed to alleviate flooding. The intent is to provide a structure that will convey all channelized runoff from the south side of Silver Lake Boulevard to the north side, thereby eliminating overtopping of the roadway. A drop structure is proposed for the south side of Silver Lake Boulevard at the culvert crossing. Additionally, two large, high capacity combination inlets are proposed to be placed west of the channel in Silver Lake Boulevard. These structures will convey street flows from the west (basin SLE) to the rail ditch and prevent flooding of the roadway and the subsequent introduction of flow onto Stead Boulevard.

The channel reach through basin GC1 has problematic erosion north of Silver Lake Boulevard, but is otherwise intact and able to convey the proposed flows. Improvements to the section shape and erosion control will be required for the upper reach at the proposed Silver Lake culvert outlet. The middle and lower reaches will require minor improvements to the section shape, unless the Sierra Sage golf course is amenable to overbank flow on the west side of the channel. Soils tests should be performed for these reaches, since the flow velocities would be permissible for a non-erosive soil. The 36" corrugated metal pipe beneath the railroad spur should be plugged and abandoned.

The channel reach through the southern portion of basin GC2 does not have the capacity to convey the proposed flows without overtopping the railroad tracks and discharging onto JC Penney property. A larger channel section is proposed for the reach, along with soils testing to determine whether or not channel protection is required.

Modeling of the energy dissipation structure west of JC Penney indicates the structure is not adequate to convey the proposed runoff. The existing structure was designed and constructed to contain a maximum flow of approximately 420 cfs. Widening of the structure will be required to contain the proposed conditions 100-year flow of approximately 1000 cfs.

The remaining reach along the northern boundary of basin GC2 will require capacity and lining improvements west to the terminus at Moya Boulevard. The existing culverts at Moya Boulevard do not have capacity to deliver storm runoff to Silver Lake without flooding the roadway, therefore new reinforced box culverts will be required.

A portion of the proposed channel improvements run adjacent to Union Pacific Rail Road property. If improvements impact railroad right of way, it will be necessary to coordinate with the UPRR for final design of improvements.

Donnelley Channel

The Donnelley channel is the main conduit for flow concentrations between the intersection of Stead and Lear Boulevards and the Moya detention basin. Under proposed conditions, flows entering the channel during the 100-year storm event are reduced by over 100 cfs due to the diversion of flows at Silver Lake Boulevard. The channel will be improved to convey the 100-year storm flows to the Moya detention basin. Both existing and proposed master plan hydrologic modeling does not account for backwater effects at the access roads to the property. Therefore, a more detailed hydraulic analysis should be performed for this site during the development of any preliminary engineering drawings. Furthermore, provisions should made to accommodate overflow at the northwest corner of Stead and Lear Boulevards during storm events greater than 5-years.

Proposed improvements for the Donnelley channel include upgrading of all culvert structures under all channel crossings and increased channel capacity (See Figure 11D). The Donnelley channel is extremely flat at the upper end and additional culverts under the two main access roads will be extremely large. An alternative solution to this problem would be to construct bridges over the two entrances along Lear Blvd.

Regional Retention Basin

The City of Reno has expressed interest in a regional retention basin to control future volume increases at Silver Lake, rather than small, individual detention basins scattered throughout the watershed. Proposed hydrologic models for the 100-year storm event indicate a volume increase of approximately 250 acre-feet for the Silver Lake watershed. After consultations with the City of Reno and the Airport Authority, Stantec proposes that a 250 acre-feet retention basin be located at the north end of the Stead Airport. After a site has been selected, a sediment analysis should be performed in conjunction with the final design. It should be noted that the Silver Lake water surface elevation increases only 2-tenths of a foot, based on planned future conditions. FEMA allows a 1-foot increase in water surface elevation due to development impacting a Special Flood Hazard Area (SFHA). The 2-tenths increase may not warrant the construction of a regional retention basin at this time. Future proposed improvements for the airport were not included in this analysis, and could create a greater need for a regional retention basin.

Moya Boulevard at Red Rock Road

Stantec

Improvements to Moya Blvd at Red Rock Road include upsizing culverts under Red Rock Road and Moya Boulevard and widening of the channel between them (See Figure 11A). Additionally it will be

necessary to construct an outlet channel to Silver Lake or the City of Reno may elect to require future development downstream of Moya Boulevard to perpetuate these flows to Silver Lake.

Moya Boulevard Culverts

Existing conditions hydrologic modeling indicates that flooding will occur at virtually every culvert structure along Moya Boulevard. At the box structures immediately east of Red Rock Road, and the outlet of the Silver Shores development at Silver Shores Drive, hydrologic studies have already been approved, resulting in fixed drainage design improvements. Even though proposed hydrologic modeling proves these structures to be inadequate, they are at least designed for 100-year storm events, albeit under different criteria. For this reason, these locations are candidates for improvement, but are deemed low priorities compared to the remaining crossings along Moya Boulevard.

The remaining culverts requiring improvement along Moya are the 48" at basin SS3, the drop structure and culverts at concentration point GC3, and the culverts at concentration point GC2 (See Figure 11B). All do not have the capacity to convey runoff from the 100-year storm event without causing flooding of the roadway. The most pressing location at present is concentration point GC2, due to large amounts of sediment accumulating at the inlet, limited culvert capacity, and minimal upstream considerations associated with structure selection. Culvert improvements for Moya Boulevard at concentration point GC2 are discussed within the Golf Course Channel Improvements section. Next is concentration point GC3, selected because it receives large volumes of runoff. Improvements to this area include channelization of flows, drop structures to reduce steep slopes and reinforced box culverts under Moya Boulevard. Finally, the 48" reinforced concrete pipe on the east side of Silver Shores basin 3 requires capacity improvements to eliminate roadway flooding, but has been deemed a very low priority.

Stead Boulevard Storm Drain System

Stantec Consulting has recently completed construction drawings for storm drain improvements in Stead Boulevard as part of a Regional Transportation Commission (RTC) of Washoe County reconstruction/rehabilitation project. The initial concept was to collect the 5 year storm flows in the storm drain system. However, the low point at Lear Boulevard is the controlling factor, limiting flows in the storm drain system to an approximate 2 year return frequency prior to exceeding the capacity of the system. Projected costs to this system exceeded 1 million dollars. Therefor, it was concluded with the City of Reno, that only storm drainage improvements related to completing curb and gutter sections, upgrading catch basins, and eliminating the one open ditch section on Stead Boulevard (north of Silver Lake Boulevard) would be incorporated in to the RTC plans.

Moya Detention Basin

Outlet and storage capacity for the Moya detention basin should be increased to alleviate roadway flooding during 100-year storm events. Preliminary studies indicate that placing additional outlet culverts will reduce the water surface enough to prevent flooding on Moya Boulevard. Increasing the detention basin storage volume should also be included in any future design improvements.

Airport Master Plan

Stantec

Means to convey storm runoff through the Stead Airport will have to be adopted as part of the airport master plan. Approximately 70% of the total storm runoff contributing to Silver Lake is conveyed through the property. The Airport Authority has conducted a preliminary channel design study, but their board of authority has not adopted it. For this reason, the plan was not incorporated into the

proposed conditions master plan models. However, storm drainage including retention/detention will need to be considered as part of the airport master plan in order to not adversely impact the elevation of Silver Lake.

PROPOSED CONDITIONS SUMMARY

The major difference between the existing conditions hydrologic models and the proposed models is the use of higher runoff curve numbers. The higher numbers are the direct result of projected development within the overall watershed. Other changes within the models include proposed channelization and improvements west of Stead Boulevard, and in the Military Road/Lemmon Drive area, as well as a regional retention basin north of the airport. The following table summarizes the hydrologic model peak flow rates and water surface elevations at key locations throughout the Lemmon Valley watershed:

TABLE 2
Stead Master Plan Proposed Conditions Hydrologic Summary

Silver Lake Watershed

Location	100-year storm event	5-year storm event
CP GR3	1039 cfs	220 cfs
Moya at Red Rock	1324 cfs	284 cfs
SS3 at 48" RCP	229 cfs	30 cfs
CP SS3	482 cfs	148 cfs
CP SL3	266 cfs	56 cfs
CP GC3	422 cfs	110 cfs
CP AW3	230 cfs	64 cfs
CP SRS	272 cfs	51 cfs
Silver Lake Blvd at RR	0 cfs	0 cfs
CP RSD	462 cfs	148 cfs
CP GC1	937 cfs	248 cfs
CP GC2	1270 cfs	307 cfs
CP ST1	105 cfs	29 cfs
DV ST2	470 cfs	98 cfs
CP LEA	568 cfs	93 cfs
Moya Detention Basin	4970.52 ft	4966.80 ft
CP SLK	10013 cfs	2140 cfs

Lemmon Lake Watershed

Location	100-year storm event	5-year storm event
CP ML3 (box inlet)	1021 cfs	262 cfs
CP ML3 (box outlet)	1021 cfs	262 cfs
CP LD2	1795 cfs	369 cfs
CP PE4	1062 cfs	211 cfs
CP ML1	1492 cfs	336 cfs
CP LLK	6514 cfs	1542 cfs

Lake Elevations

Location	100-year storm event	5-year storm event
Silver Lake *	4965.24 ft.	4960.93 ft.
Lemmon Lake	4915.12 ft.	4913.35 ft.

* Assumes no regional retention basin

Under proposed conditions and no retention basin, Silver Lake is projected to rise 0.23 feet in elevation as a result of 256 acre-feet of additional runoff during a 100-year storm event. Lemmon Lake is estimated to rise 0.32 feet during the 100-year storm event, from a projected volume increase of 319 acre-feet. No retention basin was modeled for Lemmon Lake.

MAPPING

All mapping included in this report was provided through Stantec's GIS Department. Following is a list of maps included in this report with a brief description:

- Figure 1 is a Vicinity Map of the study area.
- Figure 2 is the Effective FEMA FIRM Map for the area.
- Figure 3 is a 1:24000 USGS Quad Map with existing conditions watershed boundaries.
- Figure 4 shows a close up of the Stead area at 1"=600' with existing conditions watershed boundaries.
- Figure 5 is a 1:24000 USGS Quad Map with proposed conditions watershed boundaries.
- Figure 6 shows a close up of the Stead area at 1"=600' with proposed conditions watershed boundaries and highlighted proposed improvement areas.
- Figures 7a-7c are the National Weather Service's Precipitation Frequency Study of the United States, NOAA Atlas 14, Volume 1 – Semi-Arid Southwest United States (SSPFS, 1997) isopluvials for the 2-year, 1-hour, 6-hour, and 24-hour storm events. These maps show existing and proposed watershed boundaries and their associated centroids.
- Figure 8 is a Soils Map created in GIS using the SCS Soil Survey of Washoe County, Nevada, South Part coverage. Proposed conditions watershed boundaries are also shown.
- Figure 9 presents the existing conditions Washoe County Assessed Land Use and existing conditions watershed boundaries.
- Figure 10 is a compilation of the City of Reno and Washoe County proposed conditions land use with proposed conditions watershed boundaries.
- Figures 11a – 11e are close up maps, at various scales, of proposed improvement areas.

COST ANALYSIS

METHODOLOGY

An opinion of probable construction costs for proposed improvements was compiled for this report to give the City of Reno a basis to prioritize and budget for capital improvements necessary to reduce or eliminate major flooding areas within the Stead Area. Table 3 below itemizes costs of improvements by location. Backup calculations for proposed opinions of probable costs can be seen in Appendix 3: Volume 4 of 4.

All proposed improvements are preliminary and were evaluated for the preliminary opinion of probable construction costs only. Detailed hydrologic and hydraulic analyses will be required before final design of improvements. Phasing of improvements will be very important to the overall drainage system within the urbanized portion of the Lemmon Valley watershed. Construction of some improvements may necessitate the construction of other improvements in order to not increase flooding.

Preliminary opinions of probable cost include provisions for right of way acquisition, engineering design fees, surveying fees, and construction services fees.

SPECIFIC IMPROVEMENTS

RTC Stead Boulevard Storm Drain

Storm drainage improvements related to completing curb and gutter sections, upgrading catch basins, and eliminating the one open ditch section on Stead Boulevard (north of Silver Lake Boulevard) have been incorporated in to a RTC roadway project. The RTC project is scheduled for construction in May 2000 with completion in September 2000. Costs associated with these improvements are not included in the cost analysis.

Golf Course Channel

Although erosion protection and minor shaping of the channel may be all that is required to convey flow in the upper and middle sections of the golf course channel, it was assumed for the quantities and cost estimate that an entirely new channel would be excavated. This assumption allows for variations in proposed channel alignment and design. It was also assumed that the natural soils were erosive and that erosion protection measures would be required.

Channel improvements include excavation of a new channel, erosion protection, drop structures to reduce channel slope, and a berm along the rail behind JC Penney's. Widening of the energy dissipation structure and upgraded box culverts at Moya Boulevard and Silver Lake Drive will be required as well as combination inlet structures in Silver Lake Drive. Utility relocation may be required for the Moya Boulevard and Silver Lake Drive improvements.

Donnelley Channel

Donnelley Channel improvements include widening of the entire length of channel and upgrading of all structures crossing the channel. Double 24' x 4' Reinforced Concrete MEGA Box culverts have been proposed for the crossings and a berm will be required for the south side of the channel along Lear Boulevard. Revegetation of excavated areas will also be required for all disturbed ground.

Moya Detention Basin

Moya detention basin improvements include placement of an additional 30" RCP at the south basin outlet and an additional 36" RCP at the north outlet. It was assumed that existing right of way could be utilized for the improvements.

Red Rock Road at Moya Boulevard

Improvements for Red Rock Road at Moya Boulevard include placement of an additional 12' x 4' RCB culvert under Red Rock Road, placement of a double 8' x 4' RCB and a single 4' x 4' RCB under Moya Boulevard and widening of the grouted rip rap channel between the two. Downstream of the Moya Boulevard improvements a designed channel will be required to convey flows to Silver Lake. The downstream channel improvements have been estimated as a separate cost in order to enable the City of Reno to consider future development to provide these improvements.

Other Moya Boulevard Culverts

Improvements to Moya Boulevard near concentration point CP GC3 include a new triple-6' x 4' RCB, channel grading and protection upstream of the culverts including drop structures, and channel grading downstream of the culverts to Silver Lake. A drop inlet/stilling basin will be required at the upstream side of the proposed culverts.

OPINION OF PROBABLE CONSTRUCTION COSTS NOT INCLUDED IN MASTER PLAN

Construction costs were not included in the master plan for the following potential improvements:

- Regional Retention Basin: Due to the small increase in water surface elevation, 0.2± from existing to proposed conditions, a regional retention basin may not be warranted at this time. However, future development of the airport property could create a greater need for a regional retention basin. The proposed conditions hydrology model includes any proposed land uses contained in the City or Reno or Washoe County Master Land Use Plans. Currently, the airport does not have an adopted storm drainage master plan and therefore, no improvements were included in the proposed conditions model nor was an opinion of probable construction cost prepared for an airport channelization or on site detention.

- Southwest Lemmon Valley Flood Control: Conceptual level construction cost estimates were performed by CFA and can be reviewed in the Southwest Lemmon Valley Flood Channel Master Plan report. This report was jointly prepared by CFA, Inc. and Schaaf and Wheeler for review by the City of Reno, Washoe County and the Regional Transportation Commission in June 1998.

PHASING

Phasing of the proposed improvements will be very important to the overall drainage system within the urbanized portion of the Lemmon Valley watershed. Construction of some improvements may necessitate the construction of other improvements in order to not increase flooding.

The following table illustrates the summary of proposed improvements, the associated opinion of probable costs and the order of importance to alleviate flooding problems:

TABLE 3
Stead Master Plan Opinion of Probable Construction Cost Summary

Location	Level of Importance	Probable Cost
Golf Course Channel Improvements	1	$3,615,850
Moya Boulevard at Red Rock Road Improvements	2	$419,291
Moya Boulevard at Red Rock Road Downstream	2	$644,125
Moya Detention Basin Improvements	2	$162,081
Other Moya Boulevard Culvert Improvements	2	$635,358
Donnelley Channel Improvements	3	$2,131,768
Total		$7,608,473

In summary, this opinion of probable construction costs for proposed improvements was compiled to provide the City of Reno a basis to prioritize and budget for capital improvements necessary to reduce or eliminate major flooding areas within Lemmon Valley. Preliminary and final engineering services will be required to develop construction drawings and refine the opinion of probable construction costs. Preliminary opinions of probable cost include provisions for right of way acquisition, engineering design fees, surveying fees, and construction services fees. The golf course channel should be constructed first and the Donnelley Channel improvements should be constructed last due to the high cost of construction involved coupled with the low benefits. Improvements to Red Rock Road at Moya Boulevard, Other Moya Boulevard culvert improvements, and Moya Detention Basin improvements have no particular order in which they should be constructed. Construction of these improvements will be based on availability of funds.

CONCLUSION

This report and associated models identify existing hydrologic drainage patterns in the Lemmon Valley basin, and quantify amounts of storm runoff at specific locations. Results of the analysis provide identification of present condition flooding and problem areas within the region, so that capital flood improvements may be scheduled and undertaken. Projected hydrologic models have been prepared with the intent to provide a strong foundation for planning and future development in the area. The following actions are recommended:

- Adopt and enforce this master plan.
- Implement the phased improvements as recommended above.
- Review proposed developments for compliance with the master plan
- Require proposed developments to update the master plan for their specific development and show compliance with the master plan.
- Coordinate with Washoe County to develop threshold criteria for the implementation of a Regional Retention Basin.
- Coordinate with the Airport Authority on the development of an airport storm drainage master plan.
- Coordinate the implementation of the Southwest Lemmon Valley Flood Control projects.

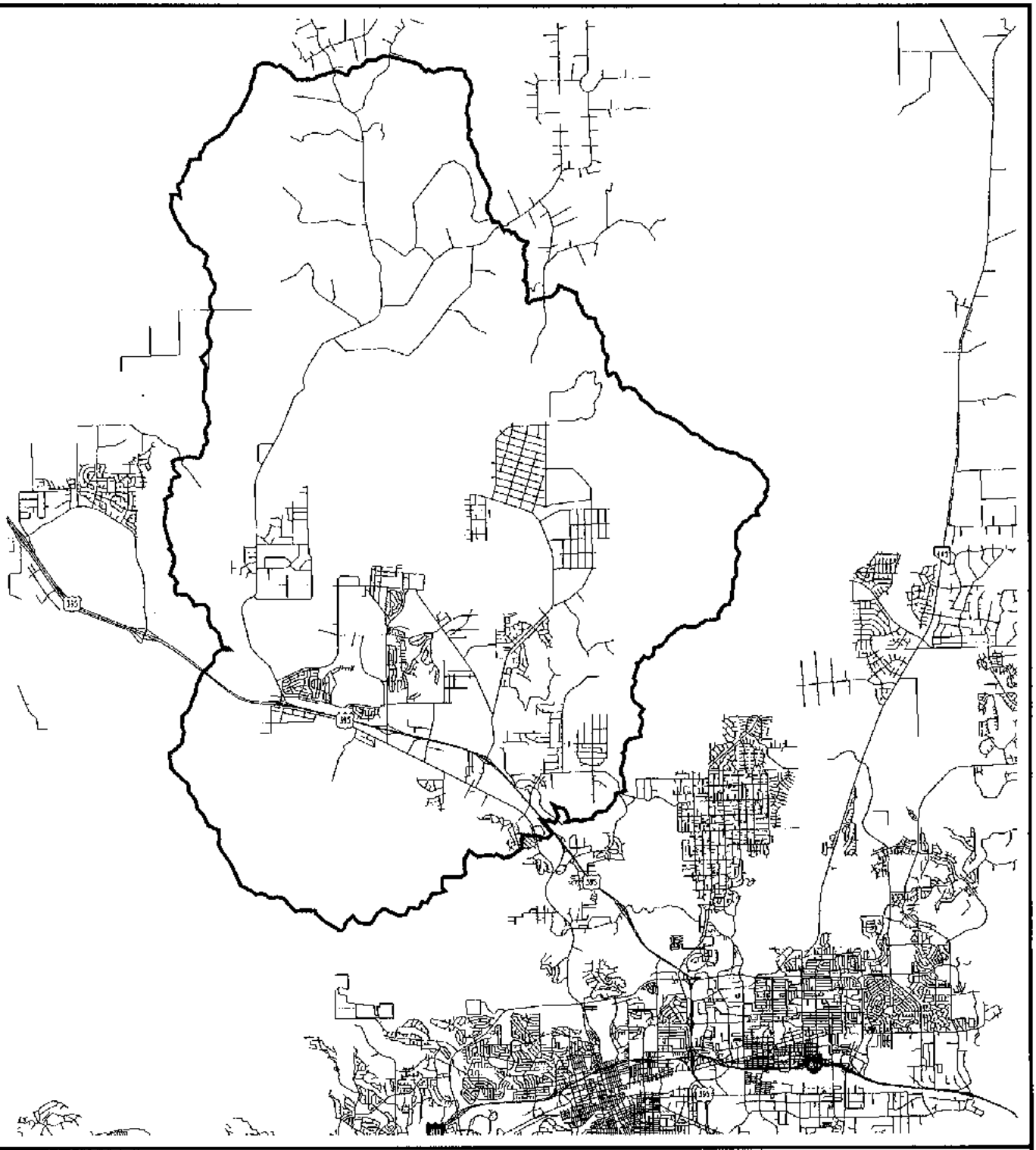
It should be noted that retention will eventually be required to reduce Silver Lake to is present day elevation. The elevation developed for this report is not in accordance with the FEMA FIRM elevation. The estimated water surface elevation for Lemmon Lake, which is influenced by areas located outside of the city's corporate boundary, is below the FEMA FIRM elevation.

The largest discrepancy between previous hydrologic models and this master plan is the precipitation and frequency parameters. Conservative runoff CN's for the Silver Lake watershed were based upon extensive field investigation of recently burned areas.

This plan was prepared solely for the City of Reno, and is not intended for review by the Federal Emergency Management Agency (FEMA) for use in obtaining a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR).

FIGURES

1. Vicinity Map
2. Effective FEMA FIRM map
3. Existing Conditions Hydrology 1:24000 USGS Quad Map
4. Existing Conditions Hydrology 2-foot Contour Map
5. Proposed Conditions Hydrology 1:24000 USGS Quad Map
6. Proposed Conditions Hydrology 2-foot Contour Map
7. NOAA 14 Precipitation Maps
    a. 2-Year, 1-Hour Storm Event Isopluvial Map
    b. 2-Year, 6-Hour Storm Event Isopluvial Map
    c. 2-Year, 24-Hour Storm Event Isopluvial Map
8. Soils Map
9. Existing Conditions Washoe County Assessed Land Use Map
10. Proposed Conditions City and County Land Use Map
11. Proposed Improvement Areas
    a. Moya Boulevard at Red Rock Improvements
    b. Other Moya Boulevard Culvert Improvements
    c. Golf Course Channel Improvements
    d. Donnelley Channel Improvements
    e. Moya Detention Basin Improvements



City of Reno
Stead Drainage Master Plan
Vicinity Map

Hydrographic Basin Boundary

Scale: 1" = 12000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 1

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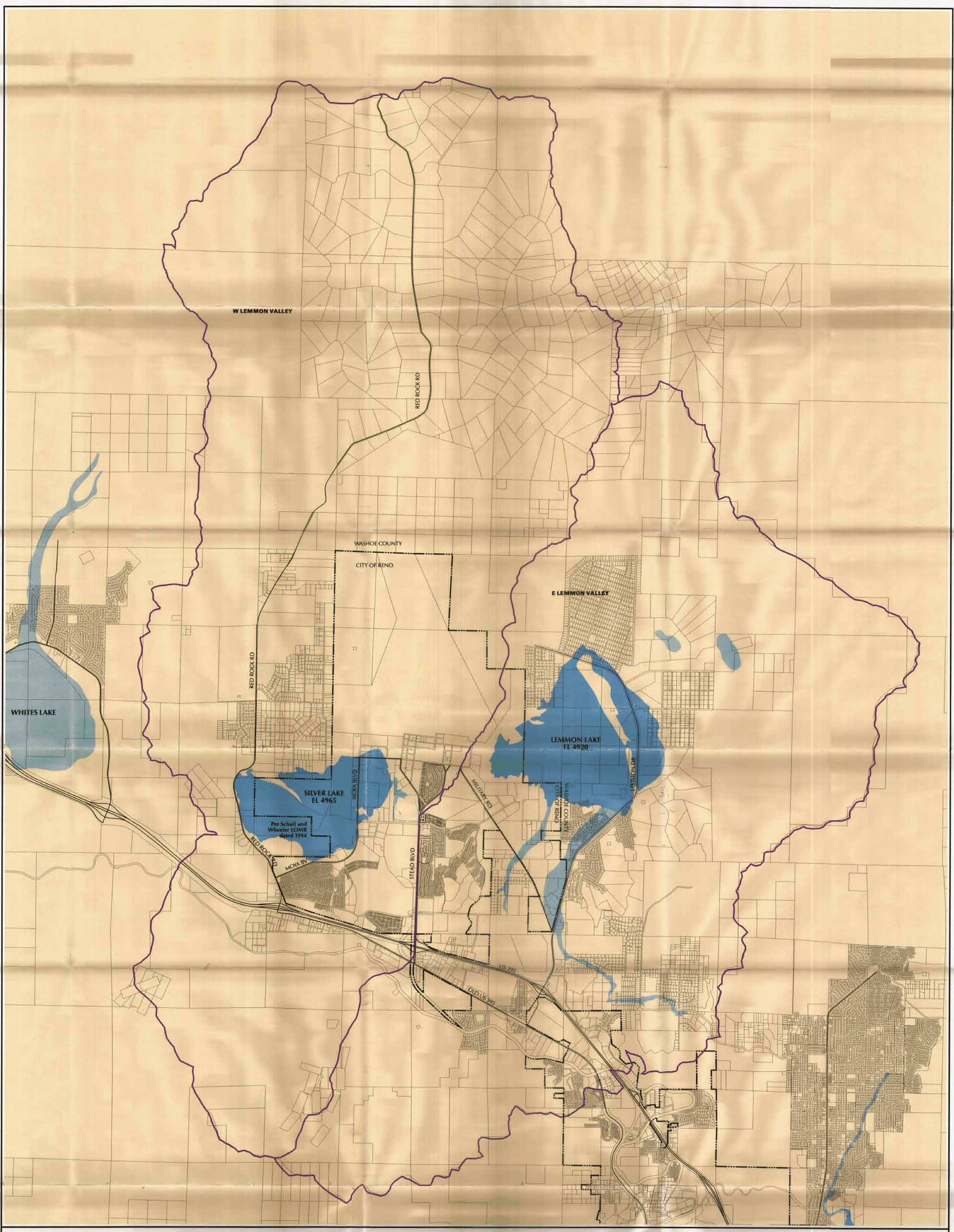
Stantec



City of Reno

Stead Drainage Master Plan

Effective FEMA F.I.R.M. Map

- Zone A
- Zone AE
- Zone AO
- Zone AH
- Zone X (Shaded)
- Zone X
- Watershed Boundary
- Corporate Boundary

N W E S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 2

Stantec Consulting Inc.
950 Industrial Way
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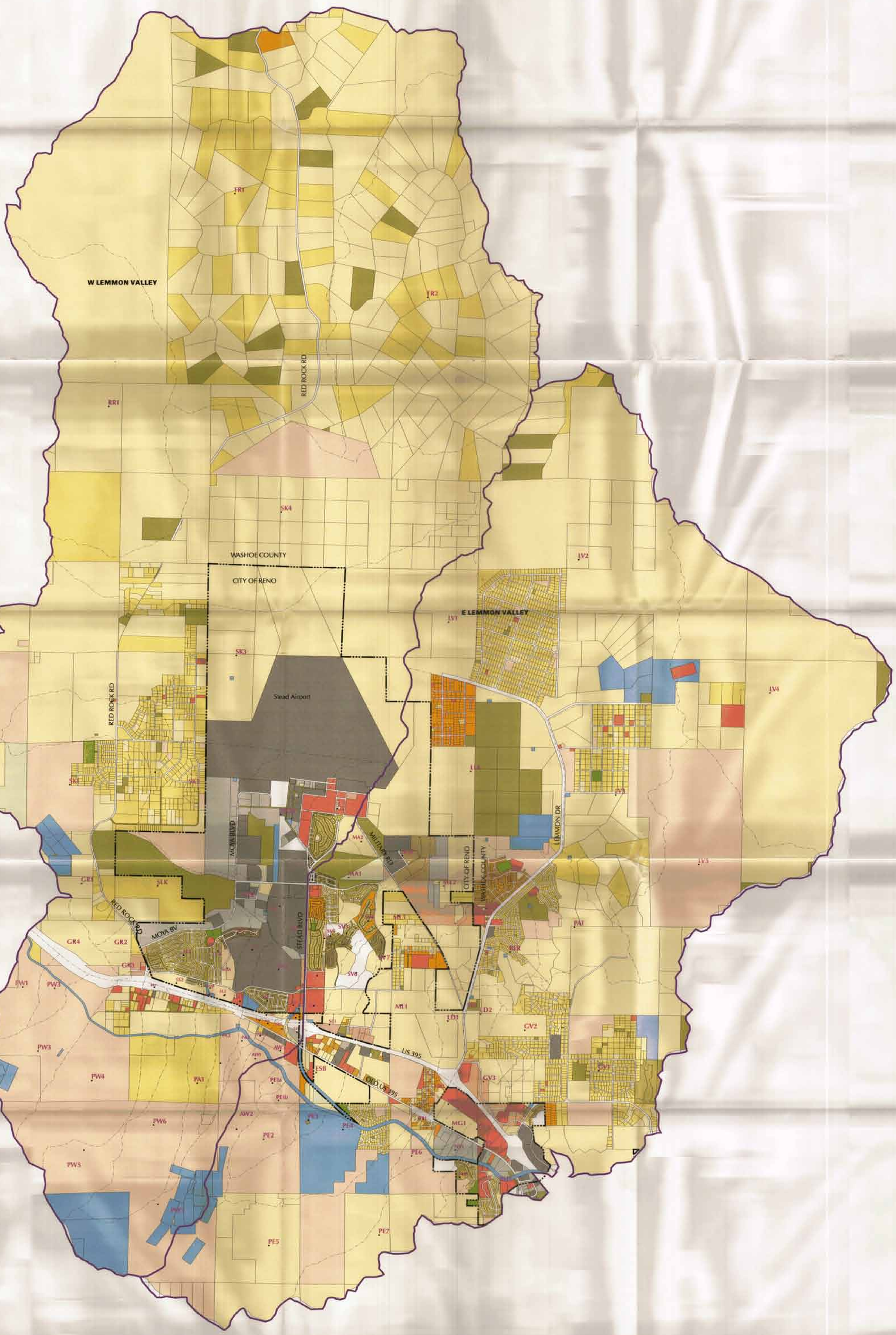

City of Reno

Stead Drainage Master Plan

Existing Conditions
Washoe County Assessed Land Use Map

- Vacant-Other or Unknown
- Vacant-Under Development
- Vacant-Single Family
- Vacant-Multi Residential
- Vacant-Commercial
- Vacant-Industrial
- Single Family
- Multi-Residential
- Commercial
- Industrial
- Rural
- Utilities
- Other / Minor Imp
- Public Parks
- Watershed Boundary
- Corporate Boundary
- Sub-basin Boundary
- PE2 Sub-basin Identifier

N W E S

Scale: 1" = 2000'

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Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 9

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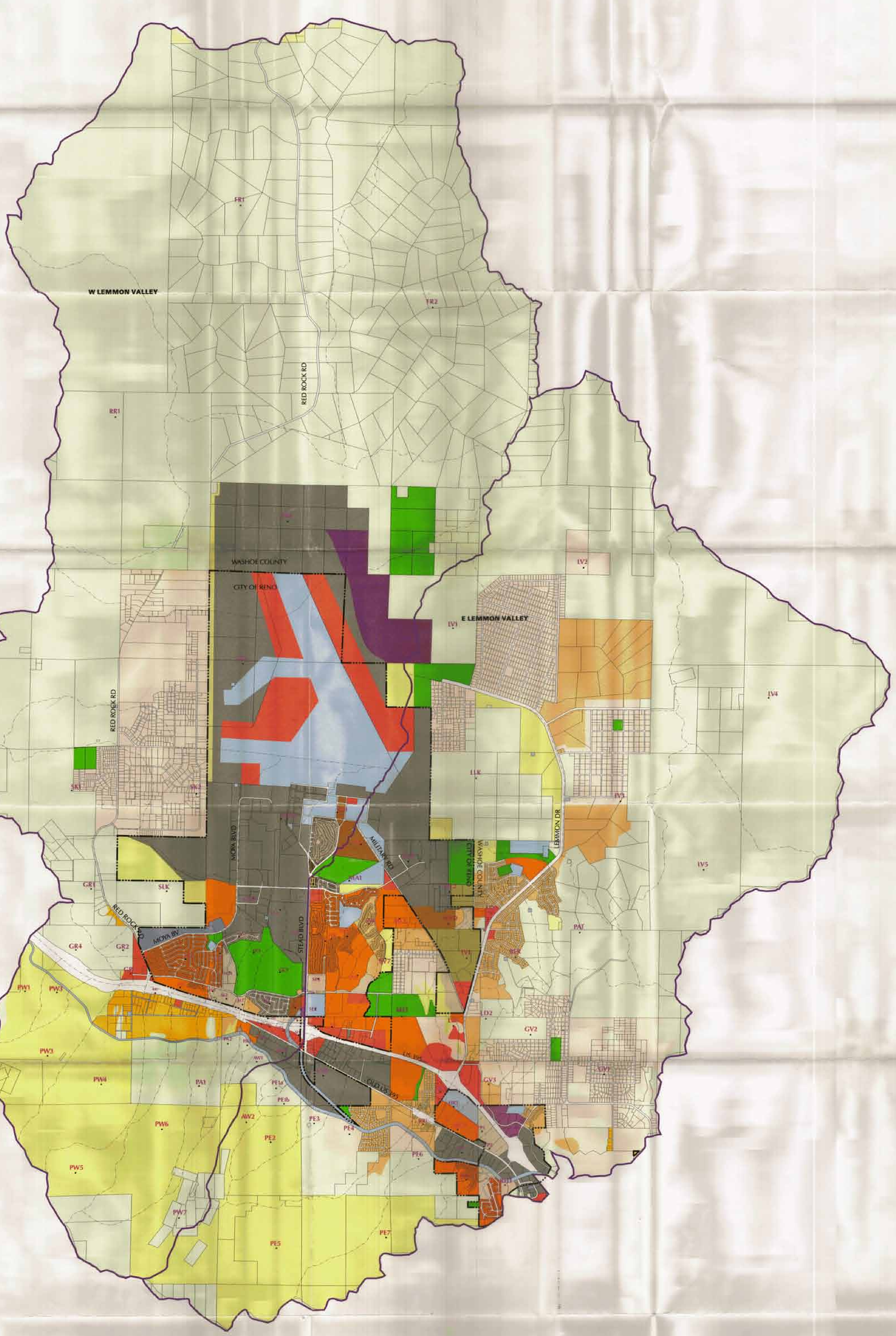

City of Reno

Stead Drainage Master Plan

Proposed Conditions
City and County Land Use Map

N
W E
S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

- Low Density Rural
- Medium Density Rural
- High Density Rural / LLR-2.5
- Low Density Suburban / LLR-1
- Medium Density Suburban / SFR-15
- High Density Surburban / SFR-6
- Low Density Urban / SFR-4 / MF-14
- Medium Density Urban / MF-21
- High Density Urban / MF-43
- General Commercial
- Neighborhood Commercial/Office
- Tourist Commercial
- Industrial
- Public and Semi-Public
- Parks and Recreation
- Open Space
- Special Plan Area
- General Rural
- Watershed Boundary
- Corporate Boundary
- Sub-basin Boundary
- PE2 Sub-basin Identifier

Figure 10

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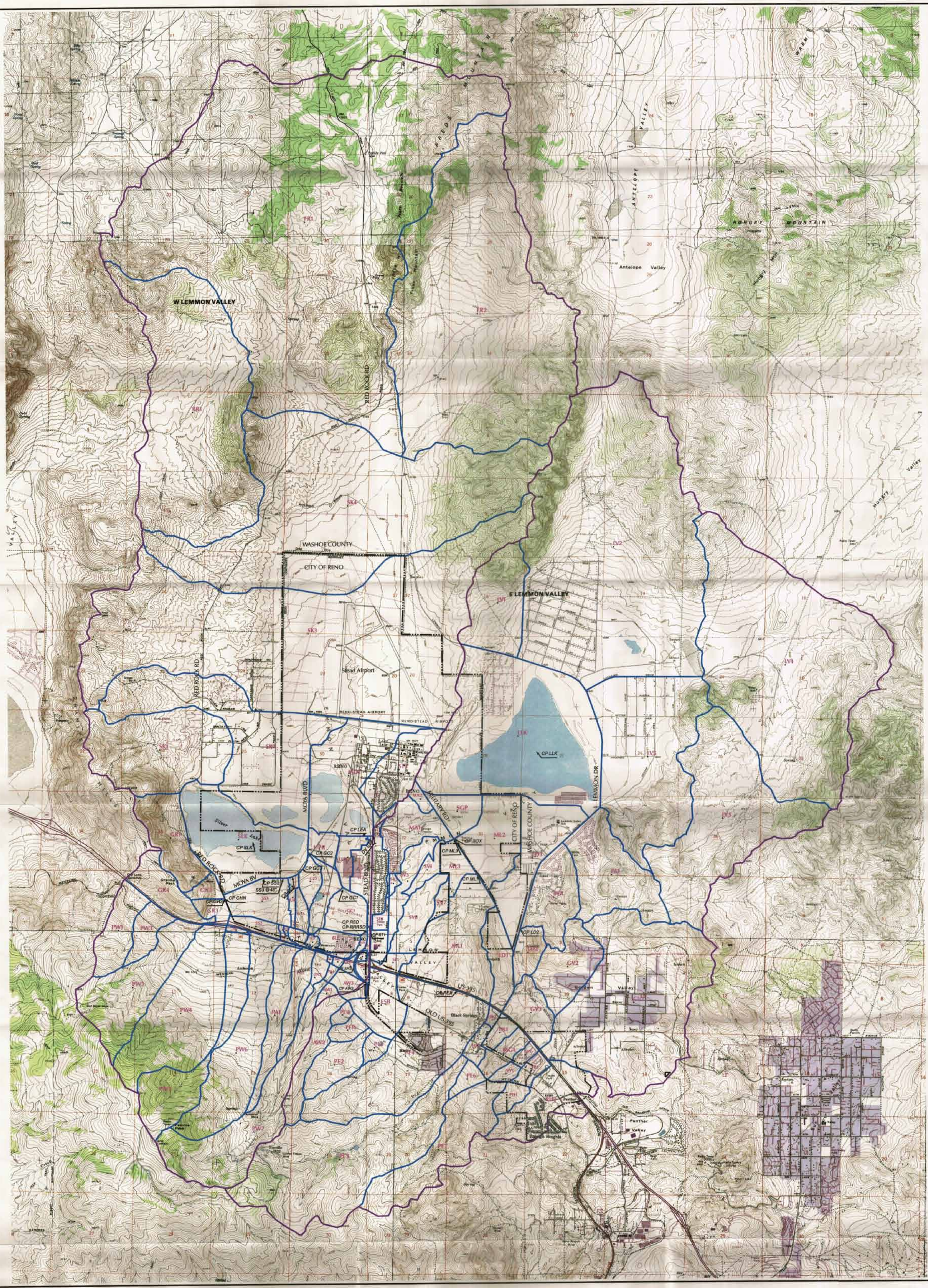

City of Reno

Stead Drainage Master Plan

Existing Conditions Hydrology
1:24,000 USGS Quad Map

- Watershed Boundary
- Corporate Boundary
- Sub-basin Boundary
- PE2 Sub-basin Identifier
- CP LLK Concentration Point

N
W E
S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 3

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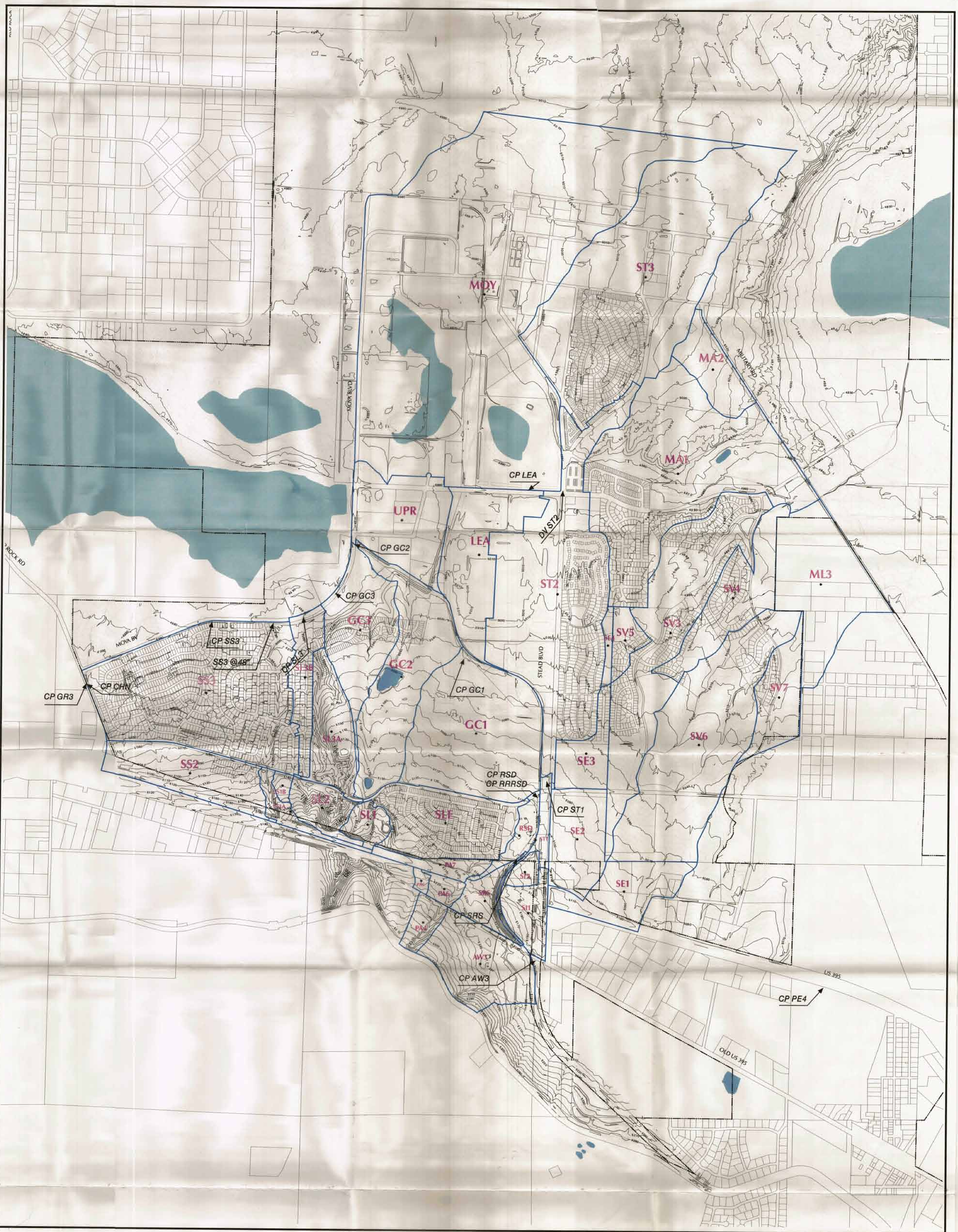


City of Reno

Stead Drainage Master Plan

Existing Conditions Hydrology
2 ft. Contour Map

Playas & Ponds
Water Bodies
Corporate Boundary
CP LLK Concentration Point
Sub-basin Boundary
PE2 Sub-basin Identifier

N
W E
S

Scale: 1" = 600'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 4

Stantec Consulting Inc.
950 Industrial Way
Sparks, Nevada 89431 USA
Tel: (775) 358-6931 Fax: (775) 358-6954 www.stantec.com

City of Reno

Stead Drainage Master Plan

Proposed Conditions Hydrology
1:24,000 USGS Quad Map

Watershed Boundary
Corporate Boundary
Sub-basin Boundary
PE2 Sub-basin Identifier
CP LLK Concentration Point

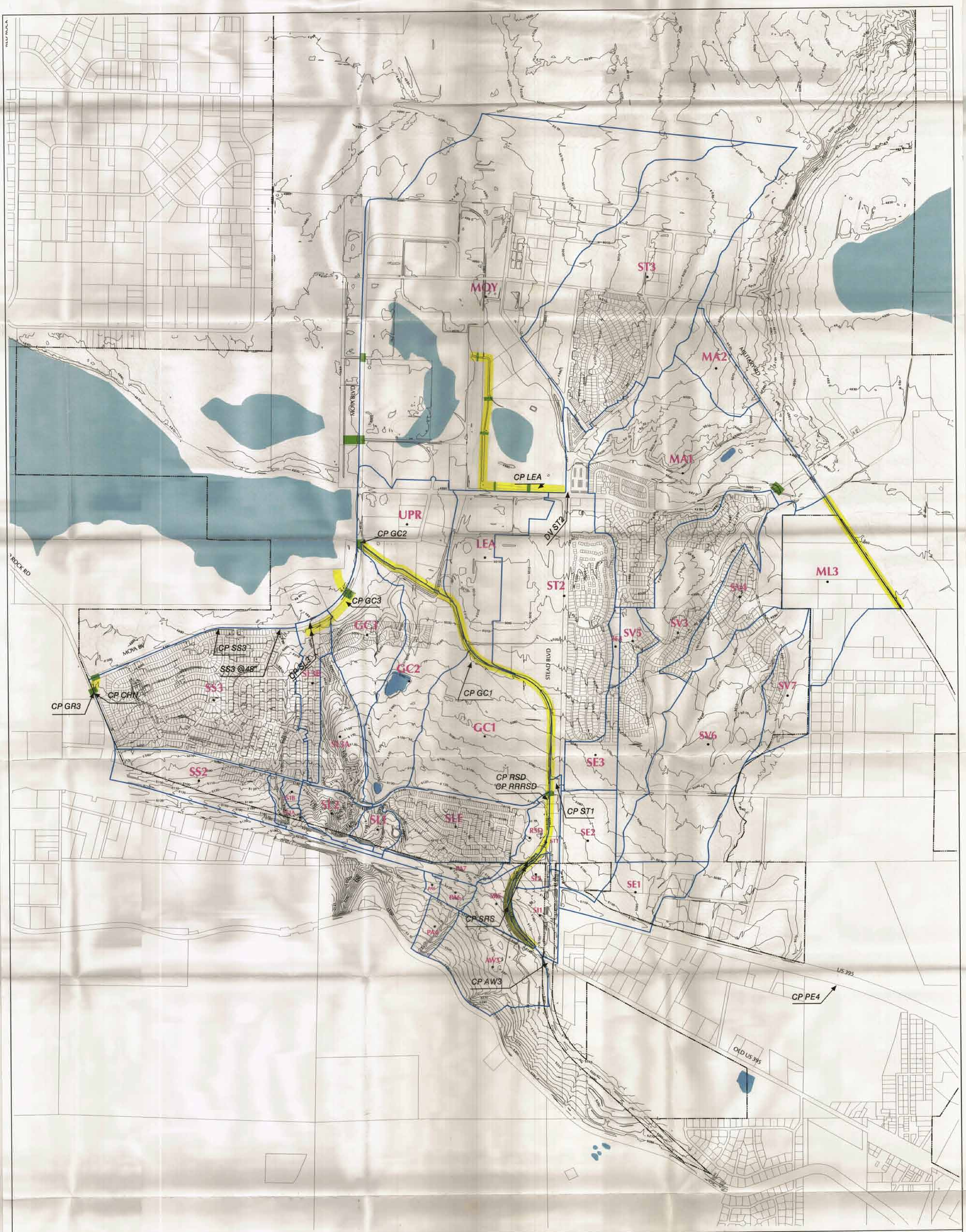
N
W E
S

Scale: 1" = 4000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 5

Stantec Consulting Inc.
950 Industrial Way
Sparks, Nevada 89431 USA
Tel: (775) 358-6931 Fax: (775) 358-6954 www.stantec.com



City of Reno

Stead Drainage Master Plan

Proposed Conditions Hydrology
2 ft. Contour Map

- Playas & Ponds
- Water Bodies
- Corporate Boundary
- CP LLK Concentration Point
- Proposed Channel
- Sub-basin Boundary
- PE2 Sub-basin Identifier
- Proposed Culvert

N W E S

Scale: 1" = 600'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 6

Stantec Consulting Inc.
950 Industrial Way
Sparks, Nevada 89431 USA
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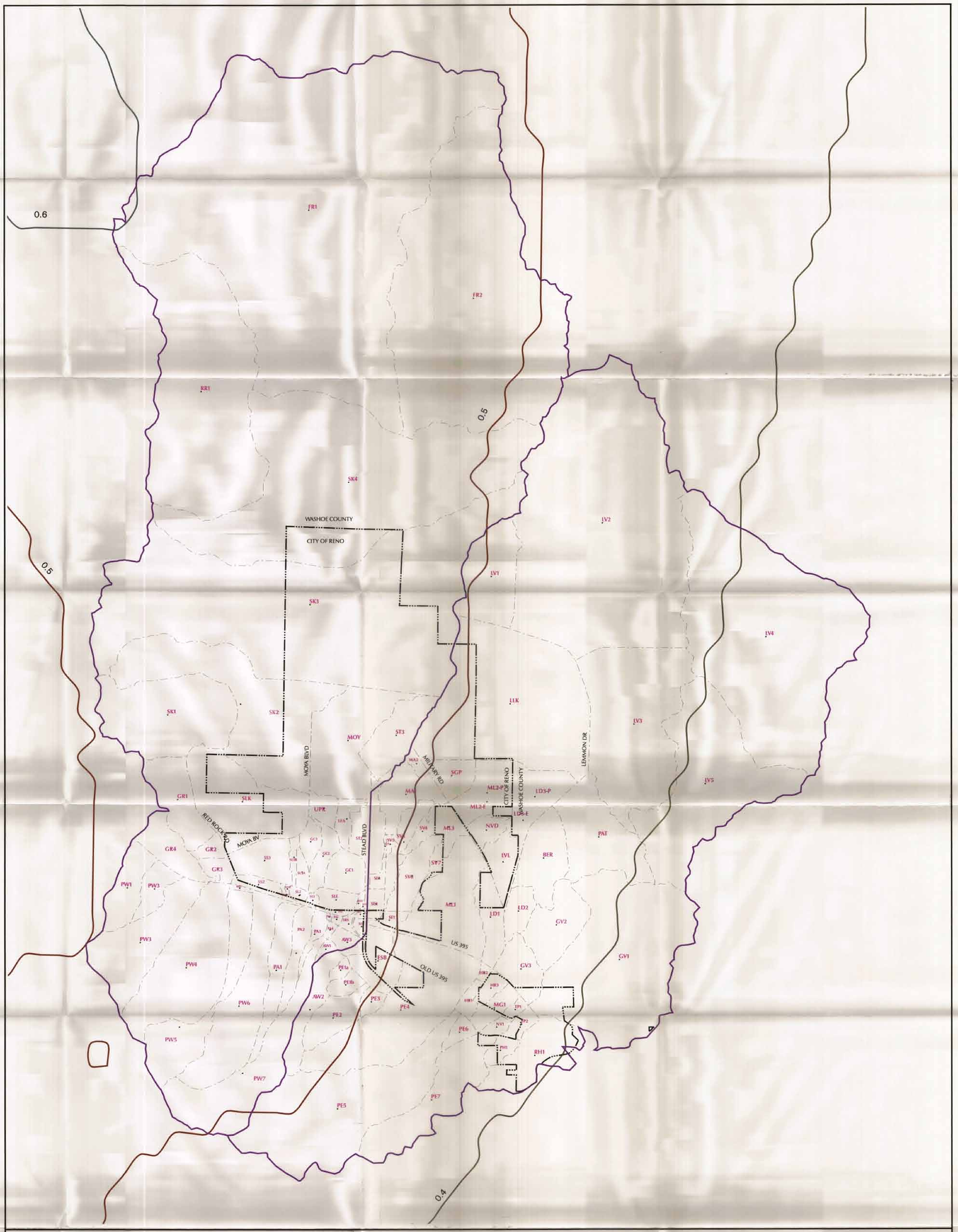

City of Reno

Stead Drainage Master Plan

Precipitation Frequency Study of the United States NOAA 14,
Vol. 1 - Semi Arid Southwest United States
Two-Year 1-Hour Event Isopluvial Map

0.3	0.6	0.9	Watershed Boundary
0.4	0.7	1.0	Corporate Boundary
0.5	0.8		Sub-basin Boundary
			PE2 Sub-basin Identifier

N W E S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 7a

Stantec Consulting Inc.
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City of Reno

Stead Drainage Master Plan

Precipitation Frequency Study of the United States NOAA 14,
Vol. 1 - Semi Arid Southwest United States
Two-Year 6-Hour Event Isopluvial Map

N
W E
S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

0.5	0.8	1.1	1.4	1.7	2.0	Watershed Boundary
0.6	0.9	1.2	1.5	1.8	2.1	Corporate Boundary
0.7	1.0	1.3	1.6	1.9	2.2	Sub-basin Boundary
						PE2 Sub-basin Identifier

Figure 7b

Stantec Consulting Inc.
950 Industrial Way
Sparks, Nevada 89431 USA
Tel: (775) 358-6931 Fax: (775) 358-6954 www.stantec.com

City of Reno

Stead Drainage Master Plan

Precipitation Frequency Study of the United States NOAA 14,
Vol. 1 - Semi Arid Southwest United States
Two-Year 24-Hour Event Isopluvial Map

0.9	1.5	2.1	2.7	3.3	Watershed Boundary
1.1	1.7	2.3	2.9	3.5	Corporate Boundary
1.3	1.9	2.5	3.1	3.7	Sub-basin Boundary
				3.9	PE2 Sub-basin Identifier

N W E S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 7c

Stantec Consulting Inc.
950 Industrial Way
Sparks, Nevada 89431 USA
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City of Reno
Stead Drainage Master Plan
Soils Map

- Playas & Ponds
- Water Bodies
- Soil Unit Boundary
- 0900 Soil Unit Identifier
- Watershed Boundary
- Corporate Boundary
- Sub-basin Boundary
- PE2 Sub-basin Identifier

N W E S

Scale: 1" = 2000'

Job No : 80100208/210
Date : February 29, 2000
Projection : Stateplane, NV West, U.S. Survey Feet, NAD83

Figure 8

Stantec Consulting Inc.
950 Industrial Way
Sparks, Nevada 89431 USA
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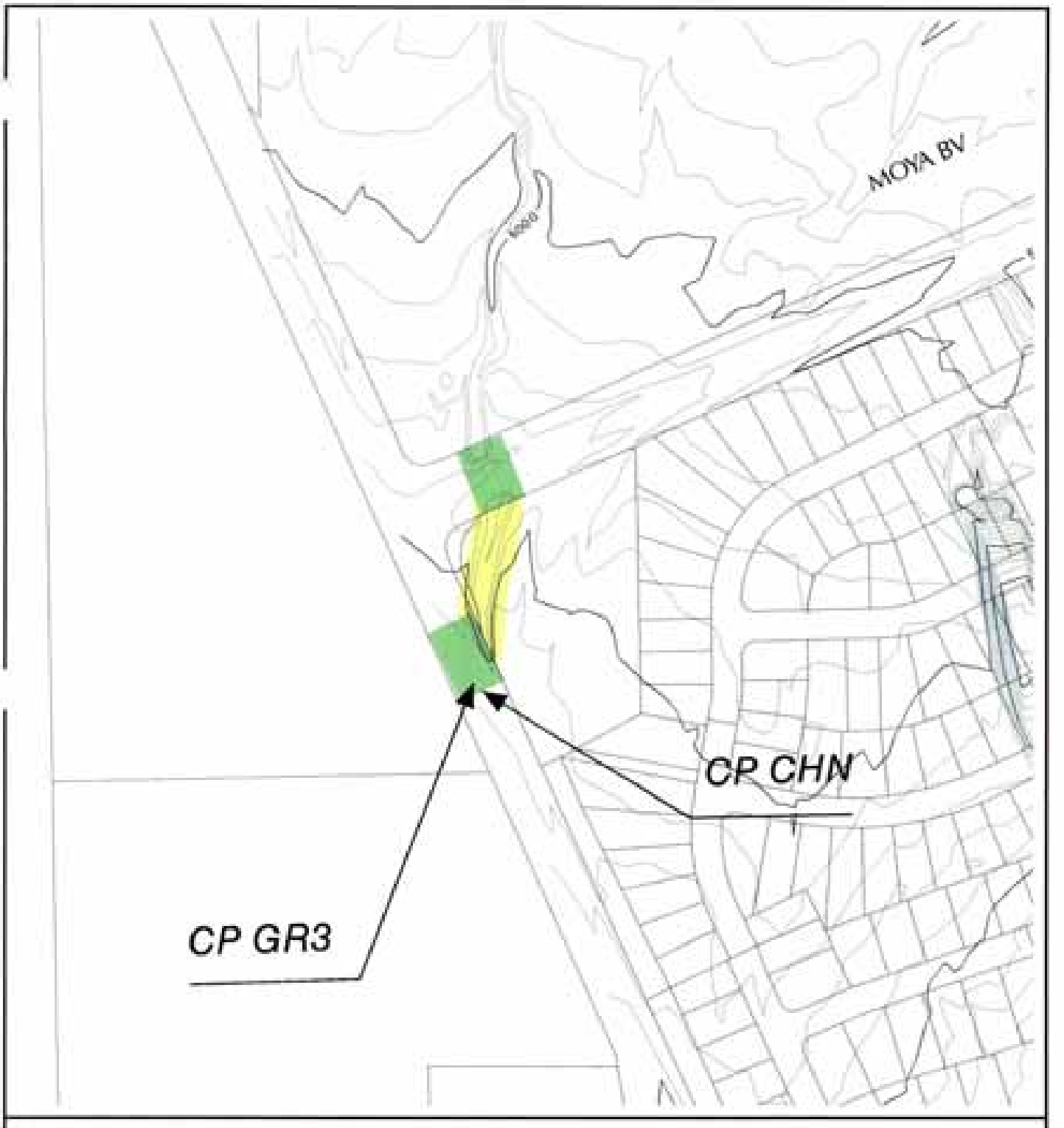


City of Reno

Stead Drainage Master Plan

Moya Blvd. at Red Rock Road Improvements

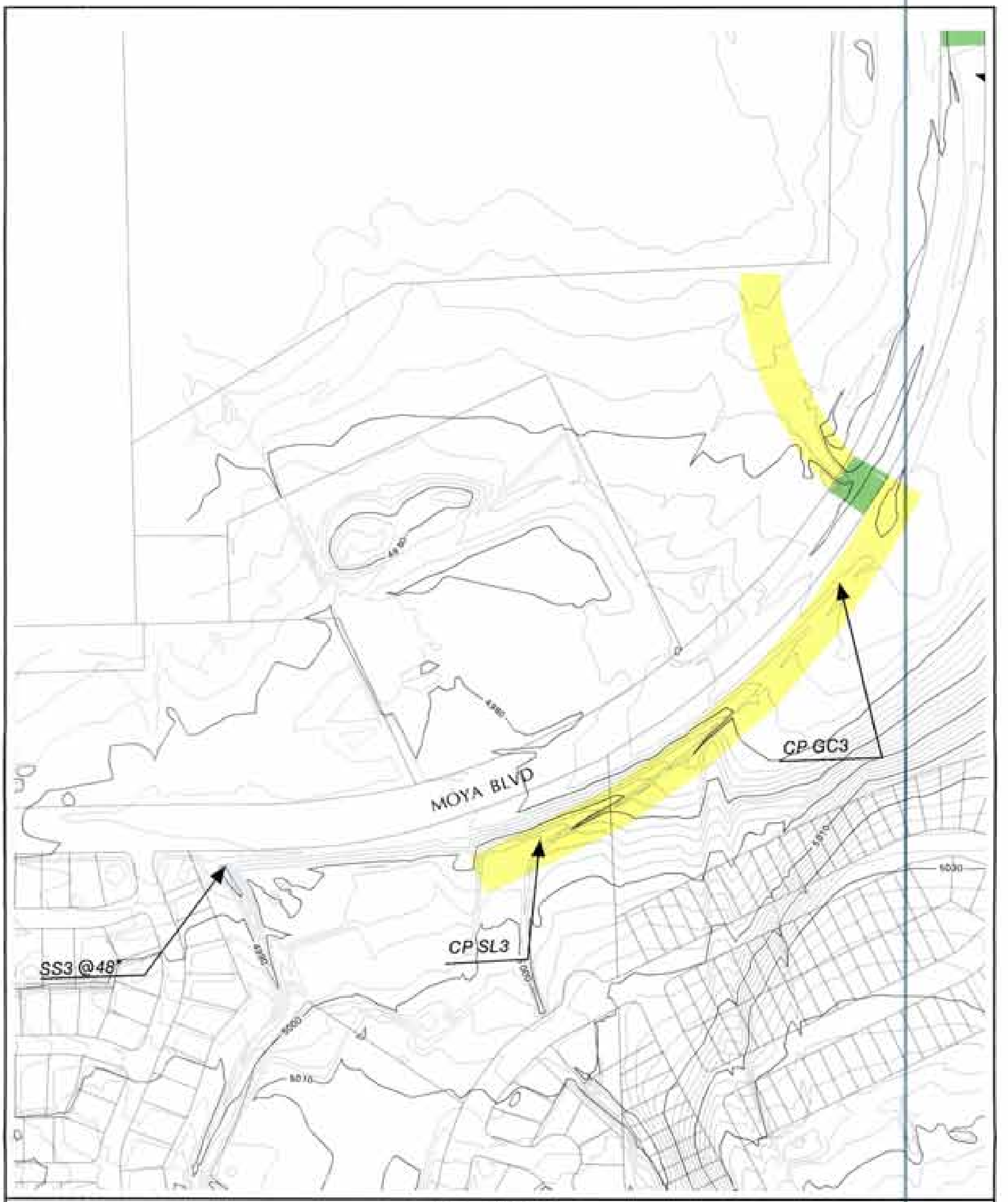
Proposed Culvert

Proposed Drainage Channel Improvements

Scale: 1" = 200'

Figure IIa

Stantec Consulting Inc.



City of Reno

Stead Drainage Master Plan

Other Moya Blvd. Culvert Improvements

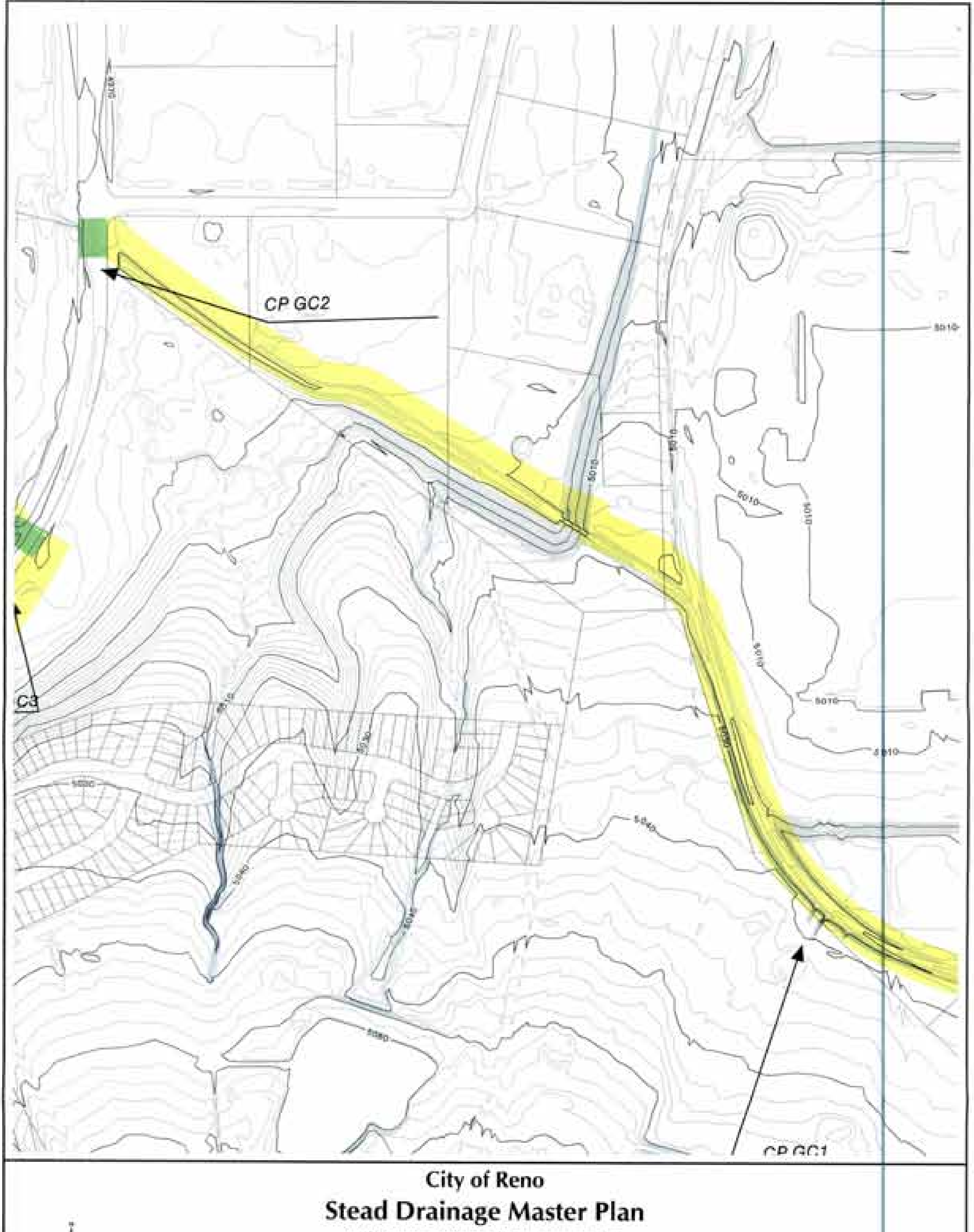
Proposed Culvert

Proposed Drainage Channel Improvements

Scale: 1" = 200'

Figure 11b

Stantec Consulting Inc.



City of Reno

Stead Drainage Master Plan

Golf Course Channel Improvements 1

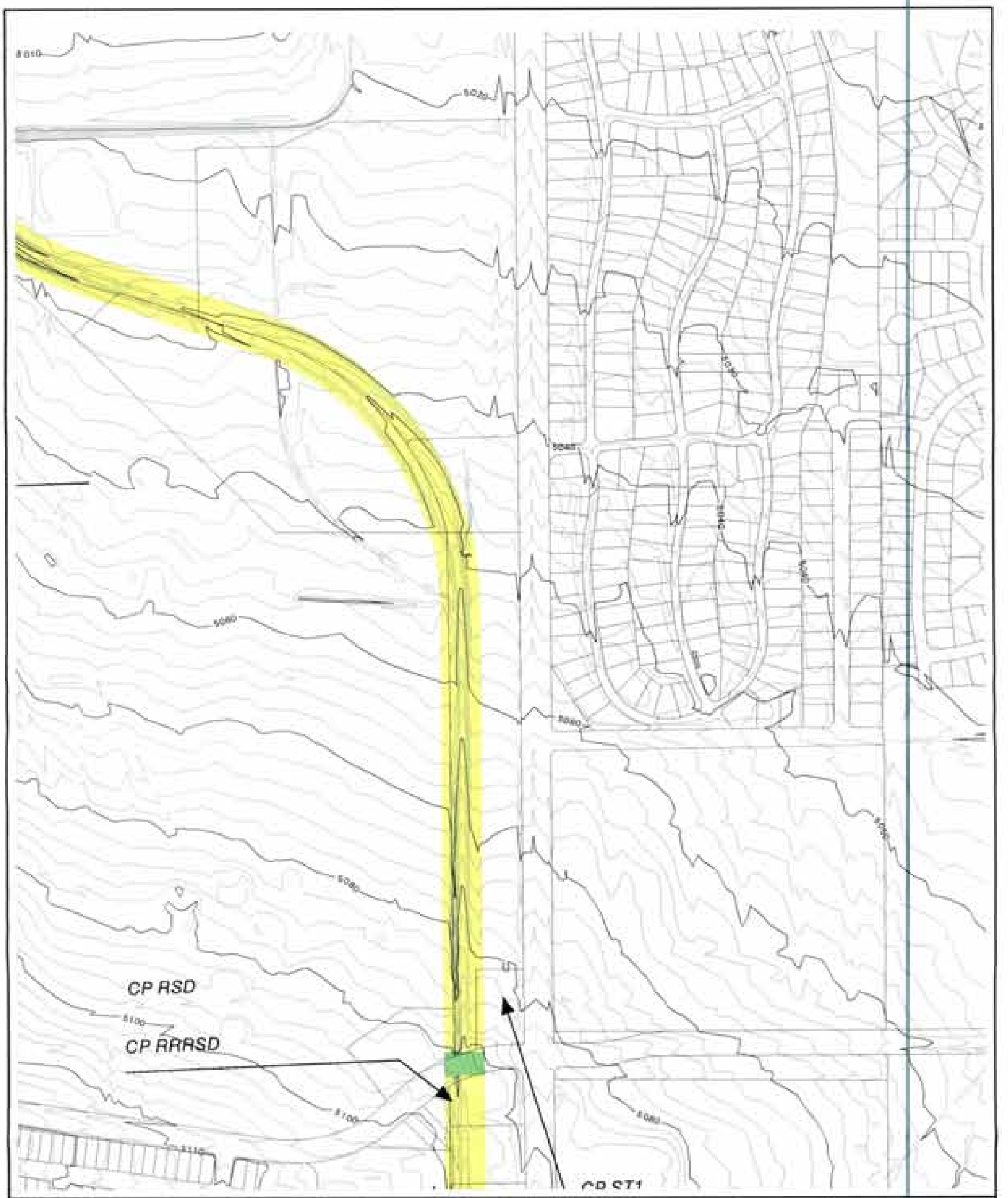
Proposed Culvert

Proposed Drainage Channel Improvements

Scale: 1" = 300'

Figure 11c

Stantec Consulting Inc.



City of Reno

Stead Drainage Master Plan

Golf Course Channel Improvements 2

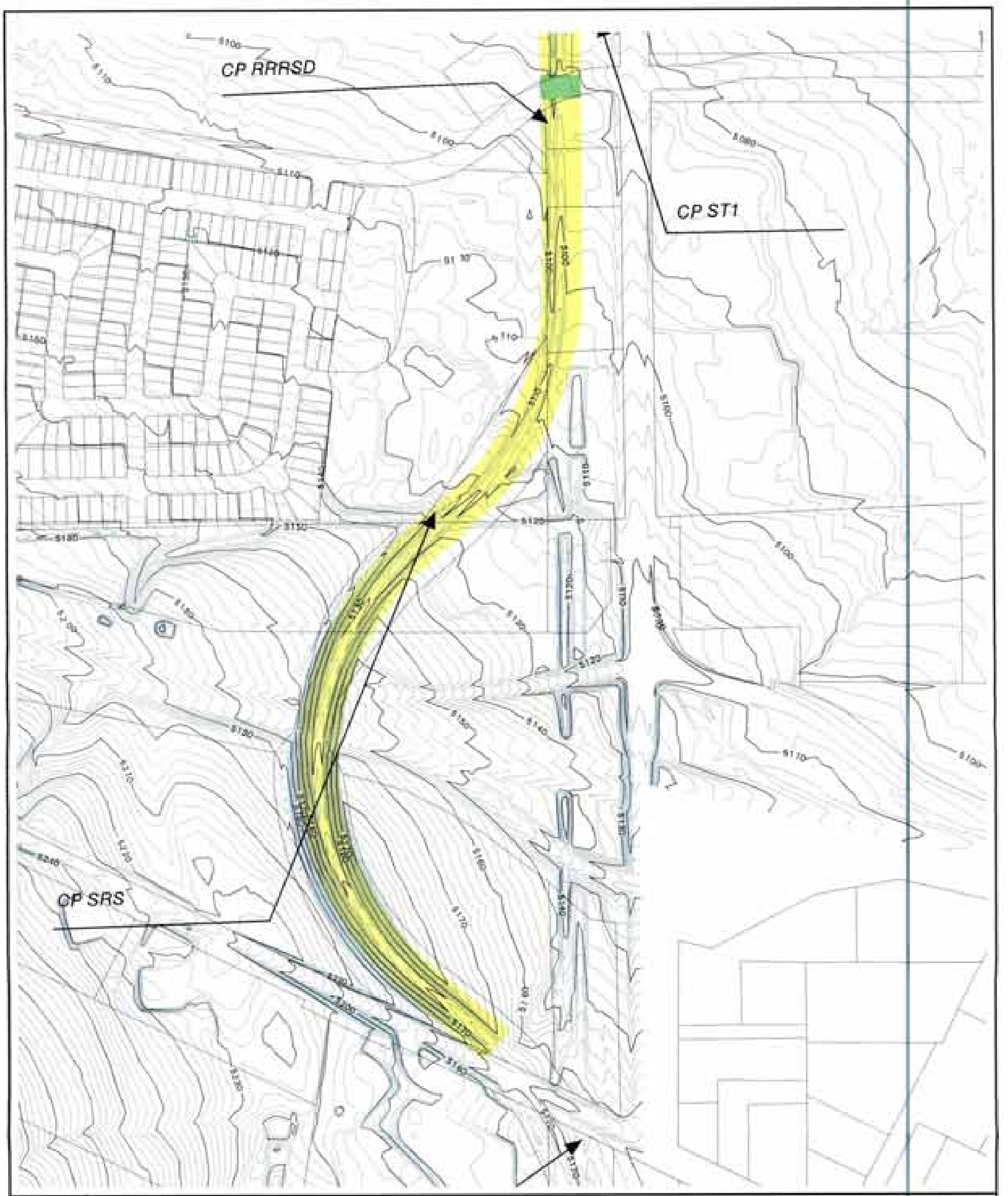
Proposed Culvert

Proposed Drainage Channel Improvements

Scale: 1" = 300'

Figure 11c

Stantec Consulting Inc.



City of Reno

Stead Drainage Master Plan

Golf Course Channel Improvements 3

Proposed Culvert

Proposed Drainage Channel Improvements

Scale: 1" = 300'

Figure 11c

Stantec Consulting Inc.

City of Reno

Stead Drainage Master Plan

Donnelley Channel Improvements

Proposed Culvert

Proposed Drainage Channel Improvements

Scale: 1" = 300'

Figure 11d

Stantec Consulting Inc.

City of Reno

Stead Drainage Master Plan

Moya Blvd. Detention Basin Improvements Map

Proposed Culvert

Scale: 1" = 300'

Figure 11e

Stantec Consulting Inc.