# USA Parkway

NDOT Project Identification Number SP-000M(091)

# Preliminary Design Report
# 30% Design

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## ACRONYMS AND ABBREVIATIONS

The acronyms and abbreviations identified below are used throughout this document. This list is intended for reference use.

AC = asphaltic concrete
al. = alia
cfs = cubic feet per second
CIPP = cured-in-place pipe
CMP = corrugated metal pipe
CUYD= cubic yards
DA = drainage area
DI = drop inlet
FEMA = Federal Emergency Management Agency
FIS = Federal Emergency Management Agency Flood Insurance Study
FHWA = Federal Highway Administration
GIS = Geographic Information System
HEC = United Stated Corp of Engineers Hydrologic Engineering Circular
I = Interstate
Inc. = Incorporated
IPES = Individual Parcel Evaluation System
LF = linear foot
LS = lump sum
m = meter
NDEP = Nevada Division of Environmental Protection
NDOT = Nevada Department of Transportation
No. = number
NOAA = National Oceanic and Atmospheric Administration
NPDES = National Pollutant Discharge Elimination System
NRCS = Natural Resources Conservation Service
NV = Nevada
NWS = National Weather Service
PS&E = Plans, Specifications and Estimate
RCP = Reinforced Concrete Pipe
ROW = Right-of-Way
SCS = Soil Conservation Service (now the NRCS)
SF = square feet
SQYD = Square yard
SR = State Route
UG = Underground
US = United States
USACE = United States Army Corps of Engineers
USDA = United States Department of Agriculture
USGS = United States Geologic Survey
WR = Wood Rodgers, Inc.
$yd^3$ = cubic yards

# I. INTRODUCTION & PURPOSE

This report summarizes the Preliminary Drainage Design for NDOT's USA Parkway Project. USA Parkway (SR 805) is being planned as a critical link between US 50 and I-80. Currently, US 395 through Carson City, SR 341 through Virginia City, or US 95A through Fernley are used to connect the Reno metro area with locations south and east; the proposed USA Parkway alignment will help improve that connectivity. In addition, the USA Parkway alignment will provide access to the development of the Tahoe-Reno Industrial Center.

Approximately 6 miles of the USA Parkway alignment have been paved starting at the interchange with I-80 about 10 miles east of Reno. The existing paved roadway consists of a four-lane divided arterial roadway, with open median and minimal shoulders. This proposed project will extend the roadway south from Storey County into Lyon County and tie into US 50 in Silver Springs, a distance of approximately 12.5 miles. This report details the drainage design of this proposed extension. The drainage design outlines the proposed facilities for roadway onsite drainage and stormwater generated upstream of the alignment to be conveyed across the proposed roadway section, allowing the peak flows generated in the 25-year storm to pass and keep the roadway free from flooding. The drainage design also analyzes 100-year peak flows and velocities in order to insure downstream properties have no increases in flows or adverse effects.

This project area is located in Storey and Lyon Counties, Nevada, southwest of Fernley. The project location and proposed alignment are shown on Figure 1: Location Map.

## II. DESIGN PROCEDURES AND CRITERIA

All design procedures and analyses followed the NDOT Drainage Manual (December, 2006) and the 2007 NDOT Plan Preparation Guide. The major design criteria are sized for a Minor Arterial Roadway and are as follows:

Hydrologic Design

- 25-year recurrence storm for offsite flows
- 10-year recurrence storm for onsite flows

Roadway Drainage

- Maximum storm water spread is the shoulder width plus ½ of the traveled way in the 10-year design storm event.
- Inlet grates are sized assuming 25% clogging (on-grade) and 50% clogging (in sump).
- Erosion control and energy stabilization will be placed at culvert outlets.
- Channels will be lined when design flows indicate erosive velocities.

### a. Drainage Criteria

#### *i. Hydrologic Procedures & Criteria*

Hydrologic methods followed the Final NDOT Drainage Manual of December 2006.

Onsite flows, namely roadside channels, channels that lie in the median and locations where concrete barrier rail will convey roadway runoff, were calculated using the Ration Method. For culverts and channels that will convey offsite flows, flows were calculated using the NRCS TR-55 method using the USACE hydrologic model HMS version 3.4. The precipitation intensities and depths were obtained from NOAA Atlas 14 using the centroid of the watersheds being studied.

**NRCS TR-55 Method**

The HEC-HMS model using NRCS method for both loss and translation computations was utilized to design of offsite drainage facilities. The roadway draining to the facilities was factored into the runoff computation by defining it as directly connected impervious area. Sub-basin inputs include lagtime (Tlag), curve number (CN), and precipitation data.

Precipitation depths were obtained from NOAA Atlas 14 (NWS, 2004) using the centroid of the overall upstream watersheds. The 24-hour duration 10-, 25- and 100-year storm events were simulated. The precipitation was treated as a balanced frequency storm event with 50% intensity position (closest to NRCS Type II Rainfall Distribution) and an intensity duration of 5-minute.

Lag time and CN calculations are detailed in Appendix A.

**Regression Analysis**

The resulting peak flows of the HMS modeling for both existing and proposed conditions were considerably high relative to the FEMA regulatory FIS flows at the downstream concentration point near Silver Springs. This may be due to the fact that the new hydrologic analysis is using NOAA 14 precipitation depths. So as not to build conveyance structures to pass flows that are unrealistically high, the USGS regional regression equation was utilized to compute peak flow rates that concentrate at large drainage paths crossing the proposed alignment- namely at Stations 252+00, 121+00 and 21+00. These flows were used in the hydraulic analysis as described below.

**Rational Method**

The Rational Method was used to obtain peak flow rates for onsite watersheds from the following equation:

$$Q = CIA$$

Where:

Q = Discharge (cfs)
C = Runoff coefficient
I = Precipitation intensity corresponding to the time of concentration (inches/hour)
A = Area of sub-basin (acres)

The time of concentration (Tc) to calculate intensity was calculated using initial sheet flow and channel flow according to the methods outlined below. Shallow concentrated flow was not utilized because of the onsite/roadway nature of the runoff.

Initial Sheet Flow

- Per the NDOT Drainage Manual (December 2006), sheet flow occurs over distances typically less than 100 feet. A maximum of 99 feet was used.
- Manning's n value of 0.011 for pavement was utilized and a value of 0.030 was utilized for soil areas. (Gupta, 2001).
- $P_2$, the 2-year, 24-hour rainfall (used in time of concentration calculations) was obtained from NOAA Atlas 14 (NWS, 2004).

Channel Flow

- Manning's Equation was used to solve for normal depth flow velocity for the channel portion of Tc. Onsite proposed channel slopes and roughness factors were based on design conditions assuming the onsite channels will be lined with riprap. Haestad Methods' FlowMaster was used to calculate velocity using the preliminary 25-year peak flow for the area, which was then recalculated with the corrected Tc and intensity.

Total time of concentration to obtain precipitation intensities (I) the proposed facilities were calculated by combining initial sheet flow and channel flow. Per the NDOT Drainage Manual (December 2006), the minimum Tc for onsite directly connected impervious basins is five minutes.

Onsite precipitation intensity values were obtained for four elevation zones within the project area from NOAA Atlas 14. For each onsite drainage area, the intensity from the closest point was utilized.

### *ii. Hydraulic Procedures & Criteria*

Hydraulic analyses were performed to evaluate the capacities of proposed drainage structures including cross culverts, DIs, concrete barrier rail and roadside channels according to FHWA methods and NDOT approved computer programs.

**Cross Culvert Analysis**

Cross culverts capacities were analyzed and designed using HY-8, which uses FHWA Hydraulic Design of Highway Culverts (HDS-5) methodology for inlet and outlet control computations (U.S. Department of Transportation, 2004).

Culvert capacities were calculated without assuming blockage. Since channels and land downstream of the proposed cross culverts are very steep (between 1.5 and 4%) normal depth at design peak flows was applied in the calculations for the outlet control condition.

Four locations, Station 21+00, Station 121+00, Station 252+00, and Station 401+00, are locations where major flow paths cross the proposed roadway alignment. These locations were analyzed for existing and proposed conditions using HEC-RAS from just upstream of the proposed road to just downstream of the proposed road. This was done to better analyze the effects of the roadway on flow and to better design culvert sizing and outlet treatments. HEC-GeoRAS was utilized during the model setup and existing and proposed contours were utilized to cut the cross sections. The exhibits showing the cross sectional layout for Stations 121+00, 252+00 and 401+00 have been provided in Appendix B. For all of the models a Manning's n value of 0.03 was used for the banks and for the channel.

Culvert outlet treatment was designed using FHWA Hydraulic Engineering Circular -14

**Channel Conveyance Capacity**

Channel and riprap sizing for channels collecting offsite flows were based on the guidelines outlined in the Federal Highway Administration September 2005 HEC#15, Third Edition for roadside channel with flexible linings. See Appendix B for methodology and detailed calculations.

Normal depth calculations within Bentley Systems FlowMaster were used to determine the channel conveyance capacity for the proposed center. Manning's n values for the center channels were set equal to 0.036 assuming riprap lining.

**Drop Inlet Capacity/Spread Calculations**

The proposed DIs were designed using FlowMaster by Bentley Systems, which utilizes FHWA HEC-22 methods and equations, The longitudinal and channels slopes and pavement cross slope were taken from the 30% design.

Spread calculations were completed in areas where barrier rail is collecting flow along the proposed roadway. The spread was evaluated using FlowMaster and drop inlets added to ensure flows do not exceed the allowable spread as outlined in the NDOT Drainage Manual.

## b. Agency Regulations

### *i. Nevada Legal Aspects*

The proposed improvements are intended to follow established drainage patterns except in cases where changes can be contained by offsite public drainage facilities and can be mitigated by erosion control and energy dissipation, as per Nevada law as outlined in Section 1.3 of the NDOT Drainage Manual. All drainage flow pattern changes are localized and will not affect any adjacent property, such as localized increases in water surface elevations upstream of culverts and localized increases in velocity at culvert outlets. One exception to this is at approximately station 21+00 which is discussed in detail in the Proposed/Selected Alternatives, Off-site Drainage Facilities section of this report. All culvert outlets will be protected with velocity dissipation facilities.

### *ii. Code of Federal Regulations*

One of the goals of design of the drainage improvements for the USA Parkway roadway is to ensure NDOT's compliance with the FHWA Federal-Aid Policy Guide, Title 23 Part 650 Non-regulatory Supplement Subparts A and B. The aspects of the design that will allow for the compliance are as follows:

- The facilities will provide drainage across NDOT ROW as accomplished by existing conditions.
- No stand-alone (without existing pipe with geometric integrity) CIPP installation is included in the design.
- The proposed roadway alignment does not affect any FEMA flood zones. There is a FEMA A and AE zone downstream of the project area starting just upstream of Silver Springs, named Ramsey Canyon on the USGS Quad and unnamed wash on the FIS. The offsite watersheds that cross the alignment through the lower portion of the roadway make up the majority of the contributing area to this flood zone.

### *iii. Federal Emergency Management Agency*

As stated previously, nearby FEMA regulated floodplains are limited to the Truckee River, which is 4.2 miles from the start of the proposed alignment, and the area downstream of the project upstream of Silver Springs, which is approximately 1 mile from the end of the project area.

### *iv. Regulatory Agency Requirements*

Regulatory agency requirements are covered elsewhere in the associated design reports.

### *v. Regional Flood Control Requirements*

The project limits have no associated regional flood control requirements. There is a regional analysis being done for Ramsey Canyon downstream of the project area in through Silver Springs. The alignment will not affect this analysis as the flows will be returned to their existing drainage paths by the upstream limits of the study unless the roadway construction concentrates the flow to convey it across the alignment near Station 21+00.

### c. Compliance

The design of the USA Parkway drainage improvements seeks to comply with all applicable NDOT policies and procedures.

## III EXISTING CONDITIONS

Existing conditions watersheds and peak flows are shown in Figures 2.0 to 2.5 and Table 1. There is a drainage divide near Station 500+00; the northern portion of the project area drains to the Truckee River and the southern portion of the project drains to Lahontan Reservoir. The southern portions drainage collects near the existing alignment of US50 and is conveyed through the town of Silver Springs, producing a FEMA FIS AE zone and flood risk issues.

### a. Existing Conditions

#### *i. Previous Reports*

A drainage master plan analysis "Ramsey Canyon Watershed Flood Control Study" was completed May 2012 for Lyon County and the Silver Springs Airport by Manhard Consulting. Data has been presented for this study and reports a 100-year peak flow of 2,400 cfs for the Ramsey Canyon near US95A. This differs from the Lyon County FIS which has a reported 100-year peak flow for Ramsey Canyon of 4,827 cfs in the 100-year event at Highway 95 with a contributing area of 46.4 square miles. Manhard Consulting contributes the difference in peak flow rates to more accurate hydrologic modeling methods and 2-Dimensional hydraulic model.

#### *ii. Drainage Basin Characteristics*

The offsite drainage sub-basins are presented in Figures 2.0-2.5. The offsite sub-basins range in area from 30 square miles to small areas draining to the roadway as sheet flow. The soil coverage is presented in Appendix A. Rainfall runoff is generally collected within distributed braided channels. Virtually all of the upstream area of the alignment is undeveloped and consists of rocky sparsely vegetated terrain. The vegetation consists of grass and shrubs. Most of the terrain is fairly steep with slopes ranging from 1.5% to over 10%. Please see the photo below for typical terrain through and upstream of the project area.

#### *iii. Flow Patterns*

The offsite watersheds intercepted by the proposed roadway alignment are shown in Figures 2.0 to 2.5. Flow paths conveying runoff from significant upstream watershed areas cross the proposed alignment in four locations near Station 401+00, 252+00, 121+00 and 21+00. These flow paths are distributed in nature, ranging in width from 100 to 1600 feet.

#### *iv. FEMA Information*

As stated previously, there are not any mapped FEMA floodplains through the project area. The major drainage in the Lahontan portion of the study area flows to a mapped FEMA Zone AE with a floodway downstream of the project area from just upstream of the Silver Springs airport through the town of Silver Springs. The latest FIS map (Lyon County number 320029 panel 0211E) has an effective date of January 16, 2009.

### *v. Existing Facilities*

There is an existing roadway alignment from the northern end of the major new grading section (near Station 695+00) to approximately Station 461+00. There are existing roadside ditches and some limited culverts associated with this roadway. The new roadway construction will have a completely revised profile and cross section design and will include replacement of all the existing drainage facilities. The grading of the existing ditch system will be incorporated into the new grading where appropriate.

### *vi. Stability Issues*

There is limited erosion in the project area where grading has occurred without stabilization protection such as along the edges of the dirt road in the photo below.

## b. Figures and Summary Tables

Please see Appendix A for the hydrologic analysis and Appendix B for the existing conditions hydraulic analysis, which is limited to the HEC-RAS modeling.

## IV. DESIGN RECOMMENDATIONS

### a. General

The roadway has been designed for construction ease and costs according to the design team's and NDOT's recommendations. The drainage improvements have been designed so as to meet the design criteria stated in Section II and convey water through the alignment as close to existing conditions as possible.

### b. Design Alternatives

Several alignments were considered in the conceptual phase of the design of the roadway as shown on Figure 4.

The only design alternative considerations in the drainage design are the various configurations of the culverts at major drainage crossings near Stations 401+00, 252+00, 121+00 and 21+00. The largest drainage path crossing near Station 21+00 near the downstream tie-in to the existing US 50 requires the largest conveyance structure. This culvert is in close proximity to adjacent developed properties. The flow is an alluvial fan which causes the flow to distribute in a wide and shallow manner. This makes collecting and conveying the flow, while not increasing flooding risks to the neighboring properties a priority. The preliminary culvert configurations are included in the Preliminary Design Plans. These could change with further discussion and input as the design progresses.

#### *i. Project & Drainage Cost Estimates*

The drainage facilities for each alignment alternative were similar so no formal cost estimates were prepared for the alignment alternatives. The proposed roadway alignment is adjacent to the existing drainage for a large section of the roadway. The proposed alignment crosses the existing drainage at fewer location than the earlier considerations, thus lessening the costs for culvert and channel facilities.

The culvert configurations at the major crossings will have slightly different costs. Because the roadway is either new or being completely regraded, the costs between different culvert configurations are minimal except near Station 21+00 where a bridge, a large box structure, or a series of smaller culverts should be considered.

#### *ii. Effects to Existing Drainage*

All alignments would have similar effects on existing drainage patterns. With all the alternative alignments, the localized impacts of the roadway construction as discussed above (increased depths upstream of the roadway crossings and increased velocities downstream of the crossings) will dissipate prior to the drainage paths encountering any developed property except around station 21+00 of the project area.

Currently, the largest impact to existing drainage will be the configuration of the crossing near Station 21+00. Because of the proximity of this crossing to developed properties both up and downstream of the roadway, it will be critical to allow conveyance without significantly increasing the water surface upstream of the crossing or increasing the downstream velocity markedly.

### *iii. Regional Flood Control Facilities*

None of the alternative alignments would affect regional flood control facilities differently.

Except for near Station 21+00, none of the culvert configuration alternatives would impact regional flood control facilities. The collection and dispersion of flow at the crossing near Station 21+00 could affect local future flood control facilities that are being planned by Lyon County and the Silver Springs Airport.

### *iv. Developer Local Drainage*

Except for the crossing of the highway at the very downstream end of the project near Silver Springs near Station 21+00 there is no development in the project area. Again, the design of this crossing will be finalized so as to minimize affects to upstream and downstream properties.

### *v. Temporary Drainage Facilities*

All the alignments and culvert configurations under consideration would have similar needs for temporary drainage facilities during construction so as to convey water through the project area safely and so as not to cause erosion.

### *vi. Roadway Geometrics Constraints*

All but two of the culvert configurations under consideration will work with the current roadway geometric design with the appropriate cover. At Station 252+00, under the most logical design option, the upstream channel will be required to be excavated. The design of the roadway has been lowered but further changes near the crossing near Station 21+00 may need to be analyzed as design moves forward to accommodate the large flow path.

### *vii. Geotechnical*

The only difference from a geotechnical perspective with the elements under consideration would be a bridge near Station 21+00.

### *viii. Utility Conflicts*

There are no utilities in the area; no considered design element will affect any utility.

### *ix. Constructability*

As all the facilities would be constructed in a new roadway, there would be no difference in constructability between the elements being considered unless a bridge is proposed at the crossing near Station 21+00.

### *x. Traffic Control*

Because this is a new roadway, no considered elements or alignments would require traffic control.

### *xi. Environmental Issues*

There are no environmental issues with any of the considered design elements.

### *xii. Water Quality*

There are no different water quality issues with any of the considered design elements.

### *xiii. Special Maintenance*

The maintenance of all considered design elements would be similar.

### *xiv. Right-of-Way Impacts*

For the crossings near Stations 252+00 and 21+00, different configurations would require different right-of-way impacts. The rest of the crossings would require similar right—of-way.

### *xv. Structural Issues*

If a bridge crossing is considered for the final roadway drainage crossing near the existing US50, there will be structural considerations.

## c. Proposed/Selected Alternatives

### *i. On-site Drainage Facilities*

The proposed features are shown on Figure 6.1 to 6.29, and detailed in Appendix B and on the Preliminary Design Plans. They consist of limited a median drainage channel, concrete barrier rail, and some roadside channels.

### *ii. Off-site Drainage Facilities*

Off-site drainage facilities are detailed in Appendix B and shown on Figure 6. They consist of roadside channels and cross culverts. The recommended sizing of the channels shown in the Proposed Conditions Summary of Channels in Appendix B. The culvert sizing is shown in the Proposed Conditions Summary of Culverts in Appendix B and included in the 30% Plans Drainage Sheets. There are several culverts that are sized for drainage that is running parallel to the road for conveyance beneath cross streets. These are in the Culvert Summary Table but are not yet included in the 30% Plans.

The most critical aspects of the design from a hydraulic standpoint are the larger flows that cross the alignment. HEC-RAS outputs for these large crossing are included in Appendix B and discussed below. Armoring the embankment at these major crossing should be considered as design moves forward.

- Station 401+00: A concentrated flow path crosses the alignment from west to east. The peak 25- and 100-year flow rates calculated using the NRCS methodology are 618 and 978 cfs respectively. The existing channel, according to the HEC-RAS results, has a super-critical slope. A culvert crossing with 1- 6’ X 10’ RCB will convey both the peak 25-year and 100-year flow with approximately 4’ of clearance before overtopping the road.

- Station 252+00: A larger more distributed flow crosses the alignment in this location from north to south. Peak flows were calculated for the drainage utilizing the USGS regional regression equation. The the computed peak flows for the 25- and 100-year events are approximately 972 and 2,450 cfs, respectively. Because of the nature of the distributed flow, forcing excessive headwater upstream of the crossing will cause the flow to overwhelm the upstream channel and change its drainage path considerably. Because of this, it is recommended that the upstream channel approach to the culvert be excavated to direct flow adjacent to the roadway embankment to accommodate the crossing. A crossing consisting of 3-6' X 10' RCB culverts would accommodate the 25-year peak flow without escaping the upstream channel and without overtopping the roadway. The peak 100-year flow would break out of the upstream channel. The culvert size was designed to accommodate backwater and minimize overtopping of flow, changing its flow path. The culverts size may be minimized with further excavation.
- Station 121+00: A distributed flow with a peak of 287 and 824 cfs in the 25- and 100-year events, calculated with the USGS regional regression equation, concentrates at the roadway alignment. 2-4' X 8' RCB culverts will accommodate the 25-year peak flow without overtopping the roadway. The peak 100-year flow approaches the top of the roadway surface however does not overtop the roadway.
- Station 21+00: This is the most critical roadway crossing location as it is close to developed properties and is just upstream of the town of Silver Springs. The Ramsey Canyon Watershed Flood Control Study, being done by Manhard Consulting for Lyon County, has computed a 100-year peak flow of 1,070 cfs, a 25-year peak flow of 976 cfs, and a 10-year peak flow of 342 cfs, concentrating in this area. This was done using a rainfall runoff model and two-dimensional flow model that includes the assumption that significant flow concentrating within Ramsey Canyon will weir over US50 upstream of the proposed USA Parkway crossing. The analysis, as described in the report submitted on May 12, 2004, seems reasonable. The hydrologic analysis computed flows that compare well to the Zone 6 USGS Regional Regression Equations. The Zone 6 equations generally estimate lower frequency flows than Zone 5. The project area is on the border between Zones 5 and 6.
- The flow path is wide and distributed spanning over 1,000 feet. An additional design challenge is that the new roadway is proposed to be higher than the natural ground at this location. The options for this crossing are multiple boxes (approximately 10-3'X12' RCBC would convey the 25-year peak flow without excessive excavation), many pipes over a wide area, a low spanning bridge or a dipped section of roadway with a low flow culvert system. The current option, as shown in the 30% drainage design plans, will install 3-3'X12' RCB culverts to convey the approximate 10-year peak flow in conjunction with a dipped portion of the roadway between station 21+00 and 13+00, allowing for roadway overtopping. This option will raise the upstream water surface so as to impact nearby properties. It may be necessary to acquire additional right of way or easements to mitigate flood impacts to adjacent properties. Due to the alluvial flows and area of impact, it is recommended that as the project proceeds into intermediate design that a more detailed study of the effects of the roadway, backwater and overtopping be done in a 2-dimensional hydraulic model.

### *iii. Water Quality*

All culverts are proposed to be protected with outlet control. All roadside channels are proposed to be lined with riprap with sizing depending on the design storm velocities and shear stress.

### *v. Cost Estimates*

The Preliminary Cost Estimate for the drainage improvements includes the following:

- Excavation within existing channels to install rip rap lining where necessary and for culvert/drainage inlet/manhole installation below existing ground surface
- Rip rap to line new and existing channels where required by velocity and sheer stress and for culvert outlets.
- All proposed culverts and drainage inlets

The prices per cost items were taken from averages of recently bid NDOT construction projects. The cost estimate is approximately $21 million and is detailed in Appendix E.

### *vi. Right-of-Way Impacts*

The suggested right-of-way for the drainage improvements is 20-feet beyond all drainage improvements including culverts and associated outlet protection and channel excavation.

### *vii. Utility Relocations*

There are no utilities in the area; no proposed design element will affect any utility.

### *viii. Special Provisions Issues*

Currently, in the preliminary drainage design, there are no items that will require special provisions that are not typical to NDOT drainage plans. The crossing at Station 21+00 could require some additional special provisions depending on what is decided at that location.

### *ix. Maintenance Plan*

Currently, in the preliminary drainage design, the drainage facilities proposed require typical maintenance such as annual culvert cleaning, annual vactoring of inlets, occasional rip rap repair, and occasional channel cleaning. If a dipped crossing is chosen for conveyance at Station 21+00, the roadway would have to be cleared after a storm event.

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