Eldorado Canyon at Nelson Landing, Nevada

(Miscellaneous ungaged site, USGS Nevada Water Science Center)

Review of peak discharge for the flood of September 14, 1974

Location: This flood was located about 19 mi southeast of Boulder City, Nev., at 35.7066 N and 114.7148 W.

Published peak discharge: The computed peak discharge is 75,800 ft^3/s and was rated poor. This was published as 76,000 ft^3/s in Glancy and Harmsen (1975). The rating should be downgraded to estimate.

Drainage area: Drainage area at the indirect measurement site is listed as 22.8 mi^2. Glancy and Harmsen (1975) list the drainage area of Eldorado Canyon as 22.9 mi^2 at the mouth. However, most runoff was generated in the central and downstream part of the basin.

Data for storm causing flood: The flood was the result of an intense convective thunderstorm that moved slowly down the drainage basin. The storm and subsequent flooding are summarized in Glancy and Harmsen (1975), National Weather Service (1974), and Cleveland (1975).

The National Weather Service report (1974, p. 3) states that the flood

> "…was caused by a classical convective runoff-producing event. Area coverage was small — less than 50 square miles. Duration of rainfall was short — generally less than one hour. Intensities were very high — at least three inches per hour, and as high as 7 inches per hour for ½ hour."

The down-basin movement of the storm intensified the flooding. According to local observers referenced in the previously cited reports, the storm lasted less than 1.5 hours, with maximum intensity spanning less than 0.5 hour. Storm totals of about 1.9 in. were reported at Nelson Landing. The National Weather Service (1974, p. 3) report also notes

> "The entire 23 square mile basin appears to have received over one inch of rainfall, with the storm center receiving at least 3.50 inches."

Given the magnitude and unit discharge of this flood, it is likely that much more rain fell in parts of the basin.

At least nine people were killed by the flood as it passed through the marina area where Eldorado Canyon enters Lake Mojave. As a result, there was extensive newspaper coverage of the flood and the recovery efforts. The Nevada State Journal, Las Vegas Review-Journal, and the Las Vegas Sun all carried articles about the flood in their September 16–18, 1974, issues. Articles about the recovery of flood victims noted that all bodies recovered were nude, their clothing having been completely stripped by the force of the flow.

The September 17 issue of the Las Vegas Review-Journal carried a photograph (fig. A119) of the flood at the resort with the caption,

> "The photograph was taken by a witness who ran to high ground and pointed his camera down the canyon."

The same photograph is figure 7*A* of Glancy and Harmsen (1975) and has the caption

> "On September 14, 1974, probably during the recession of flooding (photograph by Kenneth E. Beales, Las Vegas, Nevada)."

The photograph shows a water flood. However, the newspaper caption suggesting that the photograph was taken before the peak is in error. The restaurant is missing, giving graphic testimony that the photograph was taken after the destruction of the restaurant.

All eyewitness accounts mention that the flood arrived as a "wall of water" laden with debris, but the details of the height of this "wall of water" vary. What is not clear from those accounts is whether the "wall of water" was in the form of a wave in which the following flow was at a lower level or if it was just the snout of the floodflow that followed. It is very rare for any eyewitness account (or subsequent newspaper coverage) of a flash flood to be described as other than a "wall of water." Glancy and Harmsen (1975, p. 9) note,

> "The flow rate and velocity of the damaging initial flood surge at Eldorado Canyon cannot be determined because later flow apparently erased high water lines of the initial surge."

If true, this indicates that the flood stage of subsequent flows surpassed the stage of the initial surge.

Cleveland (1975, p. 54) notes,

> "Considerable speculation exists regarding the crest of the flood at the landing. Some observers reported unrealistic heights of the water surface… . Some mobile homes parked only a few feet above the floor of the canyon were not reached by the flood waters. Yet elsewhere downstream, floating debris was carried up to about 30 feet, perhaps by surges of water meeting natural obstacles along the canyon walls."

Figure A119. Flood in Eldorado Canyon at Nelson Landing, Nevada, September 14, 1974 (from Glancy and Harmsen, 1975, fig. 7*A*). Photograph taken by Kenneth E. Beales, Las Vegas, Nevada.

The canyon would be expected to experience higher velocities than the slope-area reach because flow is more greatly contracted in the canyon. Average velocity at the downstream cross section of the slope-area reach was 39 ft/s. That velocity converts to a static head of 23.6 ft, which would contribute to a similar depth of run-up on channel-bank protuberances, obstructions, and around channel bends. Historical photographs taken after the September 14, 1974, flood and during the 2003 review and described herein are provided in figures A120–144.

Method of peak discharge determination: The discharge is based on a three-section slope-area measurement surveyed September 17, 1974. The survey was made at a site upstream of the road where it switchbacks into Nelson Landing. A 780-ft reach was surveyed, and the three cross sections covered a 556-ft reach and fall was extreme; total fall was 30.32 ft. However, the reach was sharply contracting, and about one-half the fall was attributed to change in velocity head.

Velocities and Froude numbers were large. Mean velocity ranged from 25 ft/s at the upstream section (number 1) to 39 ft/s at the downstream section (number 3); Froude numbers were 1.56, 2.22, and 2.58 at sections 1–3, respectively.

As part of this review, the original results were analyzed using the current slope-area computation (SAC) program. The results confirmed the peak discharge of 76,000 ft^3/s computed in 1974.

The measurement summary notes that five slope-conveyance studies were done upstream to help define sources and magnitude of the flooding. Those five sites are described as one on Eagle Wash, two on Eldorado Canyon, one on Tachatticup Wash, and one on Morning Star Wash. Glancy and Harmsen (1975; table 2) give results for three sites including Eagle Wash, Tachatticup Wash, and Eldorado Wash upstream of the confluence with Eagle and Tachatticup Washes. Those results, assuming coincidence of the peak discharges and inflow from the unmeasured areas, are noted as giving credence to the value of about 76,000 ft^3/s. The actual computations for the slope-conveyance measurements could not be located during the 2003.

Because of the significance of the flood and the uncertainties in the computation, the measurement received extensive outside review. Howard Matthai (USGS) reviewed the measurement (and apparently the other slope-conveyance estimates as well) on October 8, 1974, and stated,

> "… the writer concludes that the only discharge figure that can be used is 75,800 cfs, but it may be 10 to 20 percent too high. The latter conclusion is based primarily on the extremely high velocities indicated for the discharge computed."

Howard Matthai had second thoughts after hearing the eye-witness accounts dealing with the "consistency" of the floodborne material and added an October 10, 1974, postscript to his initial review stating,

> "Under these conditions, I do not believe we can hide behind the idea that that we computed a discharge figure but do not claim it is all water. I am more convinced than ever that the discharge was not 75,800 cfs. If more evidence supports the 'semi-mud flow' condition, I would recommend that we report the peak discharge as indeterminate. If a discharge is needed, I suggest we use 20,000 cfs as a poor estimate."

Matthai then forwarded the measurement to USGS Headquarters where it was reviewed by Jack Davidian of the USGS Office of Surface Water. Davidian's review, dated October 25, 1974, recounted the uncertainties in the hydraulics of the flow and concluded,

> "Much of the above discussion is academic. All indications are that the flow was highly unsteady, and for such a condition we have no good means of measuring peak discharges. … It is definitely not recommended to give a discharge figure and qualify it with many reasons why it could be in error; it is far better to give no discharge figure, and explain the lack of it with those same reasons."

As a result of the uncertainties, Howard Matthai and Carl Nordin of the USGS research program (and one of the world's leading sediment transport experts) visited the site. That visit is documented in a hand-written note to the record by Lynn Harmsen dated November 20, 1974:

> "As a result of the review of the slope area determination by J. Davidian, Surface Water Branch, Washington, D. C., Mr. Matthai (W. R. Flood Specialist), Mr. Carl Nordin (Research Hydrologist, Denver), Mr. P. Glancy and Mr. L. Harmsen (the Carson City District Office) met in Las Vegas, Nev. on Nov. 18 to discuss the results and visit the sites in question. After careful inspection of the slope area site and the slope conveyance sites, the conclusion reached was that the numbers obtained were alright to use in the report as long as they were highly qualified. As to the probability of a gravel bar moving though the reach, there was no field evidence of this occurring."

Howard Matthai and Carl Nordin documented their reviews of the draft that would become Professional Paper 930 in memoranda dated November 25 and November 27, respectively.

In an April 28, 1983, memorandum to Patrick Glancy, Robert Jarrett of the USGS research program provided commentary on the indirect measurement. He echoed the concerns expressed earlier by Matthai and Davidian and computed flow at each cross section assuming that the flow was at critical depth. His results for total flow (sediment-water mixture) ranged from 47,700 ft^3/s at section 1 to 29,000 ft^3/s at section 3. He made the added assumption that this flow was 50-percent sediment by volume and gave an estimated water flood of 18,400 ft^3/s.

Kyle House, research geologist with the Nevada Bureau of Mines and Geology, summarized a reconnaissance study of this flood in a June 10, 2002, document presented to the Bureau of Reclamation. House estimated flow in an upper basin tributary (Huse Spring) using paleoflood-type discharge reconstruction and extrapolated that unit runoff to the entire basin to arrive at a flow of about 18 percent of the 76,000 ft^3/s. House notes, however, that the Huse Spring site is not representative of the basin as a whole and states,

> "…this unit runoff value is low with respect to what is likely to have characterized the lower part of the basin during the flood."

House further states,

> "…the estimate from Huse Spring … does not indicate that the estimate of 2,152 m^3/s from the canyon mouth is too large."

Possible sources of error: The possible sources of error have been documented in the several earlier reviews of this measurement. They include:

- Flow may have been unsteady, perhaps even in the form of translatory waves, rather than gradually varied as assumed by the slope-area procedure.
- A gravel bar may have been moving though the reach, affecting high-water mark placement.
- Unknown but obviously very high sediment concentrations.
- Possibility of a debris flow.
- Unaccounted for energy losses in the sharply contracting reach.
- Extreme velocities (25 to 39 ft/s) and suspect Froude numbers (ranging from 1.5 to 2.5).
- Unknown condition of the streambed at the peak discharge (scour/fill).

Recommendations of what could have been done differently: It is difficult to conceive what more could have been done. The indirect determinations were made within days of the flood while evidence was fresh. Slope-conveyance estimates were made at contributing reaches to corroborate the result. The credibility of the tributary results would have been enhanced if they had been slope-area measurements instead. However, the results would not have been likely to change appreciable, given the uniformity of the reaches. Because these tributary results are independent of one another, it is unlikely that all could be grossly overestimated unless *n*-values are much too small. The computations and the report documenting those results were reviewed extensively by some of the most experienced flood and sediment specialists in the country. Finally, USGS Professional Paper 930 that documented the results and the uncertainties in those results was published within about 6 months.

Harry H. Barnes, Jr., then Chief of the Surface Water Branch captured the situation nicely with his December 26, 1974, memorandum recommending approval of the Glancy and Harmsen report:

> "This is a good report and is more deserving than open-file status. I suggest it be published in the Professional Paper series. The flood in Eldorado Canyon is somewhat unique only because of the tragic consequences. From a hydrologic point of view a flood of this nature is probably not uncommon considering the West as a whole — yet the reader will be impressed by the complexity of the hydrologic and hydraulic processes that produced the event and the uncertainties of post flood analysis and documentation."

The methods used to document this flood would most likely be used if a similar flood happened today. Although some would call for use of a two-dimensional model instead of the one-dimensional model that comprises the slope-area method, unless there was definitive data (on a time scale of seconds) on the actual flood wave, a two-dimensional model would permit only generation of a larger number of alternative peak discharges for debate.

Site visit and review: A field visit was made August 28, 2003, by John Costa (USGS Office of Surface Water), and Kyle House, Gary Gallino, Patrick Glancy, Robert Burrows, Terry Kenney (USGS), and Kenneth Wahl (USGS retired). Primary focus of the visit was the slope-area reach and former site of Nelson's Landing, but the general reaches of the Tachatticup and Eagle Wash slope-conveyance sites were viewed from the basin-perimeter roadway.

The slope-area reach is remarkably unchanged from the conditions present in 1974. There appears to have been very little net change in either the streambed or the banks. This is consistent with the observation that steep channels like this may act somewhat like conveyors during large flows—moving large amounts of bed material with little accumulation on or erosion from the streambed. Those present at the field visit agreed that there was no evidence that the 1974 peak had been a debris flow at the indirect measurement site.

Recommendations: The original peak discharge of 76,000 ft^3/s should be accepted as published and the rating should be downgraded to "estimate" because of the extraordinary Froude numbers.

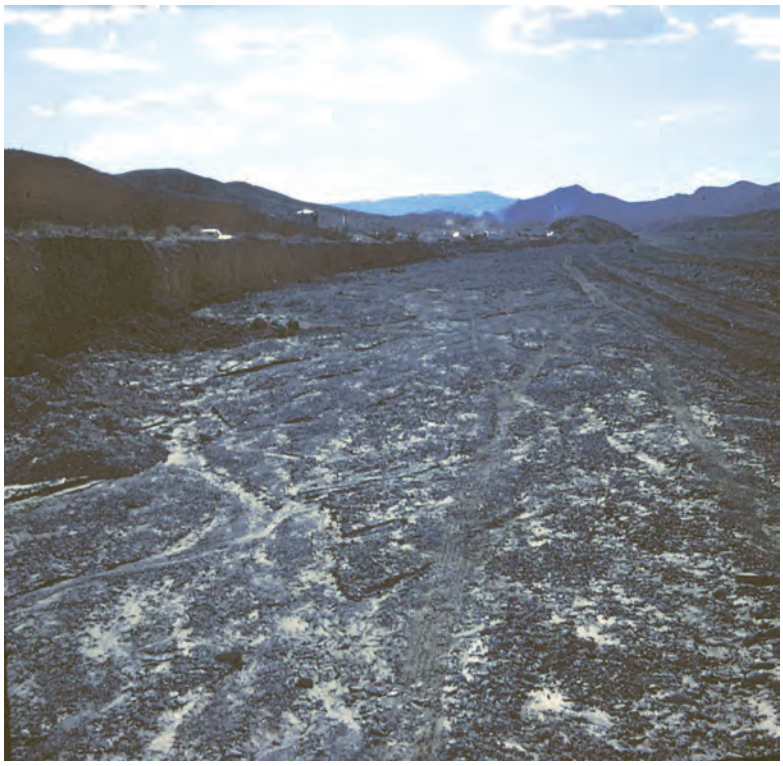

Figure A120. View looking upstream through slope-area reach, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A121. Mud marks in trees near right bank, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A122. View of trailers from left bank to right bank, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A123. View of left bank high-water mark at trailer profile, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A124. Right bank high-water mark at trailer profile, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A125. Right bank high-water mark at restaurant trailer, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A126. View downstream toward lower slope-conveyance site, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A127. View downstream through cross-section 1, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A128. View downstream at right bank through cross section 1, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A129. View downstream through cross-section 3, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A130. View downstream at left bank through cross section 3, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A131. View downstream at right bank through cross-section 3, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A132. View downstream at upper slope-conveyance site, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A133. View upstream at lower slope-conveyance site, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A134. View upstream through cross-section 1, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A135. View upstream to left bank through cross-section 1, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A136. View upstream to right bank through cross-section 1, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A137. View upstream to left bank through cross-section 3, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A138. View upstream to right bank through cross-section 3, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A139. View upstream toward upper slope-conveyance site, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A140. High-water mark in parking lot on right bank, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

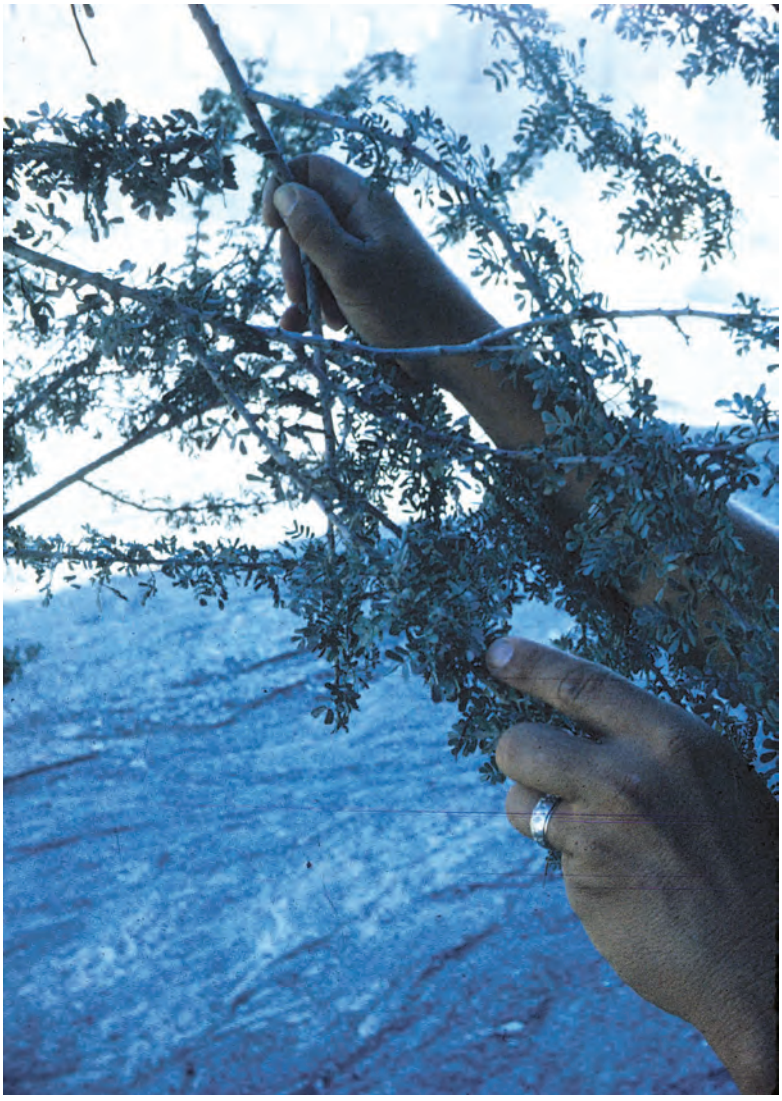

Figure A141. Mud on leaves near treetop, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A142. Mud on leaves of tree on right bank near trailers, Eldorado Canyon at Nelson Landing, Nevada, September 1974.

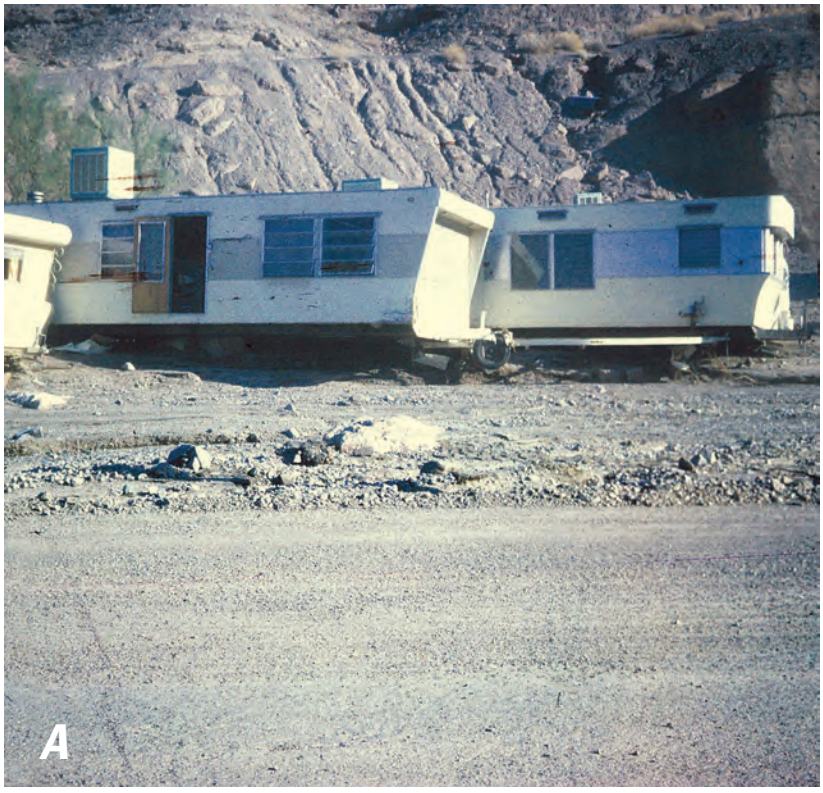

Figure A143. Damage to trailers (a), Eldorado Canyon at Nelson Landing, Nevada, September 1974.

Figure A143. Damage to trailers (a), Eldorado Canyon at Nelson Landing, Nevada, September 1974.—Continued.

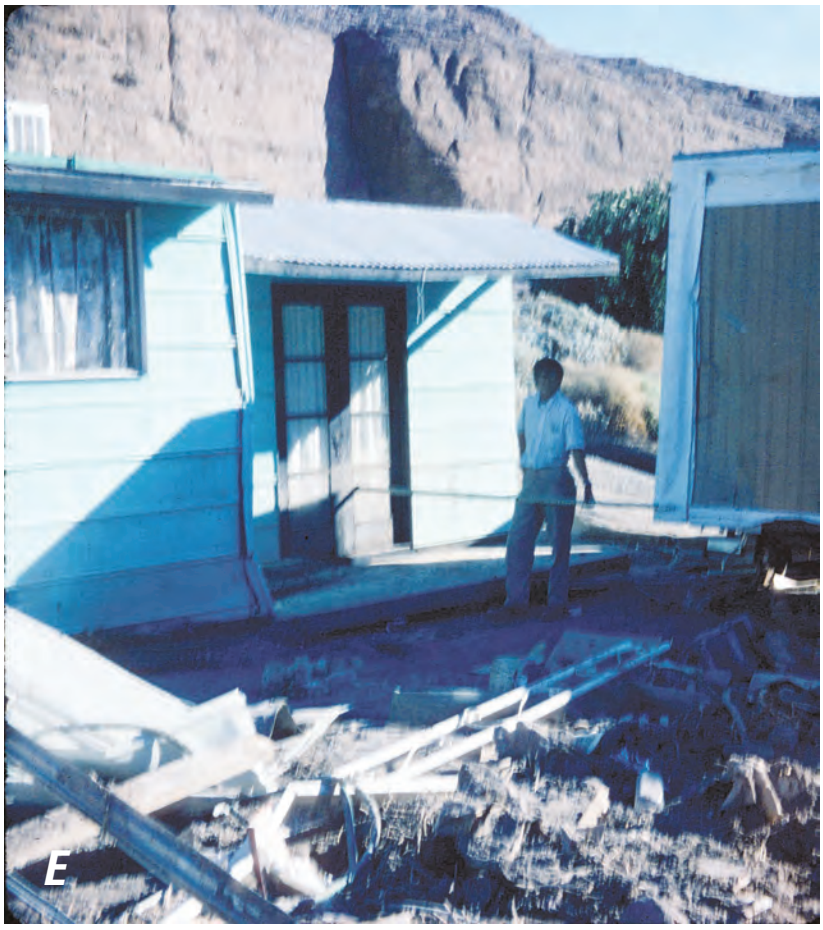

Figure A143. Damage to trailers (a), Eldorado Canyon at Nelson Landing, Nevada, September 1974.—Continued.

Figure A143. Damage to trailers (a), Eldorado Canyon at Nelson Landing, Nevada, September 1974.—Continued.

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Figure A144. View looking upstream through slope-area reach, Eldorado Canyon at Nelson Landing, Nevada, August 28, 2003.

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