U.S. FOREST SERVICE
NATIONAL STREAM and AQUATIC ECOLOGY CENTER

October 5, 2018

TULAROSA RIVER at NFSR-233: SITE VISIT and RECOMMENDATIONS

Client: Gila National Forest, Reserve Ranger District

Location: NFSR-233 crossing of the Tularosa River, Catron County, New Mexico

Date of Visit: 7/25/2018

On-Site Participants:

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Dustin Myers, Gila National Forest
Carolyn Koury, Hydrologist, Gila National Forest
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Paul Brown, Watershed Program Manager, Apache-Sitgreaves National Forests
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Harley Allsup, Engineer, Gila National Forest
Eileen Henry, Gila National Forest
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Summary: The National Forest System Road (NFSR) 233 crossing of the Tularosa River was assessed. Primary resource concerns at this crossing include wetland loss, lack of aquatic organism passage, and the structural stability of the crossing, with key impacted species being the loach minnow and the Chiricahua leopard frog (critical habitat upstream and downstream of the crossing), and the narrow-headed gartersnake (proposed critical habitat).

It is recommended that three actions for this crossing be considered, specifically:

1. the removal of the concrete apron added in 2009;
2. restoration of the downstream channel; and
3. the addition of a shallow and wide concrete conduit at the crossing.

Scour downstream of the crossing and apron is preventing aquatic organism passage, with this scour likely made more severe by the apron – removal is warranted. Restoration of the downstream channel and floodplain would consist of filling the high unit stream power channel with borrow material from a suitable local source, to eliminate the knickpoint at the downstream limit of the crossing, provide aquatic organism passage, reconnect the channel with its floodplain (reducing unit stream power), and raise groundwater levels to reestablish riparian conditions and protect the downstream wetlands. Additionally, a shallow and wide concrete conduit at the crossing should be considered, to aid with aquatic organism passage while maintaining the upstream wetland. This may require reconstruction of the crossing, with a new alignment that is perpendicular to the valley profile preferred.

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INTRODUCTION

The National Forest System Road (NFSR) 233 crossing of the Tularosa River was assessed at the request of the Gila National Forest and Forest Service Region 3. This crossing is 4 miles northeast of the town of Reserve, New Mexico. In response to a 2017 call letter for assistance needs, the National Stream and Aquatic Ecology Center was requested (by Carolyn Koury and Amanda Gehrt) to provide technical assistance with resource concerns at this crossings, to help the District and Forest with decision making. Primary concerns include wetland loss, lack of aquatic organism passage, and the structural stability of the crossing, with key impacted species being the loach minnow and the Chiricahua leopard frog (critical habitat upstream and downstream of the crossing), and the narrow-headed gartersnake (proposed critical habitat). This report provides an overview of current conditions and recommendations for future actions.

Currently, the stream is experiencing scour just downstream of the structure, as well as incision further downstream. This erosion and incision may likely threaten the stability of the crossing, if not addressed. Additionally, upstream of the crossing is a valued wetland that is being protected from incision and draining through grade control by the structure. This crossing is downstream of the 2018 Buzzard Fire, which is expected to be causing increased flow and energy for geomorphic change.

The watershed above the NFSR-233 crossing of the Tularosa River watershed (406 mi^2) has average annual precipitation ranging from 17 to 28 inches (PRISM, Daly et al. 2008). The majority of the watershed is considered "functioning at risk" within the Forest Service Watershed Condition Framework (Potyondy 2011).

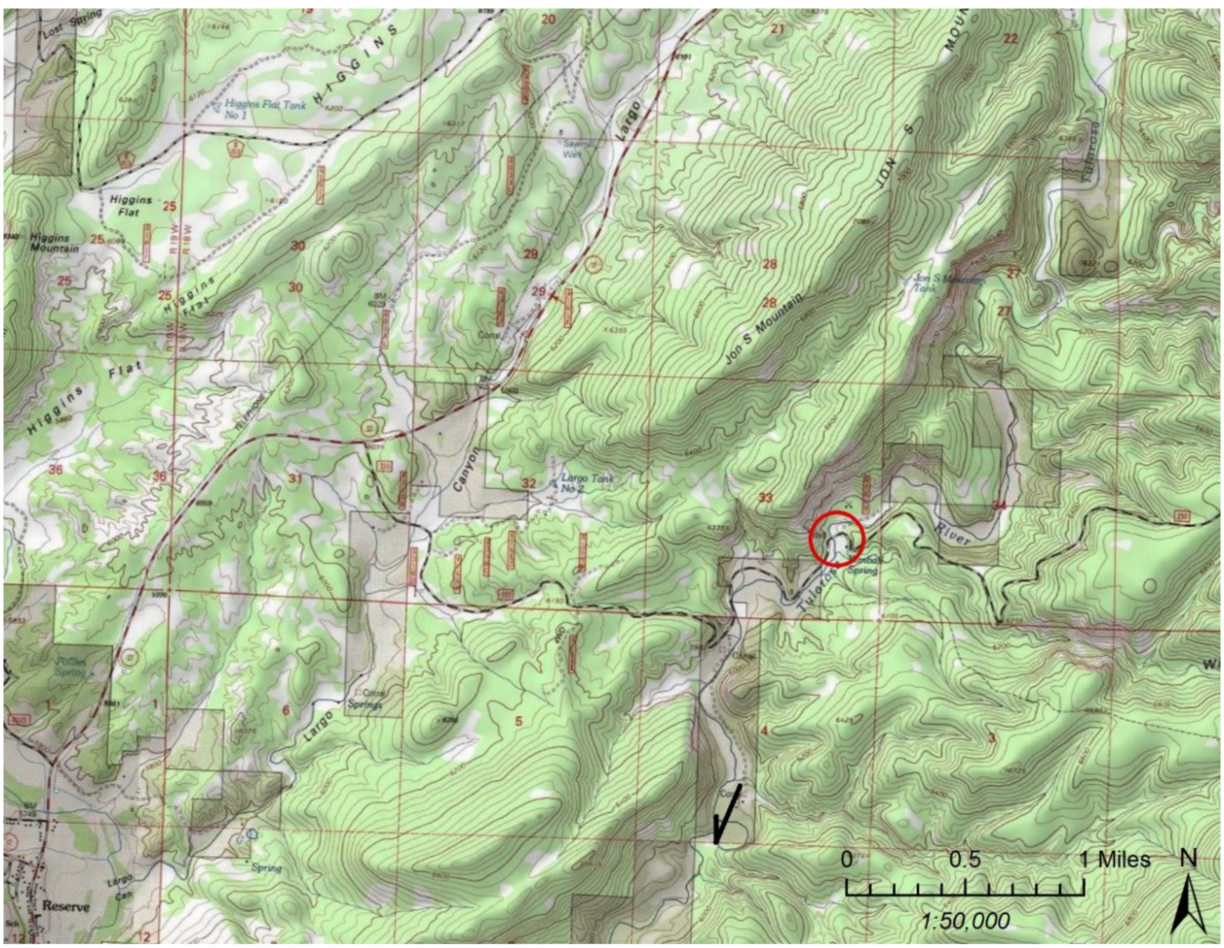

Figure 1: Topographic mapping of the Tularosa River in the vicinity of the NFSR-233 crossing (red circle).

CURRENT CONDITIONS

The NFSR-233 crossing of the Tularosa River consists of a concrete low water crossing (Figure 2) that spans a bit more than half of the valley width (Figure 3) at an angle to the valley profile. The 2009 addition of a concrete apron just downstream had the intent of increasing aquatic organism passage for the loach minnow; it is unknown if this feature was effective in satisfying this objective. Immediately upstream of the crossing is a wetland, with a multi-thread channel (Figure 4, Figure A-1). Just downstream of the apron is a scour hole (Figure 5) with a depth of 4 to 6 feet (from apron surface). Large rocks have been placed along the edge of the apron, with the intent of arresting headcutting proceeding along the edge of the apron towards the crossing.

Figure 2: National Forest System Road 233 crossing of the Tularosa River (flowing left to right), with concrete crossing, downstream concrete apron, and upstream wetlands.

Figure 3: Aerial imagery (2017-10-14) of the Tularosa River at the NFSR-233 crossing.

Figure 4: Wetlands upstream of the crossing.

Figure 5: Scour at downstream limit of concrete apron. This is an aquatic organism passage barrier for the target species (loach minnow).

Downstream of the crossing the channel is incised for a distance of roughly 1000 feet (Figure 6, Figure 7), with this incision in a predominantly fine-grained material. Gravel-sized dominated material was observed on the channel bed. This incision decreases in the downstream direction until the channel appears to be more connected with its floodplain (Figure 8) in the vicinity of a National Forest boundary with downstream private lands. (Further downstream the channel appears to be once again incised, and may have been channelized.) The incision just downstream of the crossing has resulted in dropped groundwater table elevations immediately downstream of the apron, for at least a few hundred feet (Figure A-1). A spring is present 300 feet downstream of the crossing, on the left side – this incision may also be impairing this feature.

Upstream of the crossing the channel is multithread (Figure A-1), with one the threads eroding against the edge of the concrete crossing at the left edge of the structure. Historic aerial imagery (Figures A-1 to A-3) indicates that this multithread pattern has existed for some time since the hardened crossing was installed, but did not exist prior to the installation, when this upper reach was single thread (Figure A-4). The downstream reach appears to have been predominantly single thread throughout the available historic record. Incision downstream of the structure was present since at least 2006 (Figure A-3), before the apron installation, though appears to have gotten substantially worse in recent years.

Figure 6: Incision downstream of the NFSR-233 crossing. Viewing downstream ~200 feet downstream of the crossing.

Figure 7: Incision downstream of the NFSR-233 crossing. Viewing upstream from ~600 feet downstream of the crossing.

Figure 8: Tularosa River at downstream limit of the incision-dominated reach. Viewing upstream from ~1000 feet downstream of the crossing.

Buzzard Fire

The Buzzard Fire burned in June of 2018, with an extent of 50,300 acres (Inciweb 2018). Most of the high and moderate soil burn severity areas are within the Tularosa watershed (Figure 9), which has likely resulted in substantially increased flood flows downstream (in Deep Canyon), though this affect will likely be substantially reduced at the crossing due to the distance from the high and moderate severity footprint (12 miles) and the small proportion of the overall Tularosa watershed that was impacted.

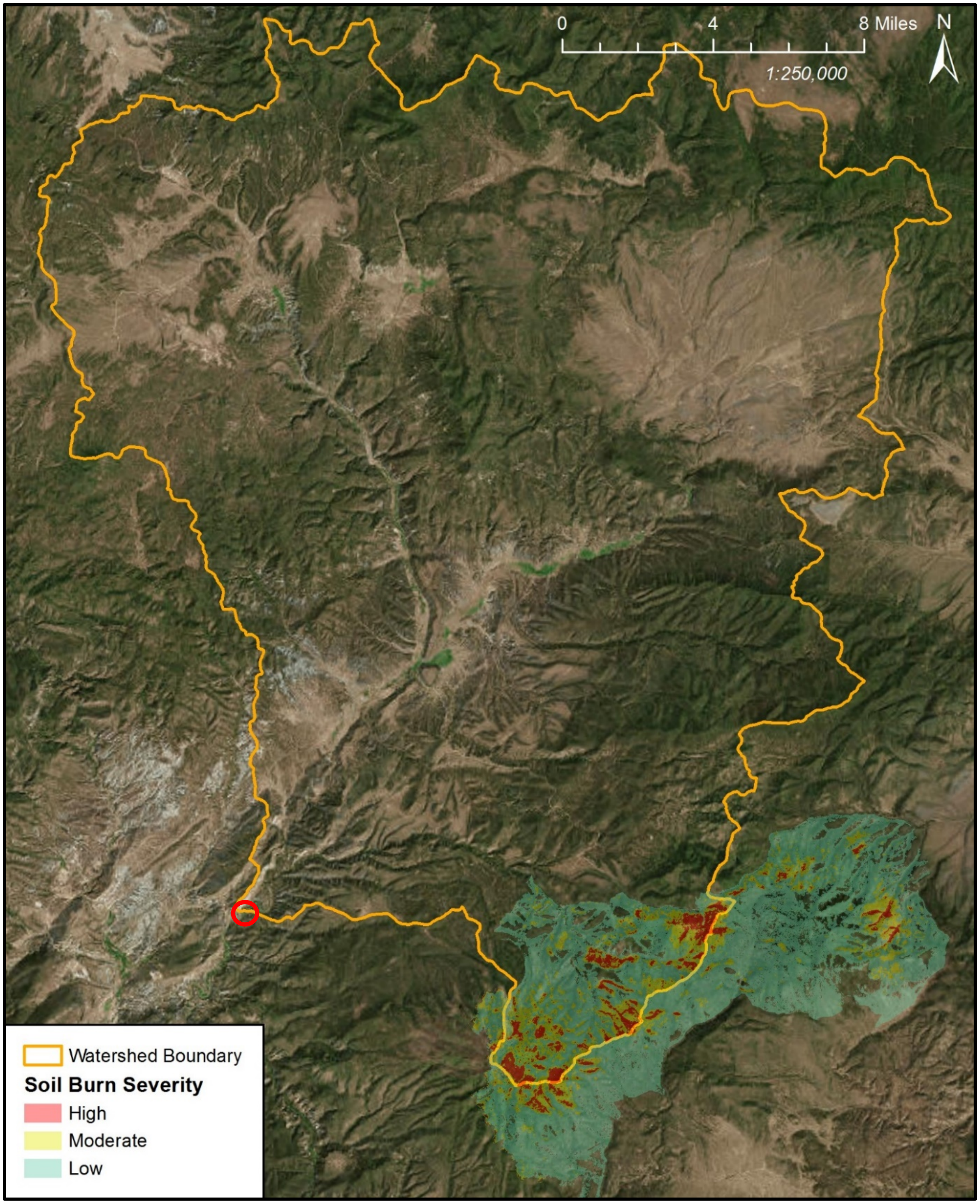

Figure 9: Soil burn severity for the 2018 Buzzard Fire, with the watershed boundary delineation for the Tularosa River (406 mi^2). The NFSR-233 crossing is circled.

FLOW FREQUENCY

Using a streamgage located at the site (USGS ID 09442740, Tularosa River near Reserve, NM), preliminary peak flow frequency estimates (Table 1) were computed using the methods of Bulletin 17B (IACWD 1982). This gage has 52 years of peak streamflow data, with annual peak flows from 0 (2010) to 3020 cfs (1983). These computations were done without the use of a regional skew adjustment. Considering the presence of a zero year and other potentially low outliers, the use of Bulletin 17C procedures (England et al. 2018) is likely needed for the development of final values.

Table 1: Preliminary flow frequency estimates for the Tularosa River at NFSR-233.

Return Interval (years)	Probability of Exceedance (percent)	Peak Discharge (cfs)	95% Confidence Limits (cfs)	
100	1	**3640**	6330	2400
50	2	**2730**	4510	1860
25	4	**1980**	3100	1400
10	10	**1200**	1750	890
5	20	**750**	1030	580
2	50	**310**	400	240
1.25	80	**130**	170	92

CONDITION and REHABILITATION SUMMARY

The Tularosa River at NFSR-233 is a flashy stream, with 2-year discharge of 310 cfs and 100-year discharge of 3600 cfs. Due to the 2018 buzzard fire, flood flows are expected to be higher and more frequent, though not drastically so considering the small fraction of the overall watershed that burned. Though this enhanced runoff can be still expected to increase the erosion rates alongside the apron and could potentially destabilize the crossing structure, unless mitigation measures are implemented in the short term.

The drop at the edge of the apron (Figure 5) is an aquatic organism passage barrier to the loach minnow and will be a long-term point of instability due to associated high energy (a knickpoint). Such scour is common downstream of low water crossings, likely due to flow acceleration across the smooth surface. Considering this, the apron likely made the problem worse by providing additional length for flow acceleration during high flow. The skewed orientation of the crossing is also a problem; a crossing perpendicular to the valley profile would be preferred. Additionally, channel incision downstream of the structure is resulting in groundwater table elevation reductions and increased geomorphic instability for a distance of about 1000 feet, which is negatively impacting riparian resources, including an adjacent spring system.

Hence, in summary, there are three key problems at this site:

1. Potential threat to the road crossing, due to instability from the vertical drop (knickpoint) on the downstream side of the structure
2. Lack of aquatic organism passage for the loach minnow
3. Negative impacts to a downstream wetland, from continued geomorphic adjustment stemming from downstream incision

Regarding the downstream channel incision (Figure 6, Figure 7), this reach appears to be predominantly in channel evolution model stages 3 and 4 (Figure 10), with stage 2 immediately downstream of the crossing. The channel evolution model (Schumm et al. 1984) is a valuable tool for understanding the dynamics of stream disturbance and recovery processes. The method describes the movement of a headcut through a channel reach and the consequential evolution of the channel over time and space. This provides a framework for evaluating longitudinal response and restoration potential. At a specific location the channel evolves from an initial stable state (stage 1) through incision (stage 2), widening (stage 3), deposition and stabilization (stage 4), and once again stable (stage 5). Stages 2 and 3 are the most challenging stages of the evolution model for managers; this is the stage where instability and sediment supply is highest and restoration options are limited. Over time, the incision (at a knickpoint) moves upstream, forcing evolution of the valley bottom on successive upstream reaches.

At this point in time this upstream propagation has been arrested by the crossing structure. This channel evolution process is the likely mechanism for the 1000 feet of incision downstream of the crossing, though it is acknowledged that other unidentified mechanisms directly associated with the crossing structure may have also influenced this incision.

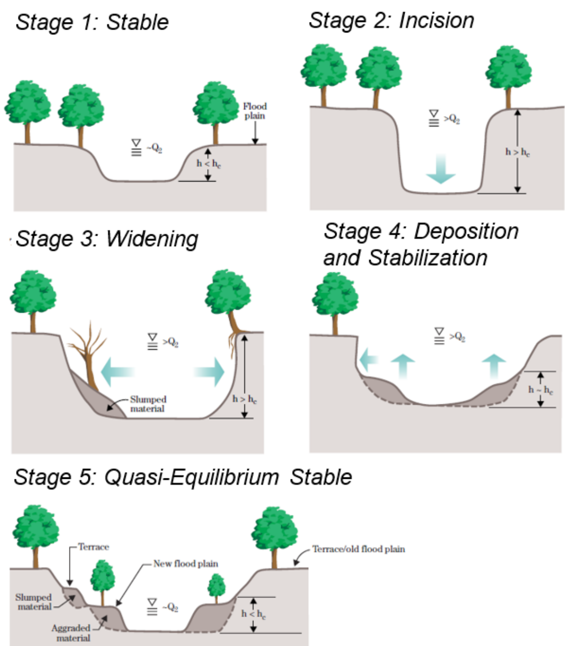

Figure 10: Channel evolution model, with channel cross sections illustrating the 5 channel stages (modified from NRCS 2007).

Within these channel evolution stages, unit stream power is dramatically elevated in stages 2 and 3, compared to a channel that is laterally-connected to its floodplain. Unit stream power is computed as

$$\omega = \frac{\gamma Q S_f}{w}$$

where, in the SI unit system, ω is unit stream power (W/m^2), γ is the specific weight of water (N/m^3), S_f is the friction slope (m/m, frequently assumed to be equal to the water surface or channel slope), and *w* is the flow width (m). Higher unit stream power is directly proportional to greater sediment transport conveyance capacity. A knickpoint has very high values of local unit stream power, due to the steep slope at this point.

Compared with the 1964 imagery (Figure A-4), more recent aerial imagery (Figures A-1 through A-3) indicates that woody vegetation is increasing in coverage within the valley bottom. Woody vegetation in the vicinity of the crossing is beneficial since it increases flow resistance of the floodplain surface and reduces velocities, increasing the stability of infrastructure.

Permanent efforts to reinforce the stability of the crossing structure while reestablishing aquatic organism passage, without reestablishing downstream lateral floodplain connectivity, will be expensive and may not reestablish longitudinal connectivity. Importantly, such an approach will maintain the presence of a knickpoint in this flashy system, leaving a high energy point in place immediately downstream of the structure. This is not recommended.

Recommendations

It is recommended that three actions for this crossing be considered, specifically:

1. the removal of the concrete apron added in 2009;
2. restoration of the downstream channel, providing aquatic organism passage at the crossing and reconnecting the channel laterally with its floodplain; and
3. the addition of a shallow and wide concrete conduit at the crossing, with a natural bed (to aid in aquatic organism passage) and removable lid (to be more easily maintained).

Some details on these proposed actions are provided in the following paragraphs.

The concrete apron placed immediately downstream was added to assist with aquatic organism passage. It is unknown if this structure actually assisted with passage, though the scour downstream of the structure is now preventing passage, with this scour likely made more severe by the apron. Removal of the apron is recommend as a part of a restoration strategy at this crossing.

Restoration of the downstream channel and floodplain is recommended. This restoration would consist of filling the high unit stream power channel with borrow material from a suitable source, to eliminate the knickpoint at the downstream limit of the crossing, reconnect the channel with its floodplain (reducing unit stream power), and raising groundwater levels to reestablish riparian conditions and protect the downstream wetlands. This channel restoration is expected to extend downstream to where the channel is currently connected with its floodplain, for a distance of at least 1000 feet. The channel(s) could consist of both a primary and secondary channels. Existing bed armoring would be harvested for use in the bed of the designed channel(s), though additional alluvial gravel and cobble may be needed. Grade control within the channel and adjacent floodplain surfaces would be required, and could consist of stacked logs in trenches and geotextile fabric; coir fabric may be best with Nedia being a potential source (https://www.nedia.com/Soil_wrap_fabric.html). An aggressive revegetation plan would be needed since this vegetation will ultimately lead to long term restoration stability, to maintain structural stability of the crossing and aquatic organism passage. Grazing and browsing exclusion would be needed, until the vegetation is well established.

A shallow and wide concrete conduit at the crossing (Figure 11) should be considered, to aid with aquatic organism passage. This feature could consist of a wide and shallow concrete box with a natural channel bottom at an appropriate grade to maintain the upstream wetland. The top would be removable (steel grating or concrete lid), for maintenance (removal of sediment deposition). This option may require reconstruction of the low water crossing, to maintain the upstream wetland and better match existing surfaces. The current crossing is lower in grade than the adjacent floodplain surface (Figure 2); it should be at the same grade as the floodplain surface, to reduce maintenance. A secondary (bypass) channel could also be added, if multiple channels are deemed beneficial. If the crossing is reconstructed, a new alignment that is perpendicular to the valley profile is recommended. Such an alignment would likely result in a more stable structure.

ACKNOWLEDGEMENTS

Bob Gubernick was consulted to help develop the recommendations of this report – his thoughts were valuable and appreciated.

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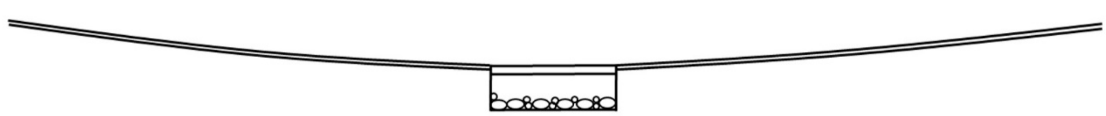

Figure 11: Valley cross section sketch at the crossing illustrating a proposed wide and shallow conduit for providing aquatic organism passage.

APPENDIX A: AERIAL IMAGERY

Figure A-1: Tularosa River at NFSR-233 (2017-10-14).

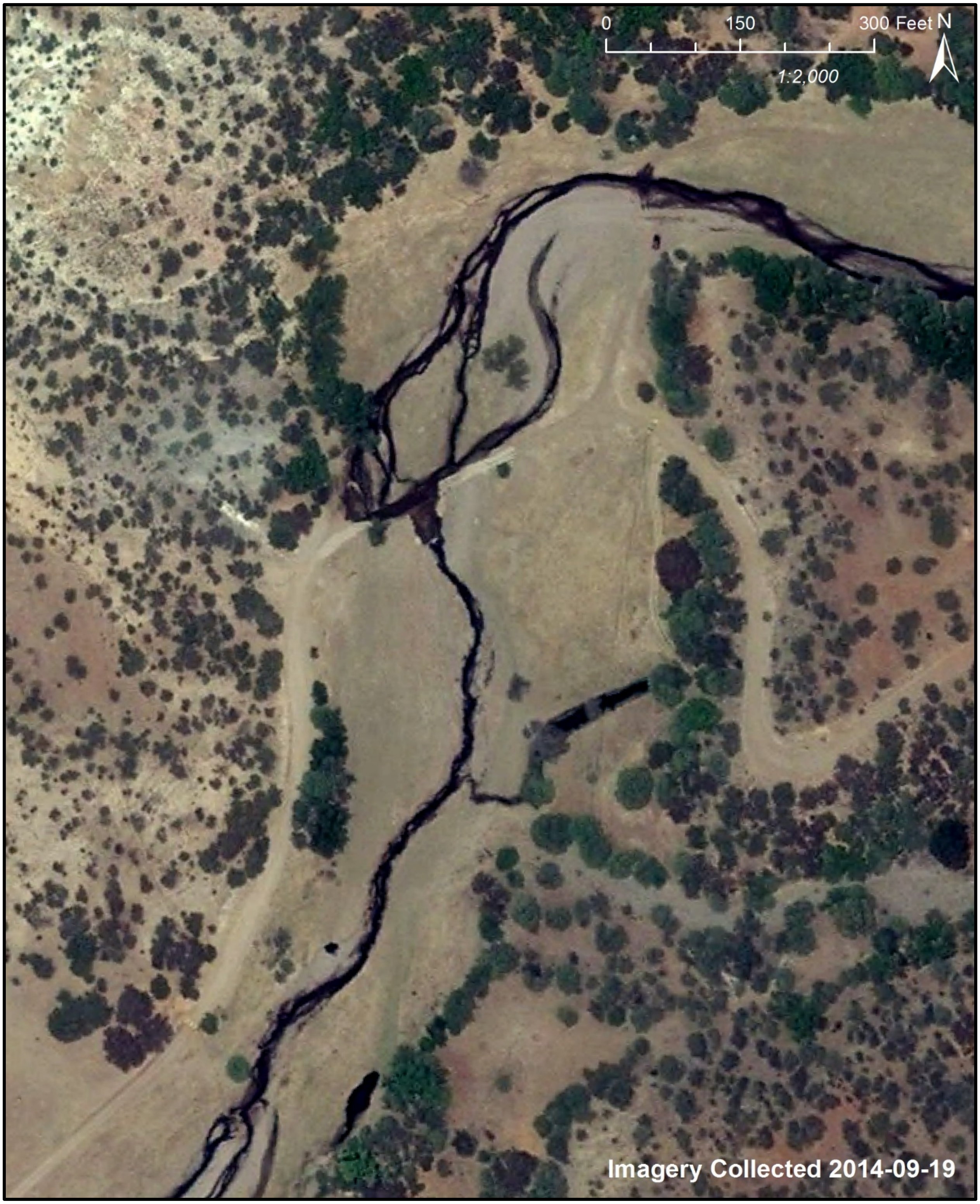

Figure A-2: Tularosa River at NFSR-233 (2014-09-19).

Figure A-3: Tularosa River at NFSR-233 (2006-07-01).

Figure A-4: Tularosa River at NFSR-233 (1964-06-23).