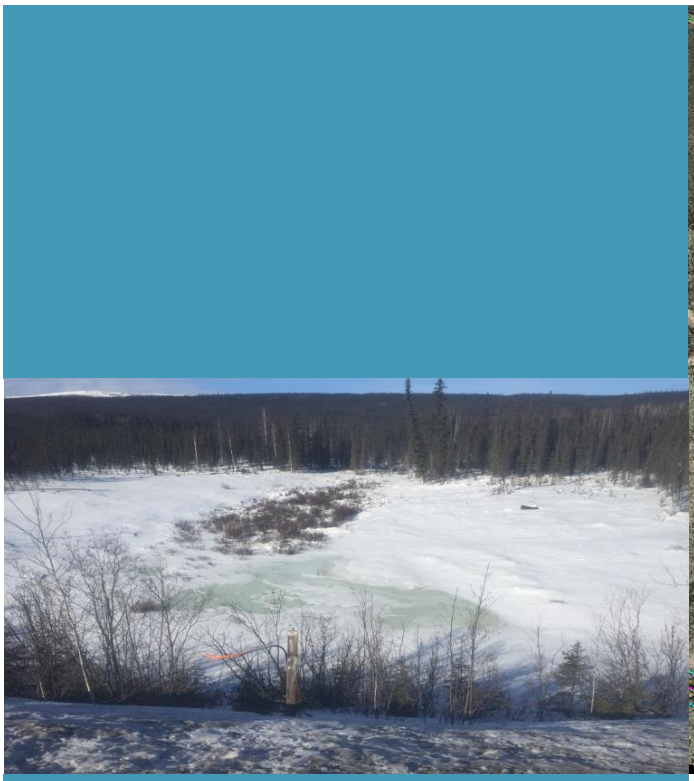

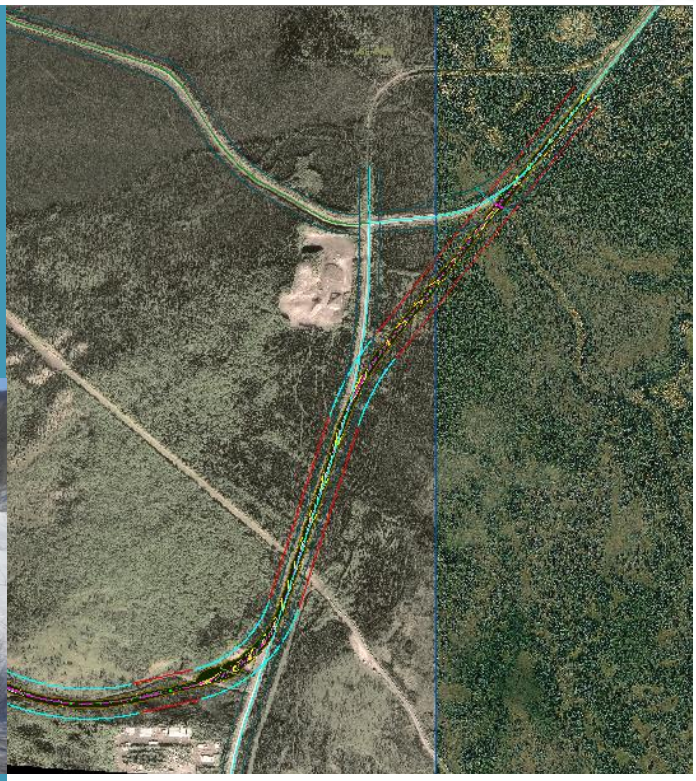

Dalton Highway MP 0 - 9 Reconstruction Preliminary H&H

Alaska Department of Transportation & Public Facilities

Prepared by
HDR

Anchorage Alaska

April 22, 2016

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Contents

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Location and Site Map

This project is located north of Fairbanks, AK at the southern end of the Dalton Highway, mileposts 0 to 9. The project includes a realignment of the first (approximately) 6.5 miles with additional work to improve safety (grades and curve radii) and capacity. Figure 1 identifies the project location in reference to the State of Alaska. Figure 2 provides an aerial view of the project which begins near MP 73 on the Elliott Highway approximately ¼ mile before its intersection with the Dalton Highway, follows the West Fork of the Tolovana River valley to its confluence with Lost Creek, and then follows that valley upstream to rejoin the existing Dalton Highway just past MP 6.

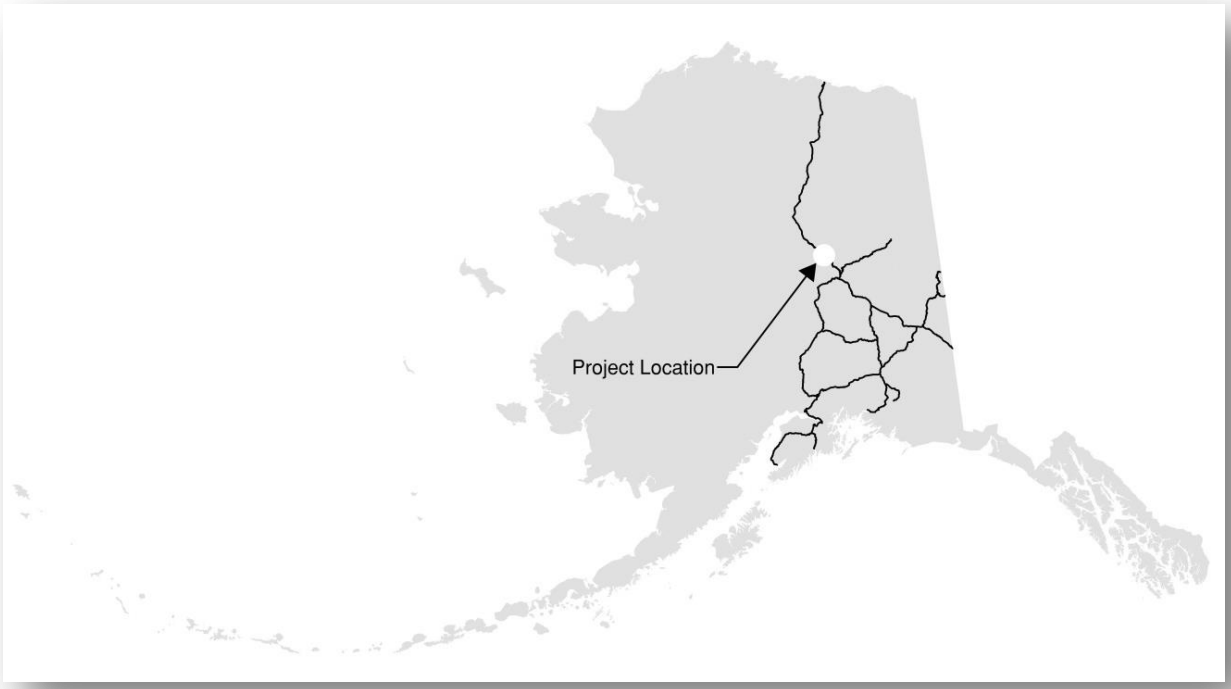

Figure 1 Dalton Highway MP 0.0-9.0 Location Map

Figure 2 shows the existing Elliott and Dalton Highway alignment (gold) which generally follows the ridgeline and two alignment alternatives which follow the river valleys; O2 alignment (yellow) and O5 alignment (green). The alternatives will be discussed in the following section.

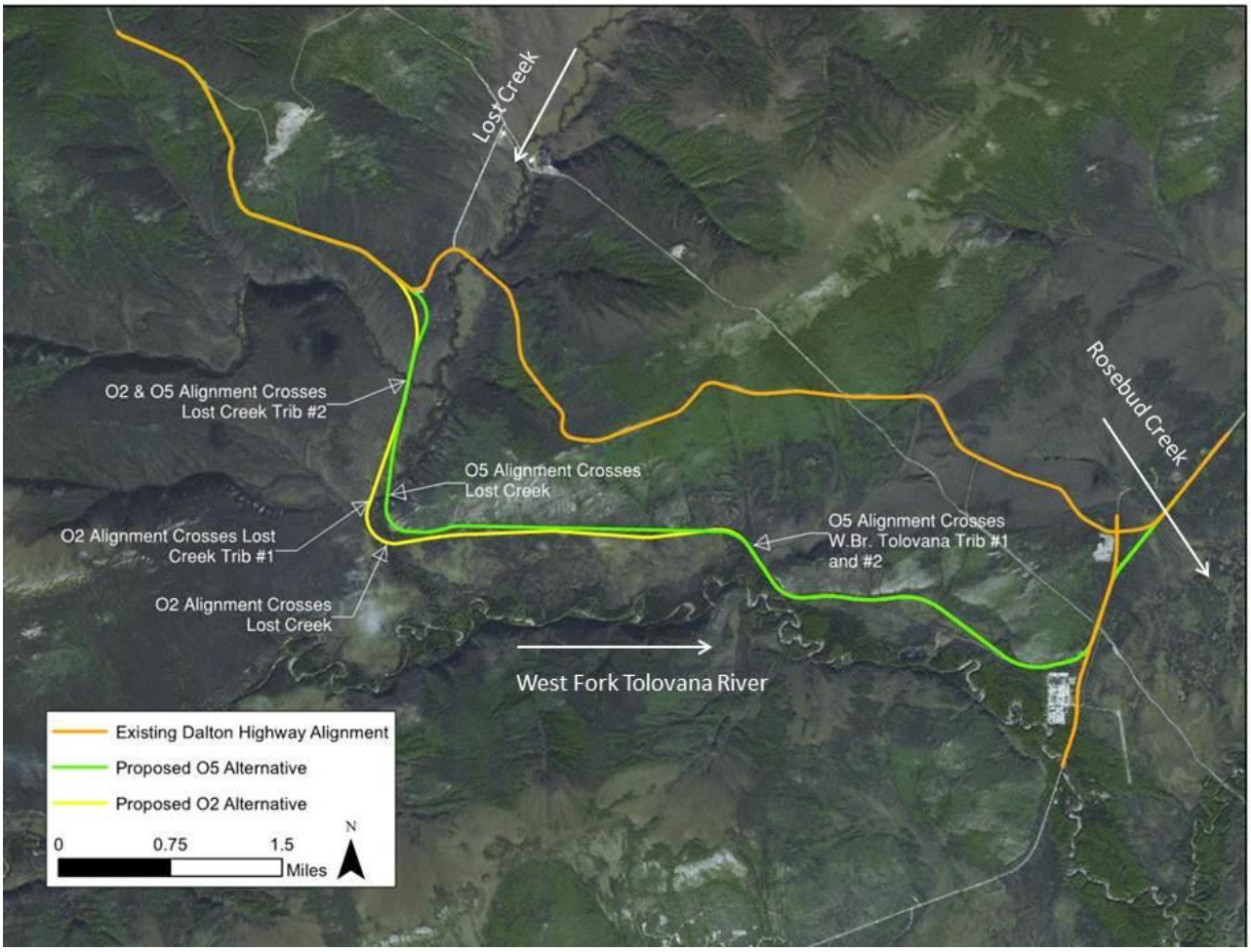

Figure 2 Dalton Highway MP 0.0-9.0 Site Map

Project Alternatives

The Alaska Department of Transportation & Public Facilities has considered two highway realignments; both have the same general routing with a few variations to take advantage of local topography. In general both of these alignments begin on the Elliott Highway (MP 73) near its intersection with the Dalton Highway. The alignment diverges from the Elliott Highway at the Rosebud Creek crossing (on the east side of the project site) and then heads to the southwest. After approximately 6,000 ft. and rejoining the existing Elliott Highway, the alignments turn toward the west and follow the West Fork of the Tolovana River valley, crossing two minor tributaries. The O2 alignment crosses Lost Creek and turns to the north, crossing Lost Creek Tributary #1 and Tributary #2 before rejoining the existing Dalton Highway alignment near MP 6. The O5 crosses Lost Creek further upstream than the O2 alignment, thus avoiding Lost Creek Trib #1 entirely and passes over Lost Creek Tributary #2 before rejoining the existing Dalton Highway alignment near MP 6. Figure 2 shows that the O5 alignment is moved slightly to the north and slightly up the base of the hill to avoid wetlands areas and poorly defined drainages. The O5 alignment is the current preferred alignment and will be the only one further discussed in this report.

Hydraulic Site History

The Alaska Department of Transportation & Public Facilities – Northern Region collected a variety of information and studies that help characterize the hydraulics of the proposed alignments. This information plus observations from a winter field trip on March 20-21 were used for this preliminary hydraulics assessment.

From an environmental perspective, the ADOT&PF has already completed a preliminary wetlands assessment for the total project area of 1257.2 acres, which includes 738.2 acres along the 500-1000 ft wide realignment corridor, 200 ft on either side of the existing Dalton Highway centerline between MP 7-9, 237.1 acres at the intersection of the Dalton and Elliott Highways and Manley Hot Springs Road, and 281.9 acres at the material site. Of this area, the project potentially impacts 436.4 acres of jurisdictional wetlands, 5.3 acres of Waters of the U.S., and 815.5 acres of uplands. The wetlands were identified as primarily shrub and forested-shrub wetlands and given a wetland function and value of low. The Waters of the U.S. represent ponds and streams/rivers and were given a function and value of moderate to high.

The Department has had preliminary conversations with the Alaska Department of Fish and Game (ADF&G) to determine which of the highway creek crossings will need to account for fish habitat. Based on inspections by the ADF&G, of the six crossings encountered in the project, two of them contain fish habitat, and consequently will require fish passage designs. Lost Creek has been identified as a bridge crossing and will be designed by the Department. The preferred O5 alignment moves slightly up the base of the hill along the West Fork of the Tolovana River valley and deletes the requirement of a crossing at Lost Creek Tributary #1, both actions further lessening the impacts to wetlands and Waters of the U.S. The following list identifies the O5 alignment crossings and fish habitat determination.

1. Rosebud Creek – No Fish Habitat
2. Lost Creek – Fish Habitat
3. Lost Creek Tributary #2 – Fish Habitat
4. West Fork Tolovana Tributary #1 – No Fish Habitat
5. West Fork Tolovana Tributary #2 – No Fish Habitat

Lost Creek Tributary #2 will be designed as a fish passage culvert (design by HDR).

Potential aufeis concerns have been identified based on the O5 alignment cross section data provided in AutoCAD Civil3D. Based on the cut and fill cross sections, Table 1 identifies ranges of stations that are cut below the existing ground surface, which may increase the potential for groundwater seepage and aufeis formation. In addition, where the existing ground slope is flat on the downslope side of the road prism, there exists potential for aufeis development, especially where local drainage or seepage flows exists. These areas will be given more scrutiny as the design progresses.

Table 1 O5 Alignment Cut Sections with Potential for Aufeis Formation

No.	From STA	To STA	Notes
1	18+00	23+00	Large Cut (>10 ft. BG)
2	38+00	40+00	Medium Cut (5 ft.-10 ft. BG)
3	51+00	84+00	Large
4	160+00	161+50	Small Cut (<5 ft. BG)
5	188+50	192+00	Large
6	206+00	210+00	Medium
7	214+00	221+50	Large
8	242+00	258+00	Large
9	262+00	267+00	Medium
10	272+00	283+00	Large
11	290+00	334+00	Large
12	336+50	350+00	Large
13	406+00	429+00	Large
14	451+00	467+00	Medium
15	504+00	508+00	Medium
16	516+00	517+50	Small
17	542+00	542+50	Small
18	545+00	547+00	Small

These stations should be evaluated further with a field visit including evaluation of borehole locations in reference to the ranges of the cuts to determine groundwater seepage and aufeis formation potential. Any areas identified to have aufeis formation potential should have design elements to reduce possible accumulations.

As the project moves forward, the following historical topics should be researched, if information is available, to further the design: flood of record discharge and elevation (local and regional events), high water marks, ordinary high water marks, navigation potential (winter and open water), sediment or debris accumulations at confluences of creeks and tributaries, mining activity, culvert debris loading issues, geomorphology and channel changes, bedload and sediment transport characteristics.

Local Input

Local input to collect institutional knowledge of the existing and proposed alignment is critical to determining and overcoming project hurdles. As the project moves forward to design, it is recommended that the team contact regional DOT operations and maintenance crews, to identify their areas of concerns. Communication should be maintained with regional contacts for local, state, and federal agencies including: U.S. Army Corps of Engineers, Alaska Department of Fish & Game, Alaska Department of Environmental Conservation, the Department of Economic and Community Development, and additional stakeholders as identified.

Hydrology

The hydrology of the five creek crossings in the project were completed at a preliminary level using the USGS Report 03-4188, Alaska peak flow regression equations. The following sections describe the drainage basins, geometry, expected flood frequency flows, and design discharges.

Drainage Basins

There are five drainages that the proposed O5 alignment will cross: Rosebud Creek, West Fork Tolovana Tributary #1, West Fork Tolovana Tributary #2, Lost Creek, and Lost Creek Tributary #2. The creek basins were delineated by the Department using the USGS 100 ft. contour maps. All of these basins are rural and contain little development with the exception of the Alyeska pipeline, the Dalton Highway, and a few remote cabins. Generally these basins are subarctic tundra covered with tundra shrubs and black spruce.

Flood Frequency Analysis

The USGS Region 6 regression equations develop flows based on the area of the drainage basin, the percent area of lakes and ponds, and the percent area of forest. Table 2 identifies the parameters for each basin, and the calculated 2-year, 50-year, and 100-year flows. These flows will be required for fish passage, culvert design flow, and bridge design flows; respectively. The table indicates the stationing for the crossings along the O5 alignment. The discharge values for Lost Creek are also shown, even thought this bridge will be designed by the Department.

Table 2 USGS Regression Equation Variables and Flow Estimates

Creek Name, Mile Post	Basin Area (Sq. Mi.)	Area of Lakes and Ponds (%)	Area of Forest (%)	2-Year Event (cfs)	50-Year Event (cfs)	100-Year Event (cfs)
Rosebud Creek, MP 24+00 (O5)	1.8	0	61.1	25	123	151
West Fork Tolovana Trib. #1, MP 203+50 (O5)	3.15	0	73	39	185	225
West Fork Tolovana Trib. #2, MP 215+50 (O5)	0.63	0	95.2	9	49	61
Lost Creek, MP 651+00 (O5)	53.8	0.54	52.8	485	1660	1940
Lost Creek Trib. #2, MP 393+00 (O5)	10.95	0	69	121	499	598

Fish Passage Flows (Culverts Only)

For the preferred O5 alignment, there is only one crossing that would require culvert stream simulation design: Lost Creek Tributary #2 at MP 393+00. As recommended by stream simulation design, the 2-year frequency flood flow is the preferred fish passage design flow. Based on the USGS regression equation analysis provided in the previous section, the 2-year flood flow for Lost Creek Tributary #2 is 121 cfs. The culvert sizing will be guided by the fish passage dimensional design as stipulated in the ADF&G-ADOT Memorandum of Understanding on fish passage designs, as well as the flood capacity design (discussed in the next section).

Peak Design Discharge

The peak design discharge for ADOT&PF highway projects is based on a number of factors, but is summarized as Table 3 below as presented in Table 1120-1 of Section 1120-9 of the Alaska Highway Preconstruction Manual (AHPCM). Because this highway realignment is in a remote section of Alaska there are no designated flood hazard areas defined by FEMA. This in turn means that the 50-year flood is the design discharge for culverts. For bridges in remote areas the flood design discharge is also the 50-year event; however, the scour design and subsequent scour design check is the 100-year event and 500-year (or 1.7x100-year) event, respectively. Therefore, bridge analysis should consider the 50-year, 100-year, and 500-year (or 1.7x100-year) events for the design process.

Table 3 ADOT&PF Design Flood Frequency

Type of Structure	Design Frequency Exceedance Probability
Culverts in designated flood hazard areas*	100 years (1%)
Culverts on primary highways	50 years (2%)
Culverts on secondary highways with high DHVs or providing sole area access	50 years (2%)
Culverts on secondary highways of less importance	10 years (10%)
Channel changes in designated flood hazard areas	100 years (1%)
Channel changes along primary highways and important secondary highways	50 years (2%)
Channel changes along less important secondary highways	25 years (4%)
Trunk storm sewers lines on primary highways	50 years (2%)
All other trunk storm sewer lines	25 years (4%)
Storm sewer feeder lines	10 years (10%)
Side ditches, storm water inlets, and gutter flow	10 years (10%)
Bridges in designated flood hazard areas*	100 years (1%)
Bridges on all highways	50 years (2%)
Scour at bridges, design	100 years (1%)
Scour at bridges, check	1.7x100 years or 500 years (0.2%)

* Unless local ordinance requires a greater design frequency

Note: In addition to the exceedance probability used for design purposes, the Federal Highway Administration under Executive Order #11988 and the State of Alaska under Administrative Order #46 (AO #46) require the evaluation of a structure's ability to pass an event with an exceedance probability of 1 percent (Q100). This evaluation is required on all tidal and freshwater stream encroachments (i.e. 100-year tidal surge and/or 100-year flood). AO #46 further requires the evaluation of flood-related, erosion-prone, and mud slide (i.e. mud flow) hazard areas. In the case of erosion, this includes currents of water exceeding anticipated cyclical levels, an unusually high water level in a natural body of water accompanied by a severe storm, an unanticipated force of nature, a flash flood or an abnormal tidal surge, or some similarly unusual and unforeseeable event that results in flooding. For mud slides, this includes periods of unusually heavy or sustained rain.

Hydraulics

As the project moves forward, the specific hydraulics at each crossing will be further refined. It is recommended that at each site an existing and proposed conditions hydraulic analysis be performed to satisfy environmental regulations, in particular flood hazard and floodplain impacts. In addition to floodplain analysis, the models will be used to determine the potential scour depth, scour counter measures, and riprap sizes for the culvert crossings. The model for the Lost Creek Tributary #2 at MP 393+00 (alignment O5) will also be used to size the stream simulation substrate placed in the culvert. These models should be developed later in the project following the gathering of additional survey and field data to assist engineers and project managers in the design and analysis. The following sections detail the preliminary hydraulics computed for each creek. HY8 results supporting the preliminary hydraulic calculations are located in Appendix A. For each of the four culvert designs (Rosebud, West Fork Tolovana Tributary #1 and #2, and Lost Creek Tributary #2), the culvert was placed at the existing general ground slope with modifications to provide adequate cover. Future design refinements will include actual drainage channel slope, widths, and banklines (measured in a future survey) to provide the optimal placement.

Rosebud Creek

Rosebud Creek has two potential alternative designs: 1) replace the existing culvert under the Elliott Highway and extend it past the toe of slope on the new proposed alignment; or 2) demolish the existing culvert and highway to reestablish that part of the creek and install a shorter culvert under the new proposed alignment. The first alternative would allow the existing roadway to be retained for local use and is the current preferred option but would create a culvert approximately 260 LF in length. The preliminary hydraulics completed before and during this report indicates that a 6 ft. diameter pipe would provide sufficient 50-year flood flow capacity; however, it would not address the aufeis problems in this area. HY8 tables for the Rosebud Creek crossing and a road prism/culvert diagram are included in Appendix A. The 6 ft. diameter circular culvert was assumed to lie at the average creek slope in this reach of 1.8%. There is adequate coverage for the culvert but the outlet velocities will require scour protection. Refinements to the design including the existing channel capacity and shape both upstream and downstream of the culvert will be addressed in future designs. This culvert currently experiences complete freeze-up through aufeis generation over the winter. Mitigation efforts will be considered in future designs.

West Fork Tolovana Tributary #1

Of the two West Fork Tolovana tributaries, #1 has a larger drainage basin and a fairly well defined channel until it reaches the crossing location. There are several relic channels and oxbows in the area. A clear channel cannot be determined from the topographic data, aerial photos, LiDAR or even observations made during the winter field trip. The preliminary hydraulics for the West Fork Tolovana tributary #1 were based on an assumption of the crossing being at station 203+00 of Alignment O5 and using the road prism cross section for that location and general channel reach slope. The analysis indicated that the required conveyance area could be met with three 4 ft diameter culverts placed at a 2.2% slope. HY8 tables for the West Fork Tolovana Tributary #1 crossing and a road prism/culvert diagram are included in Appendix A. This arrangement, however, does have a limited amount of coverage for the culverts and there may need to be a vertical adjustment of the road centerline elevation of approximately 3 ft. Field surveys and field visits will be needed to identify and detail the creek channel extents, thalweg location, banks, ordinary high water, and other parameters in order to properly design the culverts.

West Fork Tolovana Tributary #2

This small drainage basin is well defined on the side of the hill but as it approaches the O5 alignment, its path is less clear. The preliminary hydraulics for the West Fork Tolovana tributary #2 were based on an assumption of the crossing being at station 216+00 of Alignment O5 and using the road prism cross section for that location and general channel reach slope. The analysis indicated that the required conveyance area could be met with a single 4 ft diameter culvert placed at a 5.6% slope which corresponds to the general channel reach slope. HY8 tables for the West Fork Tolovana Tributary #2 crossing and a road prism/culvert diagram are included in Appendix A. The road prism at this location, however, is quite small and does not have adequate coverage for the culvert and there may need to be a vertical adjustment of the road elevation of up to 6 ft. There may be options to provide for an extended upslope embankment and creating more of a channel to collect flow or to create a more defined channel. Field surveys and field visits will be needed to identify and detail the creek channel extents, thalweg location, banks, ordinary high water, and other parameters in order to properly design the culvert.

Lost Creek

The hydraulics for this crossing were not analyzed because it will be designed as a bridge by the Department.

Lost Creek Tributary #2

Lost Creek Tributary #2 has been identified by the ADF&G as potential fish habitat. This crossing will be designed to account for fish passage. The preliminary hydraulics for Lost Creek Tributary #2 looked at the 2-year fish passage flow calculations and estimated a 9 ft. diameter circular culvert with 40% embedment (3.6 ft.) to satisfy the stream simulation design requirements. This culvert was based on a crossing location at station 393+00 and an existing channel reach slope of 2.4%. It was verified that the proposed culvert would have sufficient flood flow capacity to pass the 50-year event. HY8 tables for the Lost Creek Tributary #2 crossing and a road prism/culvert diagram are included in Appendix A. A field visit and survey will be needed to identify fish passage parameters, ordinary high water and bank full widths, thalweg slope, channel substrate, etc. Other design guidance requirements of stream simulation could dictate a different size or culvert configuration.

Removal of Existing Culvert Crossings

There are two crossings on the existing Dalton Highway alignment that will be removed following the construction of the new roadway section. The crossing of West Fork Tolovana Tributary #1 at existing MP 1.7 is a deep fill section with unknown culvert sizing and location. Removal of the roadway section will allow the tributary to return to pre-road construction conditions with potential improvement of the natural channel habitat immediately upstream and downstream of the existing culvert. This tributary crossing is not in fish bearing waters.

The culvert crossing at existing MP 5.6 consists of several culverts with varying invert elevations. A large (5 ft) single culvert carries the main channel of Lost Creek under the Highway and discharges into an off-channel pool before returning to the main channel. The off-channel pool at the culvert outlet is used as a water supply for road maintenance operations. The large culvert appears to remain submerged throughout the year. Three additional culverts (4 ft) pass beneath the Highway slightly to the NW with their inlets at a higher elevation to provide floodplain connectivity. Their perched outfalls discharge to the main channel just upstream of the off-channel pool. Additional culverts further NW provide a similar function. Aerial photography shows a pool on the upstream side of the Highway at this location. The Lost Creek valley at MP 5.6 is characterized by a tree-lined meandering channel with wide low shrub wetlands. Removal of these culverts would improve

wetlands and flood plain function, and fish passage on Lost Creek. The length of roadway embankment removal will impact of the degree of remediation.

Drainage Ditch Design

The O5 alignment generally follows the hillsides along the West Fork Tolovana River and Lost Creek. As such, a drainage ditch that will be created on the uphill side of the highway and require several cross drainage culverts. As the design progresses and the locations of these cross drainage culverts are identified, the ditch flow rates, aufeis potential, culvert sizing and need for scour protection will be determined.

Regulatory Flood Hazard Analysis

23 CFR 650.111

Crossings of perennial streams must comply with federal flood hazard regulations. Because this project does not cross any special flood hazard areas or jurisdiction by National Flood Insurance Program (NFIP) participants, the Federal Highway Administration (FHWA) flood hazard regulations take precedence. FHWA and ADOT&PF, 23 CFR 650.111, “Location Hydraulics Study” defines the federal flood hazard regulations. These regulations address the impacts of proposed encroachments on natural floodways and floodplains. The design of the highway, culverts, and bridges should include an assessment of the impacts of the project on the natural and beneficial floodplain values. The assessment should consider measures to minimize impacts, measures to preserve or restore floodplain values, and the practicality of alternatives to significant encroachment.

If as this project moves forward, the flood hazard federal regulations change due to Executive Order(EO) 13690 revision of EO 11988, agencies may be required to establish Federal Flood Risk Management Standards (FFRMS). This process is underway but may take several years before any modifications are made to the regulations. Progress of the EO should be tracked by the team to make sure this project takes into consideration the potential change in regulations.

Conclusions

Preliminary analysis and design has verified many of the initial calculations conducted by ADOT&PF in terms of the hydrologic and hydraulic design of the realignment of the Dalton Highway MP 0-9. ADF&G has verified that only the Lost Creek crossing (bridge designed by the Department) and Lost Creek Tributary #2 are potential fish habitat and require design for fish passage. The peak flow hydrology developed for these crossings was based on the USGS Regional Regression Equations. Basin delineations were developed from USGS topographic maps with 100 ft contour intervals. Further refinements to the hydrology would not likely change these flow estimates significantly. A consideration of potential climate change within the 50-year design life of these crossings is prudent.

The preliminary hydraulic design of each of the crossings (Rosebud Creek, West Fork Tolovana Tributary #1 and #2, and Lost Creek Tributary #2) are based on previously collected data, the proposed O5 alignment, and the road prism cross section data provided. As more detailed information at the specific crossing locations are collected, the hydraulic designs will be modified to account for natural channel locations and dimensions, scour protection requirements, and fish passage (Lost Creek Tributary #2).

The removal of existing culvert crossings on the Dalton Highway represents opportunities to earn mitigation credits for restoration of the historic creek bed and adjacent floodplain plus improvement of fish passage in Lost Creek. As the designs progress, details on the amount of roadway embankment removal, any channel modifications required, and bank protection necessary will be determined.

Future tasks include Plans, Specifications, and Estimates (PS&E) at the 95% review phase, 100% (final stamped), support during bidding, construction, and permitting. These tasks will be covered under amendments to the project and NTP.

Appendix A Preliminary Hydraulics

Rosebud Creek

Site Data - 6' 1.8% slope
Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 494.90 ft
Outlet Station: 260.00 ft
Outlet Elevation: 490.00 ft
Number of Barrels: 1

Culvert Data Summary - 6' 1.8% slope
Barrel Shape: Circular
Barrel Diameter: 6.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: NONE

Tailwater Channel Data - Rosebud Long Span
Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 6.00 ft
Side Slope (H:V): 2.00 (_:1)
Channel Slope: 0.0500
Channel Manning's n: 0.0400
Channel Invert Elevation: 490.00 ft

Roadway Data for Crossing: Rosebud Long Span
Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 300.00 ft
Crest Elevation: 512.00 ft
Roadway Surface: Paved
Roadway Top Width: 36.00 ft

Crossing Discharge Data
Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 25 cfs
Design Flow: 123 cfs
Maximum Flow: 151 cfs

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
25.00	490.64	0.64	5.40	1.99	1.29
37.60	490.80	0.80	6.15	2.51	1.33
50.20	490.95	0.95	6.73	2.95	1.36
62.80	491.07	1.07	7.21	3.34	1.38
75.40	491.18	1.18	7.61	3.69	1.40
88.00	491.29	1.29	7.97	4.02	1.41
100.60	491.38	1.38	8.28	4.32	1.42
113.20	491.48	1.48	8.57	4.60	1.43
123.00	491.54	1.54	8.78	4.81	1.44
138.40	491.64	1.64	9.08	5.12	1.45
151.00	491.72	1.72	9.30	5.36	1.46

Table 1 - Downstream Channel Rating Curve (Crossing: Rosebud Creek)

Table 2 - Summary of Culvert Flows at Crossing: Rosebud Creek

Headwater Elevation (ft)	Total Discharge (cfs)	6' 1.8% slope Discharge (cfs)	Roadway Discharge (cfs)	Iterations
496.80	25.00	25.00	0.00	1
497.26	37.60	37.60	0.00	1
497.65	50.20	50.20	0.00	1
498.01	62.80	62.80	0.00	1
498.35	75.40	75.40	0.00	1
498.68	88.00	88.00	0.00	1
499.00	100.60	100.60	0.00	1
499.31	113.20	113.20	0.00	1
499.54	123.00	123.00	0.00	1

499.92	138.40	138.40	0.00	1
500.22	151.00	151.00	0.00	1
512.00	434.17	434.17	0.00	Overtopping

West Fork Tolovana Tributary #1

Site Data - 4'x3 2.2% slope
Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 476.00 ft
Outlet Station: 109.30 ft
Outlet Elevation: 473.60 ft
Number of Barrels: 3

Culvert Data Summary - 4'x3 2.2% slope
Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: NONE

Tailwater Channel Data - West Fork Tolovana #1
Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 14.00 ft
Side Slope (H:V): 2.00 (_:1)
Channel Slope: 0.0200
Channel Manning's n: 0.0400
Channel Invert Elevation: 473.60 ft

Roadway Data for Crossing: West Fork Tolovana #1
Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 300.00 ft
Crest Elevation: 483.00 ft
Roadway Surface: Paved
Roadway Top Width: 36.00 ft

Crossing Discharge Data
Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 39 cfs
Design Flow: 185 cfs
Maximum Flow: 225 cfs

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
39.00	474.27	0.67	3.77	0.84	0.84
57.60	474.45	0.85	4.33	1.06	0.87
76.20	474.60	1.00	4.77	1.25	0.89
94.80	474.73	1.13	5.14	1.42	0.91
113.40	474.86	1.26	5.46	1.57	0.92
132.00	474.97	1.37	5.74	1.71	0.93
150.60	475.08	1.48	5.99	1.85	0.94
169.20	475.18	1.58	6.22	1.98	0.95
185.00	475.27	1.67	6.41	2.08	0.95
206.40	475.37	1.77	6.63	2.21	0.96
225.00	475.46	1.86	6.82	2.32	0.97

Table 3 - Downstream Channel Rating Curve (Crossing: West Fork Tolovana #1)

Table 4 - Summary of Culvert Flows at Crossing: West Fork Tolovana #1

Headwater Elevation (ft)	Total Discharge (cfs)	4'x3 2.2% slope Discharge (cfs)	Roadway Discharge (cfs)	Iterations
477.53	39.00	39.00	0.00	1
477.88	57.60	57.60	0.00	1
478.20	76.20	76.20	0.00	1
478.50	94.80	94.80	0.00	1
478.78	113.40	113.40	0.00	1
479.06	132.00	132.00	0.00	1
479.34	150.60	150.60	0.00	1
479.62	169.20	169.20	0.00	1
479.86	185.00	185.00	0.00	1

480.19	206.40	206.40	0.00	1
480.50	225.00	225.00	0.00	1
483.00	344.94	344.94	0.00	Overtopping

West Fork Tolovana Tributary #2

Site Data - 4' at 5.6% slope
Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 512.78 ft
Outlet Station: 107.40 ft
Outlet Elevation: 506.78 ft
Number of Barrels: 1

Culvert Data Summary - 4' at 5.6% slope
Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: NONE

Tailwater Channel Data - West Fork Tolovana #2
Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 4.00 ft
Side Slope (H:V): 2.00 (_:1)
Channel Slope: 0.1000
Channel Manning's n: 0.0400
Channel Invert Elevation: 506.78 ft

Roadway Data for Crossing: West Fork Tolovana #2
Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 300.00 ft
Crest Elevation: 526.00 ft
Roadway Surface: Paved
Roadway Top Width: 36.00 ft

Crossing Discharge Data
Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 9 cfs
Design Flow: 49 cfs
Maximum Flow: 61 cfs

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
9.00	507.14	0.36	5.30	2.25	1.67
14.20	507.25	0.47	6.15	2.92	1.73
19.40	507.34	0.56	6.79	3.48	1.77
24.60	507.42	0.64	7.31	3.98	1.80
29.80	507.49	0.71	7.75	4.43	1.82
35.00	507.56	0.78	8.13	4.84	1.84
40.20	507.62	0.84	8.48	5.22	1.86
45.40	507.67	0.89	8.78	5.57	1.87
49.00	507.71	0.93	8.98	5.81	1.88
55.80	507.78	1.00	9.32	6.23	1.90
61.00	507.83	1.05	9.57	6.53	1.91

Table 5 - Downstream Channel Rating Curve (Crossing: West Fork Tolovana #2)

Table 6 - Summary of Culvert Flows at Crossing: West Fork Tolovana #2

Headwater Elevation (ft)	Total Discharge (cfs)	4' at 5.6% slope Discharge (cfs)	Roadway Discharge (cfs)	Iterations
514.00	9.00	9.00	0.00	1
514.33	14.20	14.20	0.00	1
514.61	19.40	19.40	0.00	1
514.87	24.60	24.60	0.00	1
515.12	29.80	29.80	0.00	1
515.37	35.00	35.00	0.00	1
515.60	40.20	40.20	0.00	1
515.84	45.40	45.40	0.00	1
516.00	49.00	49.00	0.00	1

516.30	55.80	55.80	0.00	1
516.54	61.00	61.00	0.00	1
526.00	176.48	176.48	0.00	Overtopping

Lost Creek Tributary #2

Site Data - 9' at 2.4% slope
Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 602.36 ft
Outlet Station: 104.50 ft
Outlet Elevation: 600.11 ft
Number of Barrels: 1

Culvert Data Summary - 9' at 2.4% slope
Barrel Shape: Circular
Barrel Diameter: 9.00 ft
Barrel Material: Corrugated Steel
Embedment: 43.20 in
Barrel Manning's n: 0.0240 (top and sides)
Manning's n: 0.0350 (bottom)
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: NONE

Tailwater Channel Data - Lost Creek Trib #2
Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 9.00 ft
Side Slope (H:V): 2.00 (_:1)
Channel Slope: 0.0250
Channel Manning's n: 0.0400
Channel Invert Elevation: 600.11 ft

Roadway Data for Crossing: Lost Creek Trib #2
Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 300.00 ft
Crest Elevation: 624.00 ft
Roadway Surface: Paved
Roadway Top Width: 36.00 ft

Crossing Discharge Data
Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 121 cfs
Design Flow: 499 cfs
Maximum Flow: 598 cfs

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
121.00	601.65	1.54	6.52	2.40	1.04
168.70	601.96	1.85	7.20	2.88	1.06
216.40	602.22	2.11	7.75	3.30	1.08
264.10	602.46	2.35	8.20	3.67	1.09
311.80	602.68	2.57	8.60	4.00	1.10
359.50	602.87	2.76	8.95	4.31	1.11
407.20	603.06	2.95	9.26	4.60	1.12
454.90	603.23	3.12	9.55	4.87	1.13
499.00	603.39	3.28	9.80	5.11	1.14
550.30	603.55	3.44	10.06	5.37	1.14
598.00	603.70	3.59	10.29	5.60	1.15

Table 7 - Downstream Channel Rating Curve (Crossing: Lost Creek Trib #2)

Table 8 - Summary of Culvert Flows at Crossing: Lost Creek Trib #2

Headwater Elevation (ft)	Total Discharge (cfs)	9' at 2.4% slope Discharge (cfs)	Roadway Discharge (cfs)	Iterations
608.52	121.00	121.00	0.00	1
609.23	168.70	168.70	0.00	1
609.92	216.40	216.40	0.00	1
610.59	264.10	264.10	0.00	1
612.95	311.80	311.80	0.00	1
613.67	359.50	359.50	0.00	1
614.41	407.20	407.20	0.00	1

615.24	454.90	454.90	0.00	1
616.77	499.00	499.00	0.00	1
618.52	550.30	550.30	0.00	1
620.32	598.00	598.00	0.00	1
624.00	685.62	685.62	0.00	Overtopping