Compared to the alternative at the existing crossing, the proposed bridge location near RM 44.6 minimizes the long term risk to flood and erosion hazards. The design in this segment provides a longer span and is more resilient to lateral channel migration.

ENGINEERING ISSUES

Lolo Pass Road provides public access from US 26 to the west side of the MHNF. The road is the sole winter access to the MHNF and to more than 200 residences, cabins and campgrounds north of East Barlow Trail Road.

ROADWAY CLASSIFICATION AND DESIGN SPEED

The Clackamas County functional class map shows Lolo Pass Road as a minor arterial north of East Barlow Trail Road, and it is assumed to be a rural minor arterial based on the project's location outside an urban area and without urban features, such as curbs or sidewalks. The design of the existing roadway does not meet the basic rule (55 mph) in all locations, but where possible, the new or replacement roadway would be developed to meet this standard. The alternatives analysis assumed a design for the proposed roadway that meets AASHTO standards and aims for a 50 to 55 mph design speed. Design exceptions would be written as needed if this standard were not met. During a future design phase of the project, the applicable design criteria and any design exceptions would need to be finalized.

Lolo Pass Road:

- Functional Classification: Rural Major Collector (FHWA)
- Rural Minor Arterial (Clackamas County Transportation System Plan)
- Design Speed: 55 mph
- Surface Type: Asphalt Concrete Pavement
- Design Volume: 3,000 Average Daily Traffic (ADT)

DESIGN ASSUMPTIONS

Conceptual alignments were laid out for the three primary alternatives under consideration based on the design criteria and findings regarding hydraulics, biological resources and other sensitive resources. Profile drawings and river cross-section data are presented in Appendix D.

Table 2 presents design criteria for the proposed road work for Lolo Pass Road and the new alignment alternatives. The design criteria are divided into two sections: south of East Barlow Trail Road (which currently has a speed order and is posted for 45 mph) and north of East Barlow Trail Road (which is "basic rule," allowing 55 mph). The new roadway would have 11-

foot travel lanes and 6-foot paved shoulders, and guardrail on steep embankments and bridge approaches. For a 55 mph design speed, 8-foot shoulders are the standard, so using 6-foot shoulders would require a design exception. The typical section was selected based on the criteria for a rural roadway and the design speed.

As discussed above in the descriptions of alternatives, the Zigzag Mountain Alternatives were developed with two possible options for connecting to Lolo Pass Road at both ends of the Zigzag Mountain Alternatives (i.e., at the upstream and downstream ends of the study area). After laying out the 55 mph design curve for the Zigzag Mountain Alternatives, as suggested, the design team considered slower design speeds that would reduce the length and construction (cut and fill) quantities, and associated costs of the new roadway. They also drafted a concept that shows a T-intersection with the existing Lolo Pass Road at the north end of the project, which would allow a shorter channel crossing. One alternative (Zigzag Mountain West, originating near Autumn Lane) meets a 55 mph design speed, but the other (Zigzag Mountain East, originating near Mountain Drive) would accommodate a T-intersection with the existing roadway, and would likely have a much slower (than 55 mph) design speed. This T-intersection design (for Zigzag Mountain East Alternative) would use less right-of-way than the alternative with the wider curving connection to the existing roadway (Zigzag Mountain West Alternative). Both the County and WFLHD expressed a preference for the continuous flow of traffic on the primary route, which could be accommodated with either design through future refinement.

Given the site constraints of the hydrological and geomorphic analysis, proximity of forest land, wetlands, crossing layout and slopes, the engineers adjusted the bridge crossing identified in the Reconnaissance Report to minimize the impacts associated with the crossing. Both the T-type and continuous flow intersections used the same crossing area. However, though the T-intersection would not allow a higher speed continuous free-flow travel movement for the main roadway, it would have several potential benefits. First, the T-type intersection has more flexibility to move up or down the river corridor, because it does not require that curves be developed to link back in with Lolo Pass Road. Moving the alignment of the bridge upstream could tie to a slightly better crossing location upstream. This could decrease the length of the bridge by decreasing skew and could be adjusted to avoid the potential residential displacement at the end of Autumn Lane.

Lolo Pass Road Access Alternatives Project
Table 2. Existing & Alternative Alignment Design Criteria

Existing Lolo Pass Road

	Functional Classification	Posted Speed (mph)	Design Speed (mph)	ADT (2011)	ADT (Projected)	ROW Width	Travel Lane Width	Paved Shoulder / Bikeway	Gravel Shoulder Width	Ditch Width	Max. Vertical Grade	Crest K	Sag K	"e" Max.	Min. Centerline Horizontal Radius
Existing Roadway No Build *Approx. measured values*	**Rural Minor Arterial**	**55 (basic rule)**	**35**	**1265**	**400 to 1500**	**60'**	**10' to 11'**	**0 to 2'**	**0 to 8'**	**Varies**	**8% to 10%**	**Not available**	**Not available**	**8%**	**300' to 400'**

North of East Barlow Trail Road

Design Alternatives	Planned Functional Classification	Posted Speed (mph)	Design Speed (mph)	ADT (2011)	ADT (Projected)	ROW Width	Travel Lane Width	Paved Shoulder / Bikeway	Gravel Shoulder Width	Ditch Width	Max. Vertical Grade	Crest K	Sag K	"e" Max.	Min. Centerline Horizontal Radius
45-mph Option Zigzag Mtn. West	**Rural Minor Arterial**	**55 (basic rule)**	**45**	**1265**	**400 to 1500**	**60'**	**11'**	**6'**	**8'**	**8'**	**7% to 10%**	**61**	**79**	**8%**	**587'**
50-mph Option (Not Shown) *Zigzag Mtn. sub-option*	**Rural Minor Arterial**	**55 (basic rule)**	**50**	**1265**	**400 to 1500**	**60'**	**11'**	**6'**	**8'**	**8'**	**7% to 10%**	**84**	**96**	**8%**	**758'**
55-mph Option Zigzag Mtn. East	**Rural Minor Arterial**	**55 (basic rule)**	**55**	**1265**	**2000 to 3000**	**60'**	**12'**	**8'**	**8'**	**8'**	**6% to 10%**	**114**	**115**	**8%**	**960'**
Clackamas County Standard	Rural Minor Arterial	55 (basic rule)	60 (intended +5 mph)	1265	< 3000	60'	11' to 12' *(11' to 12')*	6' to 8' *(6')*	5' to 8'	8'	10%	84	96	--	--
Reference *(Additional references)*	Comprehensive Plan	ORS	Roadway Standards	CC ADT Counts	CC Meeting	Standard Drawing	Comprehensive Plan Figure 5-2a	Comprehensive Plan Figure 5-2a	Comprehensive Plan	Comprehensive Plan	Standard Drawing	Roadway Standards	Roadway Standards	--	--
	Map 5-4b	811.105	250.1.2, page 50	near Barlow Road intersection	Feb. 5, 2015	C140	*(Standard Drawing C140)*	*(Standard Drawing C140)*	Figure 5-2a	Figure 5-2a	C140	Table 2-14, page 58	Table 2-14, page 58	--	--
AASHTO	--	--	40 to 50 (Mountainous)	--	--	--	11' to 12'	6' (ADT 400 to 2000) 8' (ADT > 2000)	--	--	8% @ 40 7% @ 45 to 50 6% @ 55 (Mountainous)	44 @ 40 61 @ 45 84 @ 50 114 @ 55	64 @ 40 79 @ 45 96 @ 50 115 @ 55	12% (8% where ice and snow are a factor)	444' @ 40 587' @ 45 758' @ 50 960' @ 55
Reference	--	--	AASHTO	--	--	--	AASHTO	AASHTO	--	--	AASHTO	AASHTO	AASHTO	AASHTO	AASHTO
	--	--	7.2.2	--	--	--	Table 7-3	Table 7-3	--	--	Table 7-2	Table 3-34	Table 3-36	7.2.2	Table 3-10b

South of East Barlow Trail Road

Design Alternatives	Planned Functional Classification	Posted Speed (mph)	Design Speed (mph)	ADT (2011)	ADT (Projected)	ROW Width	Travel Lane Width	Paved Shoulder / Bikeway	Gravel Shoulder Width	Ditch Width	Max. Vertical Grade	Crest K	Sag K	"e" Max.	Min. Centerline Horizontal Radius
Modify Existing Lolo Pass Road *Replace Extg. Bridge*	**Rural Minor Arterial**	**45**	**50**	**1870**	**1500 to 2000**	**60'**	**12'**	**6'**	**8'**	**8'**	**7% to 10%**	**84**	**96**	**8%**	**758'**
Clackamas County Standard	Rural Minor Arterial	45	50	1870	< 3000	60	11' to 12' *(11' to 12')*	6' to 8' *(6')*	5' to 8'	8'	10%	84	96	--	--
Reference *(Additional references)*	Comprehensive Plan	Speed Zone Order	Roadway Standards	CC ADT Counts	CC Meeting	Standard Drawing	Comprehensive Plan Figure 5-2a	Comprehensive Plan Figure 5-2a	Comprehensive Plan	Comprehensive Plan	Standard Drawing	Roadway Standards	Roadway Standards	--	--
	Map 5-4b	Order No. 1437D	250.1.2, page 50	near US 26 intersection	Feb. 5, 2015	C140	*(Standard Drawing C140)*	*(Standard Drawing C140)*	Figure 5-2a	Figure 5-2a	C140	Table 2-14, page 58	Table 2-14, page 58	--	--
AASHTO	--	--	--	--	--	--	12'	6'	--	--	7% (Mountainous)	84	96	12% (8% where ice and snow are a factor)	758'
Reference	--	--	--	--	--	--	AASHTO	AASHTO	--	--	AASHTO	AASHTO	AASHTO	AASHTO	AASHTO
	--	--	--	--	--	--	Table 7-3	Table 7-3	--	--	Table 7-2	Table 3-34	Table 3-36	7.2.2	Table 3-10b

REFERENCES

Roadway Standards	Clackamas County Roadway Standards - Feb. 1, 2013
Comprehensive Plan	Clackamas County Comprehensive Plan - Last revised 3/1/14
CC ADT Counts	Clackamas County ADT counts - cmap.clackamas.us/traffic/
CC Meeting	Clackamas County Project Meeting - Feb. 5, 2015
Standard Drawing	Clackamas County Roadway Standard Drawings
AASHTO	Geometric Design of Highway and Streets (Greenbook) - 2011
Roadside	Roadside Design Guide - 2011
ORS	Oregon Revised Statutes
Speed Zone Order	ODOT Speed Zone Order requested by Clackamas County, Dec. 8, 1998

BRIDGES AND STRUCTURES/WALLS

The Modify Existing Lolo Pass Road and Zigzag Mountain Alternatives would all involve new bridge crossings of the Sandy River, as outlined above. Specific assumptions about the bridges follow.

MODIFY EXISTING ROAD: REPLACE BRIDGE IN EXISTING LOCATION

The new bridge across the Sandy River under the Modify Existing Lolo Pass Road Alternative would be at the location of the existing bridge. The new bridge would be longer and the profile grade would be raised to provide for a greater hydraulic opening to pass the design flood. A second bridge would also be constructed approximately 50 feet to the north of the main river crossing to provide for overflow stream passage during extreme event flows. The area between the two new bridges would be contained within near vertical retaining walls on both sides of the roadway.

Both new bridges are proposed to be approximately 200-foot-long, single-span structures. A single span is recommended in order to eliminate any substructure elements within the active steam and overflow channels. Substructure elements within the channel areas would restrict stream flow, cause areas of turbulent flows (greatly increasing the potential for scour and channel degradation) and introduce debris catch potentials at the bridges. The debris catch potential is particularly critical, because the increased area of channel restriction caused by a debris dam would further reduce the flow area, thereby increasing water velocities and scour potential.

The most appropriate bridge type that is 200 feet long is a steel plate girder structure with a cast-in-place concrete deck. Other structure types, including spliced, precast concrete girders and cast-in-place concrete box girders are also able to achieve this span length, but those alternatives require temporary falsework bents to be constructed within the river and overflow channels for extended periods of time. These falsework bents are an added project cost and increase the risk of high water flow restrictions during construction. Given these factors, steel alternatives are a cost-effective bridge type for this application. Bridge costs are further itemized in later sections of this report.

The total structure depth, including steel girder and deck section, would be approximately 7 feet. The proposed roadway profile is set to provide for a minimum of 3 feet of clearance between the water surface elevation of the 100-year flood and the bottom of the bridge structure. The 3-foot clearance is recommended for hydraulic openings with a potential for a large amount of debris flow.

The abutments of both bridges under the Modify Existing Lolo Pass Road Alternative would be relatively small concrete caps founded on small-diameter drilled shafts, as recommended in the Geological Hazards section below. Approximately 30-inch-diameter shafts would be drilled through the alluvial and debris flow sediments that contain large cobbles and boulders, and would be founded in competent rock below.

Retaining walls required at the bridges would include standard concrete wingwalls at the south abutment of the main river channel bridge and at the north abutment of the overflow channel bridge. Roadway fills on a 2-to-1 slope (horizontal to vertical) would extend up from the front face of the abutments, resulting in wingwalls approximately 15 feet long. As noted above, the roadway area between the two bridges, a distance of 50 feet, would be retained between near vertical retaining walls at the edge of the roadway on both sides. Mechanically Stabilized Earth (MSE) walls could be used for the anticipated 8- to 12-foot-high walls. The upstream river bank at the base of the wall would have to be protected from scour by large riprap keyed below the river bed.

PROPOSED UPSTREAM BRIDGE LOCATION

The new bridge across the Sandy River under both of the Zigzag Mountain West Alternatives would be located at essentially the same location. Roadway grades and embankment heights vary for both alternatives, but the bridge crossing the Sandy River is at the same location. The new bridge for both alternatives would be an 800-foot-long, multi-span bridge. The bridge length is determined in order to provide for no roadway fill to be placed in the historical river channel, which is established as the water surface elevation of the 100-year flood event. Four spans of 200 feet are proposed for this crossing. The active river channel would pass beneath the southernmost span and an overflow channel would pass beneath the northernmost span.

South of the bridge, the Zigzag Mountain alternative road alignments could be constructed largely outside of the channel migration zone. The alignments would cross a number of small intermittent drainages requiring installation of large culverts.

North of the bridge, the road alignment would extend across the channel migration zone. Roadway embankments would need to be elevated to match the bridge elevation and to tie into the existing Lolo Pass Road. Erosion mitigation measures will need to be incorporated into the elevated embankment designed to prevent erosion from potential channel migration.

For these multi-span bridges, substructure elements would have to be placed within the historical channel areas; however, the spans would be long enough to completely span the active and main overflow channels, thereby reducing the risks identified above for in-stream flow restrictions.

Similar to the bridges under the Modify Existing Lolo Pass Road Alternative, a steel plate girder bridge type is appropriate for these 200-foot-long spans. The falsework required for other structure types, including spliced, precast concrete girders and cast-in-place concrete box girders, have an additional negative element in that the falsework heights are much greater than those that would be required at the existing Lolo Pass Road crossing. The proposed roadway profiles for these two Zigzag Mountain Alternatives are 25 to 40 feet above the river bed. Temporary falsework bents of that height are much more costly and have greater risk of damage during high water storm events, thus making a steel structure a very viable alternative.

The total structure depth, including steel girder and deck section, would be approximately 7 feet. As noted above, the interior bents would require multiple columns that would be approximately 25 to 35 feet tall. The proposed roadway profile is set to provide for the tie-in to the existing Lolo Pass Road approximately 100 feet above the river channel at this crossing location, so that the distance between a flood level and the bottom of the bridge (freeboard) is not a concern.

The interior bents would require two columns, approximately 6 feet in diameter, to be supported on large concrete pile caps founded on relatively small, 30-inch-diameter shafts at each bent, as recommended in the Geological Hazards section below. A preliminary estimate is that 12 shafts would be required at each interior bent. These shafts would be drilled through the alluvial and debris flow sediments that contain large cobbles and boulders, and would be founded in competent rock below.

The bridge abutments would be relatively small concrete caps supported on concrete columns that would extend through the roadway fill, which would be contained within mechanically stabilized earth (MSE) walls (a type of retaining wall) that wrap around the front of the abutments. The columns would be approximately 17 to 28 feet tall on the south and north abutments of the Zigzag Mountain West Alternative, and 30 to 38 feet tall on the south and north abutments of the Zigzag Mountain East Alternative. These tall columns would be isolated from the MSE roadway fill by larger-diameter corrugated metal sleeves around each column. These columns would each be founded on 30-inch diameter drilled shafts drilled through the alluvial and debris flow sediments and founded in competent rock below. A preliminary estimate is that six column/shaft foundation supports would be required at each abutment.

Retaining walls would be required to retain the large roadway approach embankments at the bridge end abutments in order to minimize the bridge span length and impact area of the slopes. MSE walls that wrap around the front of the abutments would have to be protected by large riprap placed on the river banks and keyed below the river bed elevation to prevent scour from undermining these approach walls. These MSE approach walls under the Zigzag Mountain

West Alternative would be approximately 24 feet tall and 50 feet long at the south abutment and 35 feet tall and 70 feet long at the north abutment. Under the Zigzag Mountain East Alternative, these MSE walls would be approximately 37 feet tall and 75 feet long on the south abutment and 44 feet tall and 90 feet long at the north abutment. Costs for these large MSE walls are included in the cost estimate presented in a later section of this report.

SCOUR ANALYSIS

A preliminary assessment of factors affecting bridge scour was developed from review of hydraulic model results and evaluation of conceptual design sketches for proposed bridge crossings. A summary of total scour for the three alternatives is presented in Table 34. Note additional design criteria are needed to determine the upstream approach section of the alternative to widen the existing crossing. The existing crossing is most sensitive to local scour where flow impinges on the left abutment. Design alternatives propose to set back and widen the crossing. Provided adequate countermeasures are employed to prevent lateral migration towards the abutments, the design alternatives should not have the same issues with local scour. The primary element of local scour in the proposed design alternative at the upstream crossing is the pier scour when piers are subject to flow. The pier scour calculation for a cylindrical 6-foot diameter column yielded a scour depth of approximately 12 feet. Factoring in the estimate of long-term degradation, these estimates are intended to give a general description of scour at proposed bridge crossings and are to be refined as part of the design process as additional criteria are specified for the proposed crossing.

Table 34. Summary of estimated scour depth for bridge crossing alternatives.

	No Action (Existing Conditions)	Alternative With Two, 200-Foot Bridges at Existing Crossing Location	Alternative With Four, 200-Foot Bridges at New Crossing Location near RM 44.6
Long-Term Degradation	6 ft	6 ft	6 ft
Contraction Scour	2.5 ft	<5*	0.7 feet
Pier Scour	N/A	N/A	12.3
Abutment Scour	24.2 ft	0 ft	0 ft
Total Scour	32.7 ft	11*	19 ft

**** Contraction scour calculation for this alternative requires additional design information regarding partitioning of flow and proposed channel modifications in the approach section.***

Additional information from the scour analysis is presented in Appendix C.

STORMWATER TREATMENT

Stormwater treatment for any of the alternatives would be managed in accordance with applicable standards and regulations. Regulatory trending includes first tier preferences to manage stormwater on site and mimic natural hydrology to the maximum extent practicable (MEP). If a site is suitable, this can be achieved by best management practices (BMPs) that infiltrate stormwater runoff. Based on preliminary U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) Web Soils Survey investigations, the soils in the area in general are moderately well to well-draining Hydrologic Soil Group B soils. These soils are typically favorable for infiltration BMPs.

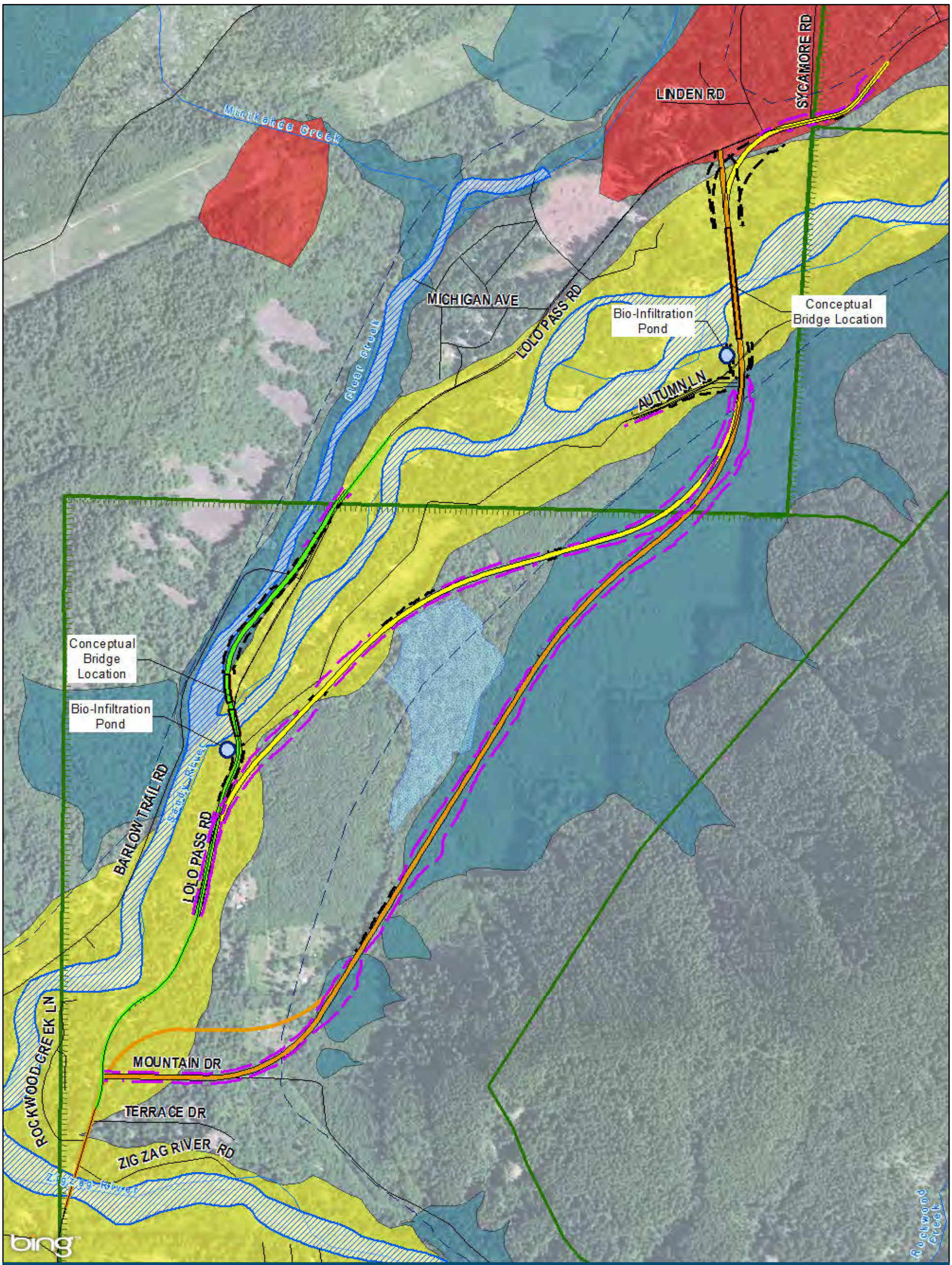
Stormwater management by infiltration can achieve multiple objectives: It can cost-effectively be used to provide water quality treatment, and it can alleviate flooding and hydro-modification pressures on nearby water bodies and infrastructure. Infiltration BMPs are often described as low impact development (LID) practices and work best in areas with low groundwater tables, which are common in Group B soils at elevation. Designs would be given special consideration so as to not exacerbate conditions in slide-prone areas. Proposed conceptual stormwater BMPs for the project include three primary types of LIDs:

1. **Bio-infiltration slopes** for areas without ditches, or a point of flow collection, and good potential for infiltrating off of the roadway shoulder.
2. **Bio-infiltration swales/ditches** along proposed roadside ditches.
3. **Bio-infiltration ponds** for areas where concentrated flow volumes need to be managed (e.g., bridge runoff).

Figure 12 shows proposed types and locations of conceptual BMPs/LIDs. As designs advance and site-specific information becomes more refined, other BMPs may be more appropriate in certain situations.

For the Modify Existing Lolo Pass Road and Zigzag Mountain Alternatives, stormwater would primarily be treated by infiltration after sheeting off of the road shoulder or by infiltration into the roadside ditch/swale. Stormwater that falls onto the bridges and other structures, especially the long bridge associated with the Zigzag Mountain Alternatives, would need to be collected and piped from the structures to an infiltration facility, likely a pond.

Stormwater conveyance would be needed only in roadway cut sections (via ditch/swale) and piped across bridges. In all other areas, stormwater runoff would be expected to sheet flow off of the road shoulder and then infiltrate.



Lolo Pass Road Access Alternatives

Legend

- Modify Existing Lolo Pass Road
- Zigzag Mountain East
- Zigzag Mountain West
- Mt. Hood Wilderness Boundary
- Mt. Hood National Forest
- Street
- River
- Bio-Infiltration Slope
- Bio-Infiltration Swale/Ditch
- Infiltration Pond
- Maximum Wetland Extent
- FEMA Floodway
- Channel Migration Zone
- Alluvial Fan
- Landslide
- Debris Flow

Figure 12

Sandy River Corridor
Lolo Pass Alternative Stormwater Management Concepts

N

0 1,000 2,000 Feet

Data Sources:
GRI, ESRI, ArcGIS Online, World Imagery. 2010. Microsoft.

Document Path: C:\Users\sast\Desktop\Fig12_Stormwater.mxd
Date: 8/7/2015 Time: 2:36:40 PM User Name: Sast

RIGHT-OF-WAY AND DISPLACEMENTS

Any of the proposed build alternatives would require the acquisition of right-of-way and likely residential displacements. Table 5 shows the estimated range of the number of parcels affected by the alternatives and the estimated number of residential displacements for each alternative.

Table 5. Summary of Project Footprint, Potential Right-of-Way, and Displacements

	Acres of Right-of-Way	Parcels Affected	Potential Displacements
Modify Existing Lolo Pass Road Alternative	5	10-18	4-5
Zigzag Mountain West Alternative	23	12-22	1-2
Zigzag Mountain East Alternative	25	25-26	1-2

ENVIRONMENTAL RESOURCES

This section presents reconnaissance and high-level field information regarding streams and wetlands, threatened and endangered species, geological hazards, floodplains, cultural resources and hazardous materials. The analysis relied heavily on existing databases and information; field work was limited, but included walking the river in the vicinity of the proposed new crossing, observations from Lolo Pass Road and other roadways in the study area, and a wetland determination conducted on a large wooded parcel in the vicinity of the Zigzag Mountain Alternatives. The information provided below is intended to provide an overview of potential opportunities and constraints, and was used to modify the alternatives to avoid critical resources. Appendices E, F and G provide additional information on the biological and wetlands, geological hazards, and cultural resource investigations completed for this study.

STREAMS AND WETLANDS

This section describes the results of database and field-level reconnaissance completed for the project. A Water Resources Report is attached as Appendix E. Lolo Pass Road parallels the Sandy River. Clear Creek parallels the Sandy River and is separated from it by Lolo Pass Road. The Powerline Corridor is adjacent to the Sandy River at its west end, and tributaries in the western tip of the Powerline Corridor drain to North Boulder Creek, a tributary of the Sandy River. The Powerline Corridor extends upstream along the Sandy River valley slope above Hackett Creek to cross seven streams: three unnamed Hackett Creek tributaries, Minikahda Creek and three other unnamed tributaries to Clear Creek.

Almost all of the wetlands shown on the National Wetlands Inventory (NWI) maps (see Figure 13) coincide with or adjoin the Sandy River channel, and are likely to be included as part of the Sandy River for jurisdictional purposes. The three exceptions in the Sandy River study area are a