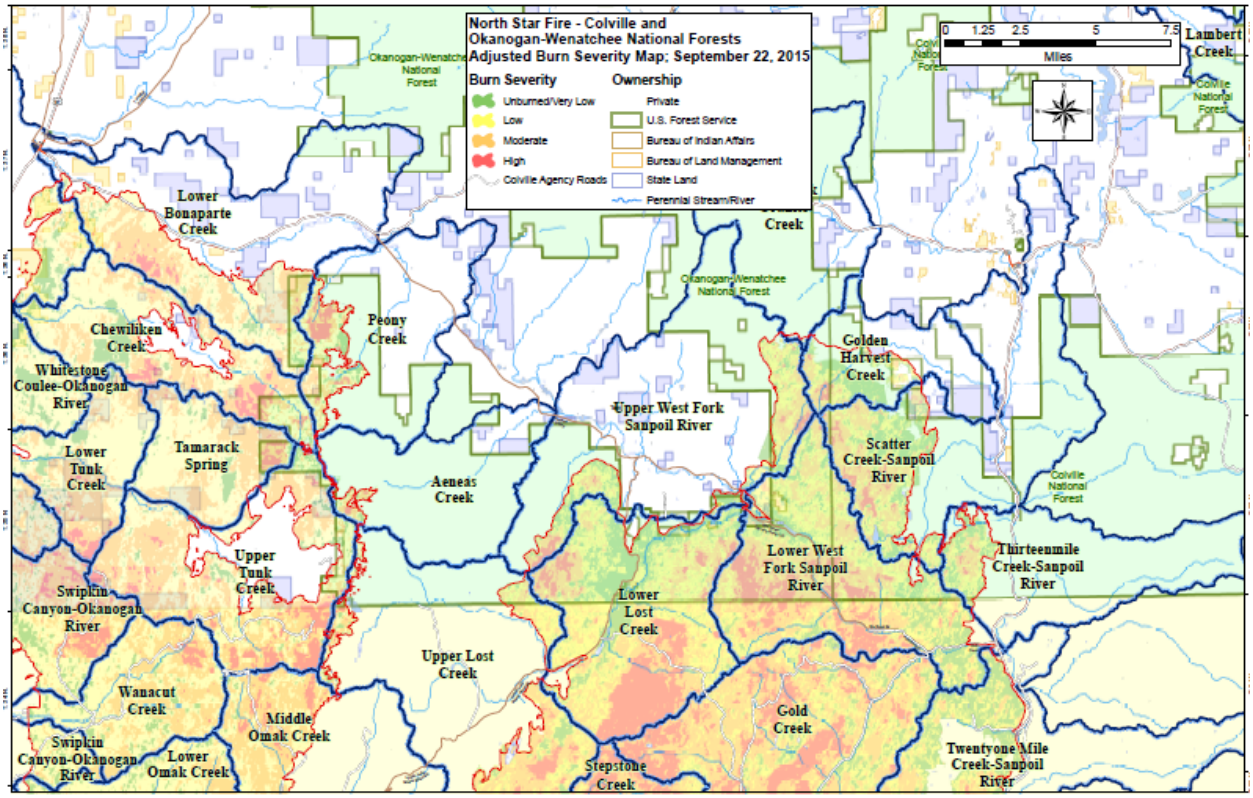
Colville & Okanogan-Wenatchee National Forests

North Star and Tunk Block Fires 2015



*Burn severity map with Forest Service lands and named subwatersheds in blue outline.

Burned Area Emergency Response
Hydrology/Watershed Report
September 26, 2016

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1. Objectives

Evaluate the effects of the North Star and Tunk Block Fires on hydrologic responses in subwatersheds including changes in runoff, surface conditions and drainage response to precipitation events. Procedures for assessing burned areas are described in Chapter 2520 of the Forest Service Manual[1]. The focus is to assess post-fire changes on hydrologic responses and how it could pose significant threat to human life and property, and critical natural and cultural resources. Values at risk were identified and determinations were made by ranking each risk as "low," "moderate," "high" or "very high." Treatments were recommended based on the level of risk and whether an emergency condition exist.

Resources used to assess fire effects to water resources include BARC map, GIS data, photos, field excursions, field validations, air reconnaissance, inspection of culverts and other infrastructures, and flow modeling exercises. Information from BARC imagery used for AGWA (Automated Geospatial Watershed Assessment) provided pre and post-fire flow and sediment volume changes. AGWA provided estimated post-fire percent increase on flow volume as a way to gauge the risk of potential debris flows.

Assessment of these effects was conducted by Forest Service hydrologists. The objectives of this report are to:

1. Evaluate fire effects on water resources.
2. Identify critical water resource values at high risk of damage.
3. Identify at risk areas to public safety and property from flooding or debris flow events.
4. Identify mitigation or protective measures to protect human life, property, and other natural resources.

2. Potential Values at Risk

A. Critical Values

Hydrologic process affected by wildfires change a number of responses such as decreased interception on plants lacking any leaves or needles to help store water causing increased runoffs; decreased litter storage on the ground reduces stored water causing an increase in overland flow; transpiration is reduced or stopped in plants from extracting stored water in the ground increasing streamflow; and reduced infiltration into ground due to water repellant soils causing an increase in overland flow and streamflow [2]. In short, the resulting effect is that burned watersheds respond to rainfall faster, producing more "flashy floods" or debris flows and thus potentially affect downstream critical values.

Potential critical values identified include:

- Life and Safety
  - Forest Service recreation areas, such as campgrounds and picnic areas at risk from flooding.
  - Downstream communities and private properties.
- Property.
  - Potential impact to bridge and culverts on Highway 21.
  - Private property at risk from flooding, erosion and woody debris.
  - Forest Service roads and culvert infrastructures at risk from flooding and erosion.
- Natural Resources
  - Water quality downstream increasing turbidity and sediment with the potential to affect agriculture and aquatics.

Table 1 describes critical values at risk, risk rating and treatment or mitigation response options based on resource specialists' findings on the ground. Results from AGWA modeling on percent change for post-fire flows using a 25 year storm design provided additional inputs to help assess downstream risk to critical values and resources.

Table 1. Downstream values at risk for North Star with AGWA modeling results (percent changed).

Subwatershed	Stream Name	Drainage Size (mi^2)	Drainage Point (Latitude & Longitude)	Descriptive Location	AGWA 25 Year Storm Post Fire Percent Change from pre-fire flow (1)	Resources/values at risk	Pre-modeling Risk Rating	Final Risk Rating	Treatments
Golden Harvest Creek	Golden Harvest Creek	1.39	48.604 -118.8462	Unnamed channel intersecting 5330 road (Swan Lake Road)	0.60%	Damage to home is likely low due to small area of moderate and high severity burn, long distance from burn area to homes and unburned stream channel	Low	Low	No treatment

Golden Harvest Creek	Golden Harvest Creek (perennial)	1.44	48.5919 -118.8584	Golden Harvest Creek intersecting road 5330 (Swan Lake Road)	314%	Steep side slopes, erodible soils, loss of canopy cover, increased peak flows, hazard trees, and agin poorly drained road network	Low	Moderate	Fall trees on 3120-200
Lower Lost Creek	Lost Creek (perennial)	81	48.485633 -119.0205	3005100 road	1270%	Steep side slopes of high and moderate burns on both sides of road, erodible soils, loss of canopy cover, increased peak flows, hazard trees, and aging poorly drained road network.	Low	Mod	Remove existing drainage on level 1 roads and then close. Signage, storm patrols, increase culvert sizes, drop select hazard trees on higher level maintenance roads.
Lower WF Sanpoil River	WF Sanpoil River (perennial)	294	48.4585 -118.7503	WF Sanpoil River @ Hwy 21 bridge.	669%	Bridge was built in 1932. Opening is approximately 35 to 40 ft long, 8 ft high. Est capacity is around 1200 cfs. Capacity is reduced with deposited rocks and sediment under the bridge. May be issues with increased flow and sediment.	Very high	Very high	Work with county and NRCS on increased risk to infrastructure
Lower WF Sanpoil River	WF Sanpoil River (perennial)	294	48.4585 -118.7504	WF Sanpoil River near Hwy 21 bridge.	669%	Damage to homes may be moderate to high based on the amount high/moderate severity burn upstream. Homes near stream channel could have a site specific assessment completed.	High	High	Work with NRCS to warn home owners of increased risk.
Lower WF Sanpoil River	WF Sanpoil River (perennial)	228	48.4815 -118.869	3115 Aenas Valley Road, High & Mod burns on both sides of road	247%	Steep side slopes on both sides of road with WF Sanpoil river running parallel with road. Poor road drainage.	Moderate	Moderate-High	Warning signage, storm patrols

Scatter Creek-Sanpoil River	Unnamed trib to Scatter Creek (perennial)	0.86	48.5313 -118.8394	5330 road @ MP 2.71 approx. 100 yard upstream dozer line crosses perennial stream	1060%	High and moderate burns flank both sides of the channel. Dozer line created a stream blockage and is currently filling up. Topping of this blockage will result a debris flow to the 5330 pipe impacting the road prism and pipe.	Moderate	Very High	High risk of impact to dozer line blockage and breach. Debris flow will impact culvert and 5330 road prism.If dozer line has not been repaired by suppression team, make this a priority to undo this blockage.
Scatter Creek-Sanpoil River	Scatter Creek	20.8	48.5487 -118.75	Road 53 and private road near Hwy 21	266%	Property road, homes and buildings, domestic water/irrigation	Very High	High	Remove existing drainage on level 1 roads and then close. Signage, storm patrols, increase culvert sizes, drop select hazard trees on higher level maintenance roads.
Scatter Creek-Sanpoil River	Scatter Creek	20.8	48.5487 -118.76	Scatter Creek and bridge @ Hwy 21	266%	Highway 21 bridge/culvert.	Low	Low-Mod	
Thirteen Mile Creek-Sanpoil River	Ten Mile Creek (intermittent)	2.38	48.5181 -118.7382	Creek @ Hwy 21 through Colville NF campground	70%	Upper and lower Colville Campground on both sides of Hwy 21. Bathrrom facility. South campground is not gate but upper campground is gated. Campground has been closed to the public for at least 3 years.	Low-Mod	Low-Mod	Add gate to restrict access to lower campground. Notify county and NRCS on increased risk on highway 21.
Thirteen Mile Creek-Sanpoil River	Unnamed trib to Sanpoil River (intermittent)	0.6	48.5054 -118.7655	5320 @ MP 3.762 (channel leads to Hwy 21)	65%	24 inch pipe and road prism at risk of failure.	Low-Mod	Low-Mod	Storm patrol, inform county and NRCS on potential increase of flow downstream to hwy 21.

Thirteen Mile Creek-Sanpoil River	Unnamed trib to Sanpoil River (intermittent)	1.46	48.4996 ; -118.7411	Same channel below 5320 road (MP 3.762) to Hwy 21	65%	Highway 21. Small debris materials, ash, and rocks may occur if 5320 road prism fails 1.5 miles upstream. Last 2000 ft of channel has a gradient of approximately 50 to 60 percent.	Low-Mod	Low-Mod	Inform county and NRCS on potential increase of flow downstream to hwy 21.
Upper WF Sanpoil River	Unnamed trib to Sanpoil River	8.83	48.5618 -119.0349	Bailey Creek to Aeanas Valley Road	0.27%	Steep side slopes, erodible soils, loss of canopy cover, increased peak flows, hazard tres, and aging poorly drained road network.	Moderate	Low-Mod	Warning signage, storm patrols

(1) - Percent change assumes rainfall falls uniformly over the entire defined drainage.

Tunk Block wildfire had much less high intensity burns. Much of the high intensity burns occurred in the subwatersheds' upper headwaters. Okanogan-Wenatchee National Forest amounted to approximately 1.4 square miles (950 acres) of high intensity burns. Overall high intensity burn for Tunk Block amounted to almost 14 square miles out of 340 square miles of burned areas representing 4% of the total burn (O-W NF's own high burn areas makes up 0.4% of the total burn). Values at risk are limited on the O-W National Forest due to the small area of burns limiting downstream risk to critical values. Road infrastructure with high risk to human life and property is the only critical value at risk. Some of the level 1 roads in Upper Tunk, Chewiliken Creek, and Peony Creek subwatersheds below high burn areas will receive attention covering culvert cleaning, storm patrols (Chewiliken Creek and Peony Creek), armoring road (Chewiliken and Peony Creeks) with rolling dips (Chewiliken and Peony Creeks), and signage.

B. Resource Condition Assessment

(a) Resource Setting

The North Star Fire began on August 13, 2015. It was a human caused wildfire with approximately 217,871 acres burned on Forest Service, BLM, Confederated Tribes of the Colville Reservation, BLM and private lands. As of September 24, 2015 it was 96% contained. Majority of the burn took place south of Colville and Okanogan-Wenatchee National Forest's boundary impacting the lands on the Confederated Tribes of the Colville Reservation.

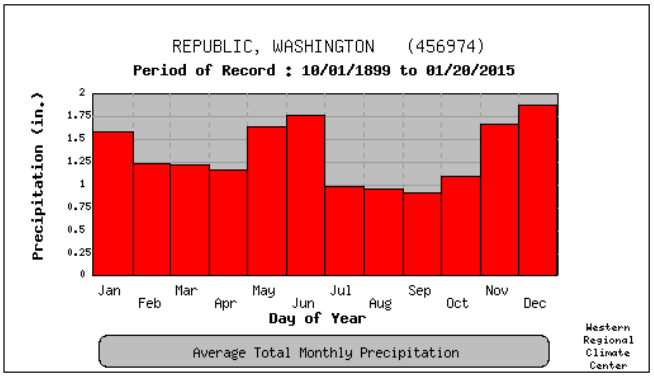
The Tunk Block Fire began on August 14, 2015. Cause is unknown. Approximately 166,000 acres burned on Forest Service, BLM, Confederated Tribes of the Colville Reservation, BLM and private lands (Table 2). As of September 24, 2015 it was 97% contained. Majority of the burn took place south of the south of Okanogan-Wenatchee National Forest's boundary impacting the lands on the Confederated Tribes of the Colville Reservation and to private lands west of the Forest Service boundary.

Much of the climate in the burn area is influence by both maritime and continental air masses providing the necessary moisture to the area. Approximately 80% of the annual precipitation falls as snow from September to as late as early May in the higher elevation from 4,000 to 5,000 feet. Lower elevation around 2,500 feet sees snow as early as October and as late as April. Heavy localized thunderstorms occur occasionally during the months of May and June briefly increase stream flow and then continues its attenuation throughout the months until October when precipitation begin to increase. Annual precipitation within the burn area ranges from 15 to as much as 20 inches with the lower precipitation amount along the Sanpoil River (approximately 2,000 ft elevation)[3]

Elevation of the area impacted by the fire range from 2,700 to 5,300 feet limiting any warm snowpack zone (rain-on-snow flow regime) while most of the area are snowpack dominated. Snowpack melt drives much of the base flow in perennial streams from March to May.

The nearest long-term precipitation record is located in Republic, Washington (2,500 ft elevation) located approximately 6 miles to the NNE of the North Star Fire. Rainfall season for the town of Republic, Washington typically occurs from January to June with precipitation amount between 1 and 2 inches. Summer season from July to September receive less rainfall precipitation with less than 1 inch before picking up again in October with December being the wettest month. The area receives an average rainfall of 30 inches per year, and snowfall with almost 50 inches a year. Period of record for the town of Republic from the Western Regional Climate Center is 115 years (Chart 1)[4]

Chart 1. Average monthly precipitation for Republic, Washington.



Both the North Star and Tunk Block fires lie east of the Cascade Mountain Range. This mountainous region lies within the Okanogan Highlands physiographic region. A central valley occupied by Curlew Lake, Sanpoil Lake, and the Sanpoil River serves as the trunk drainage for nearly all the area. Relief is nearly 5,000 feet, the highest point being Bald Mountain, which has an altitude of 6,933 feet (MUESSIG, 1967). The landscape of both adjacent fires where shaped by long periods of glaciation and river processes. The Mt. Mazama (present day Crater Lake) eruption around 7,700 years ago left an extensive ash mantle that is commonly present in the mountainous, forested areas today across this region in northeast Washington. The terrain varies from steep slopes to rolling hillsides, and flat river valleys. Drainages have been modified by several Pleistocene glaciations [5]. Bedrock is mainly composed of extrusive and intrusive igneous rocks.

Water Quality and Beneficial Uses

North Star and Tunk Block fires impacted subwatersheds that feed into the Sanpoil River to the east, the Nesplelem River to the south and/or the Okanogan River to the west. Both Okanogan River and Nesplelem River empties into the Columbia River while Sanpoil River empties into Lake Roosevelt (Table 2). Lake Roosevelt was created as a result of the Grand Coulee Dam built in 1941 which dammed up a portion of the Columbia River. Distance from the fires to Columbia River or Lake Roosevelt via rivers range from 20 to 40 miles away.

Table 2.

Wildfire Name	**Watershed**	**HUC10**	**Major Stream**	**Confluence with**
North Star	West Fork Sanpoil River	1702000402	Sanpoil River	Roosevelt Lake
North Star	Nespelem River	1702000501	Nespelem River	Roosevelt Lake
North Star	Upper Sanpoil River	1702000401	Sanpoil River	Roosevelt Lake
North Star	Middle Sanpoil Rive	1702000403	Sanpoil River	Roosevelt Lake
Tunk Block	Omak Creek	1702000619	Omak Creek	Okanogan River
Tunk Block	Tunk Creek-Okanogan River	1702000618	Tunk Creek	Okanogan River
Tunk Block	Scotch Creek-Okanogan River	1702000621	Scotch Creek	Okanogan River

Listed 303(d) impaired waters are limited and are located well outside of the perimeter burn. The closest 303(d) listed waterbody (for bacteria) is on the Sanpoil River along highway 21 just south of the Colville National Forest's boundary.

Water quality issues from wildfires (Table 3) mainly come in the form of increased sediment and turbidity in stream waters that could affect color and smell. Larger materials may get deposited from floods or debris flows and damage infrastructures like water conveyance, ditches, culverts, and even buried utility lines.

Table 3. Miles of streams on FS lands in burned areas.

Miles of Streams on FS Lands in Burned Areas		
Stream Type	**North Star**	**Tunk Block**
Perennial	18.1	3.8
Intermittent	1	1.3

Riparian plants that once lined along stream banks offered shading will not be able to provide stream shade for the next few years. Stream flows through burned riparian areas may temporarily see an increase in stream temperature that could affect aquatic life. Excessive organic debris in fire affected stream channels can potentially decrease dissolved oxygen concentrations in streams. Ash can increase pH, alkalinity, conductivity, and change the nutrient balance (e.g. ammonium, nitrate, phosphate, and potassium), although these changes are generally short lived.

(b) Findings based on the Ground Surveys

A BARC (Burned Area Reflectance Classification) map was obtained showing unburned/low, “low,” “moderate” and “high” intensity burn areas in subwatersheds (Table 4) over Okanogan-Wenatchee and Colville National Forests from both wildfires. Subwatershed name, acreage burned, severity type and percent of burn total are in Tables, 5, 6 and 7. BARC map provided hydrologists and other resource specialists the ability to assess which potential downstream values are at risk in areas of high and moderate intensity burns for field and air reconnaissance work. And determine what the potential risk rating may be for downstream critical values at risk.

Table 4. Acres Burned by Land Ownership and Fire Name.

	Total Burned (acres)	Forest Service (acres)	Other Federal (BIA/BLM) (acres)	State (acres)	Private (acres)
North Star Fire	217,871	44328	170,721	749	2,073
Percent Burned	100	20.3	78.4	0.3	1.0
Tunk Block Fire	166,000	8600	84200	15700	57500
Percent Burned	100	5.2	50.7	9.5	34.6

Table 5. Acres Burned by National Forest and Wildfire Name

Burn Severity on NF Lands			
Severity Type	**Colville NF (North Star)**	**Okanogan-Wenatchee NF (North Star)**	**Okanogan-Wenatchee NF (Tunk Block)**
Low/Unburned	4667	6208	1456
Low	5351	9665	3812
Moderate	5414	8309	2419
High	1116	2964	950
Total	**16548**	**27146**	**8637**

Table 6. Fire severity by 6th code subwatersheds for North Star wildfire on Forest Service lands.

	North Star Fire		
Subwatershed / Burn Severity	**Acres**	**Burn Severity Acres**	**% Burn Total**
Golden Harvest Creek	**11,063**	**771**	**3.09**
Unburned		198.0	0.79
Low Severity		339.0	1.36
Moderate Severity		187.0	0.75
High Severity		47.0	0.4
Lower Lost Creek	**25,474**	**5,293**	**21**
Unburned		1,866	7.3
Low Severity		1,502	5.9
Moderate Severity			6.5

		1,656	
High Severity		269	1.1
Lower West Fork Sanpoil River	**25,105**	**5,980**	**23.99**
Unburned		1,755	7.04
Low Severity		2,153	8.64
Moderate Severity		1,517	6.09
High Severity		555	2.23
Scatter Creek-Sanpoil River	**31,313**	**2,579**	**10.35**
Unburned		679	2.72
Low Severity		1,116	4.48
Moderate Severity		562	2.25
High Severity		222	0.89
Thirteenmile Creek-Sanpoil River	**18,780**	**732**	**2.94**
Unburned		193	0.77
Low Severity		343	1.38
Moderate Severity		148	0.59
High Severity		48	0.19
Upper Lost Creek	**34,697**	**2,172**	**8.71**
Unburned		646	2.59
Low Severity		748	3.00
Moderate Severity		522	2.09
High Severity		256	1.03
Upper West Fork Sanpoil River	**36,305**	**1,896**	**7.61**
Unburned		636	2.55
Low Severity		664	2.66
Moderate Severity		485	1.95
High Severity		111	0.45
Grand Total		**19,423**	

Table 7. Fire severity by 6th code subwatersheds for Tunk Block wildfire on Forest Service lands.

Subwatershed / Burn Severity	Tunk Block Fire Acres	Burn Severity Acres	% Burn Total
Aeneas Creek	**16,857**	**72**	**0.43**
Unburned-very low		17	0.10
Low Severity		23	0.14
Moderate Severity		23	0.14
High Severity		9	0.05
Chewiliken Creek	**16,890**	**573**	**3.39**
Unburned-very low		193	1.14
Low Severity		137	0.81
Moderate Severity		189	1.12
High Severity		54	0.32
Lower Bonaparte Creek	**33,121**	**481**	**1.45**
Unburned-very low		141	0.43
Low Severity		102	0.31
Moderate Severity		192	0.58
High Severity		46	0.14
Peony Creek	**20,140**	**188**	**0.93**
Low Severity		64	0.19
Moderate Severity		70	0.21
High Severity		16	0.05
Unburned-very low		38	0.11
Tamarack Spring	**10,115**	**274**	**2.71**
Low Severity		71	0.70
Moderate Severity		112	1.11
Unburned-very low		63	0.62
High Severity		28	0.28
Upper Lost Creek	**34,697**	**144**	**0.42**
Unburned-very low		20	0.06
Low Severity		64	0.18
Moderate Severity		48	0.14
High Severity		12	0.03

Upper Tunk Creek	**24,927**	**866**	**3.47**
Unburned-very low		201	0.81
Low Severity		263	1.06
Moderate Severity		271	1.09
High Severity		131	0.53
Whitestone Coulee-Okanogan River	**38,341**	**422**	**1.10**
Unburned-very low		207	0.54
Low Severity		33	0.09
Moderate Severity		178	0.46
High Severity		4	0.01
Grand Total		**3,020**	

(C) Hydrologic Design Factors and Modeled Results

The analysis for pre- and post- fire hydrologic response and probability of flows is based on the probability of a 25-year storm occurring in the fire area. Vegetative recovery, which correlates with hydrologic response, is expected anywhere from 1 to 5 years. Under North Star a 25-year design storm has a 4% chance of occurring in any given year. The 25 year, 3 hour duration storm for the area is 1.5 inches (AGWA). Hydrologic design information is displayed in Table 8.

Table 8. Hydrologic Design Factors

NORTH STAR	
A. Estimated Vegetative Recovery Period (years):	1 to 5
B. Design Chance of Success (percent):	80%
C. Equivalent Design Recurrence Interval (years)	25
D. Design Storm Duration (hours):	3 hours
E. Design Storm Magnitude (inches):	1.5
F. Design Flow (cfs/square miles):	35
G. Estimated Reduction in Infiltration (percent):	40%
H. Adjusted Design Flow (cfs/square mile):	87.5
TUNK BLOCK	
A. Estimated Vegetative Recovery Period (years):	1 to 5
B. Design Chance of Success (percent):	95%
C. Equivalent Design Recurrence Interval (years)	25
D. Design Storm Duration (hours):	3 hours

E. Design Storm Magnitude (inches):	1.5
F. Design Flow (cfs/square miles):	13
G. Estimated Reduction in Infiltration (percent):	20%
H. Adjusted Design Flow (cfs/square mile):	15

In high burn severity areas soils become water repellant limiting water infiltration into the soil. Moderate soil burn severity water repellency is discontinuous with some intact infiltration capacity than do high burn severity grounds but is still reduced from pre-fire conditions. Increased water repellency in soils increase the risk of overland flows, erosion and mass wasting events. Reduction in infiltration into soils in the high burn severity areas was estimated to be 45% for the North Star Fire due to the amount of water repellency and loss of soil cover. Few areas showed high water repellency (hydrophobicity) in soils but were found to be low to moderate amount of hydrophobicity.

Using the AGWA model to determine pre-fire peak flows using 25 year, 1.5 inches rainfall intensity for the Lower West Fork Sanpoil River subwatershed (39.2 mi^2) with 8.3 mi^2 of high and moderate burn severity it produced an estimated post-fire peak flow of approximately 2000 cfs. The "rule of thumb"[6] states that less than half of peak flow estimates are within ± 50% of observed values due to uncertainty on rainfall intensity measurements or other natural variations. Range of post-fire values could be anywhere from 1000 to 3000 cfs for Lower West Fork Sanpoil River.

Post-fire peak flow equation by Kuyumjian is used to determine estimated post-fire peak flow and compare it with AGWA.

$Q_p = 300 * A_s * I * 1.25$

where

Q_p = peak flow in cfs for post burn clean water;

I = precipitation intensity in inch/hour;

A_s = size of high burn severity area in mi^2; and,

1.25 = bulking factor.

Lower West Fork Sanpoil subwatershed high burn severity size: 6.08 mi^2

Precipitation rate: 1.5 in/hr

Q_p = 3,400 cfs

Flow of 3,400 cfs represents a little more the +50% of the AGWA's post-fire flow. This is believed to be the upper bound of 87.2 cfs/mi^2 for a 25-year storm event and is used for the adjusted design flow with the assumption that rainfall falls uniformly over the entire defined drainage.

A similar process was done for Tunk Block fire but used USGS StreamStats to obtain pre-fire 25 year flow and applied Kuyumjian's equation for post-fire flow. However, total area of high severity burns on subwatersheds affected by the Tunk Block fire is small compared to the size of the affected subwatersheds (see Table 7).

(D) Consequences of the Fire on Values At Risk (VARs)

Hydrologic Modeling Results

This analysis made use of a model developed specifically for the North Star Fire by the DOI-BIA BAER Team which utilized the Automated Geospatial Watershed Assessment (AGWA) tool. No model was developed for the Tunk Block Fire. AGWA enables the user to visualize and compare model results using a geographic information system (GIS) software for display and analysis. This program was used to analyze percent change in peak flow by comparing pre and post and fire conditions in a sub-watershed. Results are presented as a percent change and can be analyzed at numerous points within the sub-watershed using a 25 year storm recurrence interval over a three hour period and 1.5 inches of precipitation. The model assumes uniform precipitation over the entire sub-watershed which is usually a conservative approach given that most storm events occur as isolated thunderstorms or isolated rain on snow events in the spring.

Model results for different subwatersheds affected by the fire show a 0.6% to 1270% increase (Table 9) from pre-fire peak flow depending on the size of burn high and moderate severity within a drainage area, rainfall amount and rate, geology, groundcover, terrain, pattern of burn, channel gradient, change in channel bottom roughness, and travel distance. Change in post-fire peak flow responses is good during the first full year of recovery while subsequent years will see less peak flow responses due additional vegetation growth, increasing transpiration and increasing new liter on the ground to help absorb more rainfall. Caveat on percent change from pre-fire peak flow is an over or underestimated value by a factor of +/- 50 percent.

Table 9. AGWA model results on percent change in post-fire peak flow .

Subwatershed	Stream Name	Drainage Size (mi^2)	Drainage Point (Latitude & Longitude)	Descriptive Location	AGWA 25 Year Storm Post Fire Percent Change from pre-fire flow (1)
Golden Harvest Creek	Golden Harvest Creek	1.39	48.604 -118.8462	Unnamed channel intersecting 5330 road (Swan Lake Road)	0.60%
Golden Harvest Creek	Golden Harvest Creek (perennial)	1.44	48.5919 -118.8584	Golden Harvest Creek intersecting road 5330 (Swan Lake Road)	314%
Lower Lost Creek	Lost Creek	81	48.485633 -119.0205	3005100 road	1270%
Lower WF Sanpoil River	WF Sanpoil River	294	48.4585 -118.7503	WF Sanpoil River @ Hwy 21 bridge.	669%
Lower WF Sanpoil River	WF Sanpoil River	294	48.4585 -118.7504	WF Sanpoil River near Hwy 21 bridge.	669%
Lower WF Sanpoil River	WF Sanpoil River	228	48.4815 -118.869	3115 Aenas Valley Road, High & Mod burns on both sides of road	247%
Scatter Creek-Sanpoil River	Unnamed trib to Scatter Creek	0.86	48.5313 -118.8394	5330 road @ MP 2.71 approx. 100 yard upstream dozer line crosses perennial stream	1060%
Scatter Creek-Sanpoil River	Scatter Creek	20.8	48.5487 -118.75	Road 53 and private road near Hwy 21	266%
Scatter Creek-Sanpoil River	Scatter Creek	20.8	48.5487 -118.76	Scatter Creek and bridge @ Hwy 21	266%
Thirteen Mile Creek-Sanpoil River	Ten Mile Creek	2.38	48.5181 -118.7382	Creek @ Hwy 21 through Colville NF campground	70%

Thirteen Mile Creek-Sanpoil River	Unnamed trib to Sanpoil River	0.6	48.5054 -118.7655	5320 @ MP 3.762 (channel leads to Hwy 21)	65%
Thirteen Mile Creek-Sanpoil River	Unnamed trib to Sanpoil River	1.46	48.4996 ; -118.7411	Same channel below 5320 road (MP 3.762) to Hwy 21	65%
Upper WF Sanpoil River	Unnamed trib to Sanpoil River	8.83	48.5618 -119.0349	Bailey Creek to Aeanas Valley Road	0.27%

(1) - Percent change assumes rainfall falls uniformly over the entire defined drainage.

Figure 1. Highway 21 over West Fork Sanpoil River. Looking upstream on downstream side of bridge.

On the Ten Mile Creek a 24-inch culvert crosses under Highway 21. Creek flows through the upper and lower Colville NF campgrounds. Camp loop road in the upper campground has two additional squash pipes (20” x 30”) connecting Ten Mile Creek. Channel gradient of 6 to 8 percent for over a mile upstream will provide enough stream energy to carry ash and small debris materials to the campground. With enough rain it is expected sediment and small debris materials will overflow onto the loop road and across highway 21 continuing onto the lower campground. The upper camp ground is currently gated and has been closed for the last 3 years. The lower campground does not have a gate and is currently accessible from highway 21. People using the lower campground may be at risk from ash and debris flow. AGWA model

shows a 70% increase on post-fire flows to Ten Mile Creek puts the risk as low to moderate. However, due to the undersized culvert and past evidence of water that have backed up onto surrounding vegetation may push rating to a high increasing the odds of overflow onto highway 21.

Figure 2. Undersized culvert under highway 21 at Colville National Forest Campground.

Intermittent channel goes through a large area of high and moderate burn severity before coming to FSR 5320 road (Figure 3). Ash and small debris flow may obstruct the pipe causing the catchment to fill up with water and debris materials until it tops the road embankment causing erosion leading to a potential road failure. It could become a catastrophic failure turning it into a debris flow in a channel with a 5 to 8 percent gradient for over a mile. After a mile the channel increasingly gets steeper until reaches 60 percent channel gradient. This would increase the energy and speed of the flow until it reaches near the bottom attaining a gradient of 5% before reaching the highway with the potential of spilling debris materials, rocks and/or ash across highway 21.

Figure 3. On inlet side of culvert under FSR 5320 @ MP3.762.

C. **<u>EMERGENCY DETERMINATION – See Table 1 for details on emergency determination.</u>**

D. **<u>POTENTIAL TREATMENTS TO MITIGATE THE EMERGENCY – See Table 1 for details on potential treatments.</u>**

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