Upper Bulkley Fish and Aquatic Review
Summary of Data, Methodology, Thresholds, and Results
For Pressure Indicator Total Land Cover Alteration

1.0 Introduction

Total Land Cover Alteration (TLCA) reflects a suite of potential changes to hydrological processes and sediment generation, with potential impacts to downstream salmon habitat, as well as changes in biodiversity. The Wild Salmon Policy Habitat Working Group has ranked TLCA as a high value pressure indicator.

Total land cover alteration (TLCA) consists of two components - anthropogenic alterations to the land base and natural disturbances. Anthropogenic alterations to the land base include settlements, agricultural activities, transportation infrastructure, and resource-based activities such as forestry, mining, and energy development.

Natural disturbances include abiotic elements, such as wildfires, windthrow, and geomorphic activity such as landslides and debris or snow avalanches. Natural biotic disturbances include insect infestation and disease[1]. When viewed over the long-term natural disturbances help preserve a diverse, resilient, and healthy ecosystem[2].

This project presents TLCA in two parts - the results for anthropogenic disturbances, referred to as Total Human Development Footprint (HDF) and natural abiotic disturbances (wildfires). The first section analyzes the Total Human Development Footprint and applies interim thresholds to the results of the analyses. The second section presents analyses based on the natural disturbance agent fire. Biotic disturbances such as insect infestation and disease including mountain pine beetle, placed within the context of natural disturbance zones, is not include in these analyses as it was beyond the scope of the project.

2.0 Total Human Development Footprint Analyses

2.1. GIS Data

The following spatial information was utilized in the analyses:

- Consolidated Skeena roads (DRA, FTEN database, Bing imagery)
- Railway, natural gas pipeline, and transmission lines (NTS 1:50,000)
- Provincial Harvest Depletion Layer 2015 (consolidated cutblock data from BC Gov't)
- Crown Tenures (Agriculture, Industrial, Utility, Transportation, Commercial, Quarrying, Residential, Community)
- Mineral Tenures/Advanced Exploration Sites
- Bing Maps Aerial photos
- Fire History data (BC Wildfire Service)

[1] Parminter, J., and Daigle P. (July 1997). FORREX Extension Note. Landscape Ecology and Natural Disturbances: Relationships to Biodiversity. Retrieved from https://www.for.gov.bc.ca/hfd/pubs/Docs/En/En10.htm

[2] Wong, C., H. Sandmann, and B. Dorner. 2003. Historical variability of natural disturbances in British Columbia: A literature review. FORREX – Forest Research Extension Partnership, Kamloops, B.C. FORREX Series 12.

2.2. Methodology

The various land cover datasets listed above in section 2.1 were integrated to form a comprehensive dataset representing the total human development footprint.

A variable buffer was applied to the roads based on type of road (highway, mainline, secondary, in-block) based on criteria determined by Coombes (2010) for the Lakes Timber Supply Area[3].

The existing and approved (but not constructed) natural gas pipelines, including Pacific Northern Gas, Pacific Trails Pipeline, and Enbridge are represented by their tenure boundaries, resulting in a 75 m corridor. Proposed pipelines with no tenure issued were not considered for this analysis.

The Provincial Harvest Depletion Layer (2015) was utilized to represent harvesting activity.

Crown Tenures designated as commercial recreation, environmental conservation and recreation, and miscellaneous land uses were removed for the analyses, as these tenures did not show a significant visible footprint on the ground as per Bing Maps.

Agriculture tenures were included, including hay and livestock grazing tenures. Expired tenures within the past 10 years were also included due to the overlapping nature of the tenure system. Most of the active agricultural tenures are grazing licenses except two which are allocated to hay.

There were no significant advanced mineral exploration sites (point data) within the Bulkley watershed that showed ground disturbance on Bing Maps or Google Earth.

2.3. Thresholds

Interim thresholds representing the percentage of the land base altered by human development applied in these analyses follow the recommendations put forth by the Pacific Salmon Foundation's Sockeye Habitat Assessment Project.

Low risk: < 6.4%
Moderate risk: >= 6.4%
High risk: >= 22%

2.4. Results

The results of the Human Development Footprint (HDF) are reported out by a variety of boundaries including the Upper Bulkley Watershed, twenty-two sub-watersheds and face units within the Upper Bulkley watershed, nineteen Wet'suwet'en house territories within or adjacent to the Upper Bulkley Watershed, the WSP Chinook Conservation Unit, and the Bulkley River Resource Management Zone as determined by the Morice LRMP.

[3] Coombes, T., A. Bernard, and G. Nigh. 2010. Forest access road widths in the Lakes Timber Supply Area. BC Journal of Ecosystems and Management 11 (1&2):84-90.

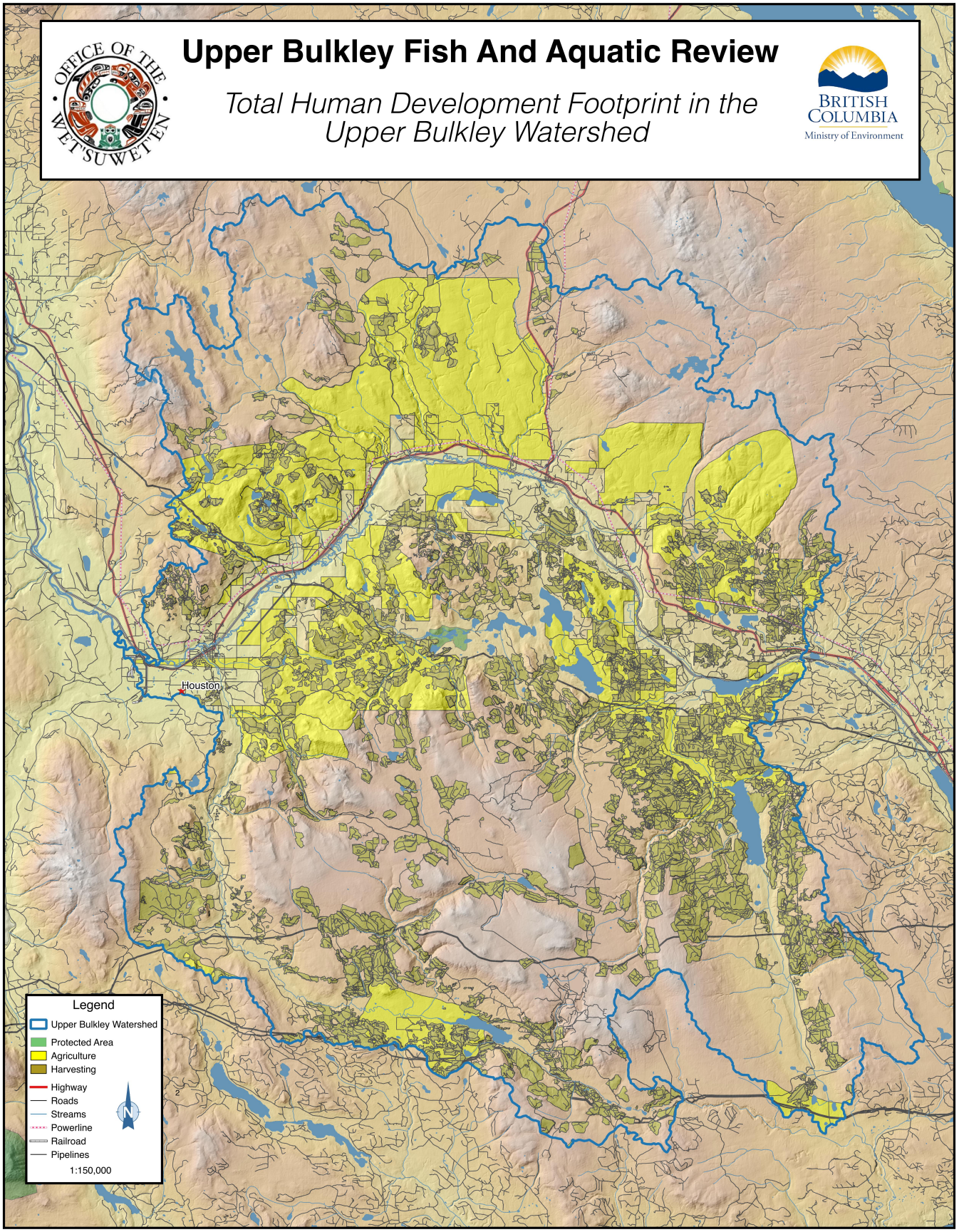
2.4.1. Upper Bulkley Watershed

Within the Upper Bulkley watershed 43.3% of the watershed has a total human development as shown in Figure 2.4.1.

Table 2.4.1.1 Total Human Development Footprint within Upper Bulkley Watershed

Area (km^2)	Total HDF (km^2)	Total HDF (%)
2,315.07	1,003.17	43.33

Figure 2.4.1.1 Total Human Development Footprint in the Upper Bulkley Watershed



2.4.2. Wet'suwet'en House Territories within the Upper Bulkley Watershed

The fifteen Wet'suwet'en House Territories within the Upper Bulkley Watershed have a Total Human Development Footprint of 39.4 % (1,855.60 km^2). The HDF values across the house territories range from 16.9 % in the C'inilh K'it house territory to 67.5 % in the Tse Zul House Territory. The total HDF results indicate the C'inilh K'it House Territory falls within the moderate risk category, with the remainder of the House Territories displaying a Total HDF value in the high risk category.

Table 2.4.2.1. Total Human Development Footprint within Wet'suwet'en House Territories

House Territory	Area (km^2)	Total HDF (km^2)	Total HDF (%)
'Ilh K'il Bin	305.26	130.55	42.77%
Bi Wini	883.29	323.22	36.59%
Bikh C'idilyiz Ts'anli	142.48	43.99	30.88%
C'idi To Stan	505.42	213.45	42.23%
C'iggiz	177.29	92.74	52.31%
C'inilh K'it	396.40	67.26	16.97%
Cosl'et Bin	361.06	155.87	43.17%
Dets'inegh	70.79	39.07	55.19%
Ggusgi Be Wini	288.66	150.90	52.28%
Gguzih Keyikh	54.13	22.67	41.87%
Nelgi Cek	214.98	100.75	46.87%
Nelhdzi Tezdli Bin	417.79	137.16	32.83%
Tasdlegh	477.18	211.83	44.39%
Ts'in K'oz'ay	280.41	77.60	27.67%
Tse Zul	131.12	88.54	67.52%
Subtotals	**4,706.26**	**1,855.60**	**39.43%**

Figure - 2.4.2.1 Total Human Development Footprint within Wet'suwet'en House Territories

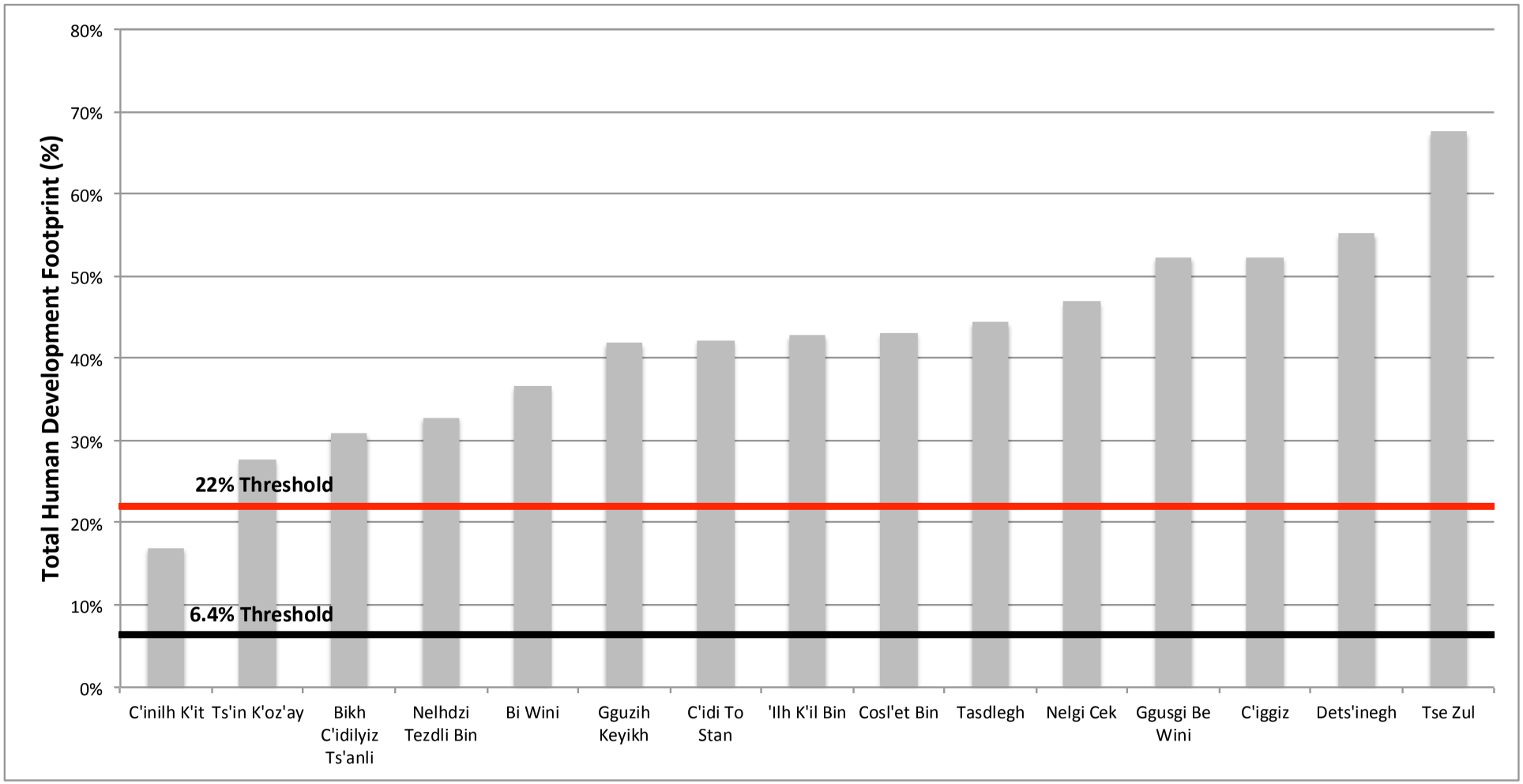
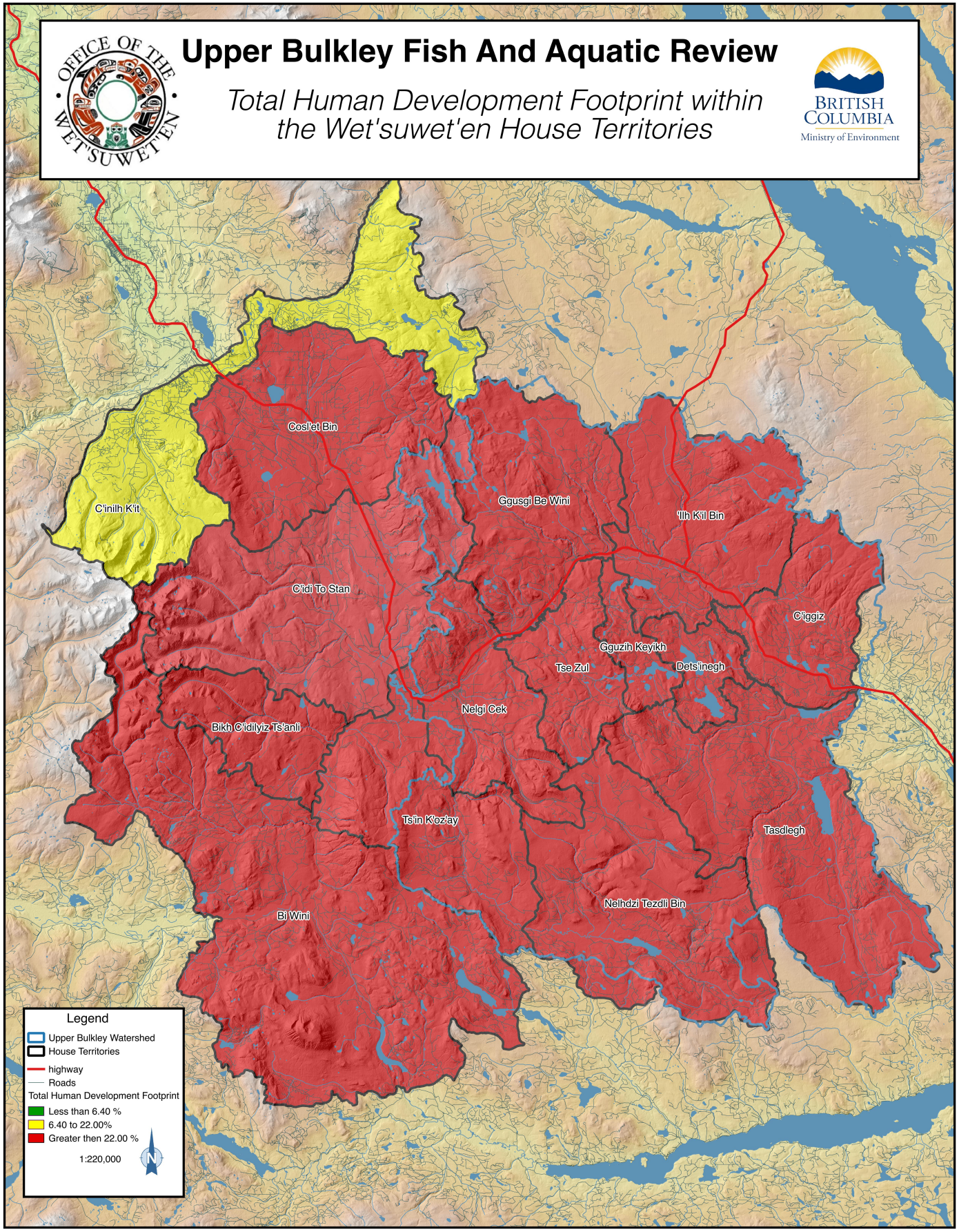


Figure - 2.4.2.2 Total Human Development Footprint within Wet’suwet’en Territories



2.4.3. Upper Bulkley Sub-watersheds

The total HDF within the thirteen sub-watersheds and nine face units situated in the Upper Bulkley Watershed range from 20.70% in Cesford Creek to 94.38% in Barren Creek. All the sub-watersheds exceed the low risk development threshold of 6.4%, two sub-watersheds indicate a moderate risk, and the remaining twenty sub-watersheds and face units exceed the high risk development threshold of 22.0 %.

Table 2.4.3.1 Total HDF within Upper Bulkley Sub-watersheds

Sub-watershed Unit	Area (km^2)	THDF Area (km^2)	THDF (%)
Ailport	97.13	63.55	65.43%
Aitken	148.66	73.43	49.39%
Barren	25.81	24.36	94.38%
Buck	566.77	175.26	30.92%
Byman	94.04	30.17	32.09%
Cesford	36.70	7.60	20.70%
Crow	73.96	28.33	38.30%
Johnny David	43.73	36.83	84.22%
Maxan	370.73	139.62	37.66%
McKilligan	38.20	33.47	87.61%
McQuarrie	114.62	24.43	21.32%
Perow	20.63	11.59	56.19%
Richfield	161.81	62.61	38.69%
Subtotal	**1,792.79**	**711.25**	**39.67%**
Bukley River Face Units			
Bulkley River 1	78.47	29.76	37.92%
Bulkley River 2	51.21	38.38	74.96%
Bulkley River 3	75.84	50.78	66.96%
Bulkley River 4	30.07	15.29	50.86%
Bulkley River 5	36.87	16.80	45.57%
Bulkley River 6	59.21	27.13	45.82%
Bulkley River 7	64.63	34.96	54.09%
Bulkley River 8	32.23	26.47	82.13%
Bulkley River 9	93.77	52.34	55.82%
Subtotal	**522.29**	**291.92**	**55.89%**
Total	**2,315.07**	**1,003.17**	**43.33%**

Figure 2.4.3.1 Total Human Development Footprint within the Upper Bulkley Sub-watersheds

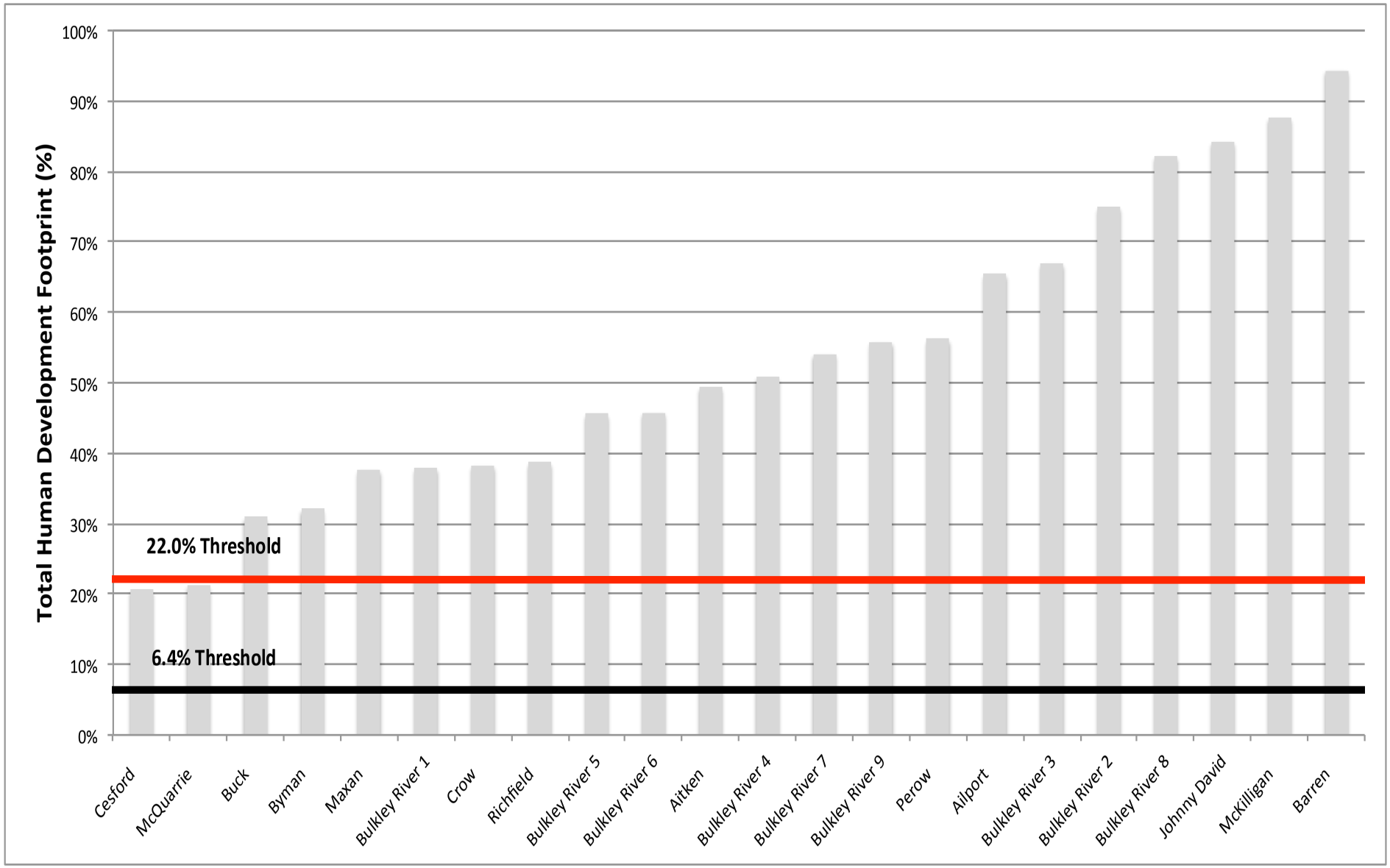
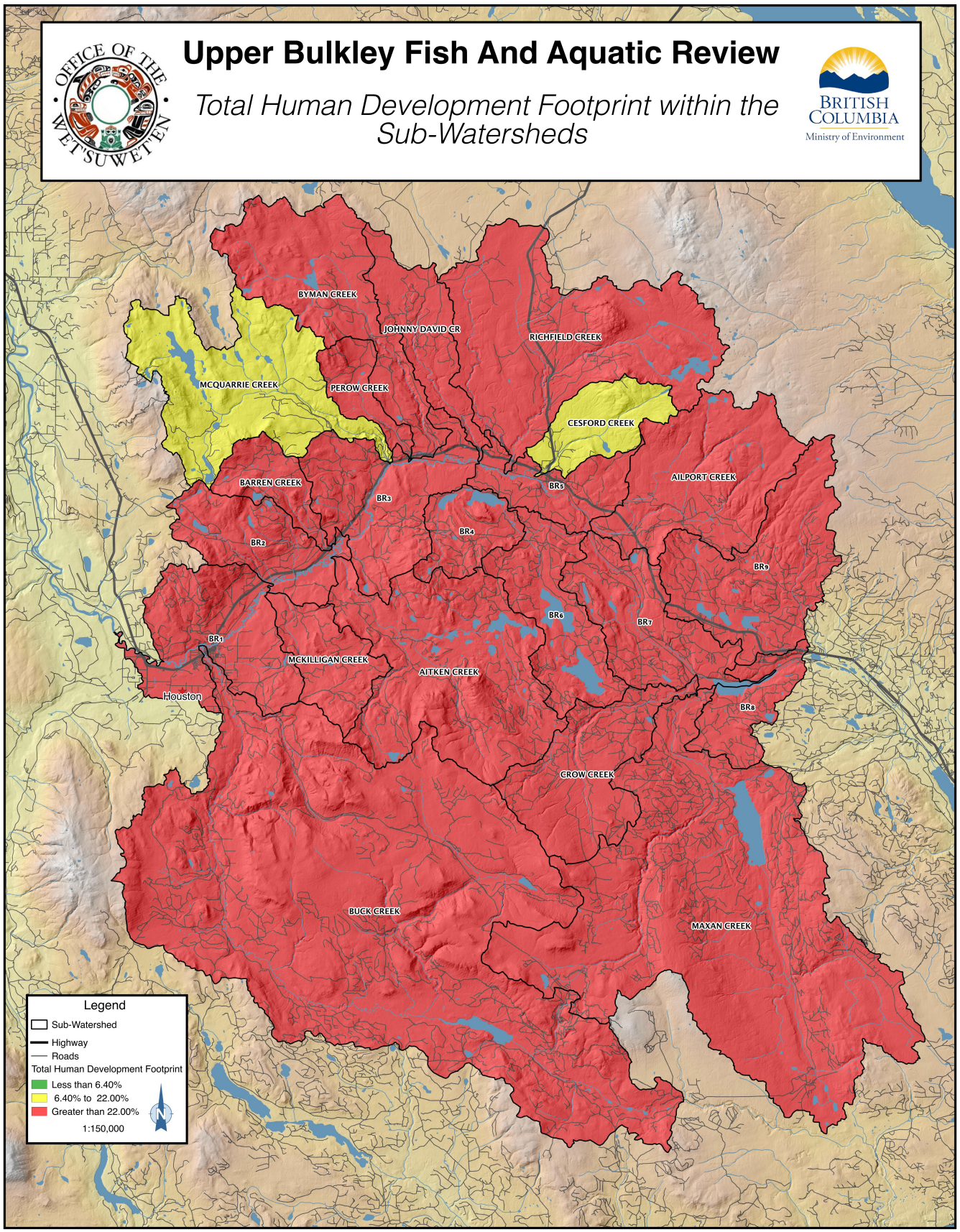


Figure 2.4.3.2 Total HDF within the Upper Bulkley Sub-watersheds



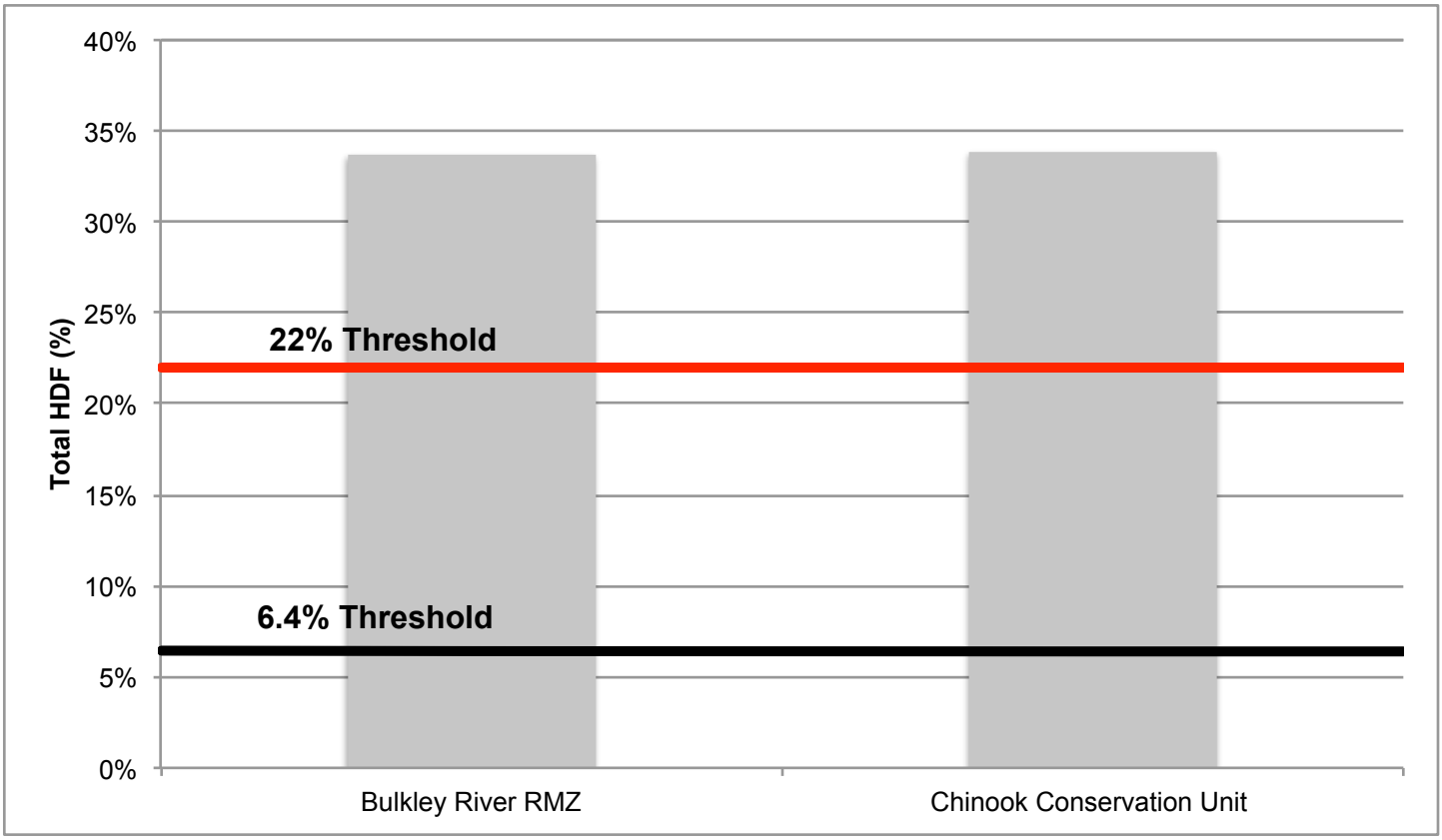
2.4.4. Additional Management and Resource Zones

This report includes two additional management and resource zones related to aquatic objectives situated within the Upper Bulkley Watershed. These areas include the Wild Salmon Policy Chinook Conservation Unit and the Bulkley River Resource Management Zone as determined by the Morice LRMP.

Table 2.4.4.1 Total HDF within Management and Resource Zones

Management Zone	Area (km^2)	Total HDF (km^2)	Total HDF (%)
Bulkley River RMZ	53.20	17.95	33.74%
Chinook Conservation Unit	117.88	39.97	33.91%

Figure 2.4.4.1 Total HDF within Management and Resource Zones



3.0 Natural Disturbance Agents

In order to determine the impact on the land base by anthropogenic factors, it is useful to first have an understanding of the underlying natural disturbance regimes at work. Information on natural disturbance types, including their distribution and extent, frequency, and intensity is essential to better understanding the level of natural landscape biodiversity. Natural disturbance is relevant in that "when an ecosystem is managed within its historical range of variability, it will remain diverse, resilient, productive and healthy." Natural disturbances are now "considered to be part of the process of forest and landscape development rather than an external goal of destruction".[4]

Currently within British Columbia five natural disturbance types (NDTs) are recognized, based on Biogeoclimatic subzones and variants:

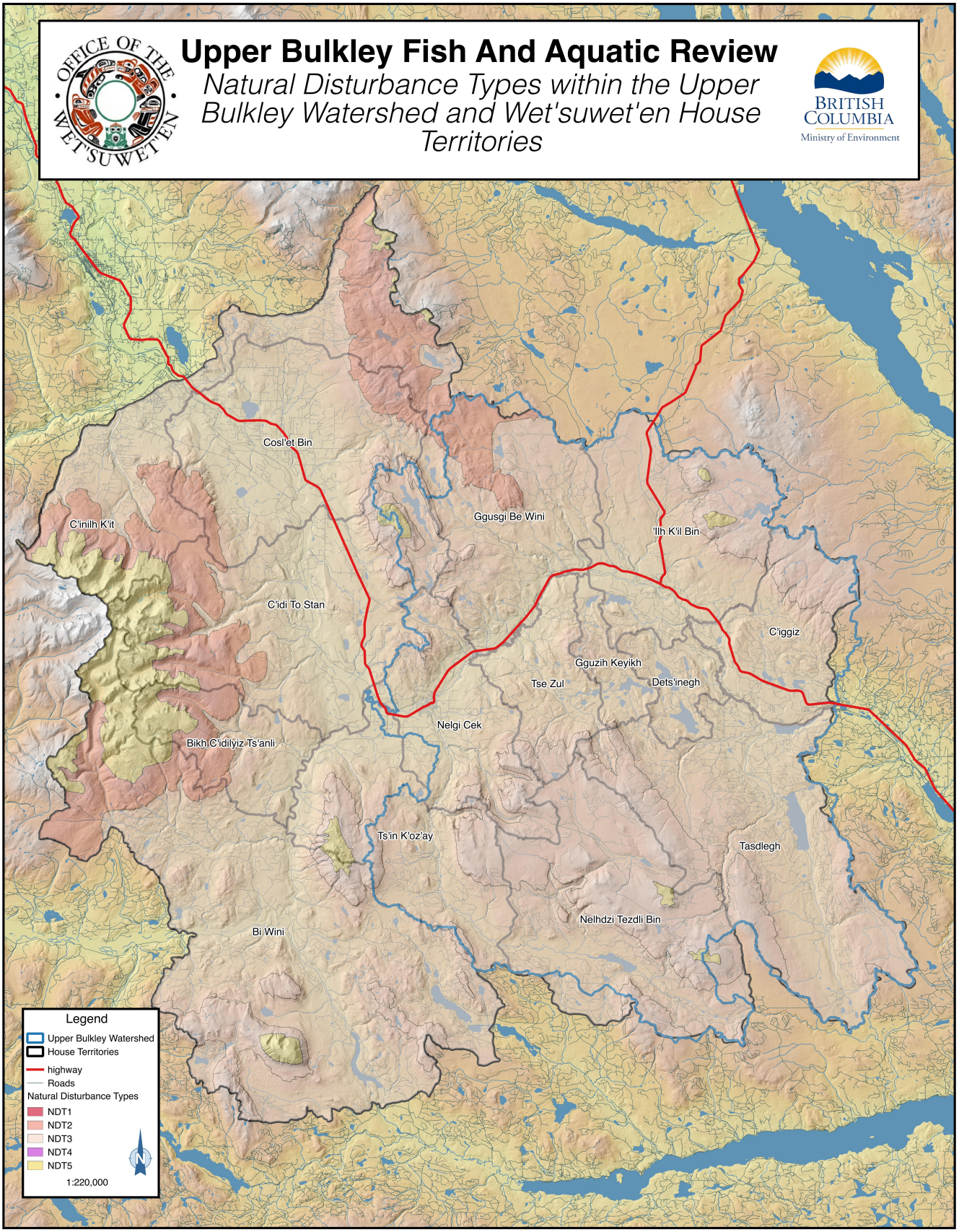
NDT1 – Ecosystems with rare stand-initiating events
NDT2 – Ecosystems with infrequent stand-initiating events
NDT3 – Ecosystems with frequent stand-initiating events
NDT4 – Ecosystems with frequent stand-maintaining fires
NDT5 – Alpine Tundra and Subalpine Parkland ecosystems

Although the NDTs in BC were created to set landscape level biodiversity objectives, which is beyond the scope of this project, the NDTs do provide a broad stratification of the landscape based on disturbance zones. The NDTs provide an ecological framework that provides context for the frequency and extent of natural disturbances discussed below.

The Upper Bulkley Watershed consists of three natural disturbance types as shown in Figure 3.1.

[4] Forest Practices Code (September 1995). Biodiversity Guidebook. Retrieved from https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/BIODIV/intro.htm#int

Figure 3.1 Natural Disturbance Types in the Upper Bulkley Watershed and Wet'suwet'en House Territories.



3.1. GIS Data

The following spatial information was used in the natural disturbance analyses:

- Historical fire data from 1920 to 2014 (Fire Protection Branch, BC Gov't)
- Current fire data from 2015 (Fire Protection Branch, BC Gov't)
- Natural Disturbance Types (NDTs) (Research Branch, MoF)

Spatial data for other natural disturbance agents, such as mountain pine beetle, were available but not included as it was beyond the scope of the analysis. Reliable data for abiotic natural disturbance agents, such as windthrow, was not available. The wildfire data does not include traditional aboriginal burn sites. The wildfire database attempts to capture the historical frequency and extent of wildfires dating back to 1915, but there are limitations, especially in the 1940 – 1959 interval[5].

3.2. Methodology

The historical fire data (polygons) from 1915 to 2014 was used as is, with the current 2015 added for context only as the data consists only of spot fires (point locations).

3.3. Thresholds

The natural disturbance types provide a general framework for extent and frequency of disturbances such as mountain pine beetle infestations, fire, and possibly anthropogenic disturbances. Thresholds applied to the Total Human Development Footprint do not directly transfer to natural disturbance agents such as mountain pine beetle and wildfires[6].

3.4. Results – Fire Disturbance

Fire History data from 1915 – 2015 was analyzed by frequency as well as extent. In order to maintain a watershed perspective, the results are presented only by the extent of the largest area of interest, the Wet'suwet'en House Territories within the Upper Bulkley watershed. The fire disturbance data is summarized by 19 year intervals, and further broken down by Natural Disturbance Type.

During the 100 year span from 1915 to 2015, 59.8% (183) of the fires recorded occurred during the 1915 – 1934 time period. During this time period, only four of the fires recorded were caused by lightning with the remaining 179 attributed to humans. The number of fires in subsequent years ranges from 51 fires in 1935 – 1954 time period to 14 fires in 1975 – 1994 time period. On average from 1935 to 2014, 94.4% of the fires within the area of interest are human caused. The year 2015 registered 19 spot fires in the area, four caused by lightning and fifteen caused by man.

Although the number of fires have somewhat reduced over time, the main cause of forest fires within the Upper Bulkley watershed has not shifted away from man-made causes. Whereas

[5] K. Rabnett, personal communication, September 9, 2013

[6] Price,M. 2011. Summary of Habitat Indicators for the Conservation of Wild Pacific Salmon. Unpublished report prepared for Skeena Wild Conservation Trust.

the provincial average over the past 10 years of fires caused by people is 39.8%[7], during the same time period of 2005 – 2014, 74.1% of the fires in the Upper Bulkley were caused by man.

Table - 3.4.1 Fire Frequency by Year and Cause

		Cause of Fire (% of Category Total)	
Fire Year	**No. of Fires**	**Lightening**	**Human**
1915-1934	183	2.2%	97.8%
1935-1954	51	3.9%	96.1%
1955-1974	29	17.2%	82.8%
1975-1994	14	0.0%	100.0%
1995-2014	29	20.7%	79.3%
Totals	**306.00**	**5.6%**	**94.4%**

3.4.1. Fire Extent

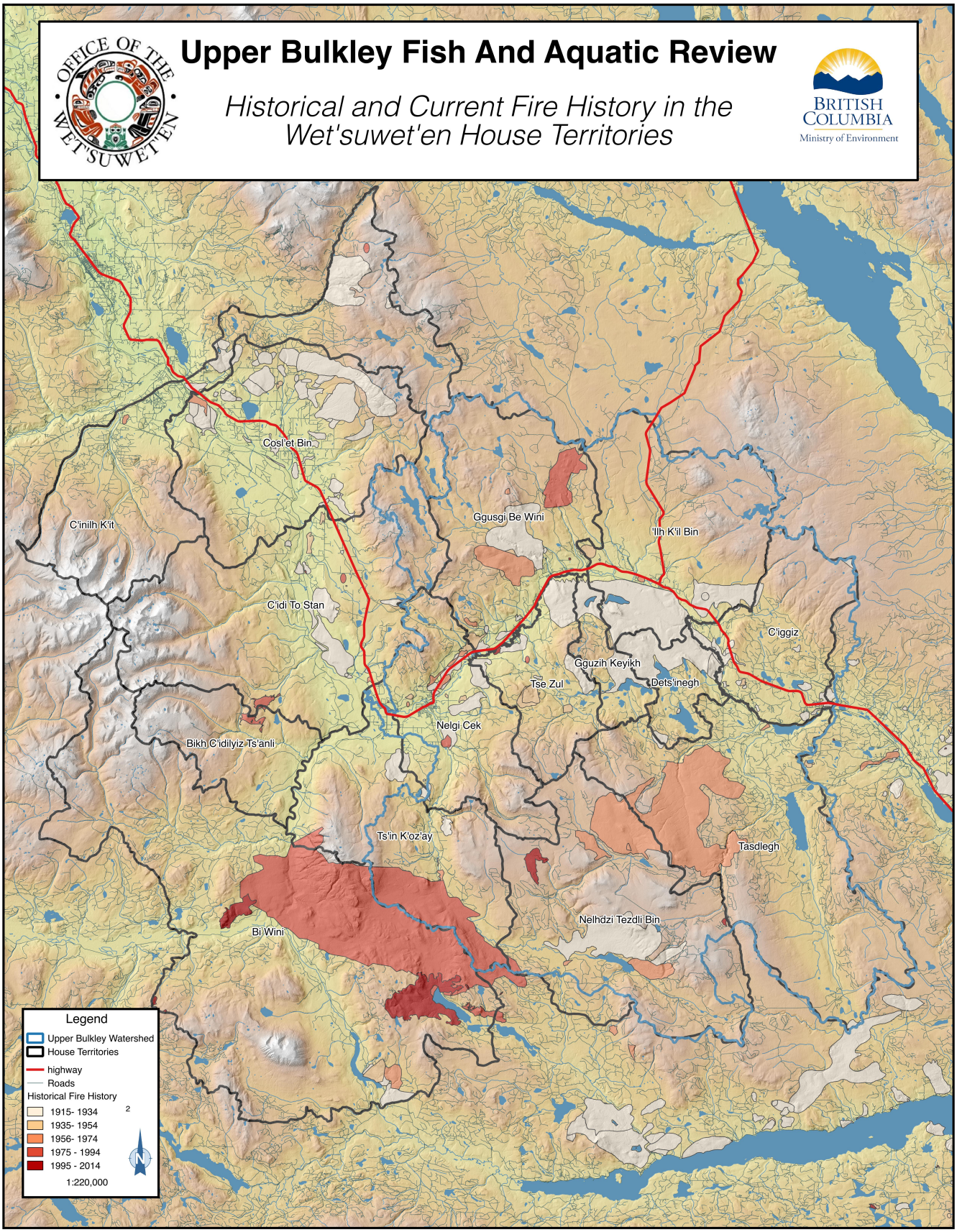
The following table presents fire extent by natural disturbance type. The average fire size from 1935 to 2014 is 5.8 km^2. The exception in the data is the Swiss Fire of 1983 which covers an area of 21,576 ha. The majority of the fires, 85.3 % occurred in the NDT3 zone.
9.5 % of the fires occurred in the NDT2 zone, and the remaining 1.63 km^2 within the NTD5 zone.

Table 3.4.1.1 Fire Extent by Year (km^2) and Natural Disturbance Type

Fire Year	NDT2	NDT3	NDT5	Totals
1915-1934	42.93	777.27	0.20	820.40
1935-1954	14.39	110.18	0.00	124.57
1955-1974	55.72	196.60	0.00	252.32
1975-1994	27.32	263.92	1.43	292.66
1995-2014	5.82	36.43	0.00	42.25
Totals	**146.18**	**1,384.39**	**1.63**	**1,532.20**

[7] BCwildfire.ca. (2016). Retrieved May 10, 2016, from http://www2.gov.bc.ca/gov/content/safety/wildfire-status/wildfire-statistics/wildfire-averages

Figure - 3.4.1.1 Historical and Current Fire History in Wet'suwet'en House Territories within the Upper Bulkley Watershed.



4.0 Summary Of Analyses by Natural Disturbance Type

These analyses provide a high level comparison of the footprint of current development placed within the context of thresholds, as well as an overview of the natural disturbance agent fire.

Table. 4.1 Extent of Disturbance Agent by Natural Disturbance Type (km^2)

	NDT2	NDT3	NDT5	Total HDF
Total HDF (km^2)	204.42	2,906.36	1.74	3,112.51
Extent of Wildfire (km^2)	146.18	1,384.39	1.63	1,532.20

Within the Upper Bulkley Watershed and the Wet'suwet'en Territories that are situated within the Upper Bulkley, the extent of the Human Development Footprint (3,112.51 km^2) is over double the footprint of wildfire. Both disturbances are predominantly situated within the NDT3 zone, with a relatively low disturbance footprint within the NDT2 zone and a slight level of disturbance within the NDT5 zone.

The wildfire analyses presented in this report only examines the frequency and extent of the disturbance. The report does not look at the severity (intensity) of the disturbance.

The results presented in these analyses represent a snapshot in time, as natural disturbance regimes are dynamic processes. The interaction between natural disturbance agents and development activities is not well understood. Natural disturbance regimes are complex processes, making projections into the future under a warmer climate extremely difficult."[8]

[8] Haughian, S.R., P.J. Burton, S.W. Taylor, & C. L. Curry. 2012. Expected effects of climate change on forest disturbance regimes in British Columbia. BC Journal of Ecosystems and Management 13(1):1-24 Published by FORREX Forum for Research and Extension in Natural Resources. http://jem.forrex.org/index.php/jem/article/viewFile/152/107