TANEx Engineering Corporation

Broadband Internet Service Speed Study Final Report

Understanding Discrepancies Between the Consumer Experience and the National Broadband Availability Map in British Columbia

Report to: Northern Development Initiative Trust

October 31, 2021

THANK YOU

There were a number of municipalities, Indigenous governments and regional governments who provided information about connectivity in their area. Those contributions are gratefully recognized. Further, the efforts of the Canadian Internet Registration Authority in developing the landing page for British Columbia to capture results of CIRA tests throughout the province as a whole were invaluable. The cooperation of those service providers that took the time to provide input was greatly appreciated. Finally, thanks go out to the individuals who took the time to take the speed test and to the Northern Development Initiative Trust, the Province of British Columbia, and the Union of British Columbia Municipalities for their insights and assistance throughout this Study.

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EXECUTIVE SUMMARY

OVERVIEW

TANEx Engineering Corporation has completed the Broadband Internet Service Speed Study (the “Study”) as an initial foray into understanding whether there are differences in rural British Columbia between the service availability shown on the National Broadband Internet Service Availability Map (the “Map”)[1] and the service experienced by consumers in those areas (“discrepancies”) and to explore and understand the factors contributing to discrepancies.

This final report provides a baseline understanding of the issue of discrepancies in small rural areas of BC and what may cause them. Its focus was on small, rural areas that are shown on the Map as having available service of 50 megabits per second download and 10 megabits per second upload (“50/10”). Those locales are referred to as “50/10 locales”. The purpose of the Study was to provide a starting point for discussions on matters related to internet speeds in rural B.C. communities with local governments, internet services providers, the province, and the Federal Government.

This subject matter is complex with many variables and, in some ways, leads to more questions than answers. The Study focused on developing a mechanism for compiling and analyzing information from local and Indigenous governments with concerns about this issue, developing a methodology for estimating the magnitude of discrepancies, conducting research and outreach, and collecting and analyzing data. More granular work into the locales identified in the Study as having evidence of potential discrepancies will be necessary to be able to validate and resolve those issues.

FINDINGS

Discrepancies can be caused by numerous factors; however, those factors fall into four primary categories.

SYSTEMIC	TECHNOLOGICAL	BUSINESS	CONSUMER
Process and definitional factors.	Factors relating to technology.	Factors introduced as a result of business decisions.	Factors introduced by consumer choice.

The Study concluded that discrepancies exist in British Columbia and that the magnitude of those discrepancies is large enough to warrant further attention and action. Initial estimates indicate that there are over 100 locales that have higher levels of evidence of a discrepancy based on the methodology used in the Study.

[1] https://www.ic.gc.ca/app/sitt/bbmap/hm.html?lang=eng

BACKGROUND

The Canadian Radio-television and Telecommunications Commission ("CRTC") established a universal service objective: **"Canadians, in urban areas as well as in rural and remote areas, have access to voice services and broadband Internet access services, on both fixed and mobile wireless networks" (the "USO").**[2] The achievement of the broadband portion of the USO is to be measured by several criteria, including that "**Canadian residential and business fixed broadband Internet access service subscribers should be able to access speeds of at least 50 megabits per second (Mbps) download and 10 Mbps upload, and to subscribe to a service offering with an unlimited data allowance"**[3]**.** The USO has been set to achieve the objective that <u>all Canadians</u> can access <u>affordable</u>, <u>high-quality</u> telecommunications services recognizing that there is a "significant disparity in the broadband Internet access service levels available in urban centres compared to those in rural and remote areas."[4]

> *CRTC Decision 2016-496 paragraphs 80 and 81: Established that measuring the successful achievement of the broadband portion of the USO would have a criterion that "Canadian residential and business fixed broadband internet access service subscribers can access speeds of at least 50Mbps download and 10Mbps upload". "These speeds are to* ***be actual speeds delivered, not merely advertised****" while recognizing that "service speeds actually experienced by users are affected by a wide range of factors, some of which are outside the control of the network provider".*

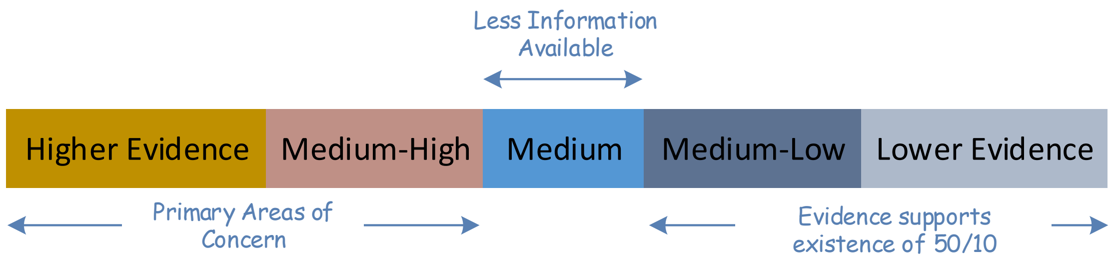
The governments of Canada and BC have implemented funding programs to improve connectivity for rural and remote areas where existing connectivity has the most work left to be done. To facilitate the expansion of broadband internet throughout rural and remote Canada, Innovation, Science and Economic Development Canada ("ISED") developed the Map to identify areas that are eligible for federal funding. Areas shown as already served at 50/10 may be ineligible for such grant programs. However, BC communities have reported that there are areas shown on the Map as already served at 50/10 which do not actually have access to services at that level.

The Study was to qualitatively assess the likelihood and estimated magnitude of rural locales in British Columbia having discrepancies and to identify factors which may contribute to the existence of those discrepancies. It focussed on small, rural BC locales that are shown on the Map as already served at 50/10 to assess the likelihood of discrepancies in those 50/10 areas (referred to as a "50/10 discrepancy").

[2] See Telecom Regulatory Policy CRTC 2016-496 at https://crtc.gc.ca/eng/archive/2016/2016-496.htm
[3] Ibid- paragraph
[4] Ibid – paragraph 48

HOW WAS THE STUDY DONE?

Conclusions reached in the Study were the result of analysis of a dataset of areas of interest which was developed using a methodology detailed more fully in Appendix "A". Deploying that methodology resulted in a dataset of small, rural locales which were within a designated distance from an area shown on the Map as already being served with 50/10 (the "Locale Dataset") and then the locales were assessed against a number of metrics to determine a score representing the likelihood of a discrepancy. The scoring output of the Locale Dataset was used to estimate the magnitude of 50/10 discrepancies for the province by categorizing them into five categories designated by strength of evidence tending towards the existence of a 50/10 discrepancy. Those evidence categories were labelled as higher, medium-high, medium, medium-low, and lower.



The metrics used to determine a score include knowledge obtained from local stakeholders / government, testing data available and technology deployed among others. To obtain the local knowledge component, a questionnaire was developed for local and Indigenous governments to participate in the Study by completing the questionnaire to provide further information about connectivity in their area and to identify areas of perceived discrepancies. For Regional Districts that represent a large geographic area, a list was generated of the locales showing as having 50/10 service and provided to them for further information about regional service. This information was validated to the extent possible and used as one metric in the overall scoring.

In addition to the other metrics, test data was obtained using a Canadian Internet Registration Authority ("CIRA") developed webpage for British Columbia[5] that allows for analysis of tests taken through that website over a period of time to ascertain the consumer experience in a locale. CIRA's internet performance test is purpose-built to assess more closely, the experience that the consumer has when accessing the internet[6].

It is acknowledged that consumer driven speed tests have inherent weaknesses such as competing traffic at the time of the speed test, use of the consumer's network in conducting the speed test, subscribed internet service levels and quality of the equipment among others. However, when comparing aggregated, rather than individual, CIRA test results from BC locales, the aggregated results are consistent with the overall impression of service quality in those locales. In other words, locales that have fibre infrastructure and other generally positive indications of internet performance have CIRA test results that indicate high levels of service. Those that have other evidence demonstrating poor levels of service, generally have low CIRA test results. These trends indicate that speed test results are a valid performance metric to be considered in conjunction with other metrics of the overall scoring for a locale.

[5] https://performance.cira.ca/bc

[6] https://www.cira.ca/improving-canadas-internet/initiatives/internet-performance-test

Finally, the Study did not look at each locale in the Locale Dataset individually to determine whether there was a discrepancy as the time and budget to do that was beyond what was available but did identify four profile areas to be analyzed more closely that could act as a proxy for other BC communities.

Profile locales were selected on the basis of including:

- a selection of different community types such as incorporated municipalities, non-incorporated rural locales and Indigenous locales.
- locales that expressed a desire to participate.
- locales that exhibited passion around the connectivity issue and had taken some initiative to address the state of connectivity in the community.
- diverse areas of the province that represented more significantly affected population.
- locales with more CIRA tests from unique IP addresses.
- locales which provided an opportunity for extrapolation to others.
- any known limitations on a locale's ability to dedicate resources to participate.

At the time of the Study and selection of the profile locales, there were some additional significant factors that had to be considered in selection. During the outreach portion of the Study, the Tk'emlúps te Secwépemc First Nation announced the discovery of undocumented remains of students on the grounds of the Kamloops Indian Residential School. That announcement was profoundly impactful to Indigenous communities so direct outreach to Indigenous communities about the Study was suspended to be respectful of the grieving process.

In addition, the 2021 wildfire season in British Columbia was extreme. It was incredibly dangerous and resulted in a provincial state of emergency with a number of fires burning very close to or inside of populated areas. This state of affairs resulted in evacuations of a number of local and Indigenous government offices, so part of the selection included recognition of local and Indigenous governments that had pressing, or emergent, public safety oriented priorities.

The findings arising out of the research on the selected profile locales is found in Appendix "E - H".

WHY DO DISCREPANCIES EXIST

The Study defines discrepancy as a difference, in rural areas in British Columbia, between the service availability shown on the Map and the service experienced by consumers in those areas. Discrepancies can occur for many different reasons and often from a combination of them. It is important to note that internet connectivity requires several components to function properly. Appendix "B" illustrates the main components that make up the end-to-end chain of systems that deliver the consumer experience. Factors contributing to discrepancies tend to fall into four main categories described below.

SYSTEMIC
Definition
Lack of Precision
Process
Updates
Errors

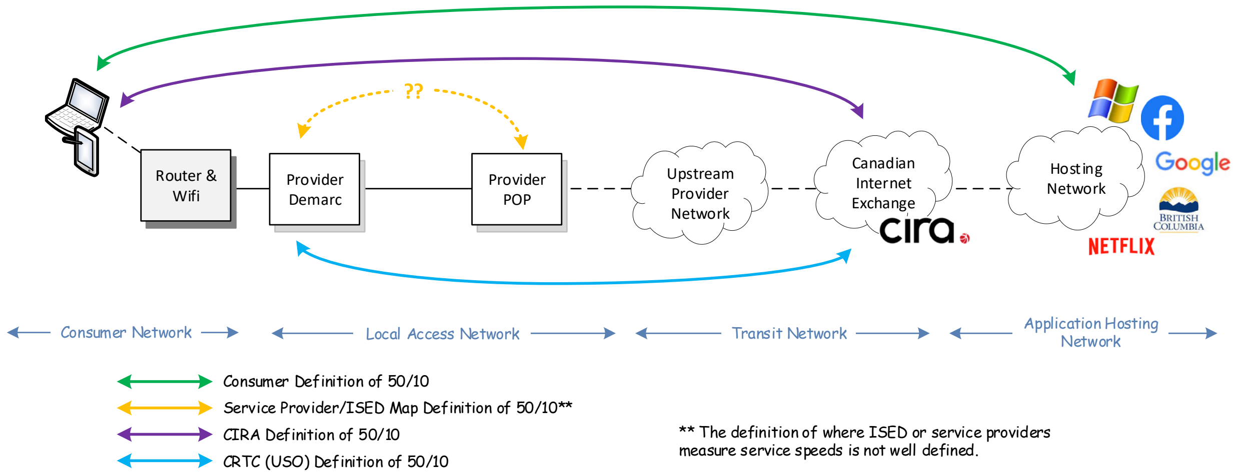
Systemic contributing factors are those that are the result of the system of reporting and mapping of service level information. Systemic factors include definition, lack of precision, process, mapping updates and errors. Mapping service levels across Canada is a significant task so it is to be expected that the Map will require refinement over time to address areas that may require changes.

DEFINITION of 50/10

The CRTC, ISED, service providers and consumers can mean different things when they refer to 50/10. The CRTC's measurement metric for the USO refers to service at 50/10 but has not specified where that speed should be measured to and from. It does specify that the speeds must be those actually experienced. It has gone on further to define quality of service metrics for latency, packet loss, and jitter and established that measurement of those metrics should be from the customer modem to an internet exchange point in a Canadian Tier 1 city. Although not specifically stated, one would expect that the definition for 50/10 would be consistent with this. Additionally, service providers report last mile service availability of 50/10 to ISED and the CRTC and sell 50/10 service to consumers. In the end however, the only definition that matters to the consumer is the entire end-to-end system and that is often measured by a consumer with a speed test. This lack of consistency in how different parties define 50/10 creates discrepancies because the parties are not talking about the same thing. While it is believed that the definition of 50/10 on the Map reflects the local access only, attempts to have ISED confirm where that level of service should be measured were unsuccessful.

CRTC Decision 2018-241: "The Commission determines that the parts of an ISP's fixed broadband internet access network to which QoS measurements should apply include all network elements from the modem at the customer's premises to a point of interconnection at an IXP in a Canadian Tier 1 city".

The diagram below demonstrates how different definitions of where 50/10 services can lead to a discrepancy.



LACK of PRECISION

Neither the ISED direct reporting form[7] nor the CRTC Form 256 Geographic residential broadband capability checklist[8] use defined terms. The reporting forms request the download and upload speeds that are "provided" or "available" or "offered". Those terms are not defined in the reporting forms nor are they found in the CRTC glossary of terms[9] and accordingly, there may be variations in what service providers are reporting. From the consumer's perspective, however, the definition is clear. The consumer cares about the performance of internet service from their device to the final internet application.

PROCESS

The process by which the Map is created and revised is another factor under the systemic theme. The Map was developed and is continually revised on a periodic basis based on reporting by service providers across Canada to the CRTC or ISED. Such reporting can be done either as part of the CRTC's annual facilities survey or by a stand alone reporting[10] but in either case, is not validated by any third party as a part of the process. As part of the Study, ISED outreach suggests that the service levels (shown as different colours) on the road segments on the Map reflect last mile speeds as reported by the service providers and do not reflect upcoming transport projects. For more detail on the Map process, refer to Appendix "C".

The CRTC did undertake a quantitative study to compare contracted speeds to the speeds experienced by those consumers and that study did conclude that consumers generally get what they pay for[11]. It is important to note however that it did not focus on whether reporting of service availability at 50/10 to CRTC or ISED means that service is in fact available at 50/10 to the consumer in that area but rather focussed on contracted for speeds.

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[7] https://www.ic.gc.ca/eic/site/139.nsf/eng/h_00004.html
[8] https://crtc.gc.ca/eng/dcs/current/lst256.htm
[9] https://crtc.gc.ca/eng/dcs/glossaryT.htm
[10] https://www.ic.gc.ca/eic/site/139.nsf/vwapj/ISED-ISDE3708E.pdf/$file/ISED-ISDE3708E.pdf
[11] https://crtc.gc.ca/eng/publications/reports/rp160929/rp160929.htm
https://crtc.gc.ca/eng/publications/reports/rp200601/rp200601.htm

The process uses pseudo-household points ("PHH Points") to create the road segment layer of the Map. Those PHH Points are an approximation based off of census data and do not line up specifically with where houses are actually located which can also contribute to discrepancies.

Additionally, the way that the information is reported to ISED may contribute to discrepancies. For example, some service providers indicate that they report to the CRTC based on address points served in a particular location and ISED then converts that reporting into the Map to show service along road segments (not at particular addresses). This can result in some locales being shown on the Map as having coverage at 50/10 more broadly than what is actually available.

Another example of a process factor contributing to a discrepancy is shown by comparing Tahsis and Port Clements. They are both serviced with local access infrastructure that supports 50/10 (in the first case, cable and in the second, fibre) and what appears to be constrained backhaul. Almost the exact same characteristics in each locale but in Tahsis, the Map shows it as served with 50/10 and in Port Clements, it does not.

Further, Tahsis reports poor internet, does not appear to have 50/10 service available for purchase, and there are no CIRA tests within the municipality that reflect service at 50/10. This provides further evidence of a difference in what the Map shows and what the community is experiencing.

MAPPING UPDATES

Timing of updates to the Map is another systemic factor. The Map is updated periodically, but in some cases, updated reporting suggests that 50/10 service exists in the absence of any changes to the available service. Road segments that were previously eligible for funding are changed to ineligible without any changes in available service. Service provider outreach suggested that areas previously reported as 50/10 are not regularly updated to reflect reduced service available arising from congestion or saturation.

In other cases, updates to technology available in an area have occurred before the project has even begun. For example, according to the Map notes on the website, at the time of writing, the last time the Map was updated was January 14, 2021. On that updated Map, Panorama is reflected as served with fibre to the home service. However, it was only in June 2021 that a project was announced to bring fibre to Panorama and during the course of this study, fibre to the home service was not available.

THE POTENTIAL FOR ERRORS

Finally, given the sheer magnitude of the task of mapping service availability across the entire country at the road segment level, there is, quite simply, potential for errors in the Map. For example, on a First Nation reserve that was researched, the Map reports that there is DSL service, but the community contact was not aware of any such service, and when asked, the service provider could not confirm availability. The onus of proof of disputing road segments is on the party challenging it so if a community believes that the road segments are incorrect, it is up to that community to prove it necessitating the expenditure of time and or money to do so. The process to challenge the Map is onerous and may result in errors in the Map not being corrected.

TECHNOLOGY
Inherent Limitations
Operating Factors
Environmental

The technology theme includes factors that are a result of limitations of, or impairments to the technology used to provide internet connectivity to the consumer. There are a number of technology related factors such as inherent limitations of the technology, operating factors and environmental factors.

INHERENT LIMITATIONS

Different technologies deployed are more or less susceptible to variations in performance that contribute to a discrepancy. All technologies have limitations and their ability to operate optimally is always subject to the ideal conditions. Discrepancies can exist because of the inherent nature of the technology used to provide service. Factors in this category include the nature of the technology itself (i.e. distance sensitive technologies), the standard (i.e. revision) of the technology deployed, and the capability of service provider components within the network or in the consumer's premises to deliver certain speeds.

OPERATING FACTORS

While the technology used may be capable of delivering 50/10 service, there are other operating factors that can contribute to a discrepancy including the consumer's network, oversubscription, network congestion and other network problems perhaps related to the number of people trying to use the technology at the same time, traffic levels on the network due to unforeseen or abnormal events, levels of maintenance and condition of cable plant, or simply technology that is not operating in an optimal fashion.

ENVIRONMENTAL FACTORS

Finally, technology factors can include practical implementation issues such as line of sight that may allow one party to achieve 50/10 service, but another may not, simply by the fact that the topography and/or foliage blocks line of sight access to a wireless tower.

BUSINESS
Business Case
Cost

Contributing factors in this theme include those that arise from the business case for service in a particular location as well as market penetration or consumer awareness (see also Consumer theme below).

BUSINESS CASE and COST

Inconsistent service distribution throughout a locale, affordability of backhaul and the failure of a business case for improved service are examples of business-related contributing factors. Inconsistencies in deployment of a particular technology throughout a locale creates potential for discrepancies between different areas of the locale because the service may not be ubiquitous throughout. This is compounded by the fact that complaints about service quality or availability often describe the locale as a whole rather than on a street-by-street basis.

Local access infrastructure may support 50/10 and a third party backhaul provider's network may support 50/10 but there is no certainty that the business case will make sense for those two parties to do business. Upgrades to provide either more robust last mile service or increased backhaul capacity may simply be cost prohibitive, either on a capital or operating basis, or there may be problems aligning schedules between access and transport projects (funding program processes can contribute to this schedule disconnect).

CONSUMER
Equipment
Affordability
Brand Loyalty
Lack of Information
Lack of Confidence

Consumer expectations, perceptions and choices contribute to discrepancies. Choices related to cost, brand loyalty or brand avoidance, choice of technology (some consumers avoid wireless service even if superior, for example), and desire for bundled services can cause consumers to subscribe for services at less than 50/10 even where it is available. Lack of awareness of other choices, quality of, and traffic on, the consumer's network, doubts as to whether upgrading service will result in significantly better service, and lack of knowledge of the actual contractual commitment of the service provider (service speeds "up to") can also create a discrepancy. Consumer related factors contribute to some degree to a discrepancy at a specific location but generally, consumer factors will not explain locale wide discrepancies.

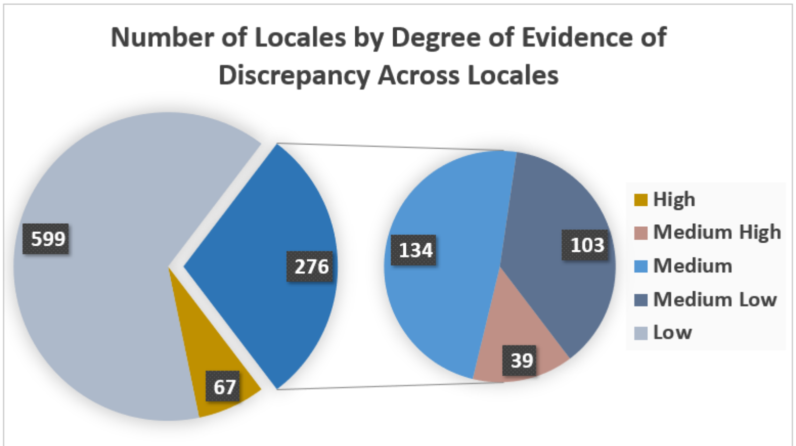
Because the consumer is primarily concerned with performance from their device to the final internet application, speed testing, such as the one available through CIRA, may be used to assess the quality of their service and report a discrepancy. As noted above, such tests are subject to variability due to a variety of factors including the quality of the consumer's network, the traffic on the consumer's network at the time of the speed test and the devices used within the consumer network. It is acknowledged that such speed tests have limitations because of those factors, however, those limitations become less important when assessing community wide testing results as individual test results become less indicative of the general trend throughout the community.

MAGNITUDE OF DISCREPANCIES?

Considering the data available, the Study concluded that it is likely that there are 50/10 discrepancies, and they are estimated to be significant enough to warrant further work to validate the locales have 50/10 discrepancies more definitively.

The magnitude of 50/10 discrepancies was estimated utilizing methodology summarized above and detailed more fully in Appendix “A”.

The number of locales that fall into the **higher evidence** and **medium-high** categories is estimated to be in excess of **100** locales.

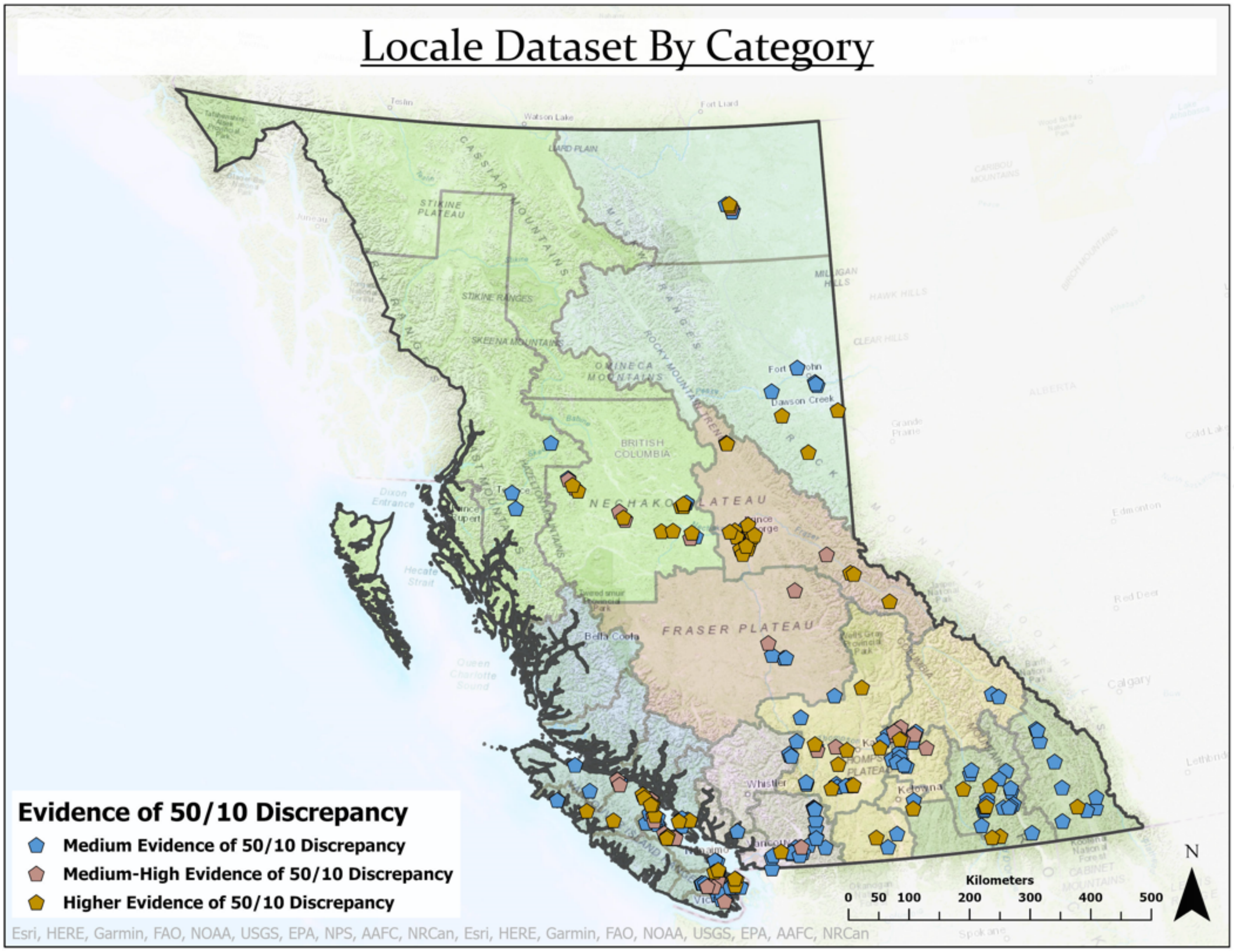


Just under **300** locales in the Locale Dataset fall into the middle category. This medium evidence category has been broken out into three sub-categories to reflect a more granular analysis of the strength of the evidence of a discrepancy. The locales within the medium category which tend towards higher or lower evidence respectively were designated as medium-high and medium-low. Often locales fall into the central medium category due to insufficient data (for example, they either did not report a problem or there were limited CIRA tests available for the locale). Additional work would need to be done to clarify whether the locales in this category tend toward having a discrepancy or not. Such work could include outreach to contacts and service providers within the locale and more granular analysis.

Finally, it should be noted that the largest number of locales in the Locale Dataset (almost 600) fall into the **lower evidence** of a discrepancy category.

GEOGRAPHIC DISTRIBUTION

The geographical distribution of the Locale Dataset by higher, medium-high, and medium categories is as follows:



NEXT STEPS

This Study has provided a foundation upon which to build. It is a snapshot in time to explore the issue of discrepancies that will change as projects are announced, funded, and implemented. The goal of this Study was not to create a definitive list of locales that have a 50/10 discrepancy but rather to understand whether discrepancies exist and to estimate the size of the problem in BC. Addressing the issue of discrepancies will require additional efforts to minimize the effect of systemic contributing factors as well as work to more definitively identify the locales that have a 50/10 discrepancy and to address those:

- REFINE - Update Study data with government and other agency information not publicly available.

- PRIORITIZE – Assess the updated Locale Dataset categories and identify locales to prioritize for a more granular assessment.

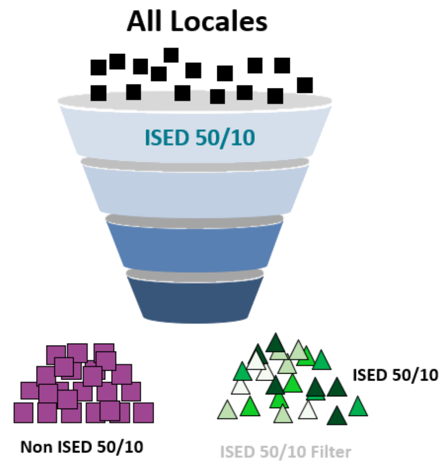
- VALIDATE – Determine more definitively that there is in fact a 50/10 discrepancy in the prioritized locales such as by undertaking quantitative field testing of actual service speeds and more granular, focussed assessment of those locales.

- RESOLVE – Create an action plan to eliminate the factors contributing to the discrepancy in the locale where possible.

APPENDIX A - METHODOLOGY

To estimate the magnitude of discrepancies for the province of BC, a series of steps were completed to filter all the locales in the province down to the dataset used to assess the overall magnitude. The following provides an overview of the methodology used to complete this.

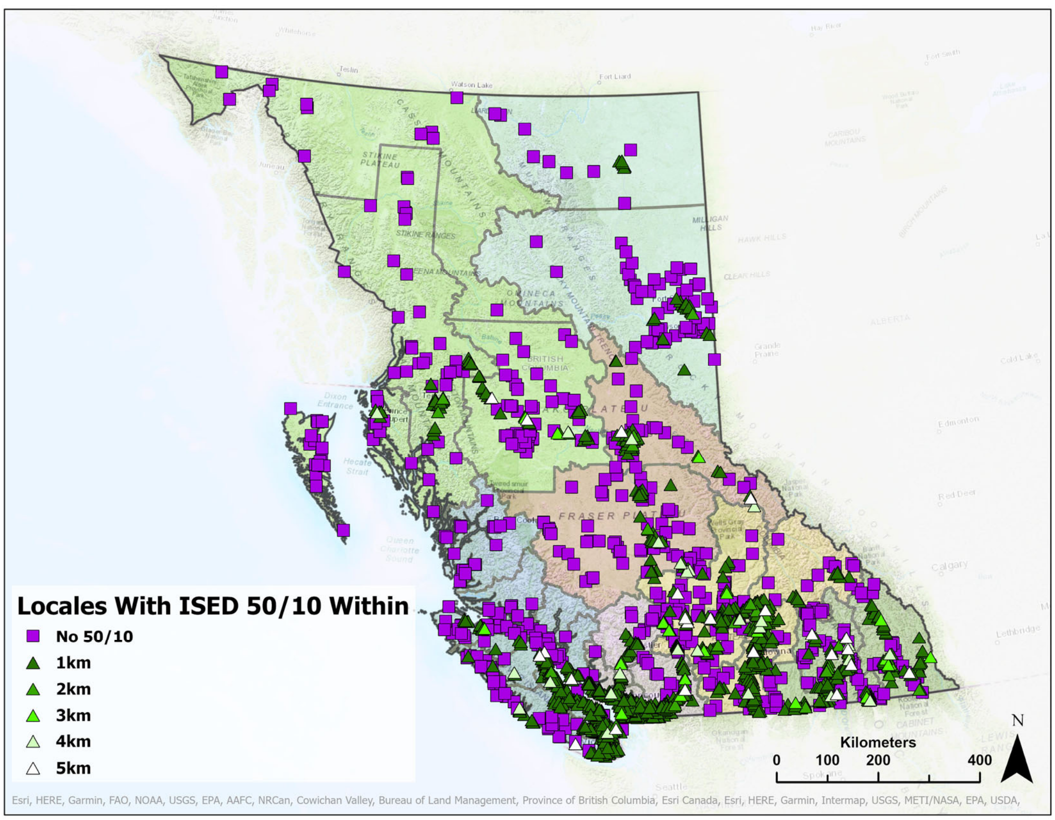
ESTABLISH the STARTING DATASET



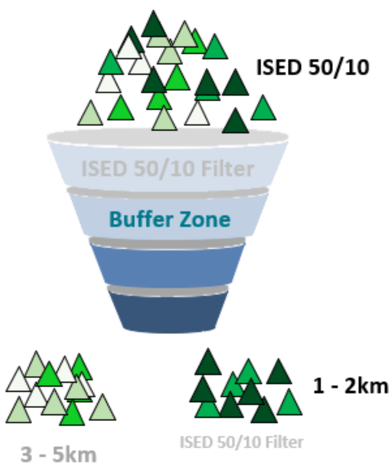
The starting point to establish the dataset was a list of locales obtained through NDIT with additional locales added to form a comprehensive list of all BC locales that show as having 50/10. As a result of the process outlined above and after the removal of duplicate locales, over 1860 locales were selected as a baseline locational dataset for further analysis.

The locales in this dataset were then identified as either <u>not</u> within 5km of an area shown as having 50/10 on the Map ("non ISED 50/10 locales") or within 5km of an area shown as having 50/10 service on the Map ("ISED 50/10 locales"). The non ISED 50/10 locales were filtered out to reflect the focus of the Study on ISED 50/10 locales only. After filtering, the ISED 50/10 locales numbered approximately 1300.

The purple icons on the map below depict the non ISED 50/10 locales and the triangle icons reflect the ISED 50/10 locales at varying distances from a 50/10 area.



PROXIMITY FILTER & SENSITIVITY TEST

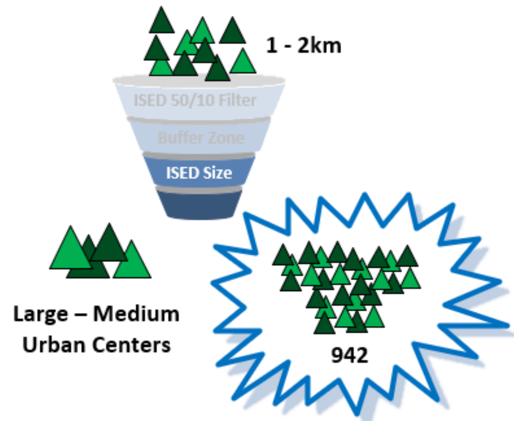


Given that the process for establishing this magnitude is based on GIS mapping and some assumptions and approximations are required, the ISED 50/10 locales were furthered refined to include only those locales that fall within a 2km buffer zone of an area shown as having 50/10 service. This was done to ensure that the dataset was not overinclusive. Further, a process to determine the sensitivity of this 2km assumption, resulting in approximately a 2% increase in the number of locales per kilometer as the buffer zone was increased from 2km to 5km.

The end result is that approximately 92% of locales in BC fall within 1km of an area shown to be served with 50/10. Extending the proximity to 2km results in an additional 2% of locales falling within the studies dataset and the area shown to be served with 50/10. Reviewing the mapping and performing manual analysis provided reasonable assurance that a 2km buffer was appropriate for the level of accuracy required for this assessment.

URBAN FILTER

As outlined, the focus of this assessment is small and rural locales. As such, further filtering of the dataset was performed to remove those locales that fall within a large or medium urban center resulting in additional locales filtered from the dataset. The final dataset for the magnitude assessment can be summed up as, **those locales that fall within 2km of an area shown to be served with 50/10 in the province of BC known as the "Locale Dataset"**.



SCORING

Once the Locale Dataset was established, the locales in that dataset were scored against a set of criteria that either supported or did not support the existence of 50/10 service. The resulting assessment provided an indication of the **likelihood of a discrepancy between the existing available service to that shown on the Map**.

Each criteria used was given a weighting to the overall score that provides a relative level of importance to each criterion. The criteria used for the assessment were:

- Local Knowledge: Based on information provided by the local stakeholders and local government, an assessment of whether there is local information that supports or disputes the existence of 50/10 service in the locale.

- Available Test Data: While the scope of the Study did not include field testing for all locales in BC, information available from the Canadian Internet Registration Authority ("CIRA") was used as part of the scoring criteria. A score was derived from actual test data gathered between January 2020 and September 2021 for each locale in the Locale Dataset. This data was used consolidated to the Mode and Mean test values for measured upload and download capacity. To ensure that repetitive testing values were not overstating the results of a particular locale, only unique test data was used which ensured that repetitive test (either high or low) contributed equally to other tests taken in the locale. Further, the test data was assessed a confidence score that provided an indication of how many unique tests were available for assessment in that locale.

- Available Technology: Locales were scored based on the available technology's ability to provide reliable, ubiquitous 50/10 service. While it is acknowledged that the main technologies deployed may have the capability to deliver 50/10 in certain cases, some technologies are much more capable of doing so on a large scale with limited variations due to things like oversubscription and loading. The available technologies considered were Fibre to the Premise ("FTTP/FTTH"), coaxial cable service, Digital Subscriber Line ("DSL"), licensed and unlicensed wireless.

- Service Availability: The locales in the Locale Dataset were manually evaluated to the extent possible to determine whether it was possible to purchase a 50/10 service from a provider in the locale. Locales where it was believed that 50/10 service was not available for purchase were given a score that reflected this.

- External Information: The final criteria was whether there was additional information available that supported the existence of 50/10 service or not. An example of this would be door to door testing that was performed by some communities.

FINAL ASSESSMENT

Through the process identified above, each locale was assessed a score that represented whether the locale has higher or lower levels of evidence that the level of connectivity experienced by residents of the locale is consistent with 50/10 as depicted on the Map. These scores were placed into categories of:

- Higher Evidence: locales that have higher levels of evidence of a discrepancy.

- Medium Evidence: locales that are considered neutral and have less evidence to determine one way or the other. Some locales in this category were close to a cut-off threshold and so this category was further delineated in three sub-categories – medium-high (those that tend towards higher evidence), medium and medium-low (those that tend towards lower evidence).

- Lower Evidence: locales that have lower levels of evidence of a discrepancy.

Finally, the locales within each category above, were totalled to provide an overall assessment of the magnitude of 50/10 discrepancies in the province of BC.

CIRA METHODOLOGY

CIRA test data between January 2020 and September 2021 was downloaded and plotted to relate such information to nearby locales. Each CIRA test has a geographic location, upload and download speed, associated IP address, test ID, and multiple other attributes but these five are the most important. Some tests have details which outline the download and upload speeds that a subscriber is paying for however this information is not always provided by the consumer and cannot be validated.

A drawback to the CIRA tests is that there were often not enough tests to represent a significant sample size relative to the population and dwellings. As a result, not only was a score indicating the availability of 50/10 created, but also, a confidence factor was assessed based on the relative number of tests, the number of unique IPs such tests were coming from, and the degree to which these tests were located over a spatially diverse area. In other words, conclusions from locales with the fewer tests from fewer unique IP addresses from more concentrated areas were less conclusive than locales with more tests from more unique IP addresses spread over a wider area. The key metrics established from the CIRA data were 1) the number of tests in a locale, 2) number of tests from unique IPs in a locale, 3) maximum and minimum speed test results 4) average speed test results with considerations to ensure that repetitive tests from a single unique IP did not skew the average speed results for the entire locale 5) mode of the average (the most common test result) 6) the ratio of the number of tests from unique IP to the PHH dwelling count.

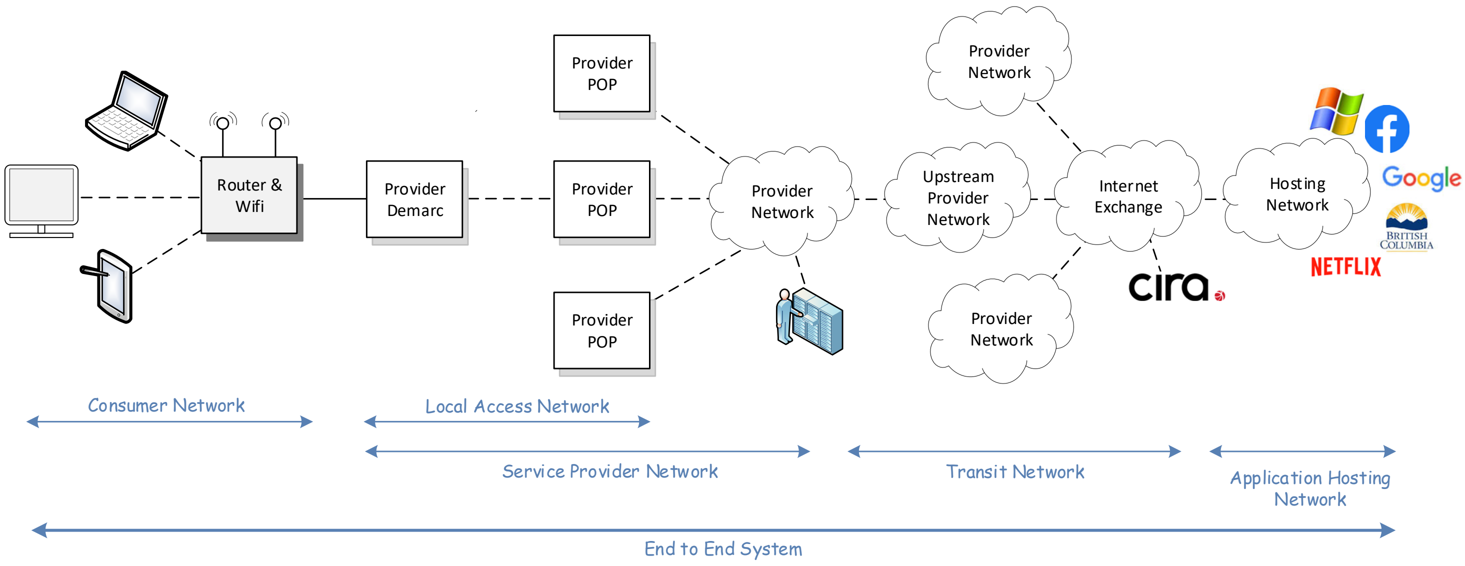
METHODOLOGY LIMITATIONS

The methodology described above is intended to provide an initial magnitude assessment for the province of BC at a point in time. It is recognized that this is an approximation and that the process used has some limitations. Throughout the process, care was taken to ensure assumptions and approximations did not significantly contribute to under or overstating the overall magnitude assessment.

APPENDIX B – INTERNET OVERVIEW

There are many reasons that an internet network can perform in a way that causes a consumer to describe their service as poor. The consumer is generally unaware of the specifics of why their service is not performing the way they expect it to and will simply describe the service as "slow" or "unreliable" when that service fails to perform. Correctly ascertaining the reason for underperformance of service in any case requires detailed analysis on a case-by-case basis, but, of course, this detailed level of analysis is beyond the scope of the Study.

Internet connectivity requires several components to function properly to provide a satisfactory consumer experience. To understand these factors, it is important to have a basic understanding of the main components that make up the end-to-end chain of systems that deliver the consumer experience. The following diagram provides a basic overview of the main building blocks required for internet connectivity.



Consumer Network: This includes the components that are connected within the consumer's premises by the consumer. This can include computers, laptops, TVs, telephones, personal tablets and mobile devices, gaming systems, security monitoring systems, among others! The Consumer Network often, but not always, has wireless (WiFi) functionality enabled to distribute the internet service throughout the consumer's premise.

Local Access Network: The local access network is defined as the connection between the consumer's premise and the service provider's local Point of Presence (POP). It is commonly owned and managed by the same entity as the service provider network. The local access network may use a variety of technologies including fibre, DSL, coaxial cable, wireless, cellular and satellite technology, each of which having advantages and disadvantages.

Service Provider Network: Multiple local access networks and POPs are often connected over a large geographic area forming the larger service provider network. Service providers networks may provide local services such as email or web hosting but the service provider network itself generally does not provide global connectivity to the internet and its many applications.

Transit Network: For the service provider network to connect to other providers, external applications, and the global internet, it must be connected to a transit network. This transit network may also be referred to as the backbone or transport network. This network forms the connectivity between local geographic areas and the global internet. A major component of the transit network is the internet exchange (IX). The IX is a hub location where many service providers can come together and create connectivity so that consumers connected to their local network may exchange information with other providers or internet applications. Internet exchanges are available in many locations across Canada.

Application Hosting Network: The application hosting network(s) are used to connect the actual internet applications from the application providers to the consumers. These networks may be very large and can support perhaps tens or hundreds of thousands of connections.

End to End System: In the end, the consumer only cares about the entire end-to-end chain and the technical details about where service metrics are measured do not matter. For the consumer to have a satisfactory experience using an internet application, all components in the chain of networks must be functioning properly. If any of the components or links in the chain are broken or not operating properly, the end-to-end performance will be negatively impacted, and consumers view their internet service as poor or unreliable.

There is no "boss of the internet" so there is no authority that dictates performance metrics that must be met. The system works on the free market so if one business component in the chain is substandard, the natural business consequence of consumer complaints or loss of revenue will replace the weak link with available alternatives. This can only occur of course where there are choices to be made – if there are no choices, then the free market system does not work properly.

Key Performance Metrics: As outlined in the CRTC decisions, aside from the simple upload and download speed, there are many other metrics that must be considered in analyzing the performance of the consumer experience. These metrics are as follows:

- **Packet Loss**: Packet loss occurs when information that is sent by one party does not reach to intended receiver for some reason. This is due to a variety of reasons, but the end result is that when information is lost (or dropped by the network), the internet application must re-transmit that information (although not all applications will re-transmit) effectively doubling the amount of information sent for that transaction. When this situation occurs, it creates a compounding effect and quickly degrades the service resulting in service that is slow, unreliable, and unresponsive. Packet loss can happen for a variety of reasons some of which are capacity related but also can be related to poor quality or malfunctioning equipment.

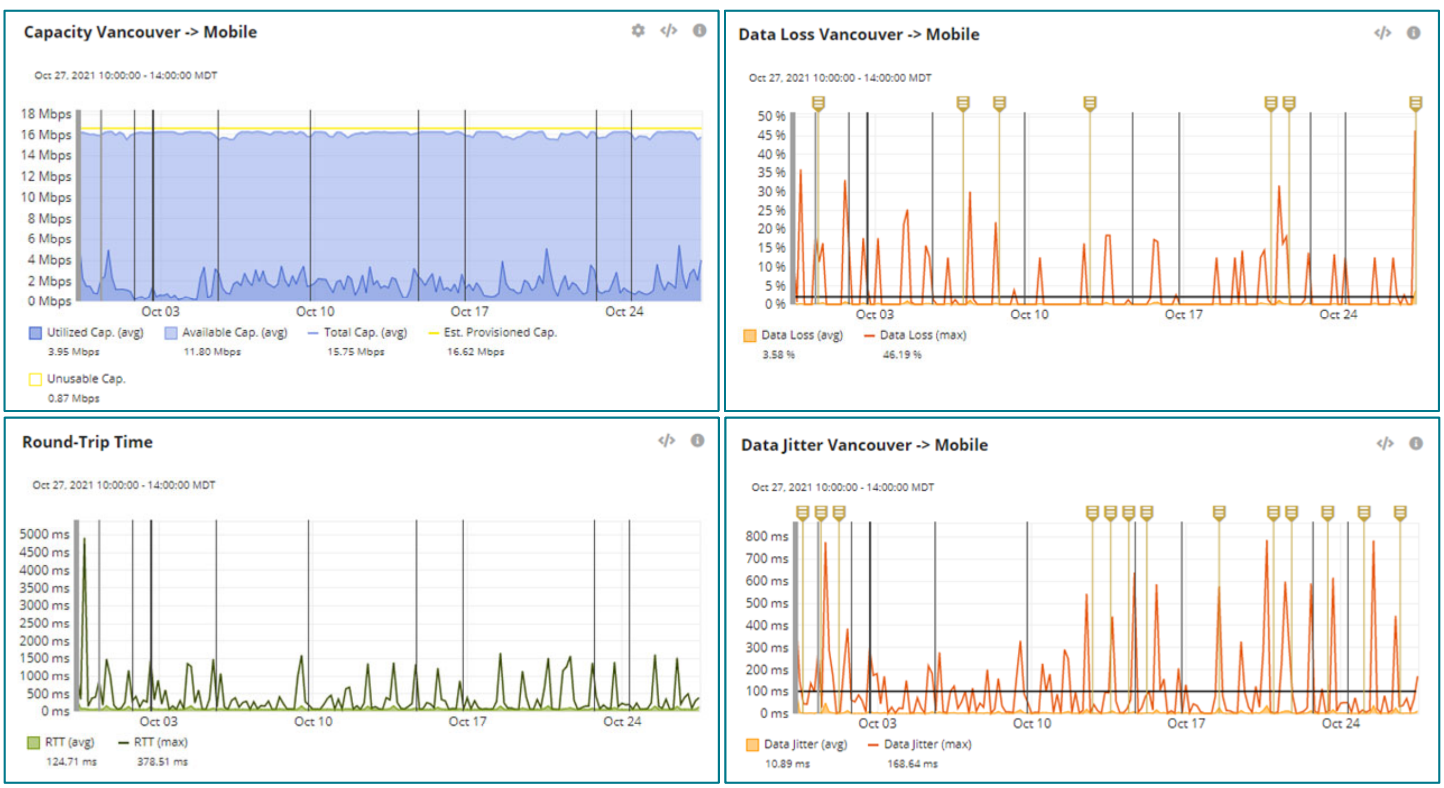
- **Latency**: Latency is the time it takes to send information from one party to another and is often measured in milliseconds (msec). Different technologies can have drastically different latency measurements, and this will have a major impact to the consumer's experience. As latency increases, there is a direct correlation to how fast information can be transferred between parties. A well performing internet connection may have latency values in the range of 30 – 50 msec (or less depending on technology and connectivity to internet exchanges) but as this latency increases, the speed of the connection will appear to degrade, and consumers will view this as slow and unresponsive.

- **Jitter**: Jitter is the variation of timing between packets of information being sent between sender and the receiver. Large variations in this timing, shown as increased jitter, result in poor performance and most often manifest as poor-quality voice, video and real-time applications.

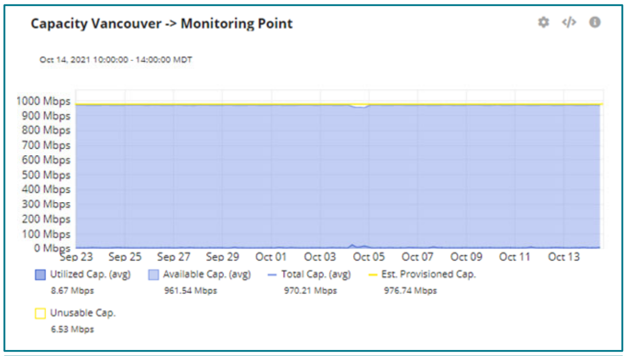
Performance of the end-to-end system is what the consumer sees when they access the internet on their device and if one of the components is defective or underperforming in some way, that negatively impacts the consumer's experience. How the performance of the service is measured has a major impact on whether it delivers its promise of service at the USO. It is entirely possible to have a service that is provisioned by the service provider as 50/10Mbps to the consumer but will still be described by the consumer as poor or unreliable due to the key performance metrics above and other factors, some of which may be within the service providers control and others may not.

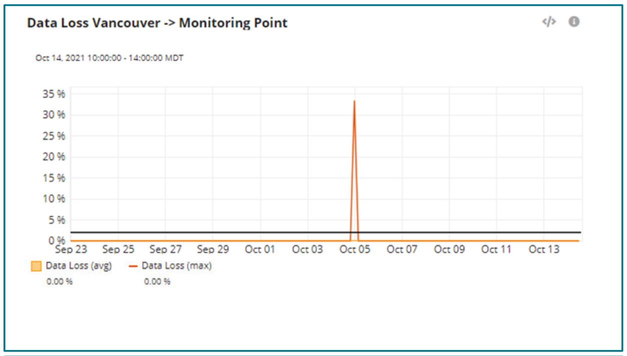
Often, performance measurements for these metrics are not visible when running a speed test or when performing a single test at a point in time. To gain a comprehensive understanding of the performance of an internet connection, the test must be performed using appropriate test devices connected between appropriate end points (e.g. customer modem and internet exchange) over a longer period of time.

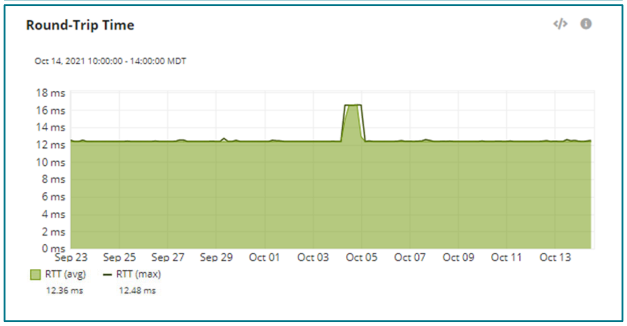
The following provides an example of performance data gathered during this Study (measured from a consumer modem to an internet exchange) demonstrating an available capacity at nearly 15Mbps download but packet loss, latency and jitter well above the USO thresholds that may result in a poorly performing internet connection.

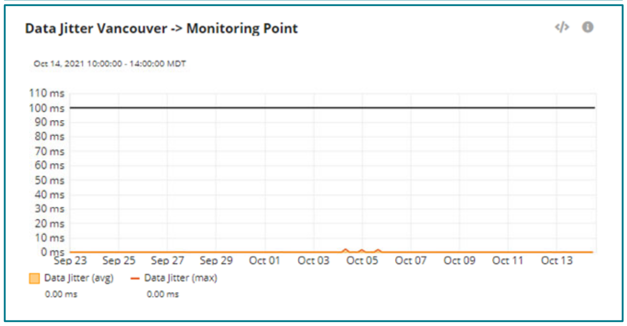


In contrast, the following provides an example gathered during this Study demonstrating available capacity at nearly 1000Mbps download with virtually zero packet loss (other than a short disruption), very low latency (under 13msec) and jitter well below the USO thresholds that illustrates an excellent performing internet connection.









APPENDIX C – CONTRIBUTING FACTORS

The following provides some additional information on why discrepancies exist.

SYSTEMIC FACTORS

Map Process and Methodology Contributing Factors

The road segments layer of the Map is to reflect local access service currently commercially available on a reliable basis based on reporting by the service providers and does not reflect service that will be available upon completion of upcoming transport projects. What this means is that a consumer on a road shown as green should be able to subscribe for service from at least one provider at speeds of 50/10.

Process for Creating the Map:

- Providers of last mile services and transport services are to report information about the geographic area where services are provided and provide details about areas where residential service is **commercially available to households and are publicly advertised**. In addition, details about the access technology deployed, service speeds availability, and the backhaul technology supporting the access technology are required.
- Reporting is provided in one of two ways, a) through an annual CRTC Facilities Survey b) through a direct submission form.
- The information is input into the ISED database which is then provided in a dataset form and the visual depiction of service availability is created resulting in the Map.
- The map provides multiple layers that can be enabled showing different information including currently available last mile technology and future transport projects. The area information shows the area ID for the area selected along with the estimated population and houses. In addition, it provides links to the service providers operating in the area providing either last mile services or high capacity transport services. If there is an announced project in the area, the area information provides a link to the service provider undertaking the project.

Interpretation of the ISED Dataset and Map:

- In an effort to maintain the confidentiality of the information provided by service providers, the information about providers and the technology deployed by them is aggregated into 25 sq km hexagons and detailed information provided is not available publicly through this dataset.
- 25 sq km hexagons lose granularity because they indicate technology deployed within the hexagon, but that technology may not be available ubiquitously throughout the hexagon.
- There is no third party validation of the data reported by providers. The accuracy of the information provided is taken as fact.
- The onus of challenging the accuracy of the Map lies with the party disputing it.
- Service levels reported are to be currently available and not based on future capabilities or upcoming projects.
- Service providers should only be reporting services at a level currently commercially available on a reliable basis and publicly advertised, but there is no pre-determined location where those service speeds should be measured (i.e. service levels between what two network points). Research did not elicit any ISED ordained measurement points, however, the Study was unable to confirm this point with ISED despite diligent efforts.

- There is potential for the Map to be out of date because of timing of reporting and updating.
- It does not appear that service providers “downgrade” service levels in their annual reporting as a matter of course.

Further to the definitional factors outlined earlier the submission forms uses the terminology such as “… maximum download speed **offered**”, “… maximum upload speed **offered**”. This loose definition may be cause for discrepancies because those terms “offered” are subject to different interpretations. Different interpretations include maximum speed, service packages “up to” 50/10, some may be 50/10 subject to the terms of the service contract any of which may not be consistent with ISED reporting expectations and the resulting Map which, according to ISED, is intended to show currently available and guaranteed service levels. While there are CRTC decisions that clarify some of these things, it is unclear that all service providers apply those specific definitions in reporting.

Finally, it should be noted that the Map reflects consumer grade services that are commonly available to residents and businesses. Within BC locales, there are often examples of private industry, federal and provincial government locations that have a higher-level commercial grade services not typically available to the average consumer. These generally require significant capital expense and higher monthly fees.

TECHNOLOGY CONTRIBUTING FACTORS

Different technologies have different inherent capabilities and the technology deployed will govern the operating characteristics and capabilities.

Fibre to the Premise (FTTP): FTTP is more than capable of delivery high quality, reliable, consistent, scalable, and very high-capacity connectivity to consumers. Locales that have FTTP are less likely to have a discrepancy for consumers that are connected.

Coaxial Cable: While cable networks cannot match the capability of fibre, they can deliver very high-capacity internet providing they have been maintained and upgraded to support the latest Digital Over Cable Service Interface Specification (DOCSIS) standards.

Digital Subscriber Line (DSL): DSL technology is most often deployed as a way to deliver internet connectivity over existing phone lines. DSL is cost effective as it uses existing phone lines and does not require an overbuild of infrastructure. However, DSL technology is some what of a legacy technology and may suffer from inadequate capacity due to the physical characteristics of old copper phone lines and is further degraded with aging infrastructure and many years of maintaining the phone lines. It simply has maximum capacity limitations and while it is capable of delivering 50/10Mbps in ideal conditions, it has severe limitations and locales using DSL technology will be far more likely to experience a discrepancy.

Fixed Wireless (Licensed): Licensing reduces competition on the frequency or channel resulting in a more consistent and reliable delivery of service but other challenges such as line of sight (“LoS”) still exist. While licensed wireless may be higher quality than unlicensed alternatives, they are still more likely to have a discrepancy than fibre or cable.

Fixed Wireless (Unlicensed): While it is possible to deliver 50/10Mbps connectivity using this technology it cannot match the capabilities of fibre and there are some critical factors to impede its ability to deliver high quality, scalable connectivity including LoS and competition for unlicensed frequencies or channels. Locales served with unlicensed wireless are more likely to have a discrepancy because of the difficulty in providing ubiquitous service in addition to scalability limitations and potential interference that are beyond the control of the provider.

OTHER TECHNOLOGY FACTORS

Along with the underlying technology that provides connectivity within a locale, there are a number of other technology considerations.

Consumer Network: A major component in overall system chain and a potential for an observed discrepancy is the consumer network. As this component of the network is not within the control of ISED or the service provider, it can be a major source of discrepancy. Some of the major considerations for the consumer network and potential sources for a discrepancy may include:

- Consumer Equipment: Devices including local routers, Wi-Fi equipment, computers, and other devices. All of these components have performance considerations and there are always trade-offs in capability and affordability. As connectivity speeds increase, so must the consumer devices to ensure this equipment is capable of meeting the performance expectations.

- Poor Quality: As with all components of the network, if the equipment and the cabling infrastructure that connects all the components together is not functioning properly, it can have a major impact of the performance of the network. A single weak link in the chain will impact the end-to-end result.

- Consumer WiFi: Wireless technology used within the consumer's premise can often be a significant reason that reported speeds are not achieved. Consumer WiFi is deployed using unlicensed spectrum meaning that it is available for all consumers to use with no regard as to whether it interferes or competes with other surrounding networks or devices emitting interfering signals. WiFi signals are not dedicated to any specific network and are shared with all networks in the vicinity and often compete for the available, and limited, unlicensed spectrum. Further, distance, building materials, and other factors impact a wireless signal, and having a high-quality wireless signal is imperative to good quality wireless communications.

- Consumer Network Load: More and more, the number of devices in the Consumer Network are increasing. As more devices such as computers, tablets, phone, televisions, gaming consoles, security systems, appliances, energy monitoring and other internet connected devices are deployed, each competes for the available capacity into the premise.

All this said, the Consumer Network is isolated, and the effects of a Consumer Network will generally only impact a single consumer and while one consumer may be experiencing poor or unreliable performance, it becomes less likely that many consumers in a community will be experiencing poor connectivity that is attributable to these factors.

Testing Method: Often times, the speed of an internet connection by a consumer is characterized by an internet speed test and this is used as a determination of how well a service is performing. While this may be useful as a general gauge of performance, it is not a scientific method and there are often factors outside the control of ISED or a service provider that can impact the results of an internet speed test. There is no substitute for actual field testing to definitively assess network performance.

Oversubscription: Virtually all service provider networks are oversubscribed at some level. Over subscription means that the connectivity from the service provider network to the transit network is not designed in a one-to-one fashion. The main reason for this is cost. Large capacity connections to the transit network are costly and providers must pay for capacity on a contractual basis. As a general rule, statistical assumptions are made that not all customers are going to require the full 50Mbps at the same time. Over subscription ratios will vary but generally providers will use an approach of provisioning enough capacity to handle the normal average usage plus some headroom with constant monitoring to determine when and if more capacity is required.

Network Congestion: Similar to oversubscription, congestion occurs when network connections or the maximum capacity of network devices is reached due to large amounts of data being transferred over the network. When more data is sent than the capacity available in the network, information gets dropped with the consequential result being, once again, poor performance to the consumer. It should be noted that oversubscription and congestion is not necessarily on the local service provider's network but rather may be within the transit network.

Network Problems: While some contributing factors are well understood and can be explained, another factor may simply be that the network is not functioning as expected. This could be the result of poor design, equipment limitations or malfunction, poor maintenance or construction practices as well as other external factors impacting the proper operation of the network that may or may not be within the provider's control.

CONSUMER FACTORS

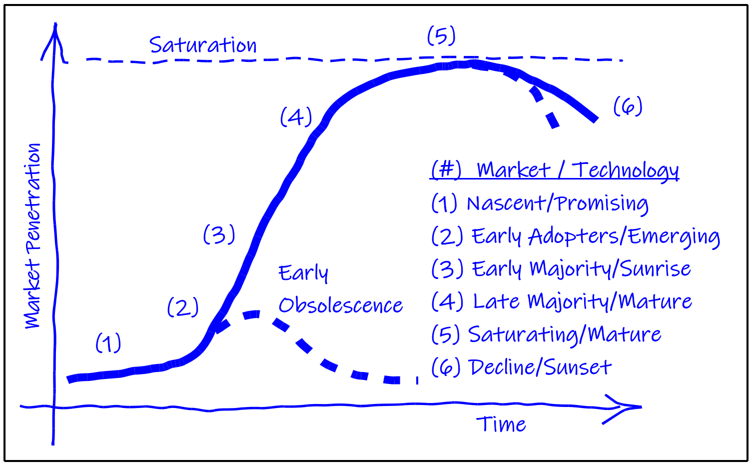
Consumer behaviour plays another important part in the explanation of why a discrepancy exists. The consumer's experience is directly related to the service plan they purchase and the provider they choose. One of the challenges is that technology is often not well understood, and consumers may not understand the difference between different service offerings. Often the choice they make for service plans are based on:

- Cost: Consumers often migrate to less expensive services and may not be willing to spend extra money for additional capacity or functionality.
- Brand Loyalty: Consumers that have always received service from a certain provider may simply choose that provider for internet service just because that is what they have always done. They can be reluctant to switch to a new provider that may offer better services.
- Lack of Information: Consumers may simply not be aware that faster or better services exist. This is a business issue and may be due to ineffective communication by the service providers.
- Lack of Confidence: Consumers often state that they are reluctant to switch to a higher level of service and pay more when the service they are currently paying for does not perform to the levels being subscribed for. The challenge with this is that the lower speed service may not work properly because it is constrained by other technology factors when, in fact, increasing the service level may solve the problem. In addition, the Consumer Network may be impacting the consumer's view on the service they are currently receiving.
- Lack of Knowledge: Providers often have a service agreement or contract as part of the service deployment. It is important that the terms of the service are understood, and the consumer needs to be aware of what the provider is promising and what they are not. Terms like, "… up to 50Mbps" may be used in the service agreement meaning that the provider cannot or will not guarantee that service level.

TESTING and AVAILABLE DATA

When consumers get frustrated with the performance of their services they will often complain to the provider, perhaps run an internet speed test to confirm the service and the provider may also run a test. How this test is completed can have a major impact on the consumer experience. As a reminder, when a consumer runs an internet application, the information proceeds through the entire chain of components outlined above. Testing applications like CIRA are purpose built to test the entire chain because that is how consumers use the service. However, provider tests or other testing applications may not test the end-to-end chain and may perhaps only test from the provider demarcation to a point on the service provider's network as this is all they guarantee in the service agreement and cannot be held responsible for components of the chain that are outside their control. The result is that the consumer experience may be poor, but the providers' network may be functioning within the contracted for terms.

APPENDIX D – TECHNOLOGY



Technology is not static. Technologies emerge, evolve and have a corresponding market life-cycle. The diagram illustrates this relationship conceptually by linking technology maturity to the traditional market penetration curve. Note that some technologies emerge but do not mature (early obsolescence). The "sunrise" stage is important as standards form, market volumes escalate with competition, and prices fall. At some point, all technologies can expect to be replaced by better or cheaper technologies or alternatives, or a new technology may make entirely new markets viable. For example, cell phones are replacing land line phones, internet technology is replacing older telephone and television delivery technologies, optical glass fiber is replacing copper based communication channels, and so on. The market is the final arbiter on which technologies flourish and when they fade.

Various technologies are used for local access networks. The next sections in this appendix provide an overview and brief explanation of the capabilities for each of the following broadband internet access network: (i) Digital Subscriber Line (DSL), (ii) cable modems, (iii) fiber to the premises (FTTP), (iv) fixed wireless access (FWA) using unlicensed radio, (v) FWA using licensed cellular mobile radio.

DIGITAL SUBSCRIBER LINE (DSL) TECHNOLOGY

Digital subscriber line (DSL) is a "local access" technology used by telephone companies to enable higher speed internet service over their existing "twisted-pair" copper telephone lines.

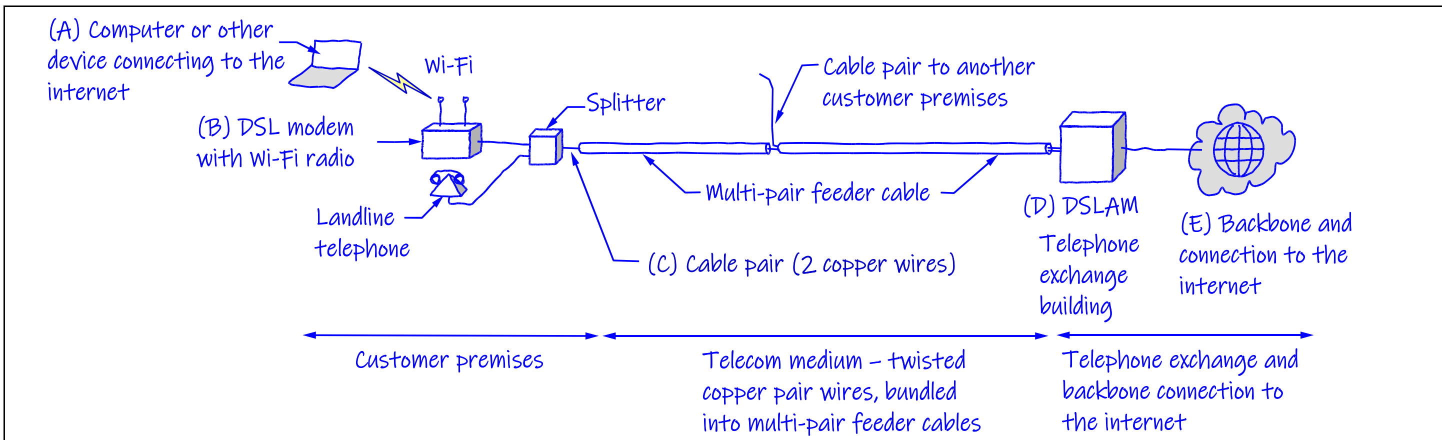
Backstory: In the 1990s, as the internet became the next "big thing," DSL technology emerged as a game changing improvement over dial-up. As prices for DSL fell, the telephone companies rushed to enhance their position as the "on ramp" to the internet. By the late 1990s DSL technology could deliver 8 Mbps down and 2 Mbps up over a distance of 2 km. Technology improvements introduced in 2001 increased the speeds to 52 Mbps down and 16 Mbps up, but the achievable distance was reduced to 1 km (no free lunch, speed and distance are a trade-off here that is set by basic physics). By 2006, technology had improved to deliver an aggregate capacity (the sum of the down and up speeds) to 200 Mbps, but distance continued to shrink, to about 300 m. The current state of the art is set by DSL technology introduced in 2014 with an aggregate capacity of 1 Gbps over 100 m. These are all ideal figures which, as noted below, are not often achieved in real life.

Performance: Under the right circumstances, DSL can deliver 50/10 performance. However, actual performance will depend on:

- the vintage of the DSL equipment used by the service provider,
- the condition of the cable plant, and
- the distance of the customer's DSL modem from the telephone exchange and the DSL access multiplex (DSLAM).

Today, the main factors limiting speed are distance from the DSLAM and condition of the copper plant. In areas where DSL is the only technology available, then the number of users may be high and this will also limit performance. In general, the condition of the legacy copper based telephone cable plant is degrading with age, and, in many instances, there is a reluctance to spend money to maintain cable plant for a technology that is sunset.

DSL technology / market status: Sunset / Declining. Telephone companies have become internet service providers and globally these companies are moving to FTTP technology.



DSL TECHNOLOGY OVERVIEW DIAGRAM ...a typical DSL internet connection.
A home computer or tablet (A) connects using Wi-Fi to the home DSL modem or router (B), usually using Wi-Fi that is "built-in" to the DSL modem. The modem uses tones (peeps, beeps and bleeps) over two copper wires, known as a copper pair (C), to communicate with a DSL access multiplexer or DSLAM (D) which is often located in the telephone exchange building. Many DSL modems will connect to the DSLAM over separate copper pairs but all pairs are bundled together in the same feeder cable. The DSLAM then connects through a backbone network to the internet (E).

CABLE MODEM TECHNOLOGY

Cable modem, or simply "cable," is a last-mile technology used by cable television companies to enable internet service over their existing coaxial cable plant.

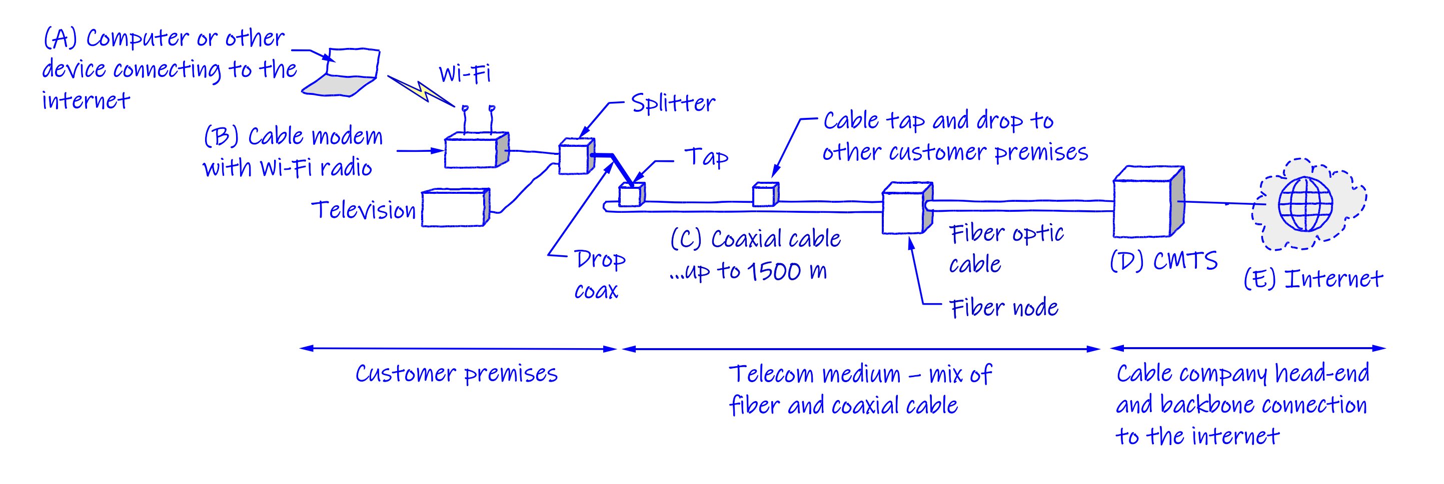
Backstory: By the late 1990s, the cable industry began developing proprietary and standards based technology to carry internet traffic by sharing the relatively high capacity of the coaxial cable amongst all users on the cable. Early cable modems delivered a shared capacity of 8 Mbps down and 1 Mbps up. By 2001, technology with 40 Mbps down and 10 Mbps up capability were being introduced. In 2006, this increased to 1 Gbps down and 200 Mbps up, again the capacity shared by all users on the cable. By 2013, technology was introduced with 10 Gbps down and 2 Gbps up capability; and in 2017, the upload speed was increased to 6 Mbps.

Originally cable television systems typically provided TV signals over a single cable to about 500 homes. Unlike television broadcast on cable where users select the channel on the cable they want to watch, each internet user will have a different session and these sessions will be bi-directional. The more users accessing the internet on a shared cable segment the more capacity is used. Since cable capacity has a limit, usage becomes a constraint.

Performance: Under most circumstances, cable modem technology easily exceeds the 50/10 target. However, actual speed will depend on:

- the standard of the cable modem equipment used by the service provider
- the type and condition of the coaxial cable plant,
- the number of subscribers sharing the coaxial cable, and
- how active these subscribers are at any given time on the internet.

Cable technology / market status: Mature / Saturating. Cable companies are becoming predominantly internet service providers (ISPs) as more television entertainment becomes available over the internet and more customers are opting for only the internet. Existing areas served with cable will continue to use cable modems in the near to medium term.



CABLE TECHNOLOGY OVERVIEW DIAGRAM…a typical cable internet connection.
A home computer or tablet (A) connects using Wi-Fi to the home cable modem or router (B), usually using Wi-Fi radio that is "built-in" to the cable modem. The cable modem uses some of the radio frequency bandwidth in the coaxial cable (C) for bi-directional communication with a Cable Modem Termination System or CMTS (D) that is located at the cable companies "head-end" or hub site. Note that multiple cable modems connect to a single coaxial cable segment that connects, in turn, to the CMTS. The CMTS then connects through a backbone network to the internet (E).

FIBER to the PREMISES (FTTP) TECHNOLOGY

Fiber to the premises (FTTP) is a "last-mile" technology used by internet service providers to deliver high-speed internet service.

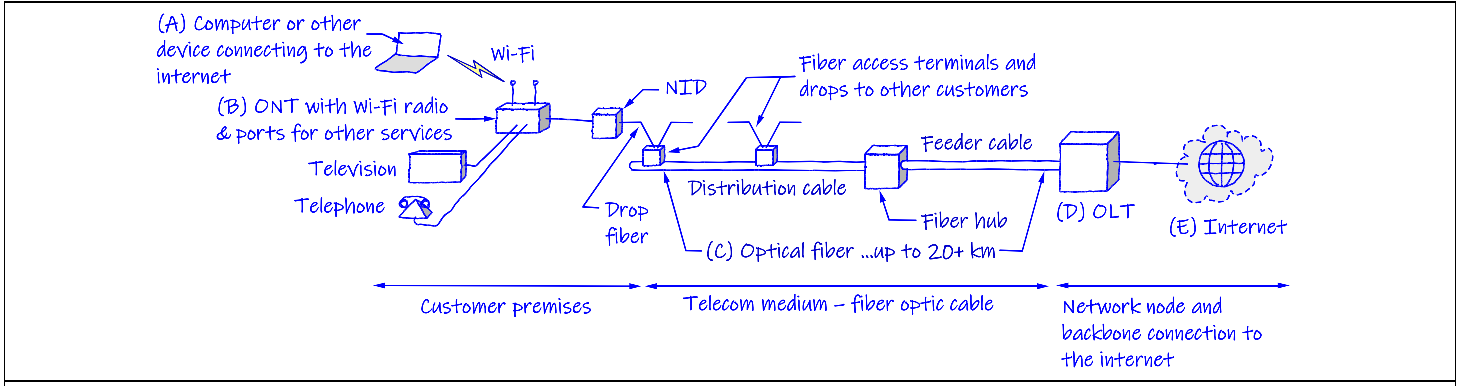
Backstory: FTTP trials began in the 1980s but there was no internet to drive the need for high speed service. This began to change in the 1990s with the rise of the world wide web, and there was renewed interest in exploiting the high theoretical capacity of fiber for economic broadband delivery. An early standard from the mid 1990s was broadband passive optical network (BPON) technology that provided shared capacity of 622 Mbps down and 155 Mbps up. This was not particularly successful. In 2003 the Gigabit PON or GPON standard was ratified with 2.5 Gbps down and 1.2 Gbps up over about 20 km, shared by typically 32 to 64 homes. This technology was more successful in the market and costs began to fall. The current standard, XG-PON, for 10 Gbps down and 2.5 Gbps up may be a stepping stone to other emerging next generation technology standards. There are also non-shared systems, often referred to as “point-to-point” systems as each customer has a dedicated fiber to their premises. This provides high performance to each customer; however, these systems require more fibre to be constructed or in a hybrid network with some point to point and some PON.

Performance: Fiber performance is typically offered to consumers as 100 Mbps to 1 Gbps service plans and, in some cases, up to 2 Gbps. Actual speed performance will depend on:

- the network type and
- the vintage of the optical line equipment used by the service provider.
- the number of subscribers sharing a fiber

If the network is a passive optical type that shares the capacity of each fiber, then the number of subscribers sharing the fiber and how active these subscribers are at any given time on the internet will be another factor affecting performance. Although "over-subscription" is a risk with PON technology if too many high usage users share a fiber, it has yet to become a significant issue due to the substantial capacity fibre provides.

FTTP technology / market status: Sunrise / Early Majority. FTTP is being rolled out globally and has a minimum 20 year life and, barring damage, will likely have a useful life in excess of 30 or 40 years.



FTTP TECHNOLOGY OVERVIEW DIAGRAM…a typical FTTP internet connection.
A home computer or tablet (A) connects using Wi-Fi to the home Optical Network Terminal or ONT (B), usually over a Wi-Fi radio that is "built-in" to the ONT. The ONT usually connects to a Network Interface Device or NID that is the demarcation between the operator’s network and the home network. The ONT sends and receives flashes of light at different wavelengths in a single fiber (C) to communicate with an Optical Line Termination or OLT (D) which is located in a network node or "central office" building. The OLT then connects through a backbone network to the internet (E). Note that passive optical network (PON) technology uses optical splitters and combiners, allowing multiple subscribers to share the high capacity of a single fiber.

UNLICENSED FIXED WIRELESS ACCESS (FWA) TECHNOLOGY

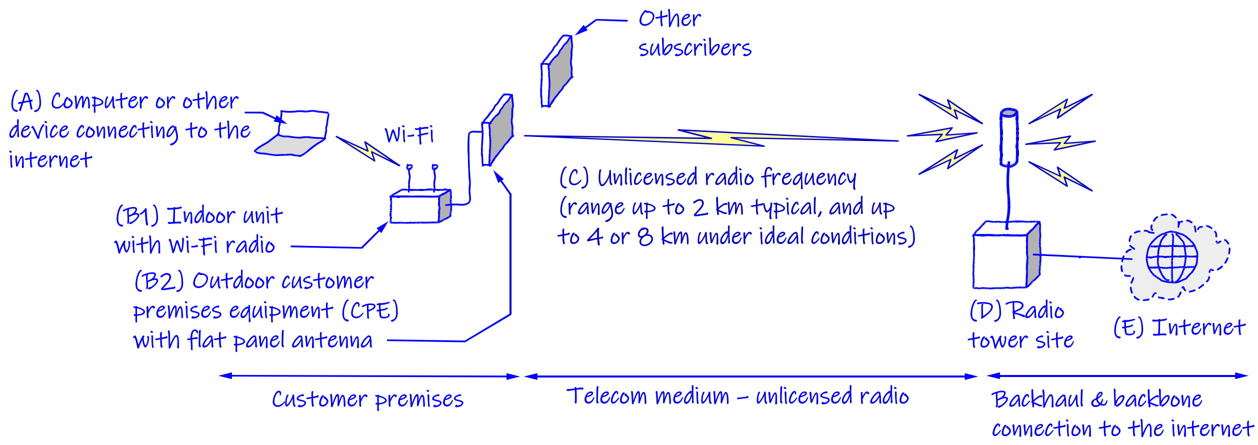
Radio technology operating in unlicensed radio bands is typically used by Wireless Internet Service Providers (WISPs) to provide "local access" connectivity in small communities and rural areas.

Backstory: In 1997, the Institute of Electrical and Electronics Engineers (IEEE) issued an open standard for wireless (radio) Local Area Networks (LANs) that used the license-free Industrial, Scientific, and Medical (ISM) band. The Wi-Fi Alliance formed around this standard to promote an open competitive market. By 2002, laptop computers were being sold with Wi-Fi embedded and by 2008, smart-phones included embedded Wi-Fi. By 2020, there were about 10 billion Wi-Fi devices world-wide and a billion Wi-Fi chips being sold annually. The primary advantage the ability of a single radio to serve a relatively large area. Free unlicensed radio frequencies and a competitive equipment market, means relatively low start up costs. Everyone in the coverage area shares the resources of the radio site and customers can be added for low cost. As new customers join, the service provider must add capacity by adding radios until all the unlicensed spectrum is used. Then capacity can only be increased through "frequency reuse" which means adding more antennas and adding more radio tower sites.

Performance: Under ideal circumstances (not too many customers and all customers with a short clear radio path to the radio tower site) the 50/10 target can be met, with state of the art systems demonstrating 100/20 user speeds. Unfortunately, it does not take many users engaged in video conferencing, video streaming and other high bandwidth activities before there is not enough capacity to go around. In addition, because the unlicensed radio frequencies can be used by anyone for anything, there is always a risk of interference that will further reduce speed. The following are the primary limiting factors:

- the number of subscribers sharing the radio capacity and the simultaneous demand
- the distance to the radio tower and any obstructions
- the amount of radio interference present

Unlicensed radio technology / market status: Mature & evolving / Saturating. As long as there are areas without an adequate last-mile service provider, there will be room for a WISP to offer internet access using unlicensed radio technology.



UNLICENSED FWA TECHNOLOGY OVERVIEW DIAGRAM ...a typical FWA internet connection.
A home computer or tablet (A) connects using Wi-Fi to a fixed radio terminal (B), often using Wi-Fi that is "built-in" to the fixed radio terminal. The Customer Premises Equipment (CPE) is a radio terminal that uses an unlicensed radio frequency band (C) to communicate with the WISP's radio tower or "access point" site (D) which is usually at a location optimized to reach customers and the backhaul (e.g., often on a hill). The tower site then connects through a backbone network to the internet (E). Note that the further a customer is from the radio tower, the weaker the signal and the lower the speed.

LICENSED CELLULAR FIXED WIRELESS ACCESS (Cellular) TECHNOLOGY

Radio systems for broadband cellular mobile radio service are used by mobile network operators in some of their service areas for "last-mile" fixed wireless internet to rural areas and small communities.

Backstory: Early cellular mobile radio systems were introduced in the 1980s. The distinguishing feature of cellular was the ability to roam anywhere in the coverage area. Today the fourth generation (4G or LTE for Long-Term Evolution) is dominant in many parts of the world and the fifth generation (5G) is being deployed, with each generation introducing more capabilities. The broadband-like speeds achievable with LTE led mobile companies to offer fixed internet service using their mobile network. Examples include Bell Wireless Home Internet, Rogers Rocket Hub and Telus Smart Hub.

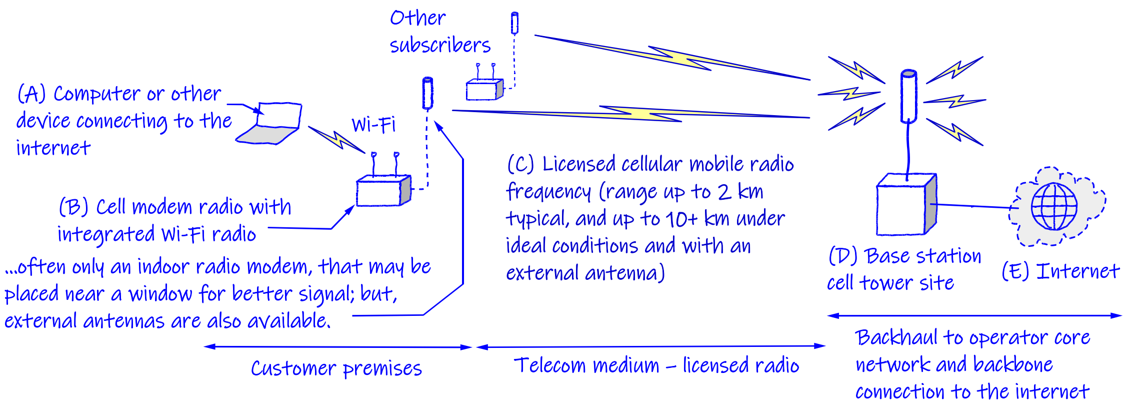
Cellular mobile systems use radio frequencies that are licensed from the national government and protected from interference. Licenses are purchased through auction processes and can be expensive. The high costs and government's desire to maximize revenue, make this largely a game for national mobile operators.

Because licensed radio frequencies are exclusive to the licensee, higher powers are allowed which translates into better range than unlicensed frequencies. In rural areas, a high cell tower can usually reach a handheld device up to about 3 or 4 km away. Fixed wireless terminals with a clear radio path, can reach 10 km and, if lower speeds are acceptable, distances of 20+ km are achievable.

Performance: In theory, the latest 4G version can hit the 50/10 target as the technology is capable of 3 Gbps down and 1.5 up. However, this is shared by all active subscribers accessing the cell site and users typically see up to 25/5. Actual average speeds may be much less and will depend on:

- the number of users contending for the service
- the capability of the subscriber's user equipment
- the distance to cell tower (and any obstructions)
- the capacity equipped at the cell site

Licensed cellular radio technology / market status: Mature & Evolving / Saturating. The planet continues to be enamored by mobile devices for internet access. We can expect a continued virtuous circle of growth and evolution over at least the next decade, and likely beyond.

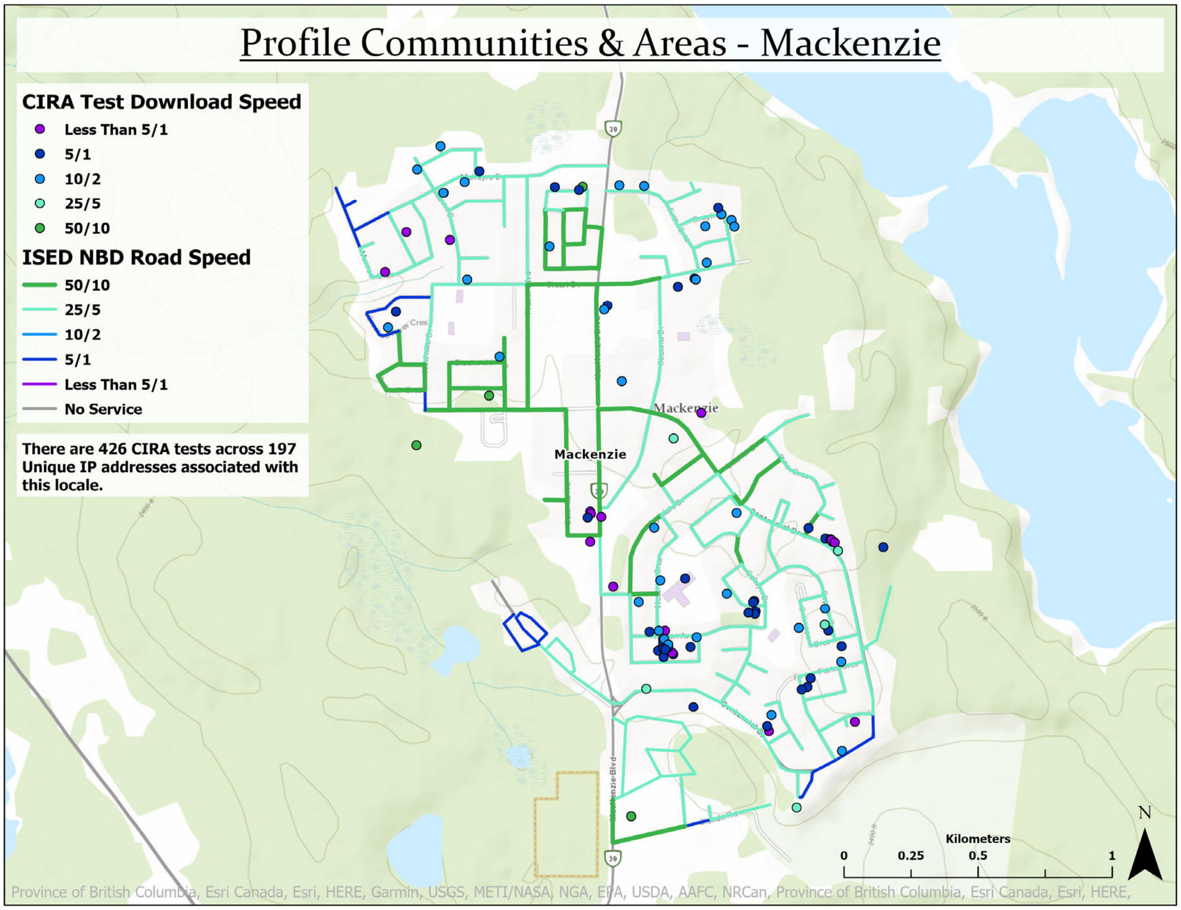


CELLULAR FWA TECHNOLOGY OVERVIEW DIAGRAM ...a typical cellular FWA internet connection.
A home computer or tablet (A) connects using Wi-Fi to a fixed cell modem radio terminal (B), often using Wi-Fi that is "built-in" to the fixed radio terminal. The radio terminal uses a licensed cellular mobile radio frequency band (C) to communicate with the radio tower or "base station" site (D). The tower site then connects through a backbone network to the internet (E). Because the cell tower capacity is shared and user speeds will decline with distance to the tower, performance is variable.

APPENDIX E – Profile Locale - Mackenzie

Background: Mackenzie is an incorporated municipality located in the Regional District of Fraser-Fort George with a population of 3,714 as per the 2016 federal census. It is located in north-central BC on highway 39, not far from highway 97 in the northern portion of the RDFFG. There are not really any further sizeable communities north of Mackenzie, so it is a community located at the end of a highway spur.

Outreach Reports of Consumer Experience: Mackenzie reports dissatisfaction with internet service levels notwithstanding the Map below which depicts service at 50/10 and 25/5 throughout the community with a couple of pockets of weaker service. CIRA test results largely reflect service at less than 50/10 and less than the service levels shown on the Map. Age of infrastructure is believed to be a factor that is an issue. Lack of competition is viewed as an issue to getting improved service and better connectivity is a high priority for the community.



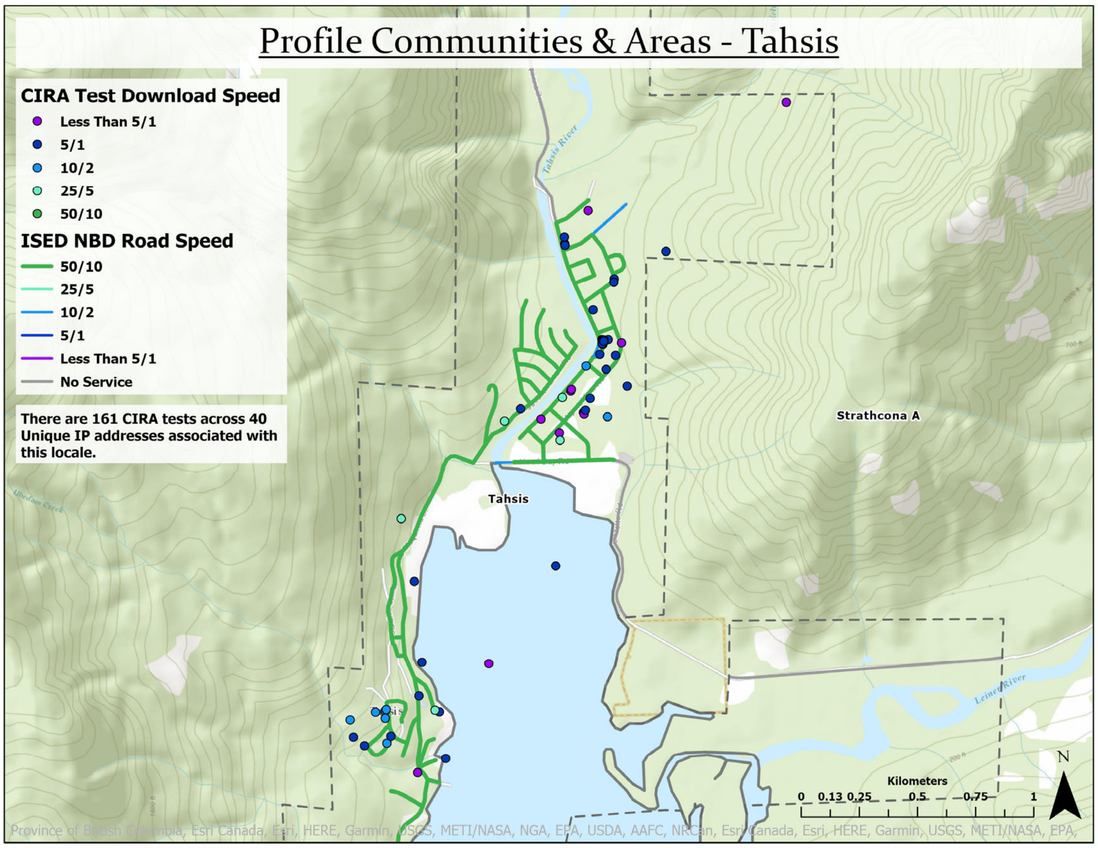
Comments:

- Service providers providing internet services in Mackenzie include Telus and ABC Communications in addition to Bell and Rogers for cellular services.
- Technologies include DSL, fixed and mobile wireless.

APPENDIX F – Profile Locale - Tahsis

Background: The Village of Tahsis is an incorporated municipality located over 400 km north of Victoria on the West coast of Vancouver Island just slightly north of Campbell River on the East coast of Vancouver Island. According to the 2016 federal census, its population is 248 people.

Outreach Reports of Consumer Experience: Notwithstanding that most of the community shows as 50/10 on the Map, outreach indications were that the RCMP detachment, BC Ambulance, Department of Fisheries and Oceans, Canadian Coast Guard and the Health Clinic may have fibre service, but no residential, commercial or industrial properties are believed to be served at that level according to Tahsis. CIRA results do not show any results at 50/10 or higher. The municipal office reports internet download at 10Mbps and maybe 3Mbps upload. Outreach reports that purchase of 50/10 service is NOT available in Tahsis.



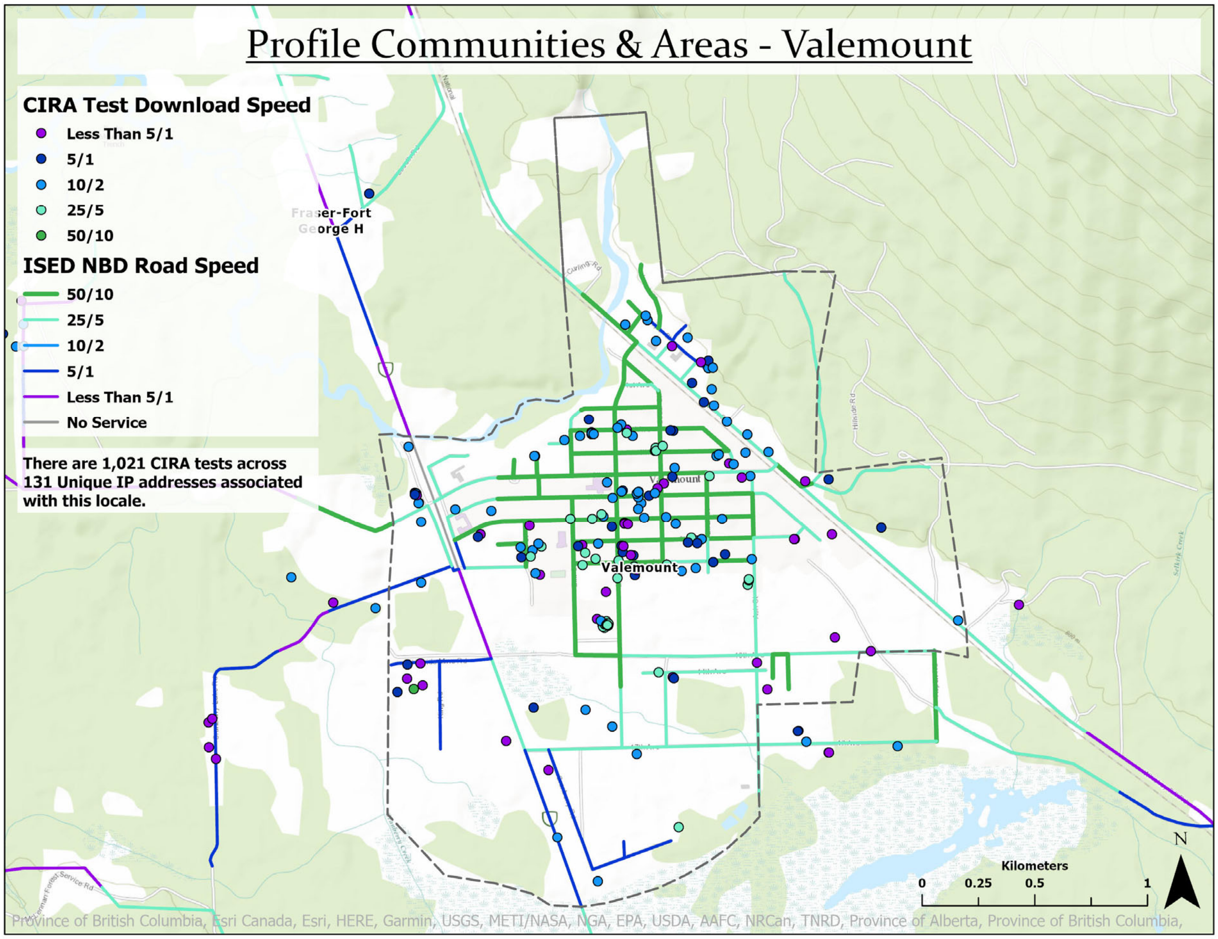
Comments:

- Service providers providing internet services in Tahsis include Telus and Mascon in addition to Bell for cellular services.
- Technologies include coaxial cable and mobile wireless.

APPENDIX G – Profile Locale - Valemount

Background: The Village of Valemount is a Resort Municipality of just over 1000 people located along Highway 16 in the southern part of Electoral Area H in RDFFG. It is just north of the northern tip of Kinbasket Lake within the Columbia Basin of south-eastern British Columbia very close to the Alberta border. It has been impacted by the boom and bust of the forestry industry but has developed a strengthening tourism industry arising out of its location between the Rocky, Monashee and Cariboo Mountains close to many different recreational opportunities.

Outreach Reports of Consumer Experience: Valemount reports that Monashee's wireless service is good if line of sight is available. It is reported that most roads shown as green on the Map do not have 50/10 which is supported by the CIRA testing numbers shown on the map below. In addition, outreach reports that infrastructure is aged in the community making it difficult to obtain 50/10 through the DSL service which is the primary service in the community.



Comments:

- Service providers providing internet services in Valemount include Telus and Monashee in addition to Bell for cellular services.
- Technologies include DSL, fixed and mobile wireless services.

APPENDIX H – Profile Area – Vanderhoof – Fraser Lake – Fort St. James Area

Background:

Fort St. James

Situated in the eastern part of the Regional District of Bulkley-Nechako, Fort St. James is a significant municipality. It has a population of around 1,600 and has a number of nearby reserves which are associated with the Nak'azdli Whu'ten First Nation. Fort St. James is at the tail end of Highway 27 which branches off of the Yellowhead Highway west of Vanderhoof. The locale economy is most based around the resource sector with an emphasis on forestry and mining. Tourism also is a significant part of the local economy in Fort St. James.

Nak'azdli Whu'ten First Nation Reserve Lands

The Nak'azdli Whu'ten First Nation Reserve Lands are situated around and close to Fort St. James. The main reserve is Nak'azdli (Necoslie 1) which borders the southern portion of Fort St. James. In 2016, there were 548 people living within the reserve per Census 2016 figures. Highway 27 from Vanderhoof runs through the middle of the reserve. The reserve along with Fort St. James border Stuart Lake to the east.

Fraser Lake

Along the south-western shores of Fraser Lake, the municipality of Fraser Lake is a sizable community along the Yellowhead Highway. Located in Electoral Area D of the RDBN, Fraser Lake is the largest town in the area. The community has a population of around 1,00 people and its jurisdictional area is roughly 4 km^2. Forestry is the main economic driver in the community but there is some tourism activity as well.

Fort Fraser

Also along the Yellowhead highway, and near the opposite end of Fraser Lake, is the unincorporated community of Fort Fraser with a population of about 500 people. Like other communities in the area, its economy is mostly centered forestry and tourism.

Vanderhoof

Vanderhoof is the first major community along the Yellowhead Highway as one enters the RDBN from the neighbouring Regional District of Fraser-Fort George to the east. The municipality has a population of about 4500 people and its jurisdiction covers an area of 55 km^2. Vanderhoof's economic drivers are the forest industry, agriculture, and tourism. Being a larger community in the area, it has a number of key anchor institutions such as government buildings, arenas, a courthouse, and a hospital.

Sai'Kuz First Nation Reserve Lands

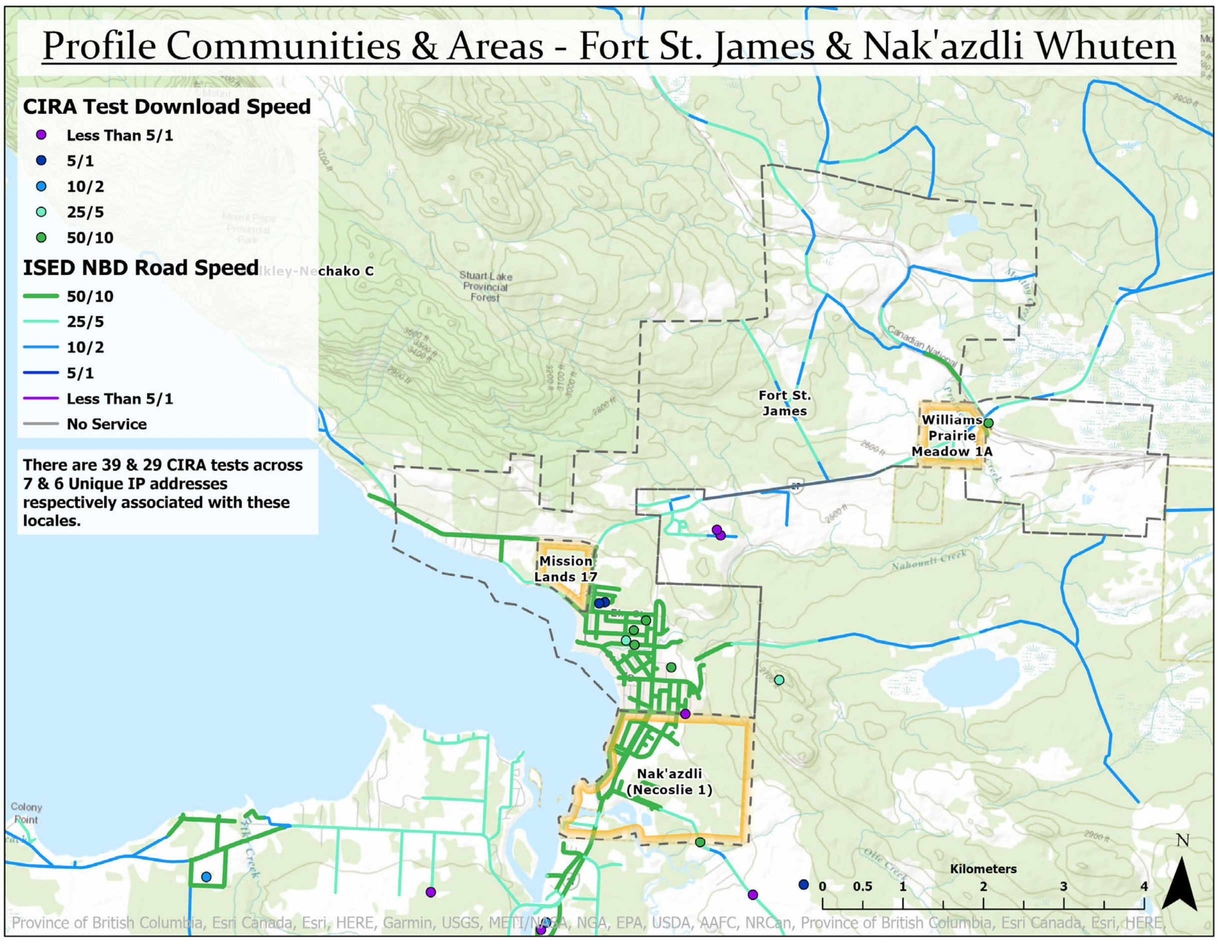
The Saik'uz First Nation Reserve Lands are situated near other communities such as Vanderhoof in Electoral Area F of the RDBN. Stony Creek 1 is the main community and is bordered by Tachick Lake to the north and Nulki Lake to the south. The community has over 300 people living within it per 2016

Census data. The Saik'uz Band Office, Firehall, and Health Centre are situated within the community and service its members as well as the members of nearby reserves.

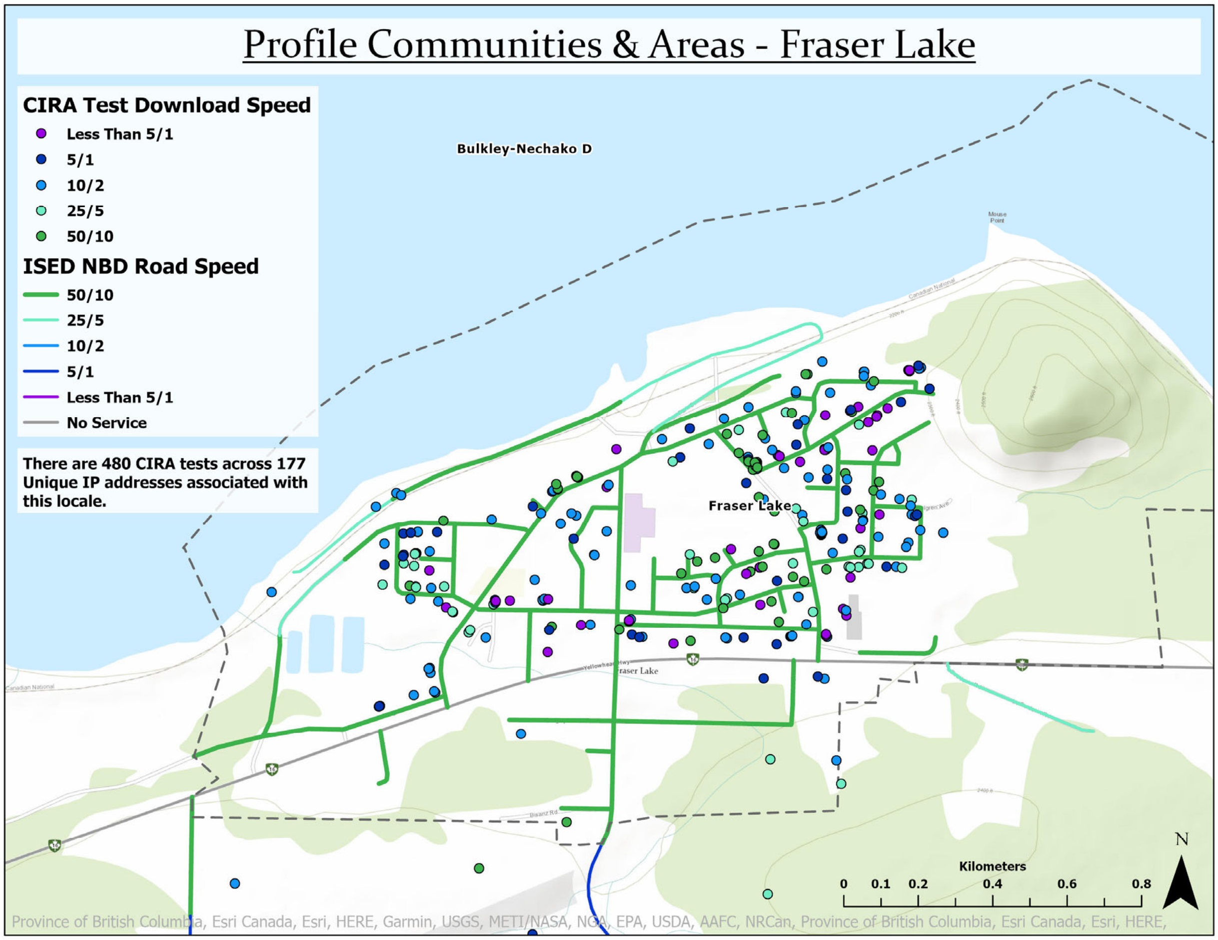
Outreach Reports of Consumer Experience, Service Providers and Technology Available:

Fort St. James: The District of Fort St. James has undertaken speed testing using fast.com and questions the Map which shows the entire community as served with 50/10. The District has invested substantial effort in identifying service levels throughout the community. The primary providers are Telus, Mascon, Evolve using DSL, cable and fixed wireless and with Rogers and Bell providing mobile wireless only.

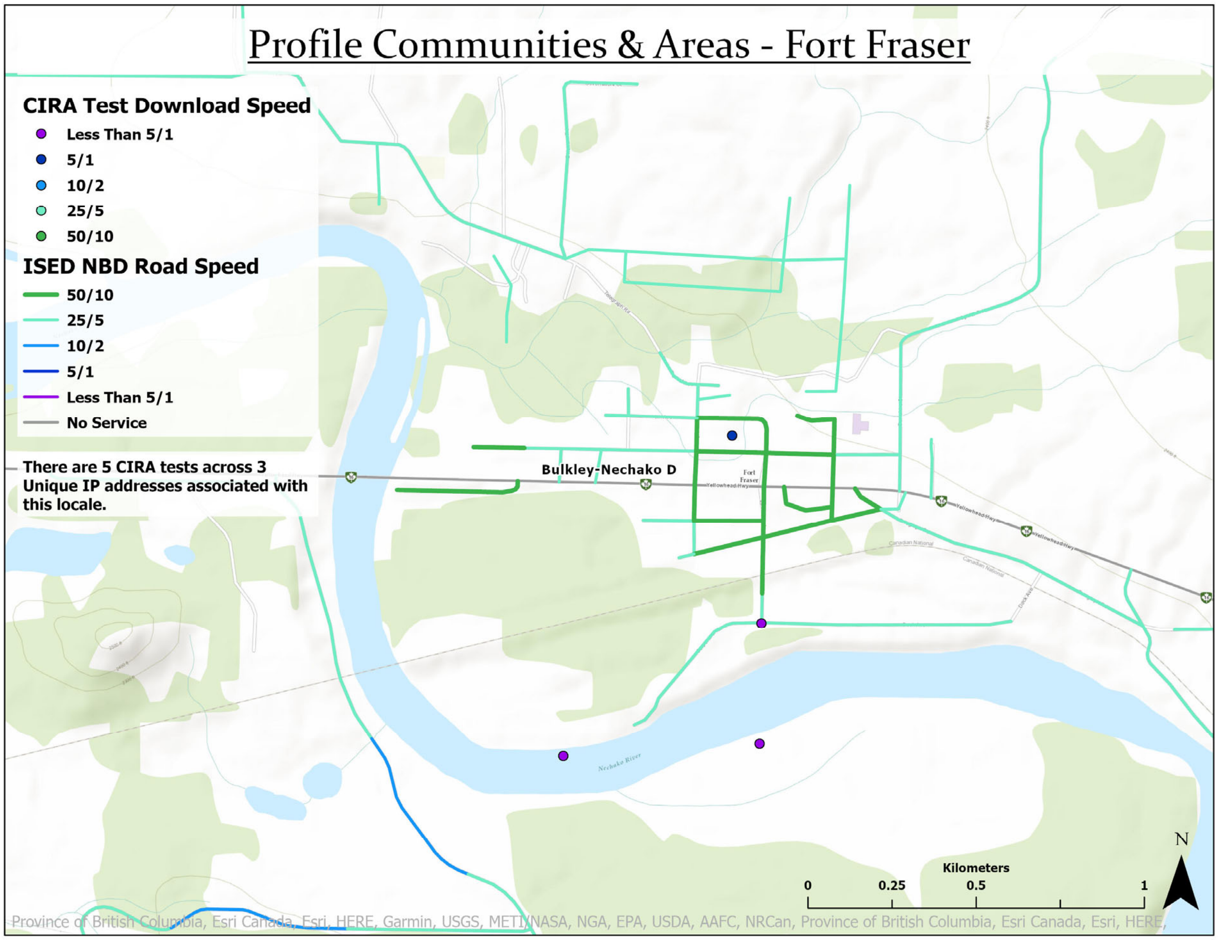
Nak'azdli Whu'ten First Nation Reserve Lands: The band office and its administrative offices have good service on TELUS fibre so residents come to the band office to use the internet. Generally, household service is perceived to be slow, but it is unclear what service levels are being subscribed for. The band office subscribes for a 1Gbps service and usually gets about 600 – 850Mbps. Limited information was available from our discussion with the local representative as they were new to the position and unable to speak for the community. The band office is unique among locations as it is connected to Telus fibre via a higher-level commercial service that performs well although the increased demand placed on the band office due to members utilizing its internet service is causing some internal capacity issues.



Fraser Lake: The Village of Fraser Lake has invested time and money into understanding what connectivity looks like in their community and has conducted testing and surveys of the community. The Telus group of companies (Telus, Mascon and ABC) are the only non-satellite choice with Telus itself being the most commonly used provider. General perception by the village is that service is inconsistent and slow with insufficient capacity. They report that video calls routinely freeze or drop and that was experienced throughout the outreach call on Teams. The belief is that the level of internet service in the area is insufficient to attract new business or new residents. The municipal office regularly loses connectivity which impacts its ability to do its work. The village reports that promised improvements have not been realized, and attempts to submit materials to correct the Map have been unsuccessful to date.

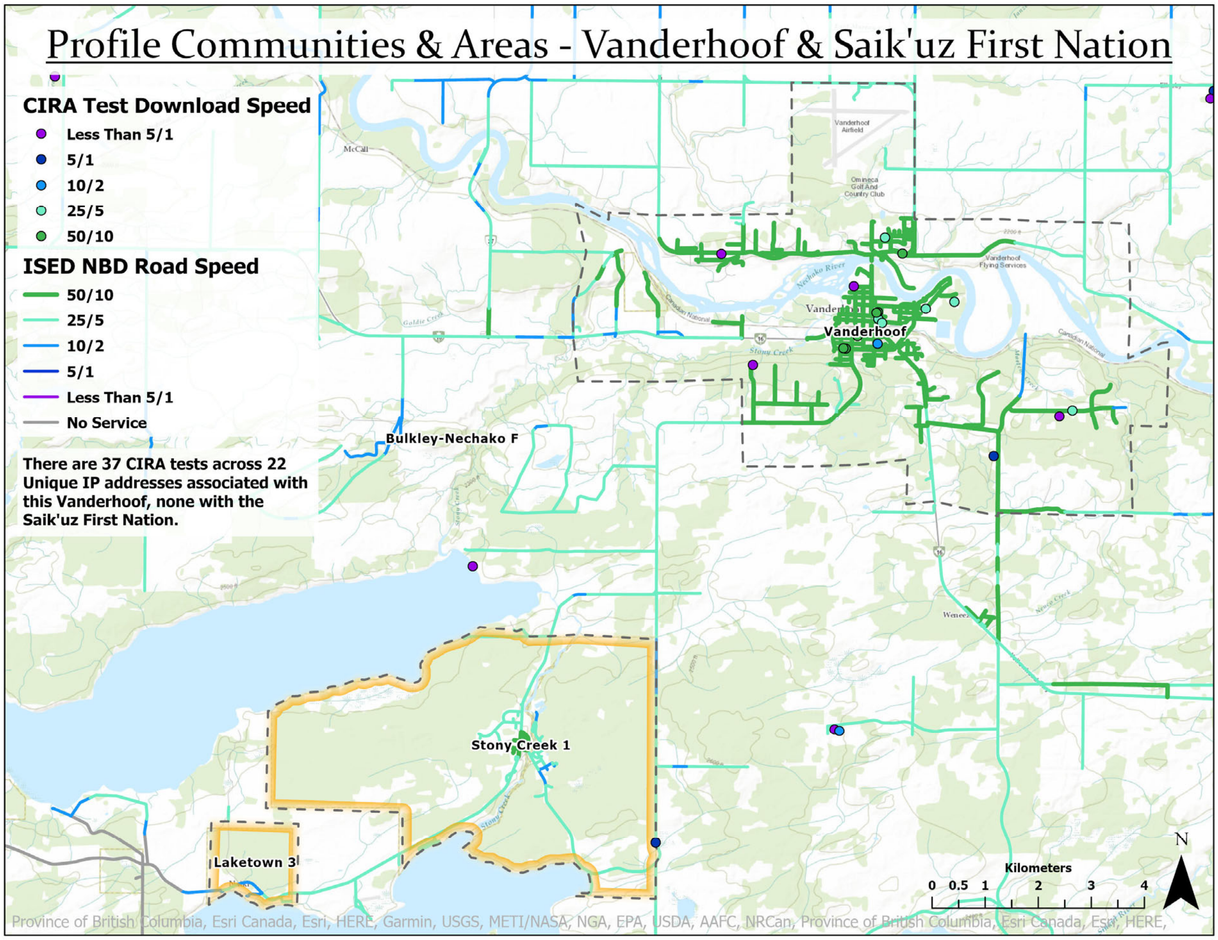


Fort Fraser: According to the RDBN, nowhere in the rural area is served with 50/10 even though Fort Fraser shows as served at that level and is even shown as having FTTP on the Map. There is a belief by the community that over-subscription to the mobile wireless service results in poor service.



Vanderhoof: Outreach indicates that there is a lack of 50/10 in Vanderhoof, and large pockets of the community have less than 50/10 despite almost the entire community showing as 50/10 on the Map. Reports suggest that Evolve's wireless service can provide 50/10 where line of sight is available. Other providers include Telus, ABC and Mascon deploying DSL technology, as well as FTTP, cable, fixed and mobile wireless.

Saik'uz First Nation Reserve Lands: According to the local representative, the administrative building is served with TELUS fibre which was put in some time ago. It is believed that there is fibre to the health centre but that no actual service is being provided. The balance of the community is served with wireless with some homes unable to access service at all. At most, service on reserve is believed to be 10/4.


Profile Communities & Areas - Vanderhoof & Saik'uz First Nation
CIRA Test Download Speed
Less Than 5/1
5/1
10/2
25/5
50/10
ISED NBD Road Speed
50/10
25/5
10/2
5/1
Less Than 5/1
No Service
There are 37 CIRA tests across 22 Unique IP addresses associated with this Vanderhoof, none with the Saik'uz First Nation.
Vanderhoof
Bulkley-Nechako F
Stony Creek 1
Laketown 3
Kilometers
0 0.5 1 2 3 4
N
Province of British Columbia, Esri Canada, Esri, HERE, Garmin, USGS, METI/NASA, NGA, EPA, USDA, AAFC, NRCan, Province of British Columbia, Esri Canada, Esri, HERE,