Infrastructure Options For Rural Villages in the RMWB

Craig Dobson *September, 2013*

Objective

Last fall for the Sustainable Communities Working Group (SCWG), TaylorWarwick completed a planning level conceptual review of five options available to improve broadband services within Janvier[1]. In this document, the estimates for the mesh wi-fi, hybrid fibre/wi-fi, and full fibre/wi-fi options are extended to include Fort Chipewyan, Anzac, Conklin, Fort MacKay, and Gregoire Lake Estates. Potential impacts of the proposed IBI fibre designs for the Regional Municipality of Wood Buffalo (RMWB or RM for short) are considered.

Recommendations

While the analyses contained herein provides a realistic and detailed assessment of the broadband infrastructure options, capabilities, and capital costs for the communities within the RMWB, as outlined in Next Steps, additional work is required prior to selecting which of the presented alternatives is the most appropriate.

[1] Dobson, C; Janvier/881 Analysis – Infrastructure and Economics; OSLI; 2012 10 09.

Infrastructure

Existing Infrastructure and Services

The rural areas of the RM receive Internet services via:

- TELUS dial-up services
- Arrow Technology Group (ATG) point-to-multipoint (PMP) fixed wireless services
- XploreNet and Galaxy Broadband Satellite Services
- TELUS, Bell, and Roger's mobility services

the specifics of which appear in the table below (thanks to Melanie[2] for some of the information summarized here).

	Access Services							
	Wired BB: DSL/DOCSIS		Fibre		Wireless		Satellite	
	TELUS	Shaw	Arrow Tech	RM Facilities	Arrow Tech	WiFi	XploreNet	GalaxyBB
Janvier			Band Office +	Proposed	√		√	
Fort Chipewyan				Proposed	√			√
Anzac				Proposed	√		√	√
Conklin	$1.2M Upgrade			Proposed	√		√	√
Fort MacKay				Proposed			Service Edge	√
Gregoire Lake Estates					√		√	√

	Access Services – continued			Backhaul			
	Cellular			Fibre	Wireless		
	Rogers	TELUS	Bell	SuperNet	SuperNet	Licensed PTP	Tridon
Janvier	3/4 G	3/4 G		√		√	√
Fort Chipewyan		4 G	4 G		√	RES*	√
Anzac	√	√	√	√		√	√
Conklin	3 G	3 G		√		√	√
Fort MacKay		4 G	4 G	POP south	into Ft. MacK	√	√
Gregoire Lake Estates	√	√		√	√		

* Regional Emergency Services network

Dial-up neither meets client requirements nor the government's definition of basic Internet which, based on the CRTC's 2011 non-binding aspirational access services goal, is set at 5 Mb/s down (toward the client) and 1 Mb/s up by 2016. ATG's PMP wireless services in the area seem to be uniformly poor from a user's perspective and, given the poor business case associated with delivering these services from ATG's perspective, are not likely to be upgraded. Data via mobility services is expensive in that a 5 GB/mo mobility data plan costing about $40/mo, for instance, is barely enough to download a single HD movie. Performance of the satellite services is currently unknown, but latency is typically an issue.

Except for the wireless SuperNet connection in Fort Chipewyan, fibre backhaul services via the Alberta SuperNet is available in each community. Other than Fort Chipewyan as well, wireless backhaul services are available from a licensed point-to-point radio network operated by the RMWB as well as from an extensive wireless network operated by Tridon. In response to client requirements, Tridon is currently looking to extend its radio network south to Conklin. Site acquisition within the RM is currently an issue as the RM waits to see what towers will be deployed via the provincial Alberta First Responder Radio Communication System (AFRRCS) program.

Proposed RMWB Network

Under contract to the RM, the IBI group completed conceptual designs for a fibre network in each community to connect RM facilities. By deliberately overprovisioning the network, extra capacity was to be made available to help facilitate Internet services deployment to residential and commercial clients by third party suppliers. Two options are currently on the table. Option 1 (Op-1) involves deploying the minimal network required to connect all RM facilities in each village[2]. Deployment options for direct buried versus trenched are presented at a high level. Though the initial plan included extra fibre that third party interests could splice into, to better enable third parties such as the SCWG to deploy their own fibre, revised versions now include either additional conduit or conduit large enough to be sub-ducted.

Option 2 (Op-2) includes Op-1 deployment as well as sufficient additional conduit runs to accommodate pretty much the entire feeder network proposed later in this report. Whereas the savings to SCWG deployment costs under Op-1 are in the 15% range, savings increase to over 30% under Op-2. Should the IBI group obtain approval for an intercommunity backbone network that would be available for third party use, operational savings would also be realized – relative to transport costs, annual operational costs could decrease by 80%.

IBI's conceptual design for Janvier appears on the next page. Designs for the remaining four communities it considered appear in the Appendix. Red indicates SuperNet infrastructure, solid yellow shows Op-1 deployment, and the dotted yellow line indicates the proposed extension under Op-2. As there are no RM facilities in Gregoire Lake Estates, no RM fibre is planned for that area. Adopting Op-2 triples the overall capital cost to the RM.

Potential Options

As discussed in the original infrastructure report for Janvier[1], in order of increasing capability and cost, the three primary options to significantly improve services include:

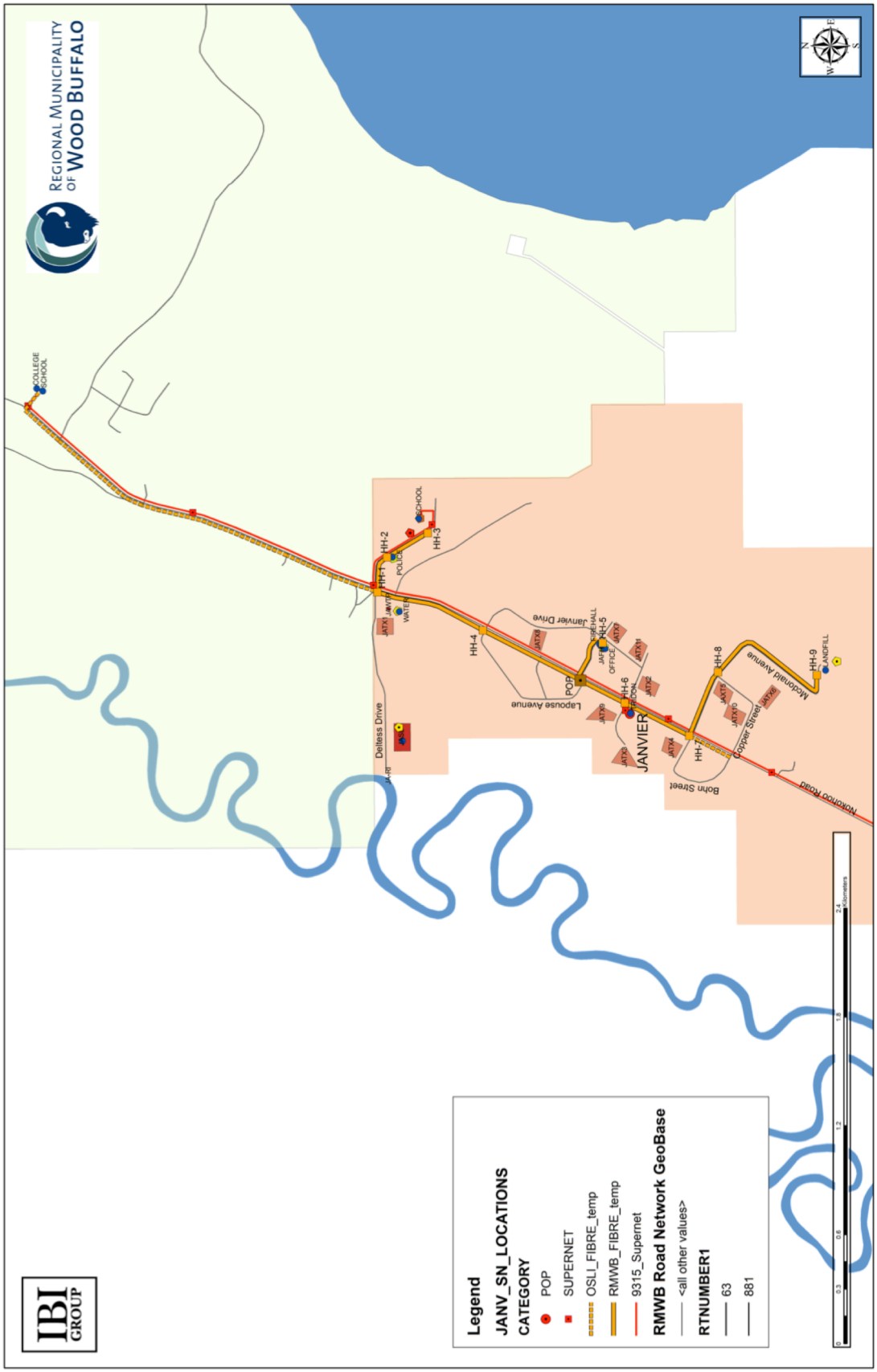
- Deploying a mesh Wi-Fi network
- Deploying a fibre-fed Wi-Fi network (the 'hybrid fibre/Wi-Fi' option)
- Deploying a hybrid fibre-to-the-premise (FTTP) + Wi-Fi network

While a mesh Wi-Fi network can be deployed quickly at low cost, overall bandwidth is fundamentally limited by the 'meshing' function – in which much of the available bandwidth is used to transfer data between the wireless access points (APs) and the backbone connection [see The Mesh Penalty later in this report].

Deploying a fibre feeder network to directly interconnect the APs and the backbone network frees up this 'transfer' bandwidth and thereby significantly increases the bandwidth available to the user community. The feeder network also helps facilitate fibre connections to those requiring it and scales to a full FTTP deployment down the road. The hybrid FTTP+Wi-Fi network provides the best of both worlds, upfront.

Capital costs for each of these alternatives are presented in this report. While costs for a pure FTTP network are not presented, they can be made available on request – or estimated by subtracting the capital costs for the first from those for the third option.

[2] Swanson, Melanie; RMWB Rural Community – Telecommunications Conceptual Design Report; IBI Group; Draft: 2013 05 13.



IBI Conceptual Design for Janvier

Mesh Wi-Fi Network

Unlike PMP systems which require specialized customer reception equipment that must be homed on a host tower, outdoor Wi-Fi networks offer significantly higher data rates and have the advantage that no specialized receiver equipment is required – any Wi-Fi-enabled client device such as laptops, netbooks, iPads, and so on, will do. Unlike their indoor counterparts, outdoor units are environmentally hardened to withstand cold temperatures and moisture, output ten times the power, and can be meshed or linked together to provide their own backhaul connections to the one unit that is 'hard-wired' to a backbone network such as the SuperNet.

The conceptual designs outlined below assume Motorola/Cambrium AP7181 equipment mounted on 25-30m stub towers. The units each support dual band 2.4/5.5 GHz operation based on 802.11n standards, are spec'ed to -40, and provide an aggregate capacity of 300 Mb/s. This Wi-Fi equipment is backwards compatible with earlier versions of the standard, so slower, dated client devices would still be able to connect. While the designs below are sufficient to provide reliable outdoor coverage throughout each community, additional access points (APs) will be needed in some areas if indoor coverage is required as well[3]. Clients remaining out of range could still obtain service from the local wireless ISP (WISP) using PMP equipment or from a satellite service.

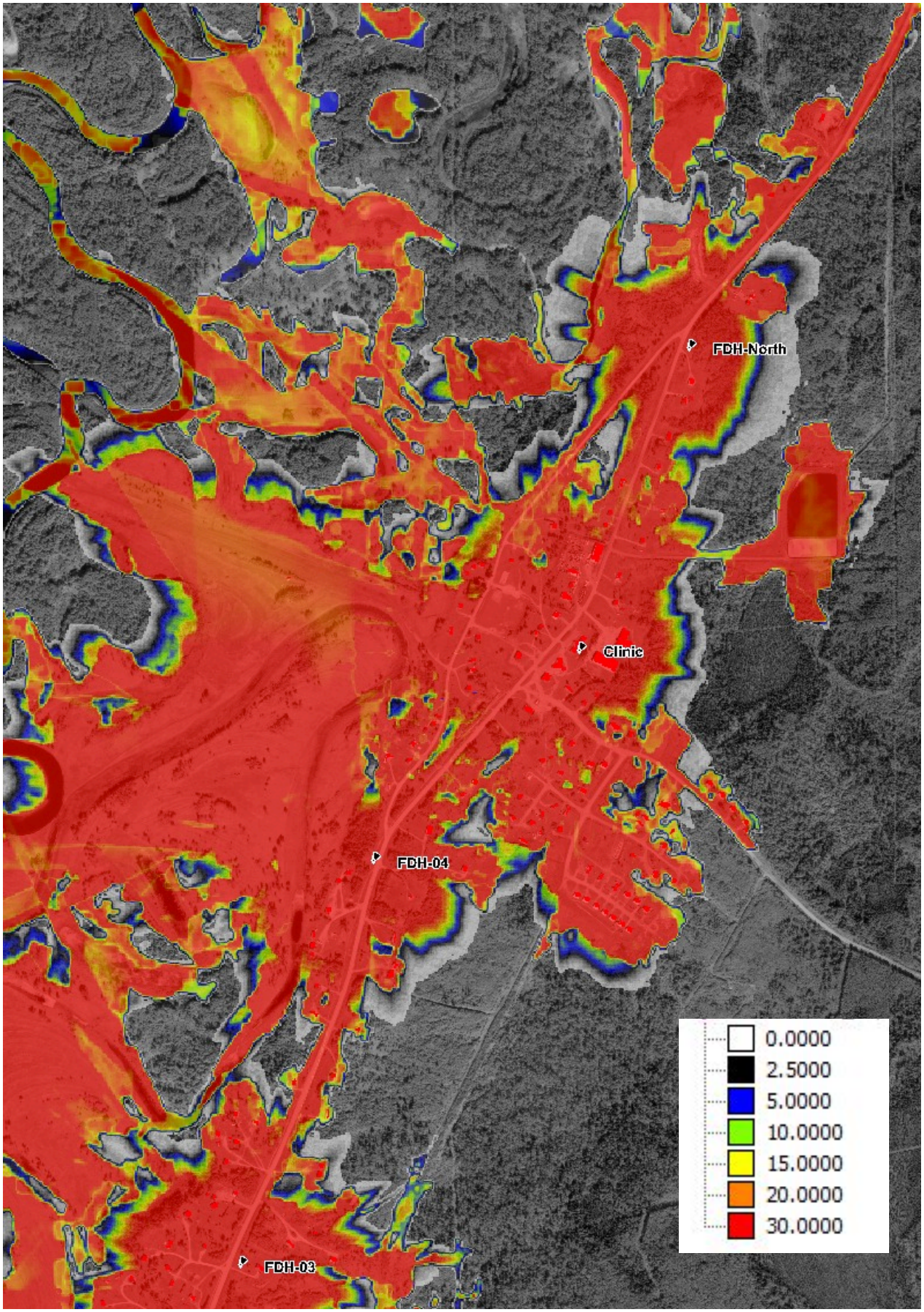
Propagation coverage estimates critically depend on topography and land cover. While digital topographic data is generally available, land (clutter) grids are not. Hence, to ensure accuracy in the conceptual wi-fi designs presented below, high resolution clutter and 3D building grids were created for each area using detailed ortho-imagery provided via the IBI group from the RMWB. The clutter maps developed appear in the Appendix.

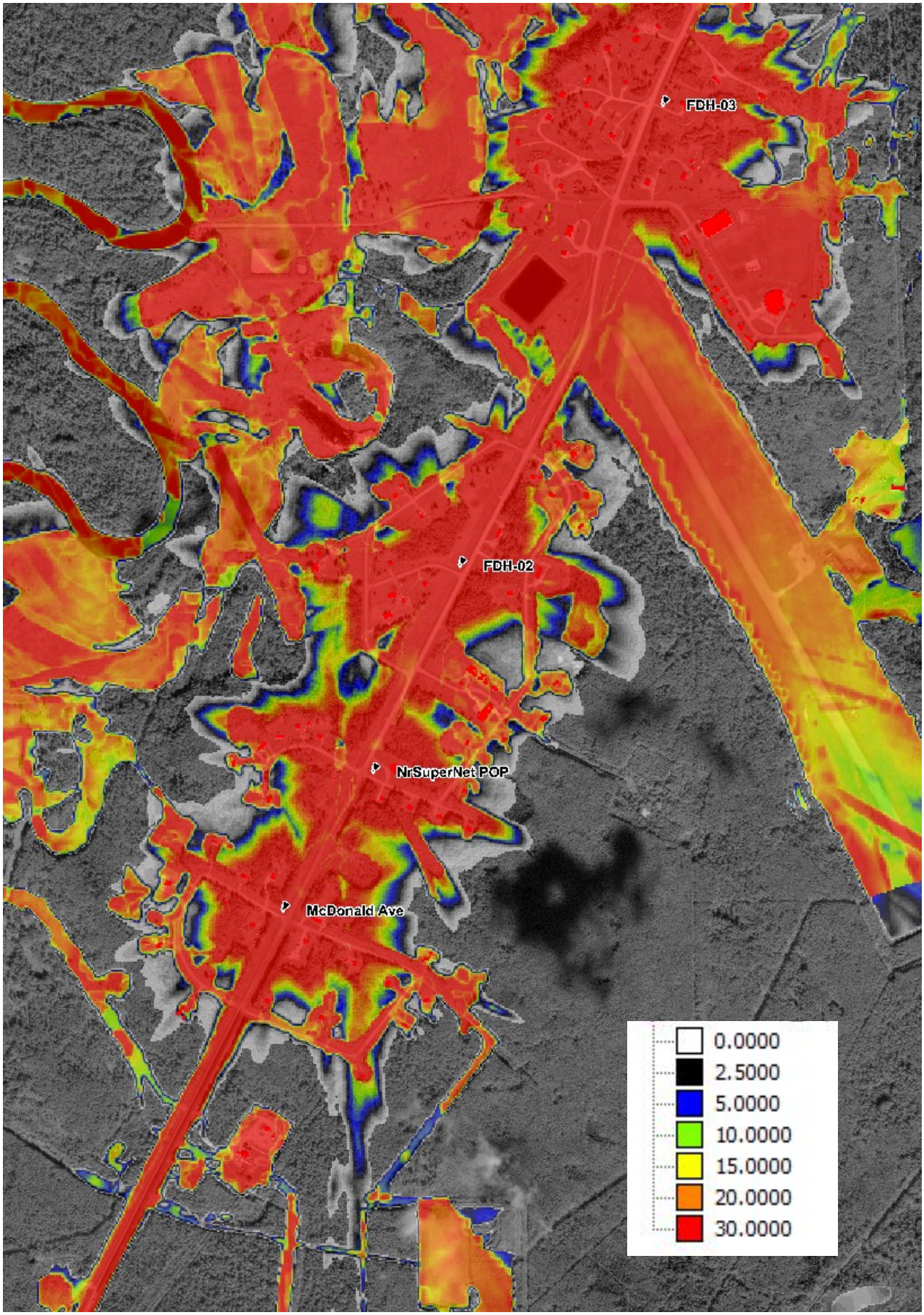
Janvier – from the Infrastructure & Economics Report

Based on a preliminary design, eight wi-fi APs would provide coverage to ~95% of the premises in Janvier. Due to the dense forest, the APs need be mounted at least 25m above ground level and costs for seven towers are included in the analysis. The analysis assumed that the remaining AP would be mounted on the existing ATG tower behind the clinic. Providing adequate signal strength for indoor coverage would require another 5 APs. The network connects to the global Internet via a fibre from the proposed tower near the SuperNet site to the SuperNet POP.

Given the AP7181 equipment, topography, and ground cover, the estimated mean download bandwidths provided by this network, in Mb/s can be seen in the two charts below. While the legends only differentiate bandwidths to 30 Mb/s, peak rates may exceed 70 Mb/s. Whether or not the full 70 Mb/s bandwidth would be available to a particular client at any point in time depends both on the amount of bandwidth currently being used for the 'mesh' function and on the number of concurrent users associated with the AP at that instant and their aggregate their bandwidth demand. To simplify deployment issues should a hybrid option be selected (discussed later in this report), the towers were co-located at potential fibre distribution hub (FDH) sites where possible. The eighth AP is located near the north end of Nokohoo Road.

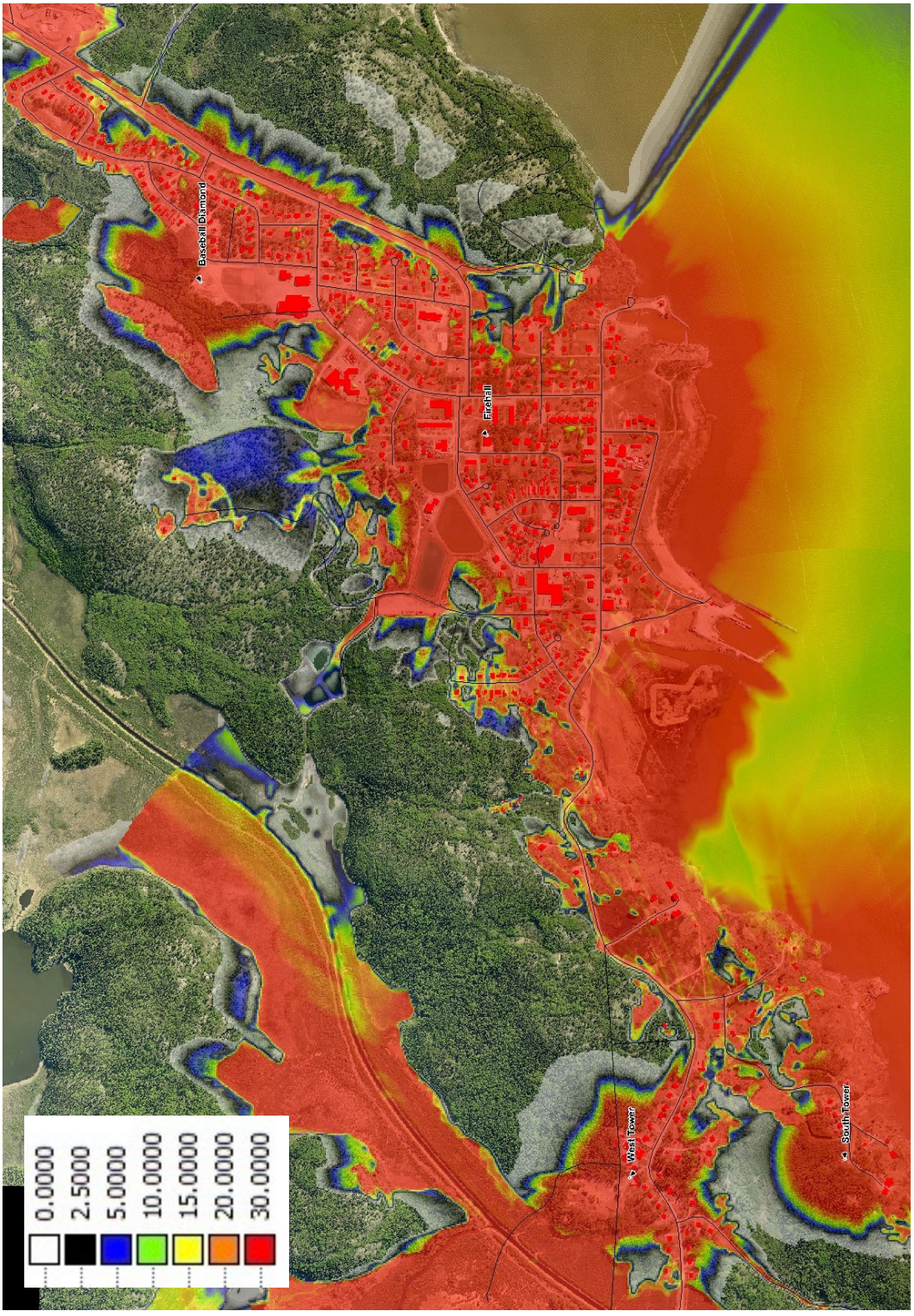
[3] Even with the additional margin provided for indoor coverage, coverage within metal trailers, basements, and buildings with low-e glass will be problematic.


FDH-North
Clinic
FDH-04
FDH-03
0.0000
2.5000
5.0000
10.0000
15.0000
20.0000
30.0000


FDH-03
FDH-02
NrSuperNet POP
McDonald Ave
0.0000
2.5000
5.0000
10.0000
15.0000
20.0000
30.0000

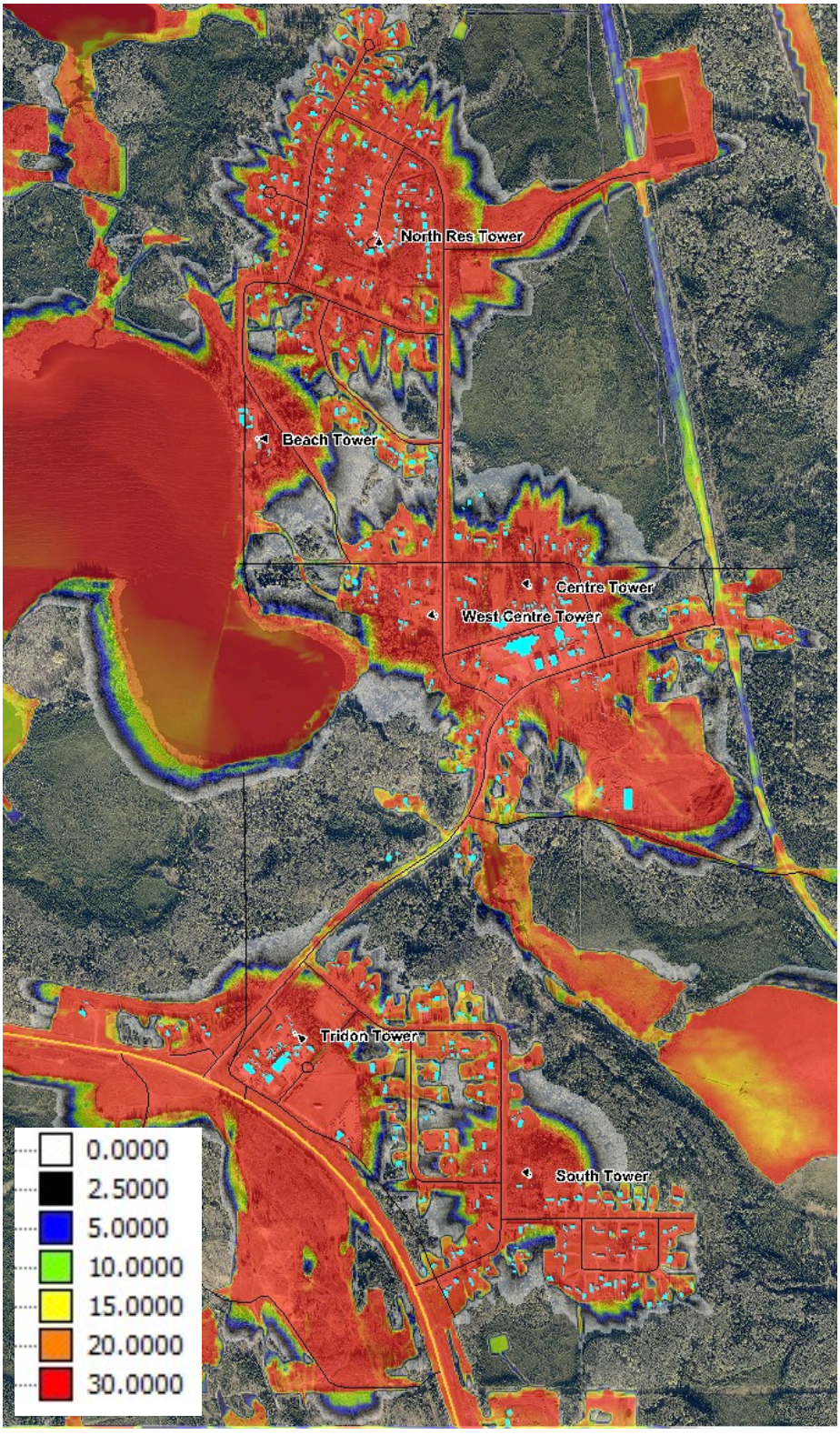
Fort Chipewyan

As shown in the average expected download chart below (legend is in Mb/s), based on the conceptual design, Fort Chipewyan can be reasonably serviced with four wi-fi APs. For indoor coverage throughout the town, four additional APs are needed.



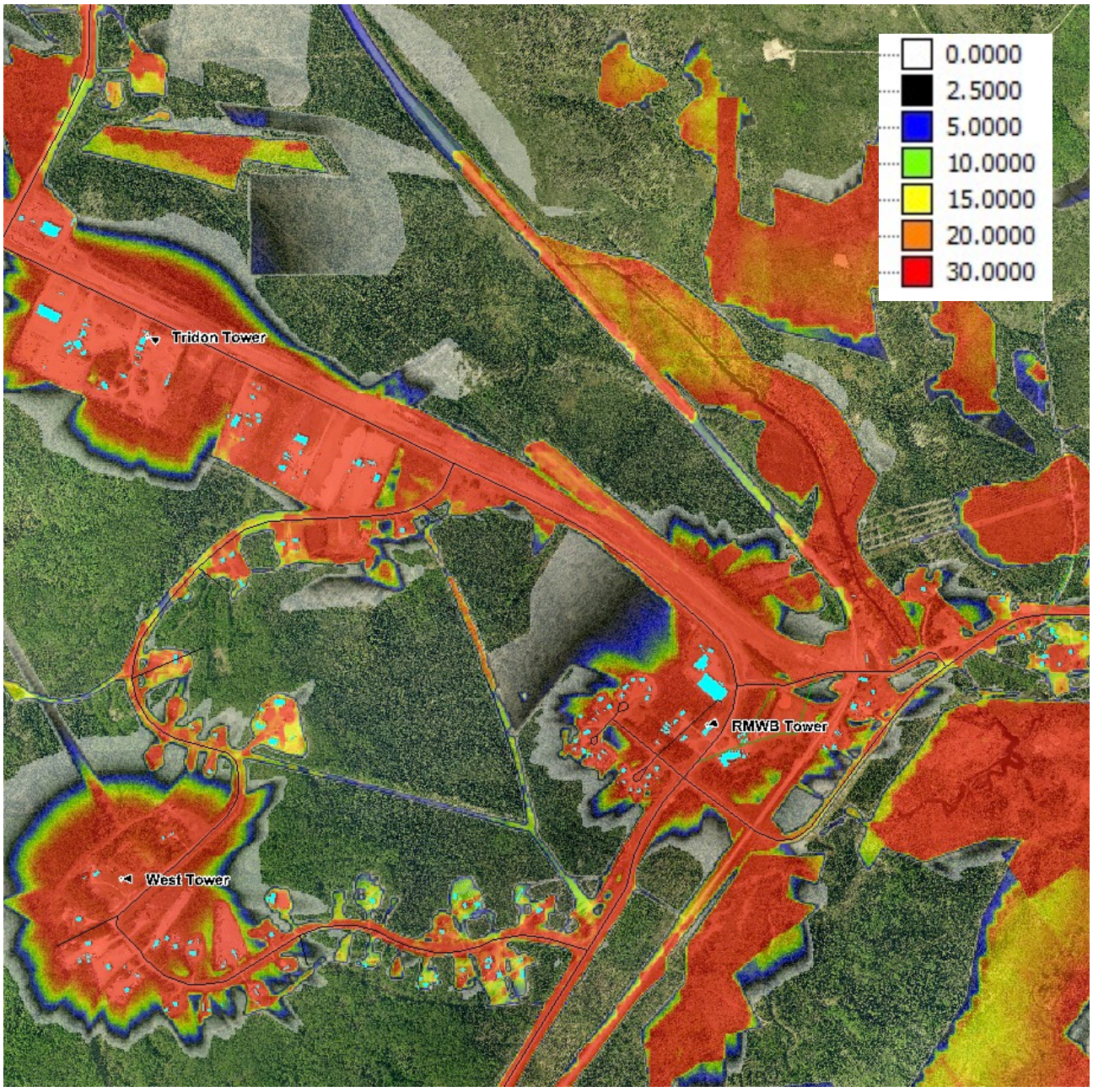
Anzac

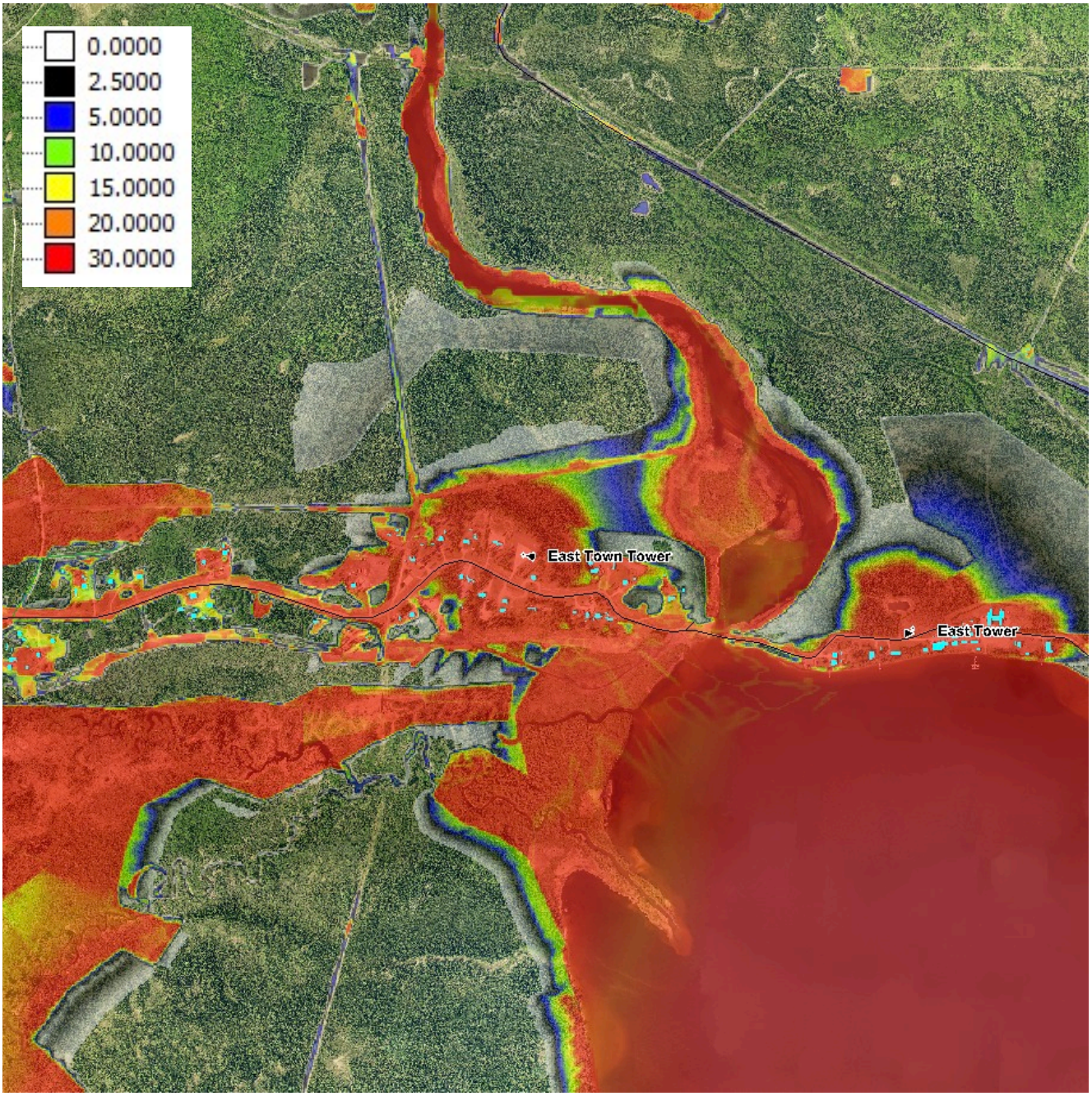
Being rather spread out, as shown in the average expected download chart below, at least six APs will be needed to reasonably provide outdoor wi-fi services throughout Anzac. For indoor coverage, three additional APs are required.



Conklin

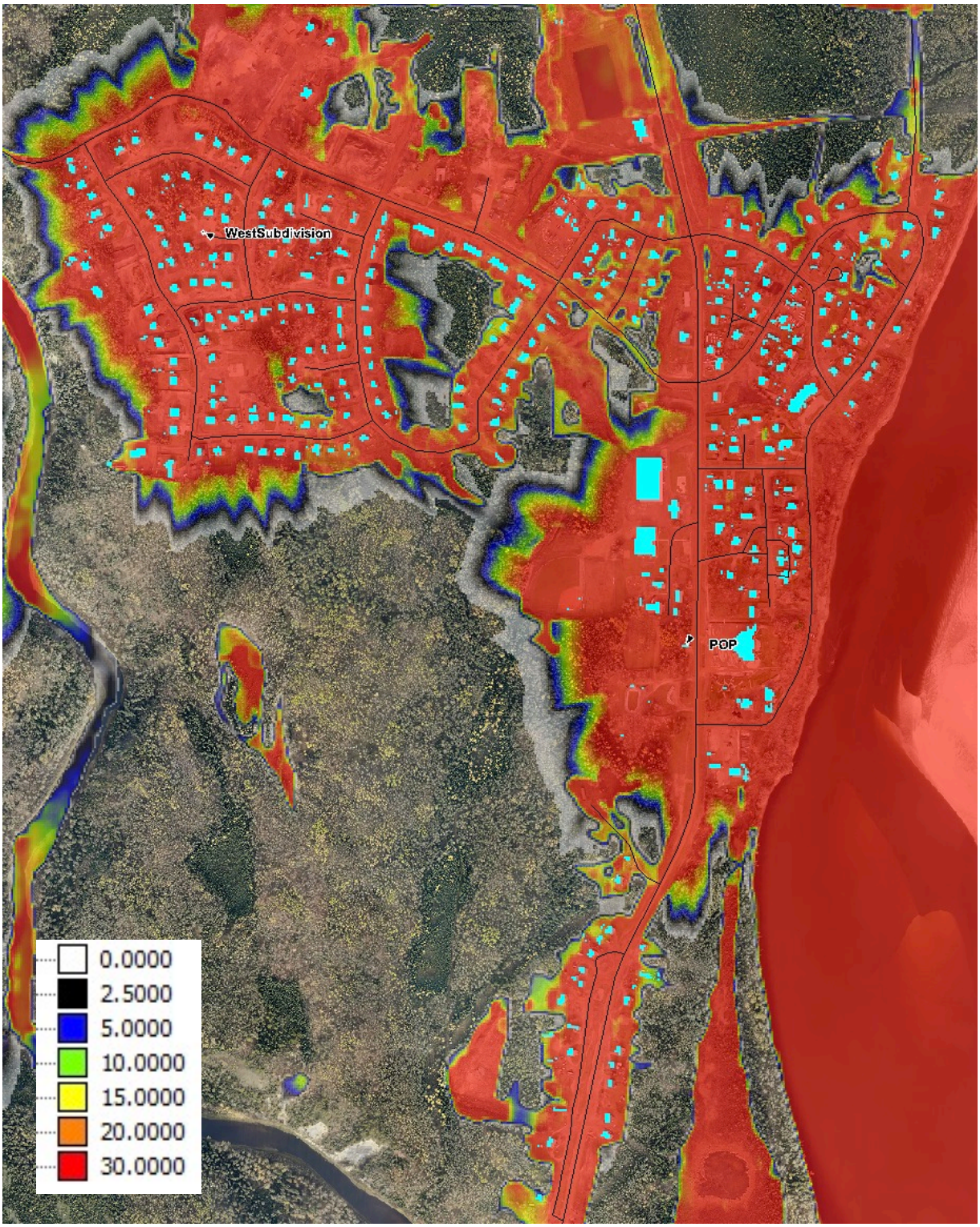
Conklin too is spread out and even with five APs, service to some homes is spotty. Providing reasonable indoor coverage will require three additional APs. Average expected download speeds provided via the conceptual design for outdoor coverage for Conklin west appears below and that for Conklin east follows.




0.0000
2.5000
5.0000
10.0000
15.0000
20.0000
30.0000
East Town Tower
East Tower

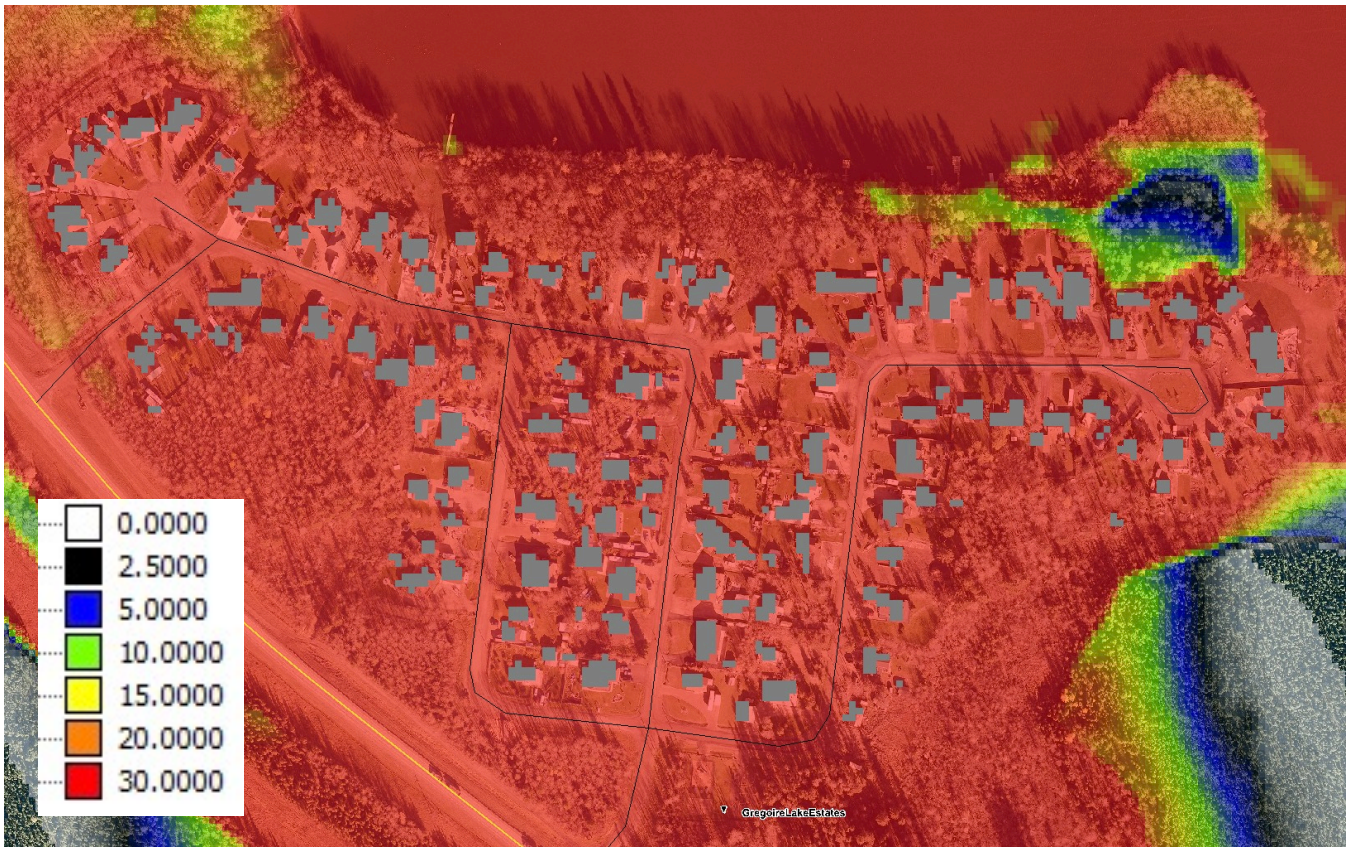
Fort MacKay

As shown in the mean expected download chart below, Fort MacKay can be well served by two Wi-Fi access points. To complete indoor coverage, two additional APs are required.



Gregoire Lake Estates

Only one Wi-Fi access point is required to service Gregoire Lake Estates. Signal strength from that access point is sufficient to provide good indoor coverage throughout the community.



The Mesh Penalty

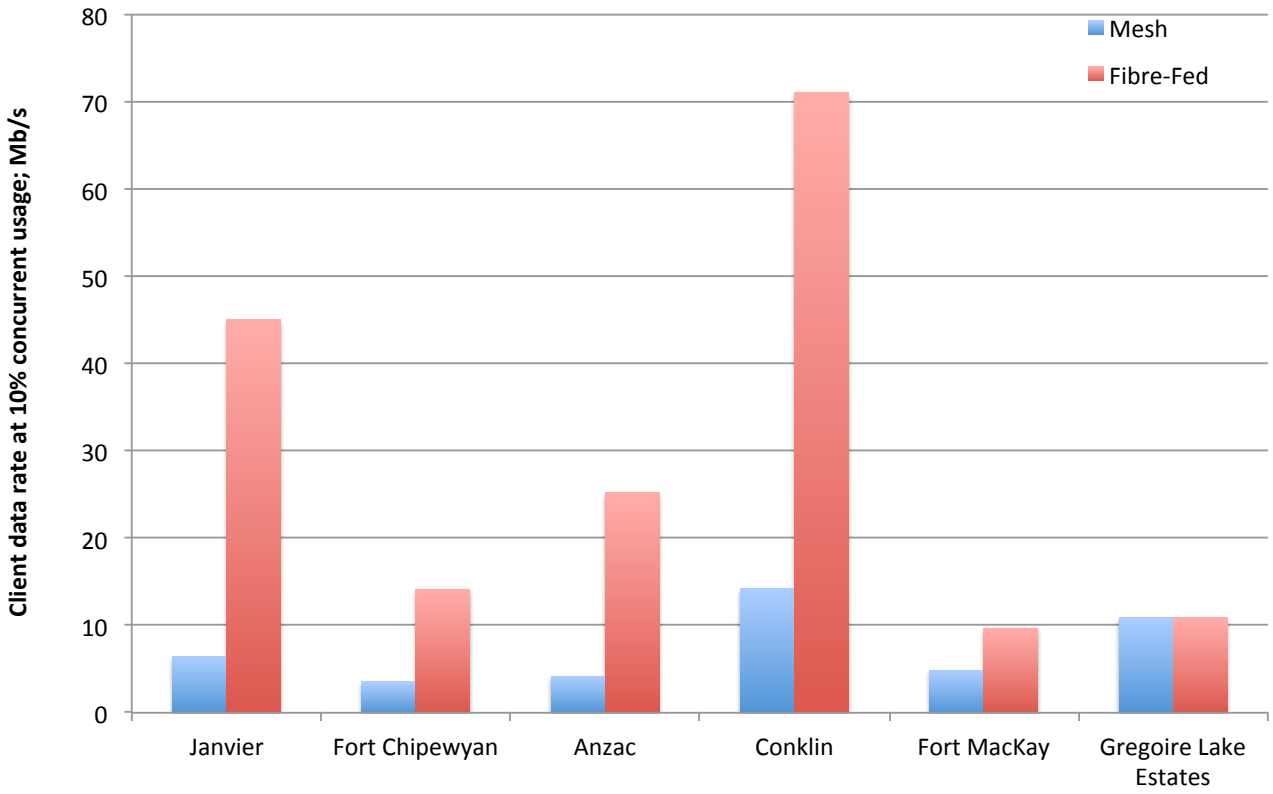
The bandwidth shown in the above figures refers to the mean bandwidth available to each device in the area, assuming it's the only connected device and no bandwidth is required for the mesh function. The mesh function refers to ability of the APs to relay signals to and from other APs enroute to the root AP that is connected to the backhaul and gateway services. The aggregate available bandwidth at a particular AP7181 that is directly connected via say a point-to-point radio or fibre link to the backbone service is 300 Mb/s. If there are 200 devices within range of that AP and 10% of them are active, the bandwidth available to each device would be $1/20^{th}$ of the aggregate. If the device is located in an area showing a mean download capability of 10 Mb/s, then they may see only about 500 kb/s.

In the conceptual design for the mesh configuration outlined for each community, only the root AP is directly connected to the backbone services and the APs' mesh functionality is used for inter-AP communication. Though mesh devices use sophisticated dynamic routing and bandwidth allocation algorithms to manage client and inter-AP connection bandwidth, on average the available client bandwidth decreases linearly as the number of APs in a mesh increases. Hence, the larger the mesh network, the less bandwidth that is available for client use.

As an example, consider that providing indoor coverage in Janvier will require 12 APs. In this case, the mesh functionality will effectively reduce the available concurrent bandwidth at each AP to 300/12 = 25 Mb/s. Simplistically, as the root AP could be receiving 11 data streams of 25 Mb/s each

(totaling 275 Mb/s) from the other APs it's supporting, it'd only have 25 Mb/s left to support clients connected to it. If each AP is supporting 40 devices with 10% active client connections, then each client in a 'red' reception area may see up to a 6.25 Mb/s service.

The impact of utilizing the mesh capability for inter-AP communication is shown below. In the chart, 10% utilization by 100% of each village's population uniformly distributed throughout the coverage area are assumed to require concurrent connectivity. The higher the population and the smaller the number of APs, the less bandwidth available to the client base. As can be seen, the impact of the mesh function can be quite significant – an 85% reduction, for instance, in the Janvier example.



Depending on the requirements eventually agreed to, it may be possible deploy a larger number of less capable, less expensive APs without the need for the stub towers. While this latter option would permit more refined coverage, 'meshing' the larger number of APs may not be practical and fibre connectivity would likely be essential.

Fibre Networks – Background

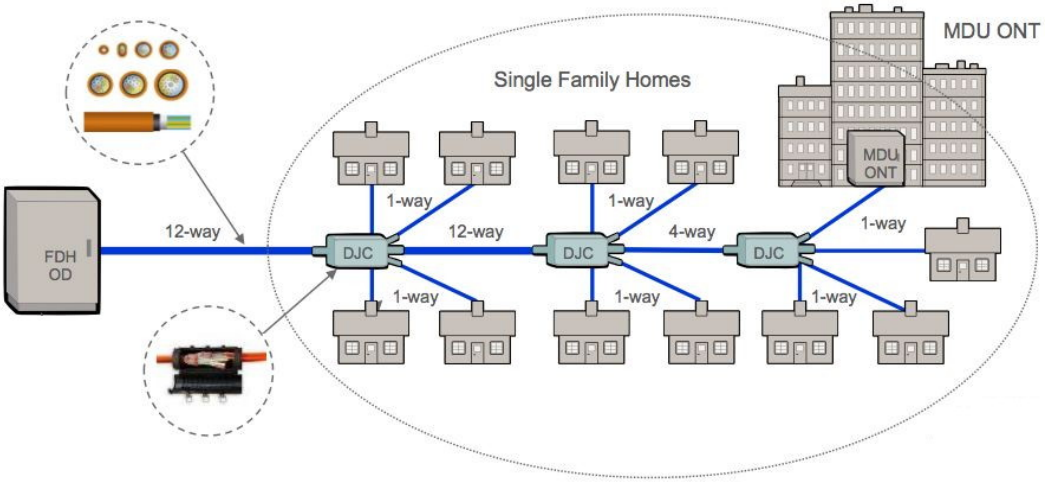
In contrast to the mesh wi-fi design presented, the pure fibre option provides the ultimate in scalability together with the lowest operational costs. Due to the civil works required to deploy fibre, however, significant upfront capital is required. To estimate costs for both the fibre-fed Wi-Fi and Hybrid FTTP + Wi-Fi options in each community, a home-run fibre architecture using Ericsson's air-blown fibre system was assumed.

The home-run architecture is ideal as it provides a unique conduit and fibre to every home and business that orders services. As fibre can support significantly more bandwidth than current opto-electronics can provide, the system can be continually updated by simply updating the opto-electronic

components at each end of the fibre – a relatively low cost upgrade path relative to shared fibre options in which additional civil work may be required. The home-run option increases upfront costs by about 10% over shared fibre systems typically deployed by the incumbents.

Ericsson's Ribbonet air-blown fibre (ABF) system is relatively new to Canada, somewhat more finicky to deploy than traditional systems, and about 25% less expensive than systems traditionally favoured by the incumbents. As ABF systems are simpler to maintain and require less upfront capital for tools, they are more amenable to local support.

As with traditional architectures, there are three parts to an ABF-based outside plant network: feeder, distribution, and drop. The feeder network connects a set of Fibre Distribution Hubs (FDHs). Each FDH serves a distribution network which initially consists of conduit runs, via a number of branch joints, to the property lines of each premise in each FDH's Serving Area (SA).



Once service is ordered, drop conduit is placed from the property line to the premise and connected to the distribution network. Fibre is then blown from the FDH to the premise. At the FDH, the fibre is connected to a feeder fibre that runs back to the opto-electronic and routing equipment located in a local data centre or Central Office (CO). When the drop is completed, an optical network terminal (ONT) device is installed at the premise. The ONT connects the client's network or computer devices to the fibre.

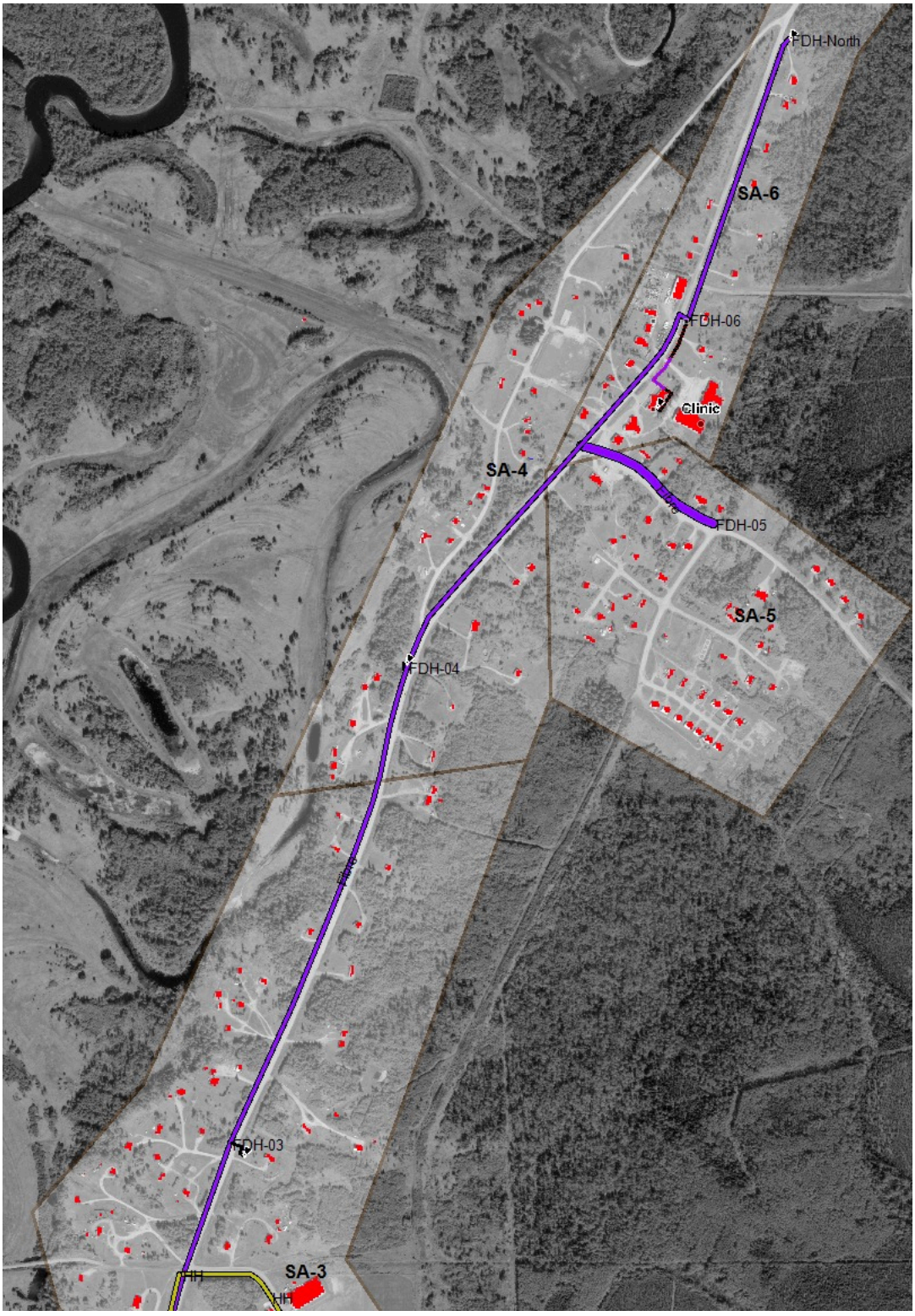
A Fibre-fed Wi-Fi Network

A hybrid solution that would minimize upfront costs and deployment time, while maximizing scalability via the option to go 'fibre' when and where needed, is possible by deploying the complete feeder network upfront, including an FDH in each SA of each community and then running fibre connections to each AP and the SuperNet. The feeder fibre would obviate the need for utilizing the Wi-Fi network's mesh features, free up bandwidth for subscribers, and ensure capacity for the foreseeable future. To serve commercial clients or residential clients who require the bandwidth, the distribution network could be either be deployed in just the required SAs or in all, if funds were available or demand materialized.

Janvier

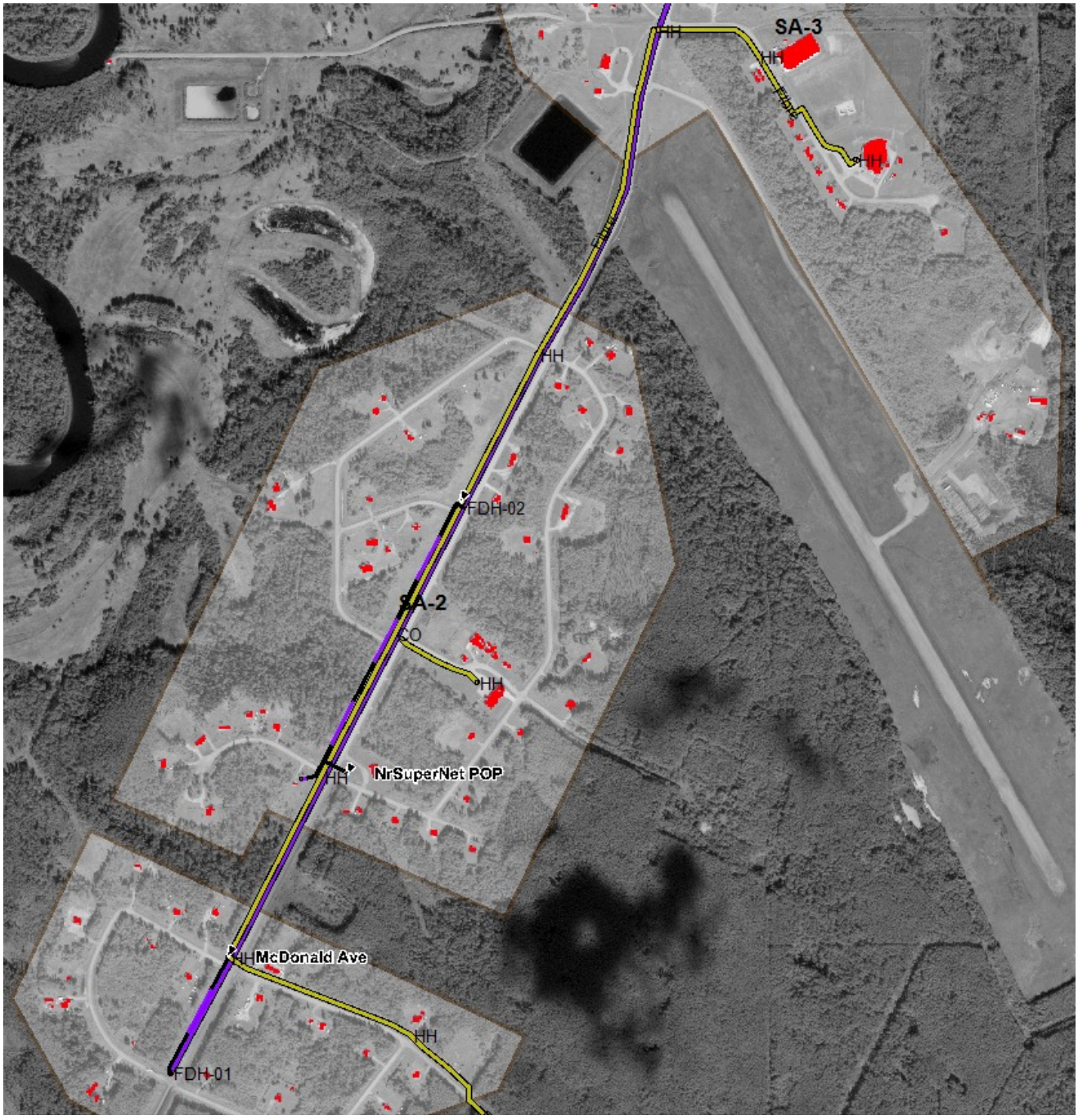
In Janvier, a traditional feeder network would be run the length of Nokohoo Road with terminations in seven FDHs or cabinets as well as in the CO site selected to host the equipment. Eight

SAs were assumed and the SA boundaries as well as the locations for the FDHs in the core Janvier area appear in the two figures below. The remaining two SAs and their FDHs are located further up Nokohoo Road. The CO would be co-located with FDH-4.



In the figures, SuperNet facilities are shown in orange, the proposed RMWB Op-1 equipment in yellow, and the facilities to be placed by the SCWG project in purple. Feeder cables are shown as purple

lines with black boundaries and feeder runs with two feeder cables (one each way) are shown by lines twice as thick. Dashed purple/black lines indicate distribution/drop cabling to the SuperNet access point and to the APs which are not quite co-located with the FDHs.



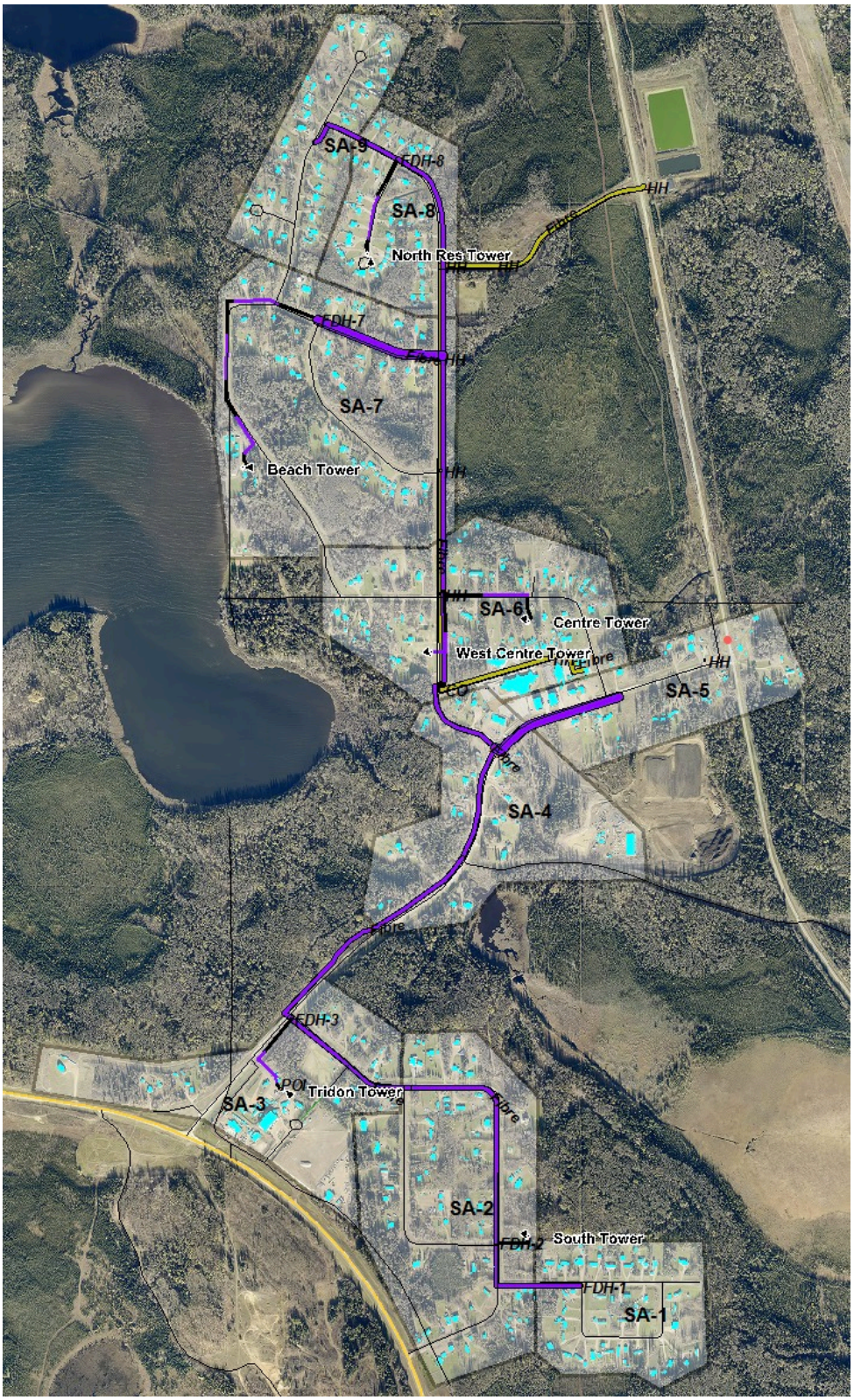
The RMWB Op-1 and the SCWG feeder runs share a trench for 1900 m; with Op-2 the complete 5777 m of feeder trenching is shared. The fibre network connects to the SuperNet at the SuperNet POP shown and from there to the global Internet. If premises north of serving area (SA) 6 could wait until the water distribution is extended up the road, significant trenching costs could be saved.

Fort Chipewyan

Fort Chipewyan will be expensive to serve as twelve SAs/FDHs are required and only 1115 m of trenching is in common with the proposed RMWB Op-1 build; 3919 m with Op-2. Given conditions in Fort Chipewyan, an aerial deployment may be necessary.

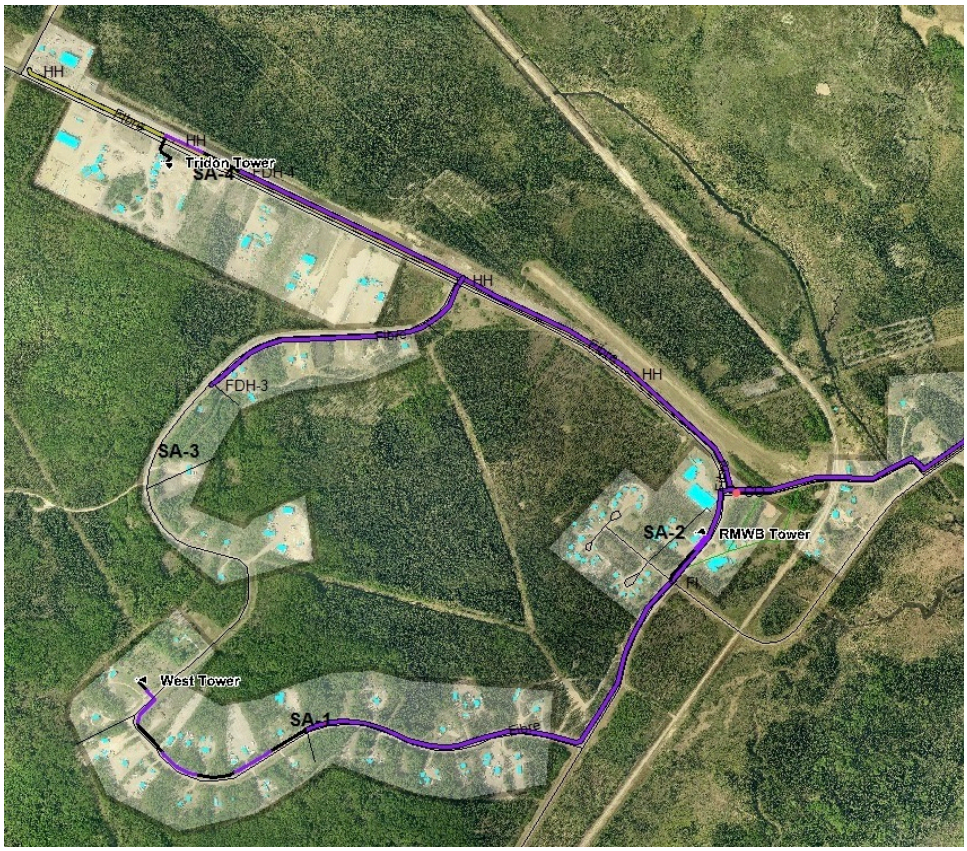
Anzac

Anzac is similarly expensive to serve as nine SAs/FDHs are required and only 1188 m of trenching is in common with the proposed RMWB Op-1 build; 4633 m with Op-2.



Conklin

Seven SAs/FDHs are required to service Conklin and 4990 m of trenching is shared with the proposed RMWB Op-1 build; 6256 m with Op-2.



Fort MacKay

Fibre service to Fort MacKay requires six SAs/FDHs. At only 572 m for Op-1, the shared trenching in Fort MacKay is the least of all six areas considered. This increases to 1317 m with Op-2.

Gregoire Lake Estates

While no RMWB network facilities are planned for the Gregoire Lake Estates area, the area is small and only three SAs/FDHs will be required to support fibre services.

Fibre to the Premise + Wi-Fi Network

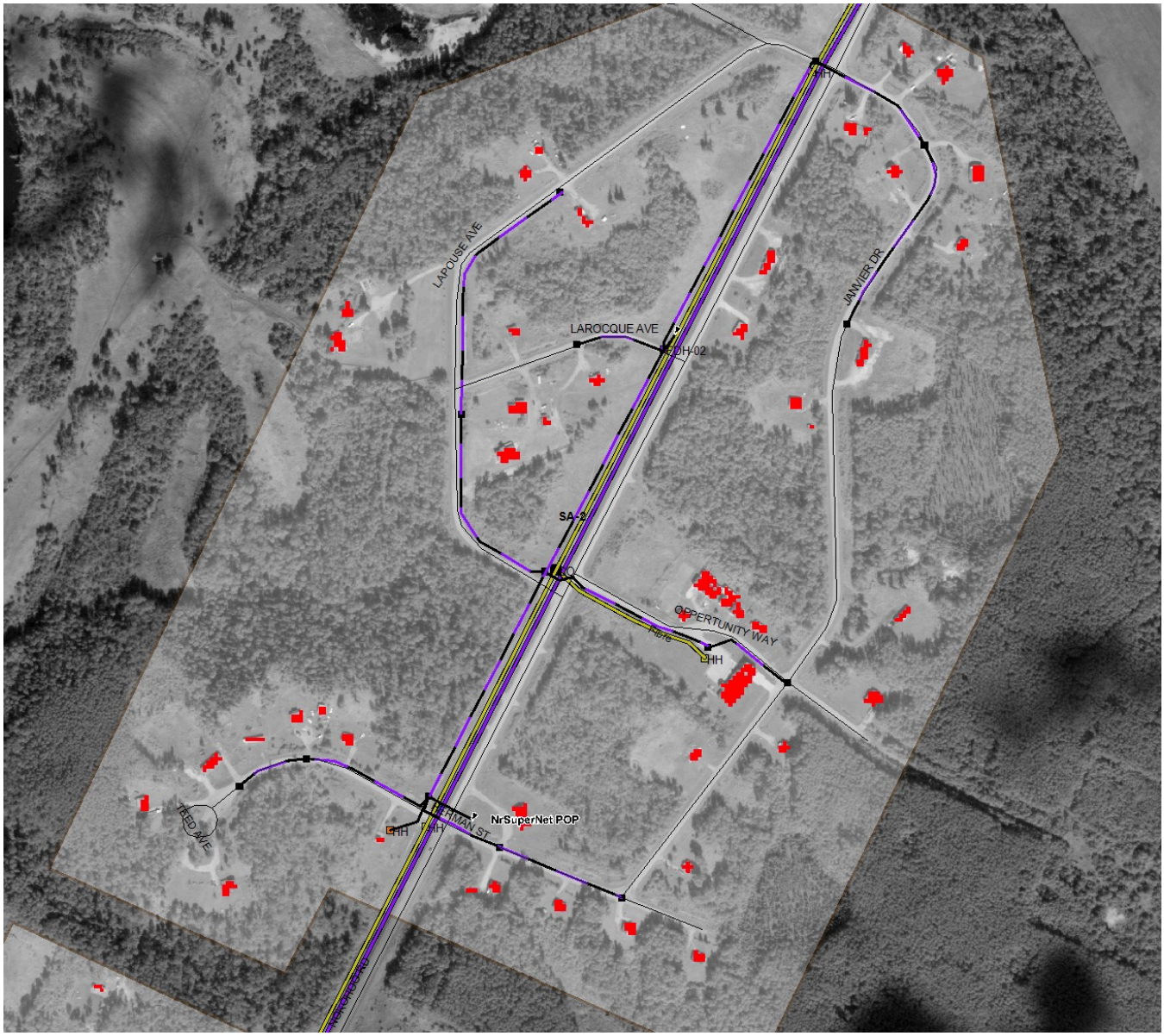
While the pure fibre option provides the ultimate in scalability together with the lowest operational costs, an FTTP network with a Wi-Fi overlay offers unprecedented flexibility from both service and client perspectives. To achieve a combined FTTP + Wi-Fi network from the fibre-fed Wi-Fi network in the previous section, the fibre distribution network is added, but drops are not. Specifically, fibre conduit is placed to the property line of every building, capped and then buried with a locator ball. Only when service to the building is ordered, is the drop conduit to the building completed and the fibre blown in. Though all drops could be provided upfront, it is significantly more expensive to do so (~$900/drop for the conduit and fibre, installed but not lit).

With fibre available to serve indoor home and business locations, from a costing perspective, the Wi-Fi network assumed here is that required to provide outdoor coverage.

The maximum bandwidths that can be provided to each premise depends on the fibre configuration at the CO. To minimize upfront opto-electronics costs, this analysis assumes that homes requiring fibre service would initially share bandwidth on a 1:16 basis – i.e., 16 homes would share an aggregate bandwidth of 2.488 Gb/s down and 1.244 Gb/s up based on the GPON standard, yielding a minimum bandwidth per home of 156 Mb/s down and 78 Mb/s up. As demand grows, the per premise bandwidths can be scaled by reducing the split ratios to 1:8 and possibly 1:4. At that point, the service would be

switched to Active-Ethernet which provides symmetric 1 Gb/s to each premise with no changes to the ONTs deployed.

Conceptual air-blown FTTP designs each of the six communities have been completed and the capital costs estimated. The design for Janvier requires six SAs and the results for the first two appear in the two figures below. As before, SuperNet facilities are shown in orange, the proposed RMWB Op-1 equipment in yellow, and the facilities to be placed by the SCWG project in purple. Feeder cables are shown as purple lines with black boundaries and feeder runs with two feeder cables (one each way) are shown by lines twice as thick. Dashed purple lines indicate distribution cabling and black lines indicate drops (which are shown to the SuperNet and AP sites only). The small black squares/diamonds appearing along the distribution lines are duct branch closures (DBCs) used for cable management and splitting.


LAPOUSE AVE
LAROCQUE AVE
JANVIER DR
OPPERTUNITY WAY
SA-2
NrSuperNet POP
THEO AVE
HH

Capital Costs

Mesh Wi-Fi Network

Estimated costs for the full mesh wi-fi network providing capable outdoor coverage including a connection to the SuperNet is $849k and the breakdown appears below. Feeder to the north end of Nokohoo Road as well as the eighth AP are not included. Professional services costs for Janvier are higher as they include equipment evaluation/selection and design verification work that only needs to be done once. This evaluation work would be done in partnership with operating partners.

Indoor coverage	No	Include Distribution	No
Deploy feeder	No	Jt Trench with RMWB	No
Complete feeder	No	RMWB supplies feeder trench	No

Outdoor Mesh	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	7	4	6	5	2	1	
# Towers required	6	4	5	3	1	1	
Feeder trenching, m	0	0	0	0	0	0	
Distribution trencing, m	0	0	0	0	0	0	
Drop trenching, m	0	0	0	0	0	0	
RMWB jt trenching, m	0	0	0	0	0	0	
# SAs	6	10	6	6	3	1	
Professional Services	39,800	12,600	15,600	13,200	8,400	7,200	
Equipment Room	0	0	0	0	0	0	
Passive OSP							
WiFi Network							
SuperNet Connection	5,895	17,729	4,237	4,237	4,237	7,088	
Towers	107,220	71,480	91,137	54,682	18,227	18,227	
Fibre network							
Mobilization and Feeder	0	0	0	0	0	0	
Distribution	0	0	0	0	0	0	
Drops	809	809	826	826	826	826	
Electronics							
WiFi	43,750	25,000	32,513	27,094	10,838	5,419	
Opto-electronics	7,040	7,040	6,174	6,174	6,174	6,174	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	0	0	0	0	0	0	
Total, with contingency	245,455	165,122	181,959	131,044	64,906	60,573	15%
					Total:	849,058	

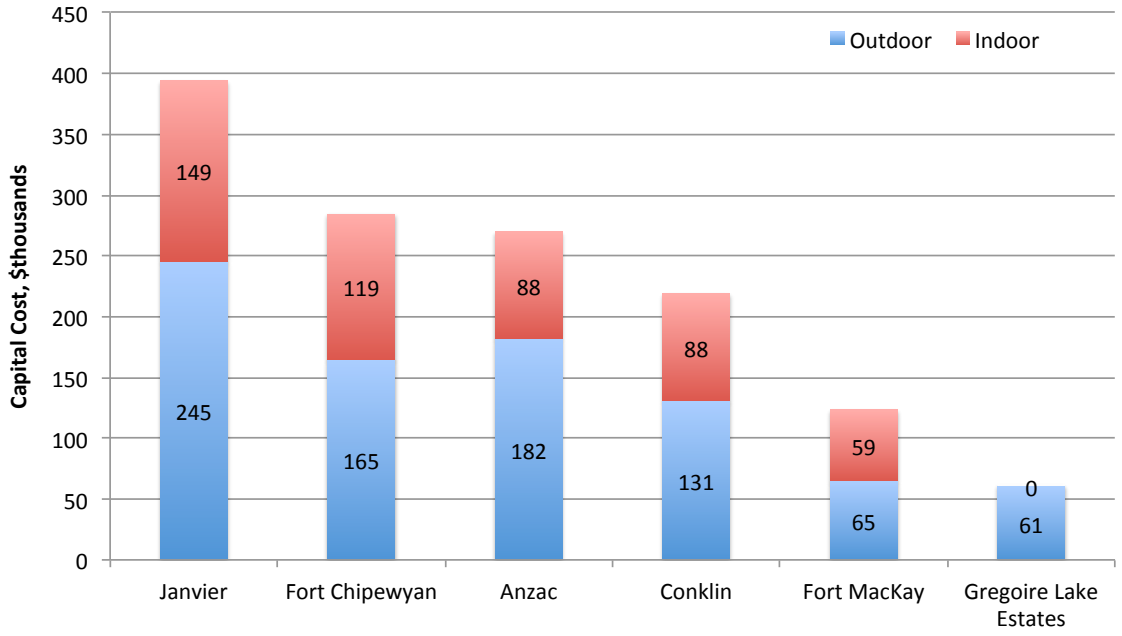
The $245k estimated capital cost to deploy the mesh wi-fi network in Janvier is less than the costs estimated in the original review last October as the 8th AP is not included[1] here.

To provide sufficient signal strength to enable reasonable indoor coverage, additional APs are required and estimated costs for this appear below. Compared to providing good outdoor coverage, costs increase by 159% or $502k to $1.35M.

Indoor coverage	Yes	Include Distribution	No
Deploy feeder	No	Jt Trench with RMWB	No
Complete feeder	No	RMWB supplies feeder trench	No

Indoor Coverage	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	12	8	9	8	4	1	
# Towers required	11	8	8	6	3	1	
Feeder trenching, m	0	0	0	0	0	0	
Distribution trencing, m	0	0	0	0	0	0	
Drop trenching, m	0	0	0	0	0	0	
RMWB jt trenching, m	0	0	0	0	0	0	
# SAs	6	10	6	6	3	1	
Professional Services	48,800	19,800	21,000	18,600	12,000	7,200	
Equipment Room	0	0	0	0	0	0	
Passive OSP							
WiFi Network							
SuperNet Connection	5,895	17,729	4,237	4,237	4,237	7,088	
Towers	196,570	142,960	145,819	109,364	54,682	18,227	
Fibre network							
Mobilization and Feeder	0	0	0	0	0	0	
Distribution	0	0	0	0	0	0	
Drops	809	809	826	826	826	826	
Electronics							
WiFi	75,000	50,000	48,769	43,350	21,675	5,419	
Opto-electronics	7,040	7,040	6,174	6,174	6,174	6,174	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	0	0	0	0	0	0	
Total, with contingency	394,495	284,354	269,748	218,833	123,432	60,573	15%
					Total:	1,351,435	
Delta - from outdoor	149,040	119,232	87,789	87,789	58,526	0	
					Total:	502,377	

Comparative costs for the deployment of the mesh wi-fi option for each village appear in the chart below. The incremental cost to provide indoor coverage appears in red.



Fibre-fed Wi-Fi Network

Estimated costs to complete the feeder network into each service area and provide a fibre connection to the SuperNet and each AP required for indoor coverage appear below. At an estimated cost of $4.28M, costs from the mesh deployment with indoor coverage increase by $2.9M.

Indoor coverage	Yes	Include Distribution	No
Deploy feeder	Yes	Jt Trench with RMWB	No
Complete feeder	Yes	RMWB supplies feeder trench	No

Complete Feeder	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	12	8	9	8	4	1	
# Towers required	11	8	8	6	3	1	
Feeder trenching, m	5,446	4,333	5,285	7,034	2,348	607	
Distribution trencing, m	0	0	0	0	0	0	
Drop trenching, m	526	380	590	448	87	30	
RMWB jt trenching, m	0	0	0	0	0	0	
# SAs	6	12	9	7	6	3	
Professional Services	61,122	31,903	33,814	32,890	21,007	13,733	
Equipment Room	15,680	15,680	15,680	15,680	15,680	15,680	
Passive OSP							
WiFi Network							
SuperNet Connection	5,024	34,334	55,559	41,163	12,724	5,710	
Towers	196,570	142,960	145,819	109,364	54,682	18,227	
Fibre network							
Mobilization and Feeder	432,505	419,906	460,808	545,671	241,898	99,670	
Distribution	0	0	0	0	0	0	
Drops	14,998	10,681	15,266	12,172	3,699	1,385	
Electronics							
WiFi	75,000	50,000	48,769	43,350	21,675	5,419	
Opto-electronics	19,129	10,727	9,861	9,400	7,557	6,174	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	0	0	0	0	0	0	
Total, with contingency	953,294	833,883	912,312	940,043	444,660	199,798	15%
					Total:	4,283,990	
Assumes additional APs for indoor coverage lie along outdoor feeder route							
Delta - addiing feeder	558,799	549,530	642,564	721,210	321,228	139,225	
					Total:	2,932,555	

Should coordination with the RMWB Op-1 deployment remove the cost of the trenching along joint feeder routes as well as eliminate the costs associated with establishing an equipment room, for the fibre-fed wi-fi deployment with indoor coverage scenario, the capital cost to the SCWG would reduce to $3.66M as shown in the first table on the next page. The overall savings to the CCTT project would be $628k, while increases in cost to the RMWB would be minimal.

On the other hand, if the RMWB were to undertake the deployment of conduit along the whole feeder router proposed here-in – Op-2, cost reductions to the SCWG project would be an additional $811k. The cost breakdown appears in the second table on the next page.

Indoor coverage	Yes	Include Distribution	No
Deploy feeder	Yes	Jt Trench with RMWB	Yes
Complete feeder	Yes	RMWB supplies feeder trench	No

Fibre-fed, Option (1)	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	12	8	9	8	4	1	
# Towers required	11	8	8	6	3	1	
Feeder trenching, m	3,547	3,218	4,097	2,044	1,776	607	
Distribution trencing, m	0	0	0	0	0	0	
Drop trenching, m	526	380	590	448	87	30	
RMWB jt trenching, m	1,899	1,115	1,188	4,990	425	0	
# SAs	6	12	9	7	6	3	
Professional Services	59,641	31,033	32,869	28,920	20,552	13,733	
Equipment Room	0	0	0	0	0	0	
Passive OSP							
WiFi Network							
SuperNet Connection	5,024	34,334	55,559	41,163	12,724	5,710	
Towers	196,570	142,960	145,819	109,364	54,682	18,227	
Fibre network							
Mobilization and Feeder	347,333	369,911	406,482	317,389	215,726	99,670	
Distribution	0	0	0	0	0	0	
Drops	14,998	10,681	15,266	12,172	3,699	1,385	
Electronics							
WiFi	75,000	50,000	48,769	43,350	21,675	5,419	
Opto-electronics	19,129	10,727	9,861	9,400	7,557	6,174	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	0	0	0	0	0	0	
Total, with contingency	835,612	757,357	830,718	654,922	396,006	181,766	15%
					Total:	3,656,381	
Delta - from no RMWB trenchin	(117,682)	(76,527)	(81,593)	(285,121)	(48,654)	(18,032)	
					Total:	(627,609)	

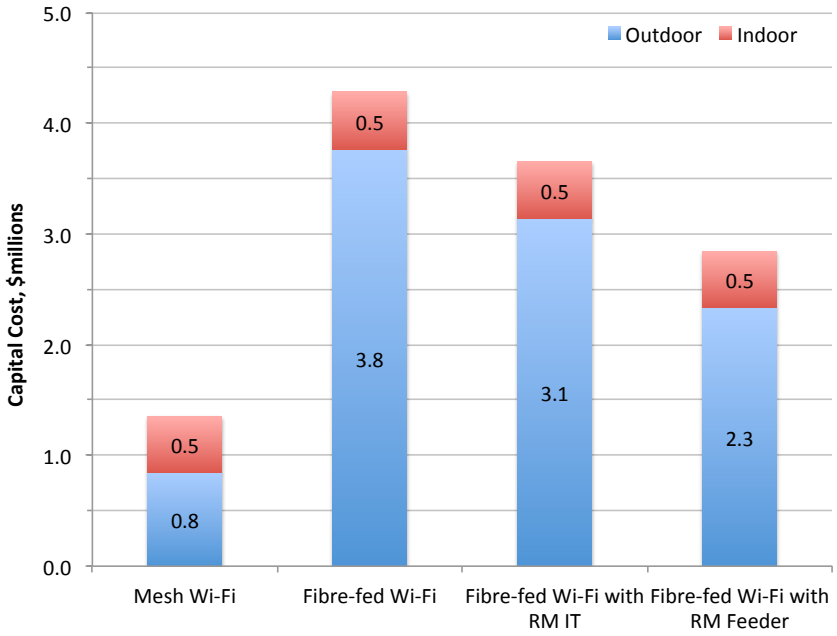
Indoor coverage	Yes	Include Distribution	No
Deploy feeder	Yes	Jt Trench with RMWB	Yes
Complete feeder	Yes	RMWB supplies feeder trench	Yes

Fibre-feed, Option (2)	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	12	8	9	8	4	1	
# Towers required	11	8	8	6	3	1	
Feeder trenching, m	0	0	0	0	0	0	
Distribution trencing, m	0	0	0	0	0	0	
Drop trenching, m	526	380	590	448	87	30	
RMWB jt trenching, m	1,899	1,115	1,188	4,990	425	0	
# SAs	6	12	9	7	6	3	
Professional Services	56,874	28,523	29,610	27,294	19,139	13,250	
Equipment Room	0	0	0	0	0	0	
Passive OSP							
WiFi Network							
SuperNet Connection	5,024	34,334	55,559	41,163	12,724	5,710	
Towers	196,570	142,960	145,819	109,364	54,682	18,227	
Fibre network							
Mobilization and Feeder	188,265	225,564	219,054	223,881	134,465	71,900	
Distribution	0	0	0	0	0	0	
Drops	14,998	10,681	15,266	12,172	3,699	1,385	
Electronics							
WiFi	75,000	50,000	48,769	43,350	21,675	5,419	
Opto-electronics	19,129	10,727	9,861	9,400	7,557	6,174	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	0	0	0	0	0	0	
Total, with contingency	649,502	588,471	611,427	545,517	300,932	149,275	15%
					Total:	2,845,123	

Assumes additional APs for indoor coverage lie along outdoor feeder route

Delta - over IT feeder only	(186,110)	(168,886)	(219,291)	(109,405)	(95,075)	(32,491)	
					Total:	(811,257)	

The impact of potential synergy with the RMWB build for the each option appears below. Whereas the joint trenching arrangement reduces costs to the SCWG project some 11%, should the RM deploy conduit throughout the proposed feeder network, costs would decrease by 34%.



Fibre to the Premise + Wi-Fi

Deploying the distribution network in addition to the feeder network discussed above would provide the rural residents of the RM with superb connectivity, whether indoor or outdoor, mobile or fixed, and whether requiring small or large amounts of bandwidth. The overall costs for the FTTP network with outdoor Wi-Fi coverage are estimated in the table below at $5.7M – an increase of $1.4M over the fibre-fed wi-fi network with indoor coverage presented in the last section. With the option, conduit would be deployed to the property lines of every residence and business in each village. Once service is ordered, the conduit run to the building would be completed, fibre blown in, and opto-electronics and customer premise equipment added. Drop installations with fibre would cost $1400 per house-hold and home installation costs plus equipment adds another $250.

Should the RM elect to deploy conduit along the entire feeder route, the overall cost to the SCWG would decrease by $1.55M.

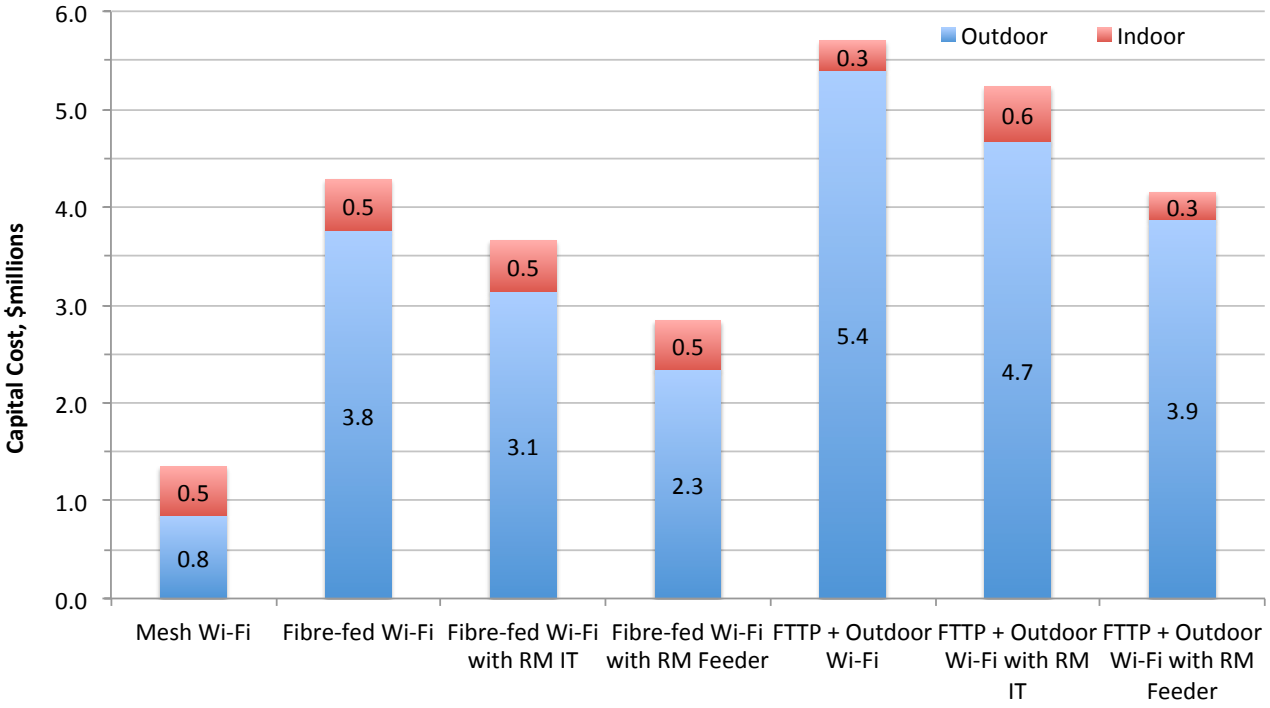
Indoor coverage	No	Include Distribution	Yes
Deploy feeder	Yes	Jt Trench with RMWB	No
Complete feeder	Yes	RMWB supplies feeder trench	No

	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	7	4	6	5	2	1	
# Towers required	6	4	5	3	1	1	
Feeder trenching, m	5,446	4,333	5,285	7,034	2,348	607	
Distribution trencing, m	7,015	6,208	6,260	3,004	4,892	922	
Drop trenching, m	245	215	418	305	68	55	
RMWB jt trenching, m	0	0	0	0	0	0	
# SAs	6	12	9	7	6	3	
Professional Services	58,653	31,224	34,902	30,659	22,352	14,836	
Equipment Room	17,330	17,330	17,330	17,330	17,330	17,330	
Passive OSP							
WiFi Network							
SuperNet Connection	5,024	4,148	4,061	4,416	4,274	5,710	
Towers	107,220	71,480	91,137	54,682	18,227	18,227	
Fibre network							
Mobilization and Feeder	432,505	419,906	460,808	545,671	241,898	99,670	
Distribution	343,381	333,729	332,707	164,749	254,727	52,151	
Drops	32,782	42,290	43,393	17,497	30,689	11,266	
Electronics							
WiFi	43,750	25,000	32,513	27,094	10,838	5,419	
Opto-electronics	44,027	43,916	37,151	19,532	28,320	17,689	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	5,735	7,827	6,131	1,842	5,312	1,842	
Total, with contingency	1,264,232	1,156,643	1,228,052	1,024,893	737,961	289,661	15%
					Total:	5,701,441	
Delta - from full feeder only	310,938	322,760	315,741	84,849	293,301	89,863	with indoor coverage
					Total:	1,417,452	

Indoor coverage	No	Include Distribution	Yes
Deploy feeder	Yes	Jt Trench with RMWB	Yes
Complete feeder	Yes	RMWB supplies feeder trench	Yes

	Janvier	Fort Chipewyan	Anzac	Conklin	Fort MacKay	Gregroire Lk Estates	
Specifications							
# APs required	7	4	6	5	2	1	
# Towers required	6	4	5	3	1	1	
Feeder trenching, m	0	0	0	0	0	0	
Distribution trencing, m	6,278	5,862	5,760	2,465	4,675	922	
Drop trenching, m	245	215	418	305	68	55	
RMWB jt trenching, m	1,899	1,115	1,188	4,990	425	0	
# SAs	6	12	9	7	6	3	
Professional Services	53,963	27,637	30,392	24,733	20,351	14,353	
Equipment Room	0	0	0	0	0	0	
Passive OSP							
WiFi Network							
SuperNet Connection	5,024	4,148	4,061	4,416	4,274	5,710	
Towers	107,220	71,480	91,137	54,682	18,227	18,227	
Fibre network							
Mobilization and Feeder	188,265	225,564	219,054	223,881	134,465	71,900	
Distribution	317,952	321,781	315,117	145,772	247,093	52,151	
Drops	32,782	42,290	43,393	17,497	30,689	11,266	
Electronics							
WiFi	43,750	25,000	32,513	27,094	10,838	5,419	
Opto-electronics	44,027	43,916	37,151	19,532	28,320	17,689	
Concentration and Routing	8,925	8,925	7,738	7,738	7,738	7,738	
Client Installations	5,735	7,827	6,131	1,842	5,312	1,842	
Total, with contingency	928,790	895,353	904,690	606,265	583,403	237,240	15%
					Total:	4,155,742	
Delta - from no RMWB assistanc	(335,442)	(261,289)	(323,363)	(418,627)	(154,558)	(52,421)	
					Total:	(1,545,699)	

An overall comparison of the costs associated with each of the options presented appears in the chart below.



Conclusion

A mesh wi-fi network could be deployed across all six communities for a capital cost of $0.849M. Improving coverage to enable indoor coverage increases this estimate to $1.35M. Linking the APs via a fibre feeder network that would support full FTTH deployment down the road increases the cost to $3.85M for the outdoor option and to $4.28M with indoor coverage. Coordination with the proposed RMWB deployment could reduce the overall capital requirements by $628k with joint trenching and $1.44M should the RM deploy feeder conduit throughout each community. Capital costs to deploy a FTTP network with an outdoor Wi-Fi overlay to the six communities would cost $5.7M with no support and $4.16M if the RM provided the feeder conduit.

Next Steps

While the analyses contained herein provide realistic and detailed assessments of the infrastructure options, capabilities, and capital costs to provide capable broadband services to communities within the RMWB, additional work is required to inform the selection of the most appropriate.

- ***Operations and sustainability:*** the capital models that underlay the results presented above are part of a larger model which includes revenue and operational projections as well as a cashflow analysis sheet that together link to an overall economic evaluation module. Budget-level quotations for key operational parameters have been requested from potential

operational partners and once these are received, an economic assessment of the alternates will be completed.

- ***Benefits assessment:*** as the major justification for the deployment of more capable infrastructure result from the positive externalities that will accrue to these communities and the region, they are 'off-balance sheet' items that are not captured in traditional operational assessments. A 'Benefits Assessment' is underway to quantify these items.
- ***Pilot network:*** establishing operations within the rural RMWB presents some unique challenges so prior to full scale deployment, a pilot network is required. With a small pilot network in Janvier, it will be possible to work through implementation issues, verify assumptions, evaluation wi-fi equipment and coverage estimates, establish and 'test' relationships with potential operational partners, stimulate demand and relationships within the community, and garner interest for and implement on a small scale applications key to realizing off-balance sheet benefits.
- ***Implementation plan:*** the conceptual level designs presented herein are for planning and discussion purposes only. While based on detailed ortho-imagery and sound design principles, once the results of the Pilot network have been obtained and a decision to proceed is made, site visits and other work will be needed to update and finalize the designs (and costs) for implementation.

Acronyms

ABF	air blown fibre
AP	access point
ATG	Arrow Technology Group (formerly SIS)
CCTT	Cultural Connections Through Technology
CO	central office, a more traditional name for what now is basically a data centre
CRTC	Canadian Radio-television Telecommunications Commission
DJC	duct joint closure
FDH	fibre distribution hub
FTTP	fibre-to-the-premise
GB	giga (billion) bytes, where a byte equals 8 bits
HD	high definition
ISP	Internet service provider
Mb/s	mega (millions of) bits per second
o-e	opto-electronics
OFDF	optical fibe distribution frame
ONT	optical network terminal
Op-1	Option 1 RMWB deployment in which the RM deploys extra conduit capacity along the routes required to connect RM facilities in each community
Op-2	Option 2 RMWB deployment in which the RM, in addition to Op-1, deploys conduit along complete feeder network proposed here-in.
OSLI	Oil Sands Leadership Initiative
PMP	point to multipoint
POP	point of presence

RM, RMWB	Regional Municipality of Wood Buffalo
SA	service area
SCWG	Sustainable Communities Working Group
Wi-Fi	wireless-fidelity. In this report, refers to a wireless distribution system based on the IEEE 802.11n standard. The standard supports data rates up to 300 Mb/s and is backwards compatible with earlier versions.
WISP	Wireless ISP

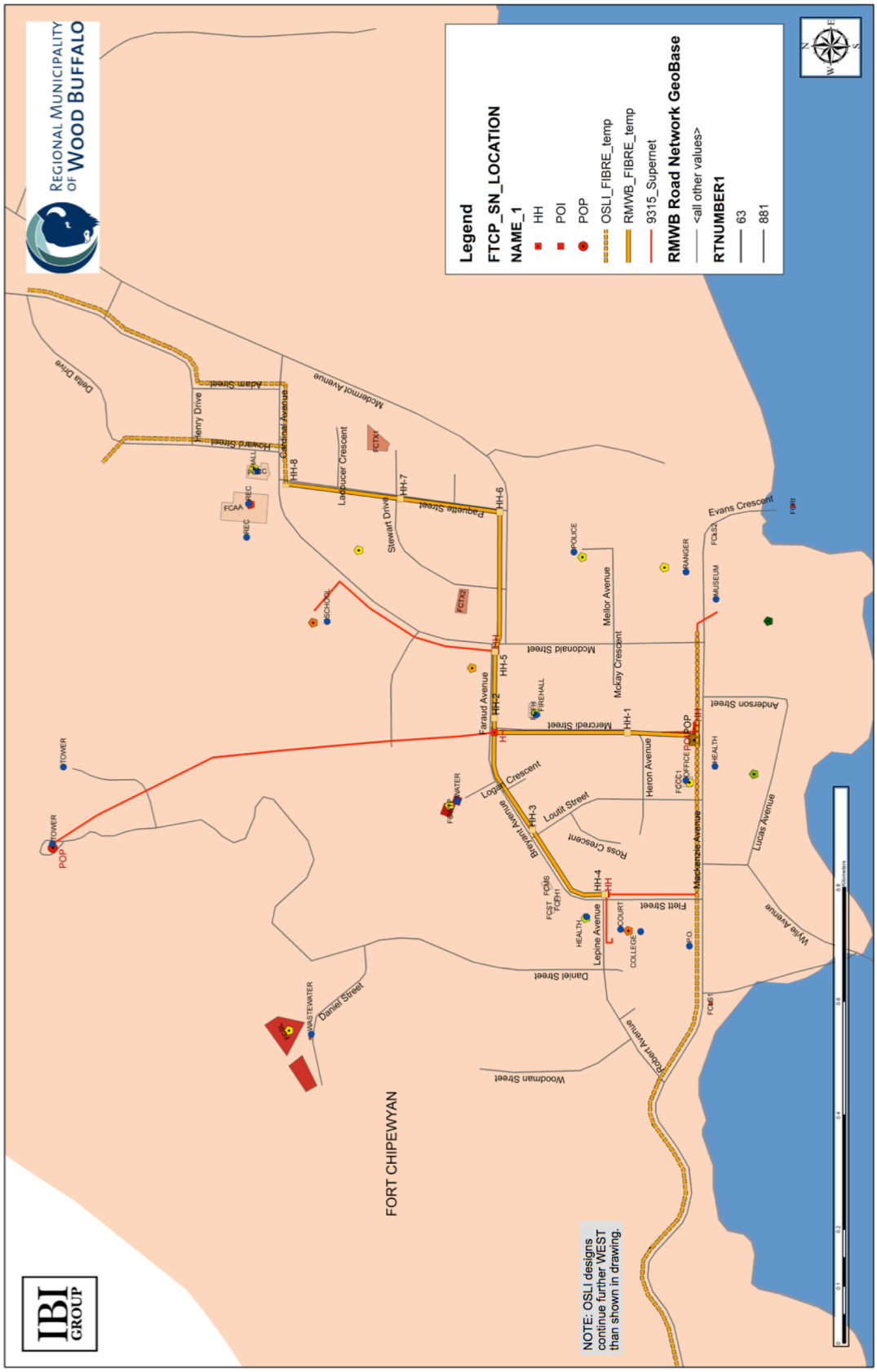
Appendix

IBI RMWB Network Designs

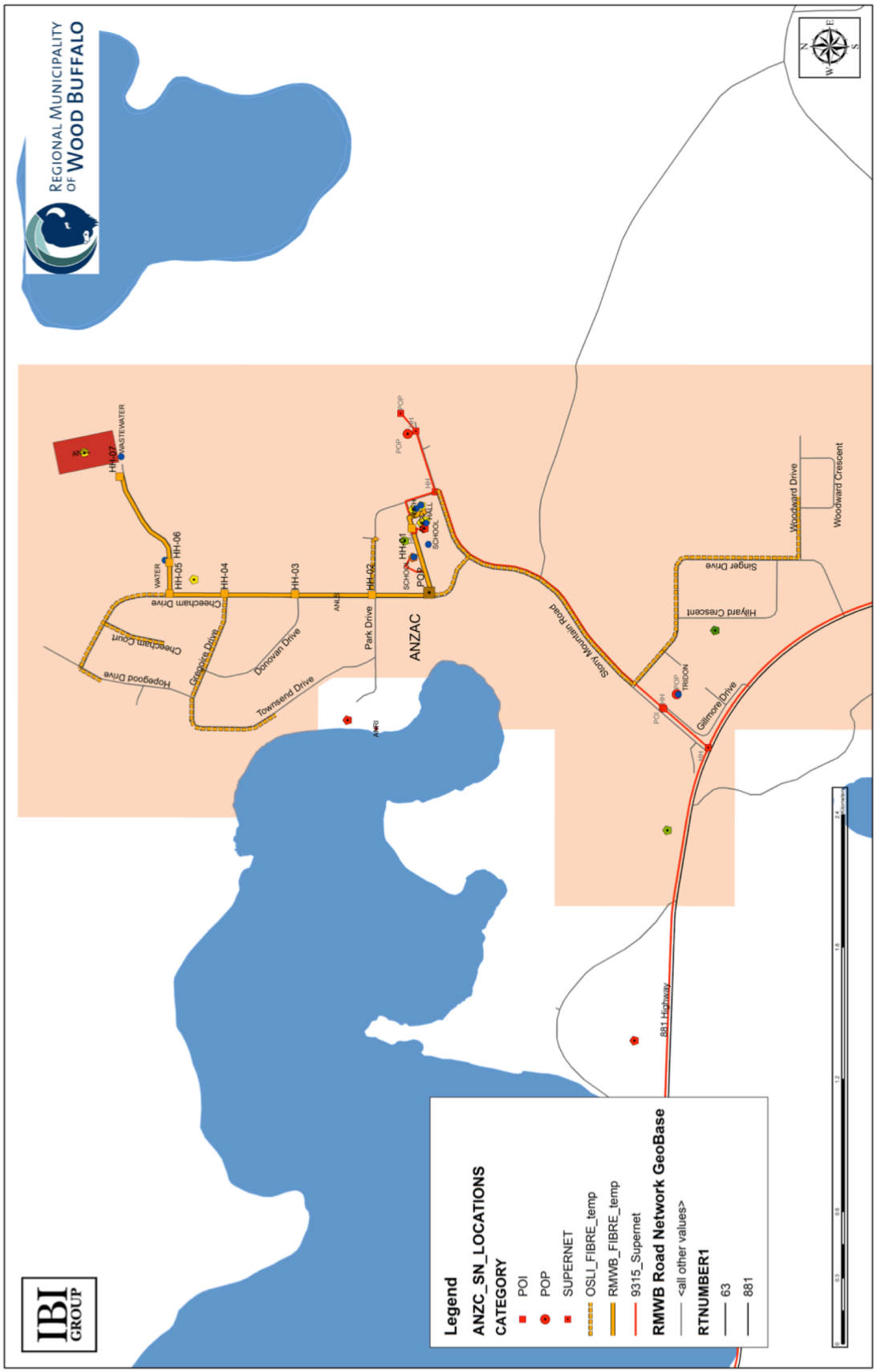
Janvier

Presented within the body of the report.

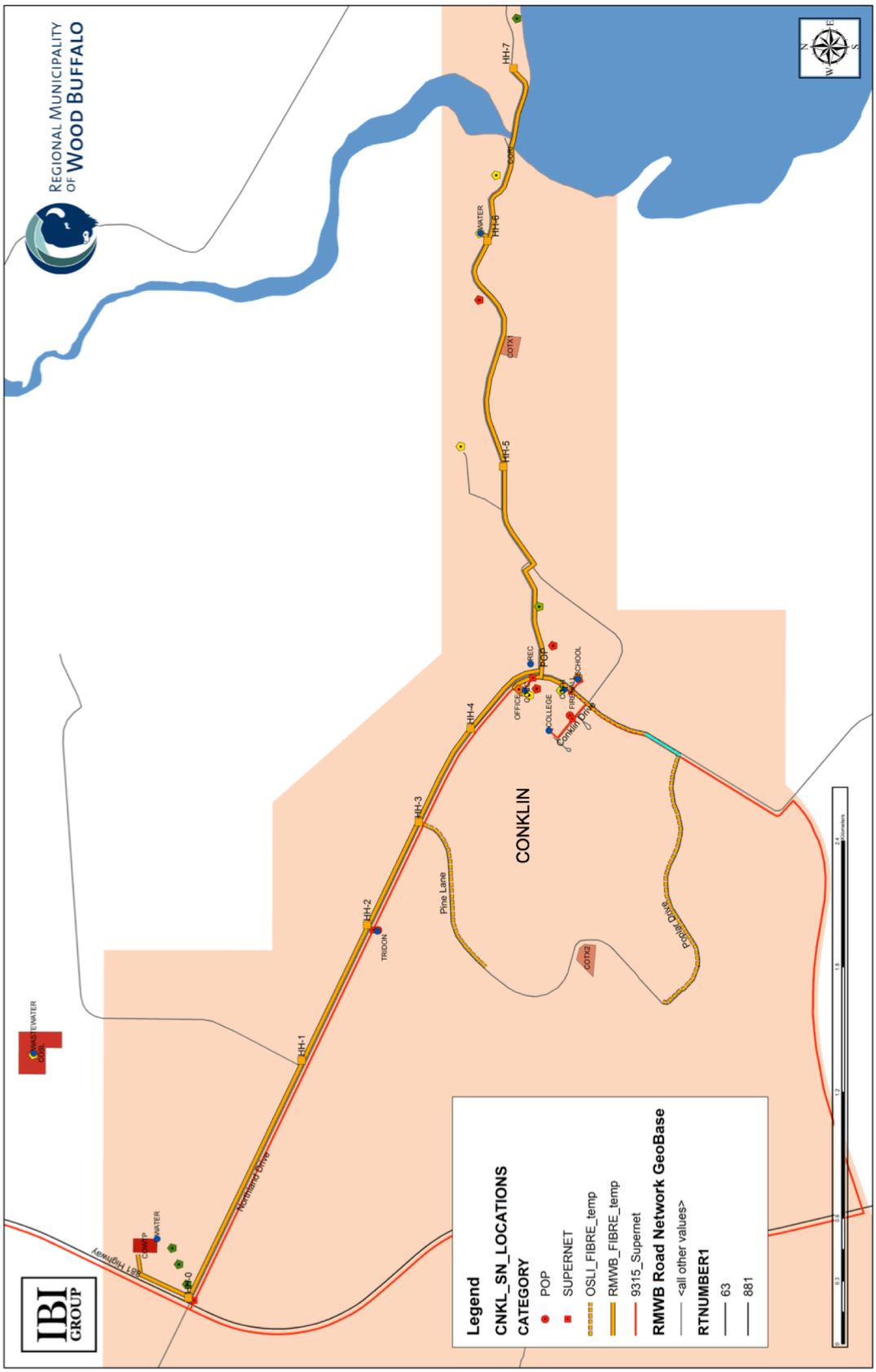
Fort Chipewyan



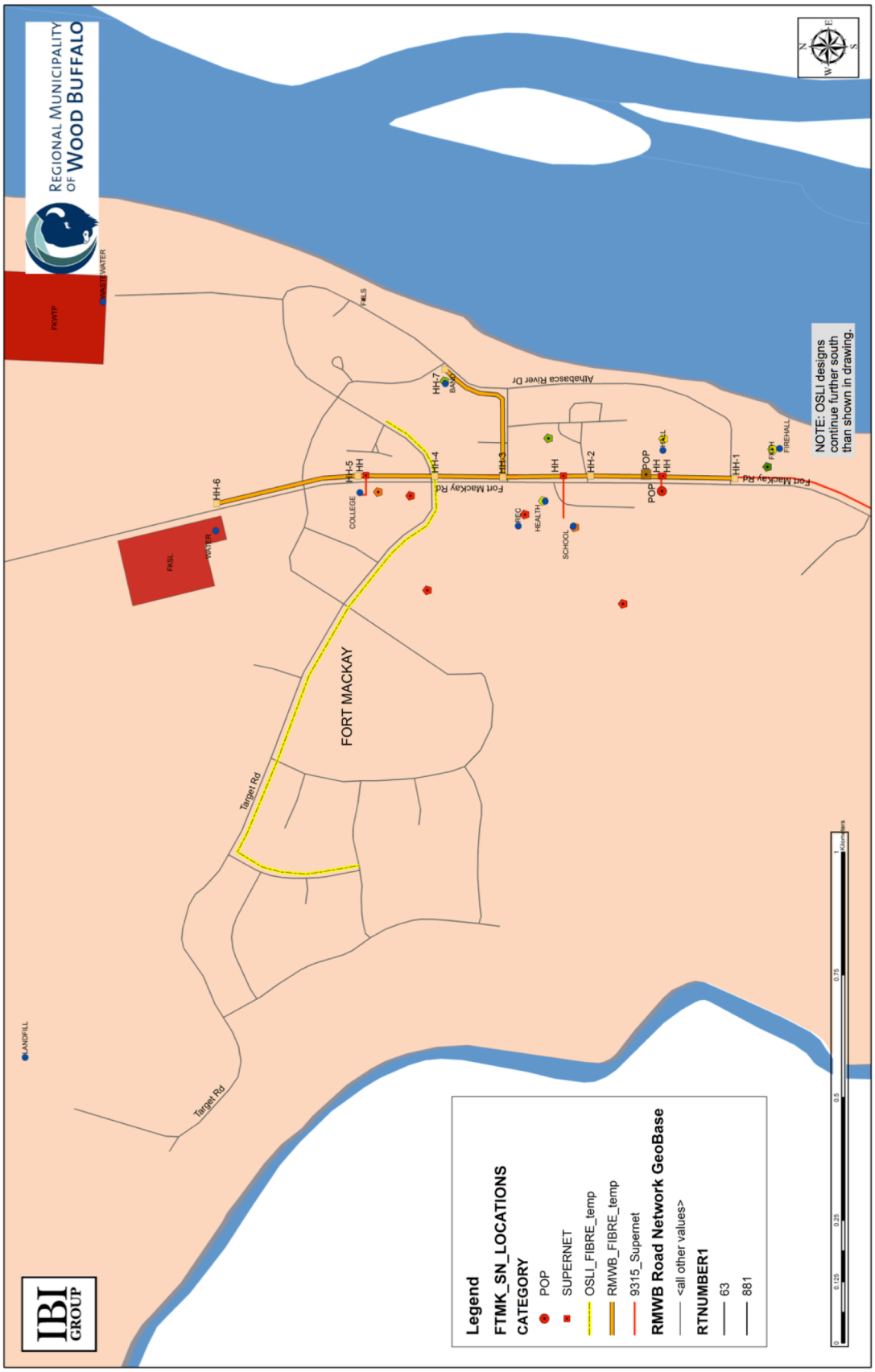
Anzac


REGIONAL MUNICIPALITY OF WOOD BUFFALO
IBI GROUP
ANZAC
HH-07
WASTEWATER
HH-06
HH-05
WATER
HH-04
HH-03
HH-02
HH-01
SCHOOL
POP
Cheecham Drive
Cheecham Court
Hopegood Drive
Georgina Drive
Donovan Drive
Townsend Drive
Park Drive
Stony Mountain Road
Singer Drive
Woodward Drive
Woodward Crescent
Hillyard Crescent
Gilmore Drive
TRIDON
881 Highway
Legend
ANZC_SN_LOCATIONS
CATEGORY
POI
POP
SUPERNET
OSLI_FIBRE_temp
RMWB_FIBRE_temp
9315_Supernet
RMWB Road Network GeoBase
<all other values>
RTNUMBER1
63
881

Conklin

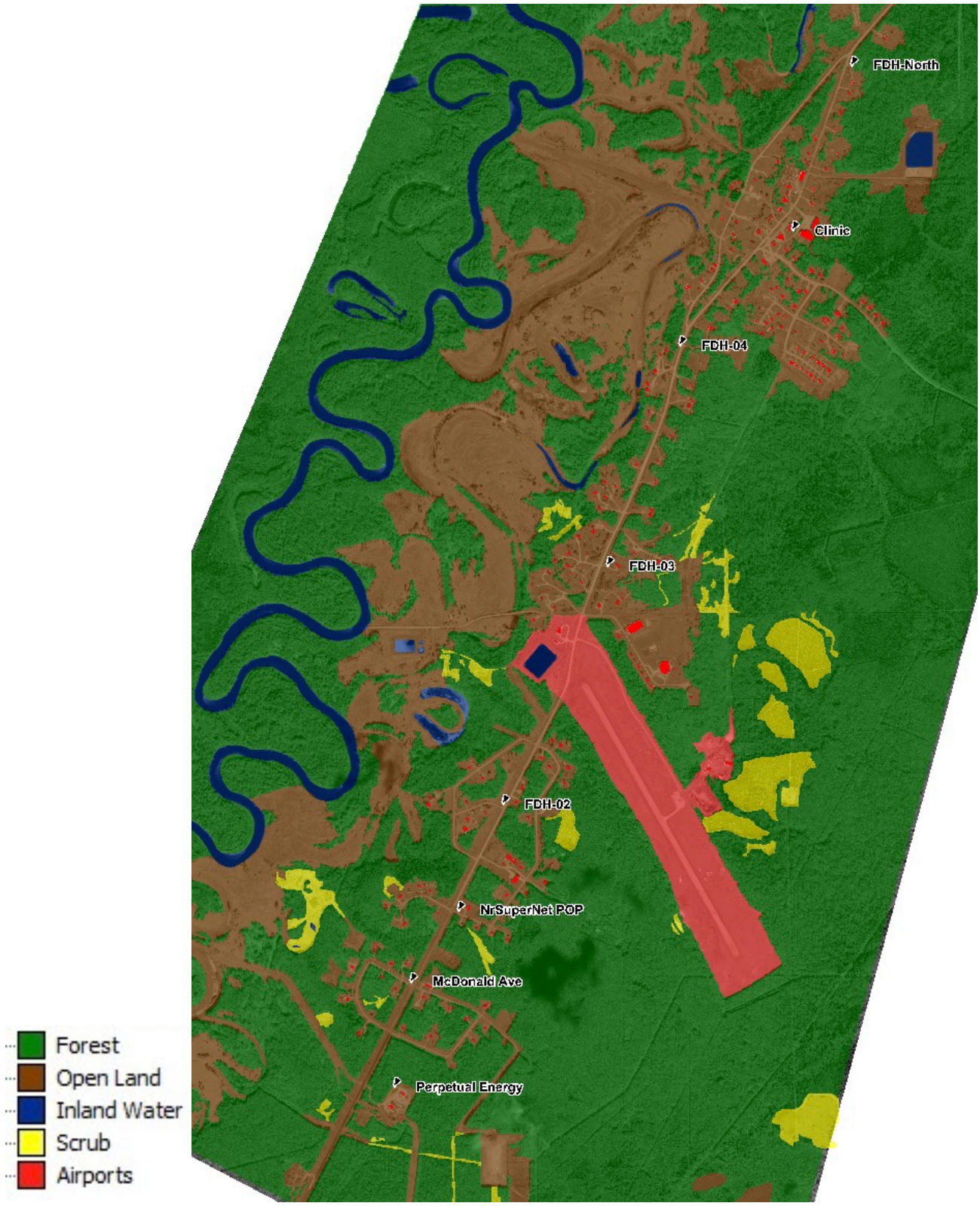

REGIONAL MUNICIPALITY OF WOOD BUFFALO
CONKLIN
HH-1
HH-2
HH-3
HH-4
HH-5
HH-6
HH-7
POP
REC
COLLEGE
SCHOOL
FIRE
TRIDON
WATER
WASTEWATER
Pine Lane
Conklin Drive
Poplar Drive
Northland Drive
Legend
CNKL_SN_LOCATIONS
CATEGORY
POP
SUPERNET
OSLI_FIBRE_temp
RMWB_FIBRE_temp
9315_Supernet
RMWB Road Network GeoBase
<all other values>
RTNUMBER1
63
881
IBI GROUP

Fort MacKay


REGIONAL MUNICIPALITY OF WOOD BUFFALO
IBI GROUP
FORT MACKAY
Fort MacKay Rd
Target Rd
Athabasca River Dr
NOTE: OSLI designs continue further south than shown in drawing.
Legend
FTMK_SN_LOCATIONS
CATEGORY
POP
SUPERNET
OSLI_FIBRE_temp
RMWB_FIBRE_temp
9315_Supernet
RMWB Road Network GeoBase
<all other values>
RTNUMBER1
63
881

Land Cover (clutter) Grids

Janvier

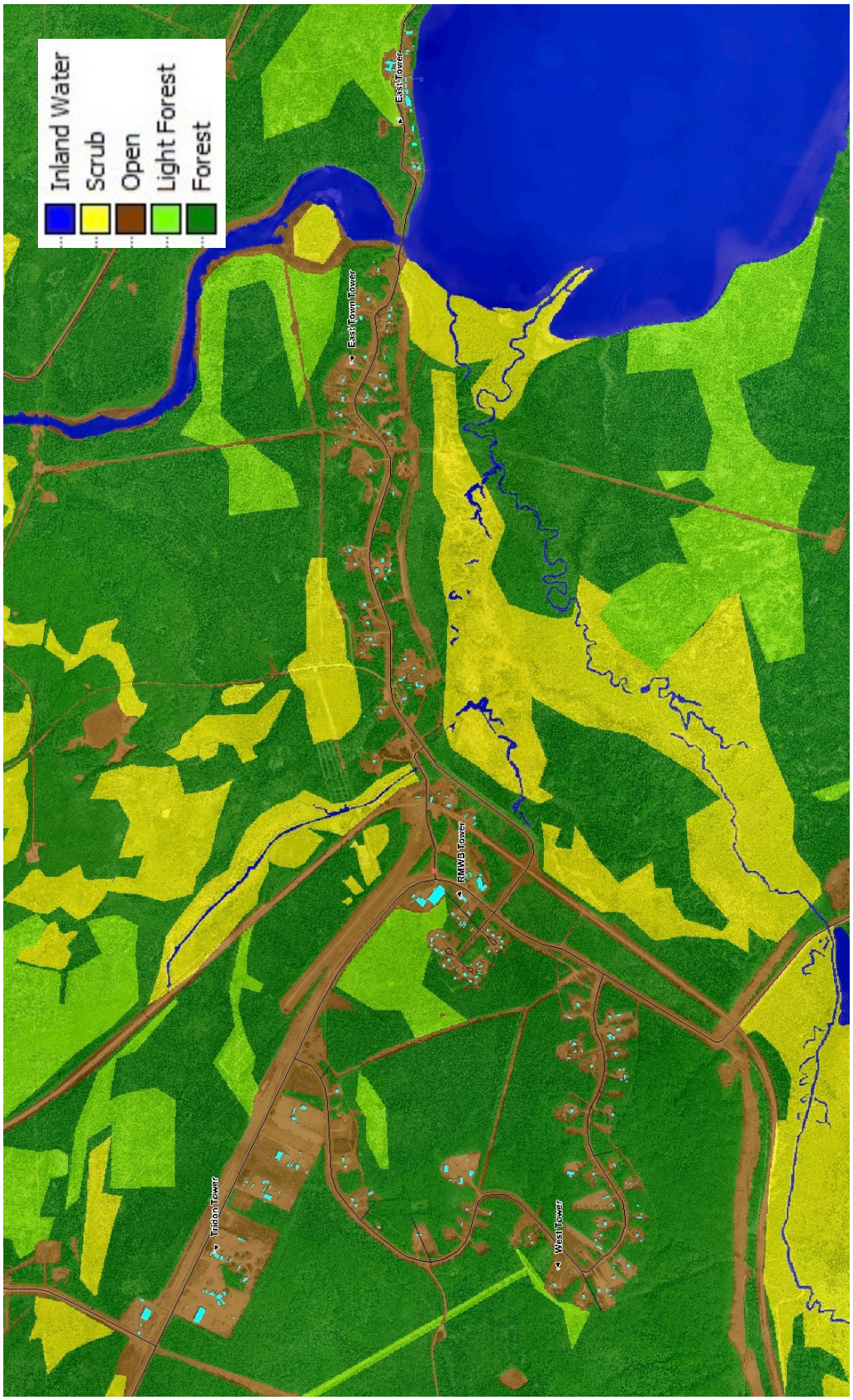


Fort Chipewyan

Anzac


Inland Water
Scrub
Open
Light Forest
Forest
North Res Tower
Beach Tower
Centre Tower
West Centre Tower
Tridon Tower
South Tower

Conklin


Inland Water
Scrub
Open
Light Forest
Forest
East Tower
East Town Tower
RMWB Tower
Triton Tower
West Tower

Fort MacKay


WestSubdivision
POP
Inland Water
Scrub
Open
Light Forest
Forest

Gregoire Lake Estates

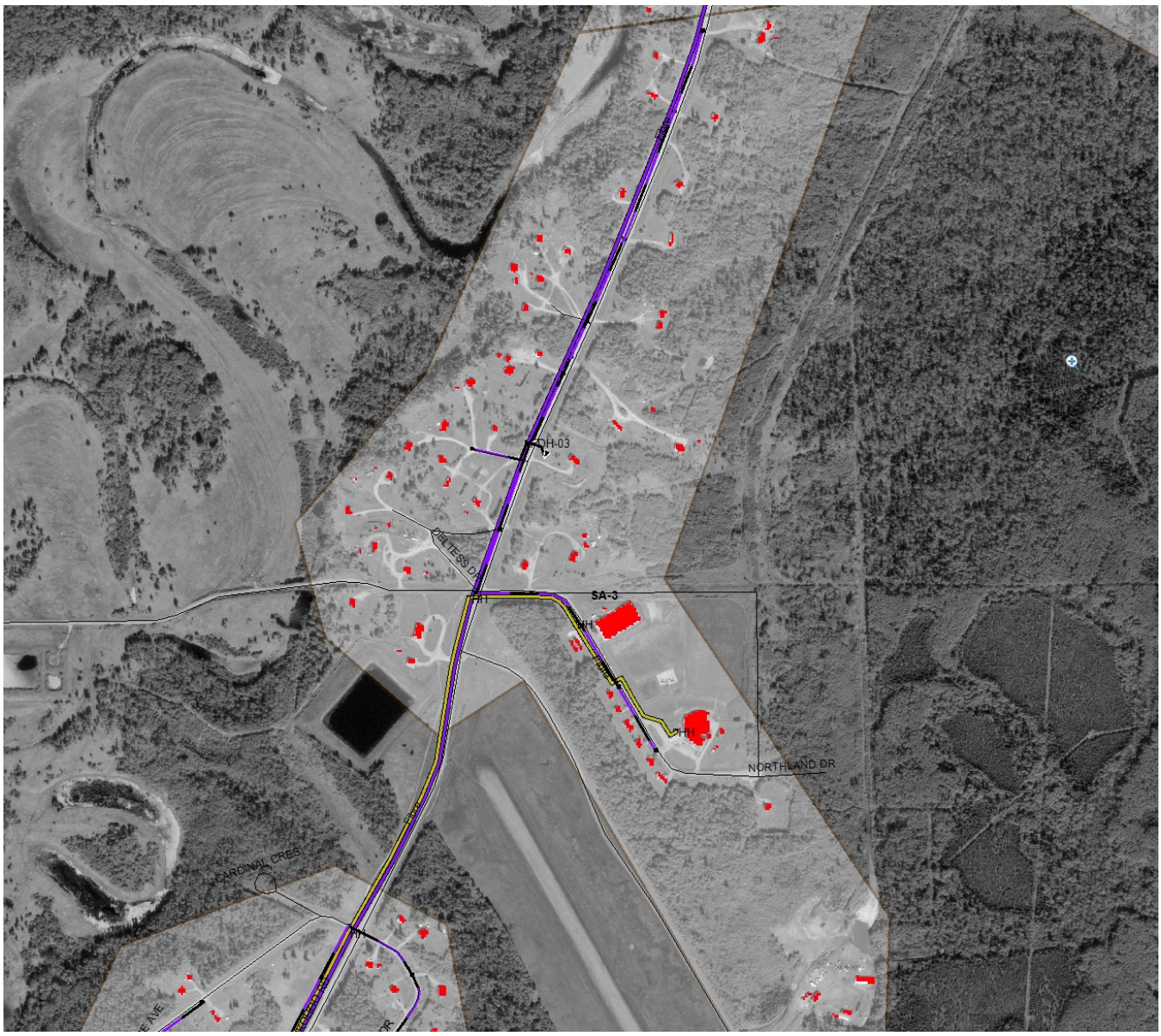
FTTP + Wi-Fi Network Designs

Janvier

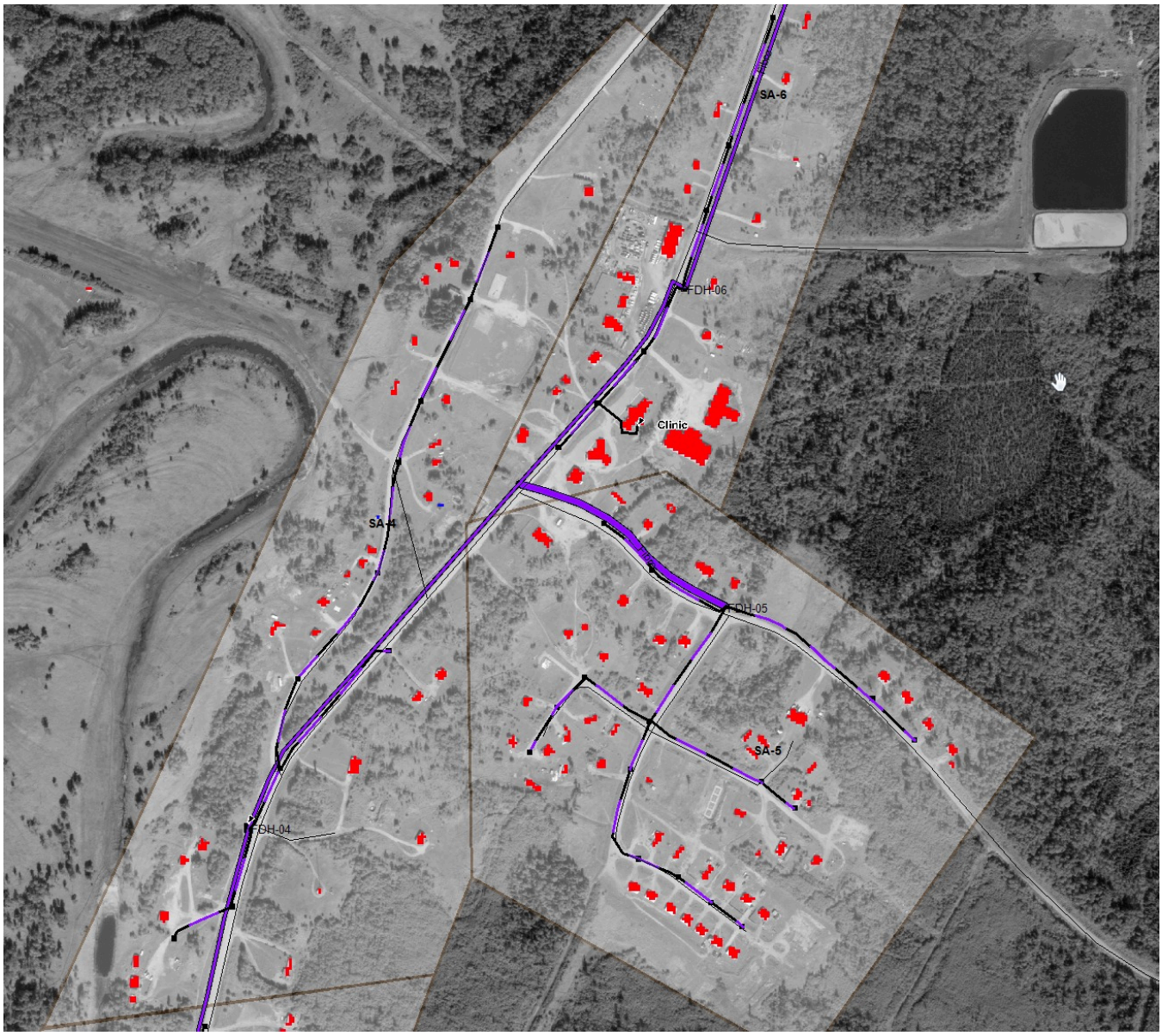
SA-1 & 2

See FTTP/Wi-Fi Section in the body of the report.

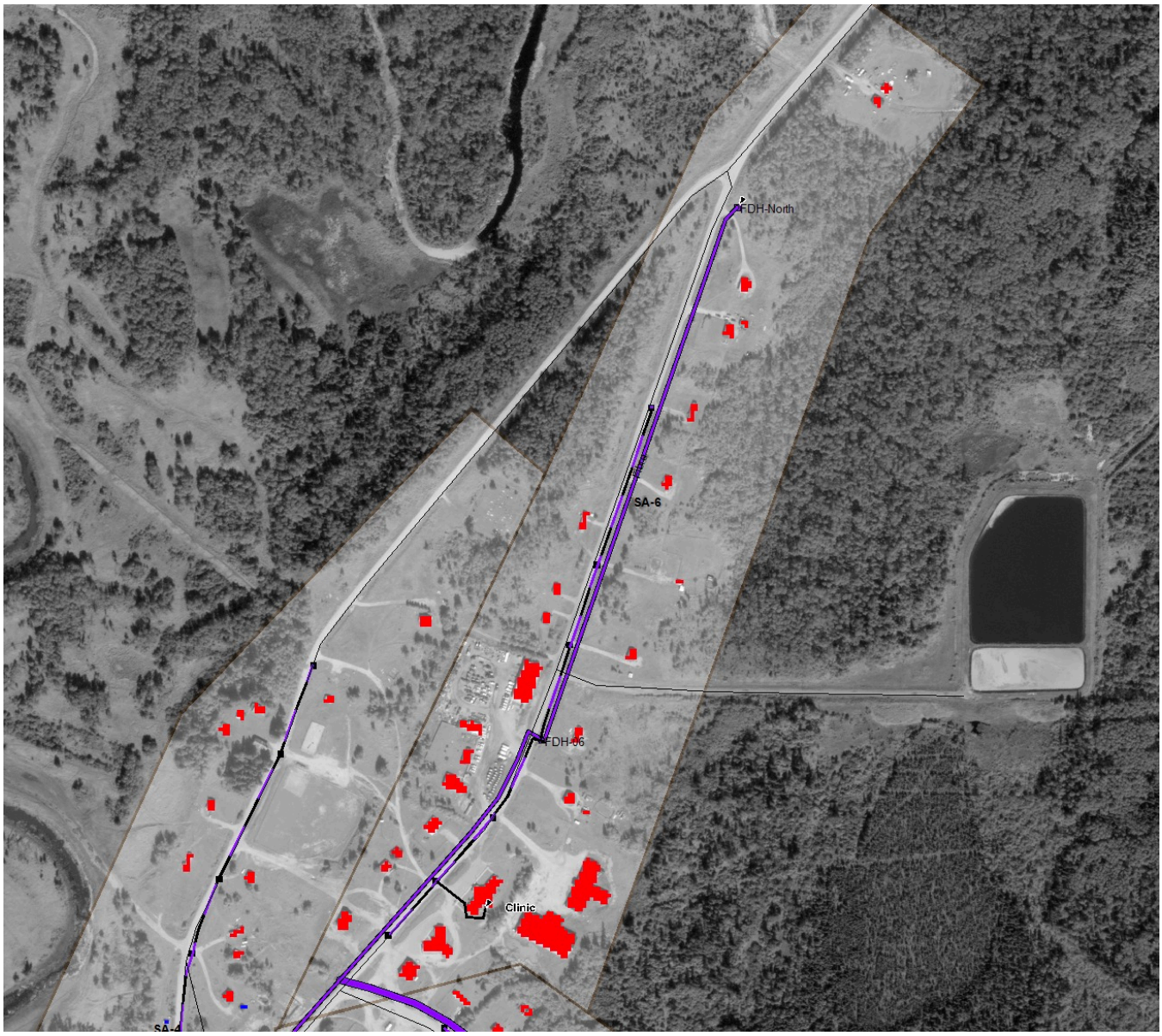
SA-3



SA-4 & 5

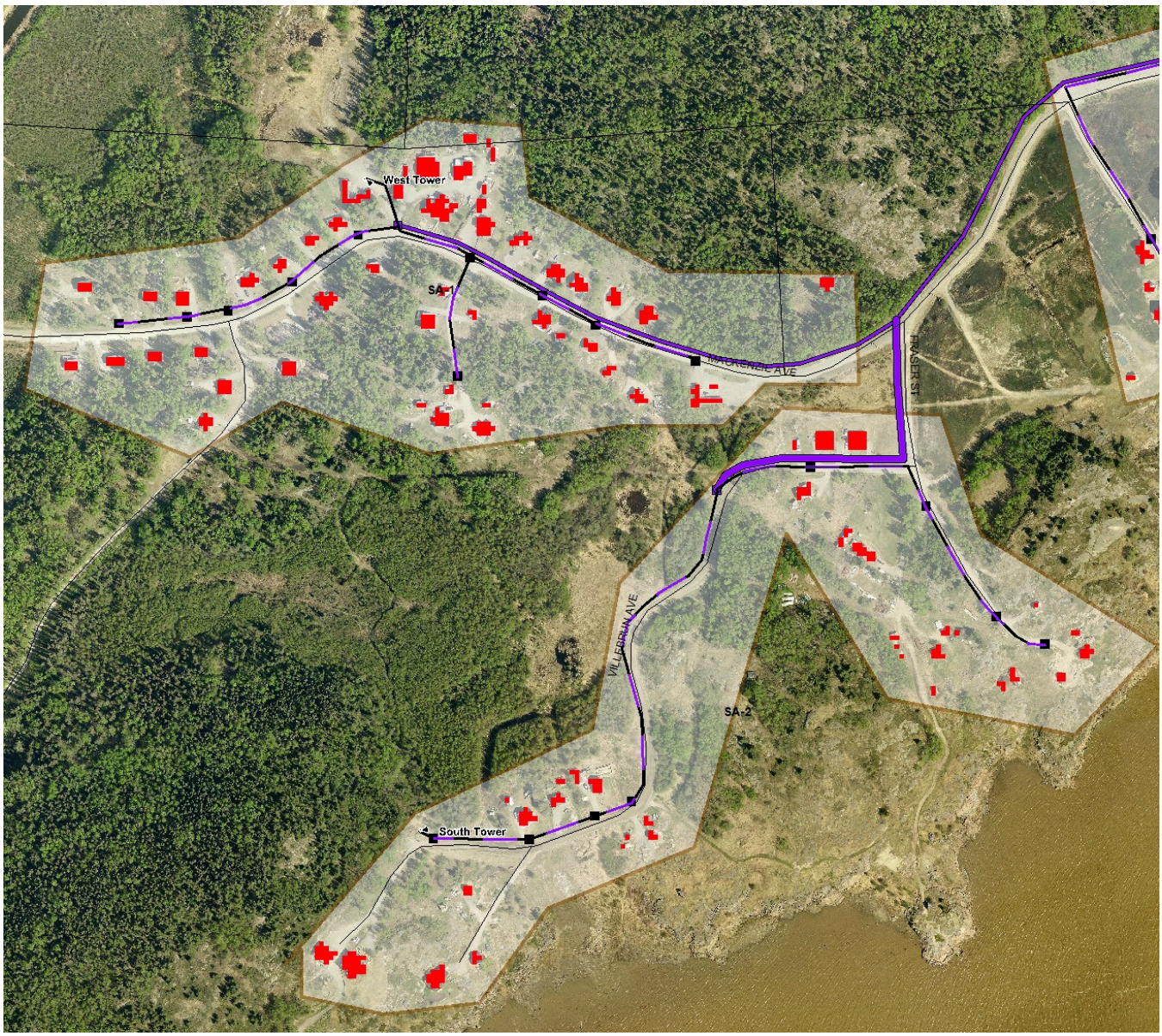


SA-6

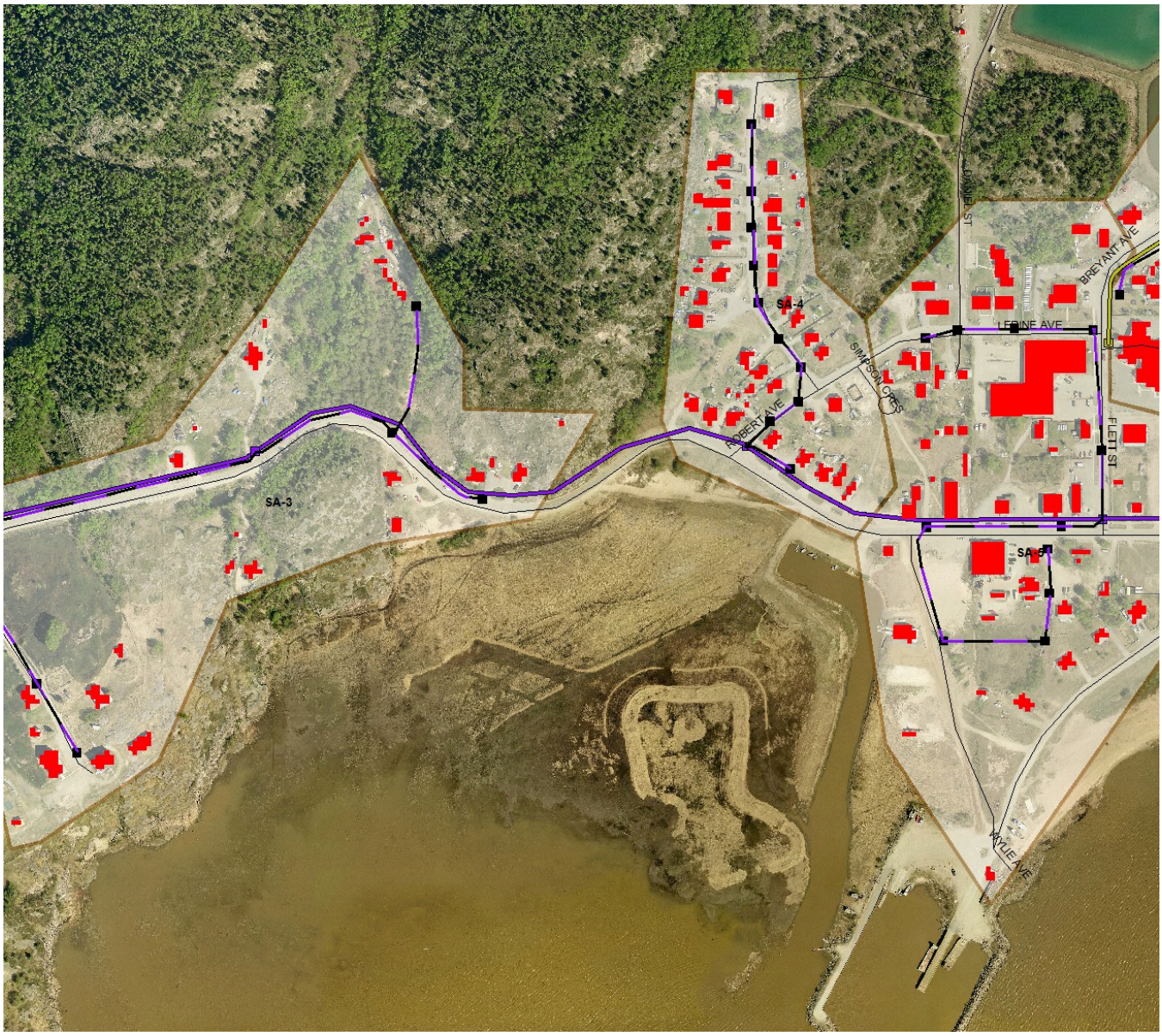


Fort Chipewyan

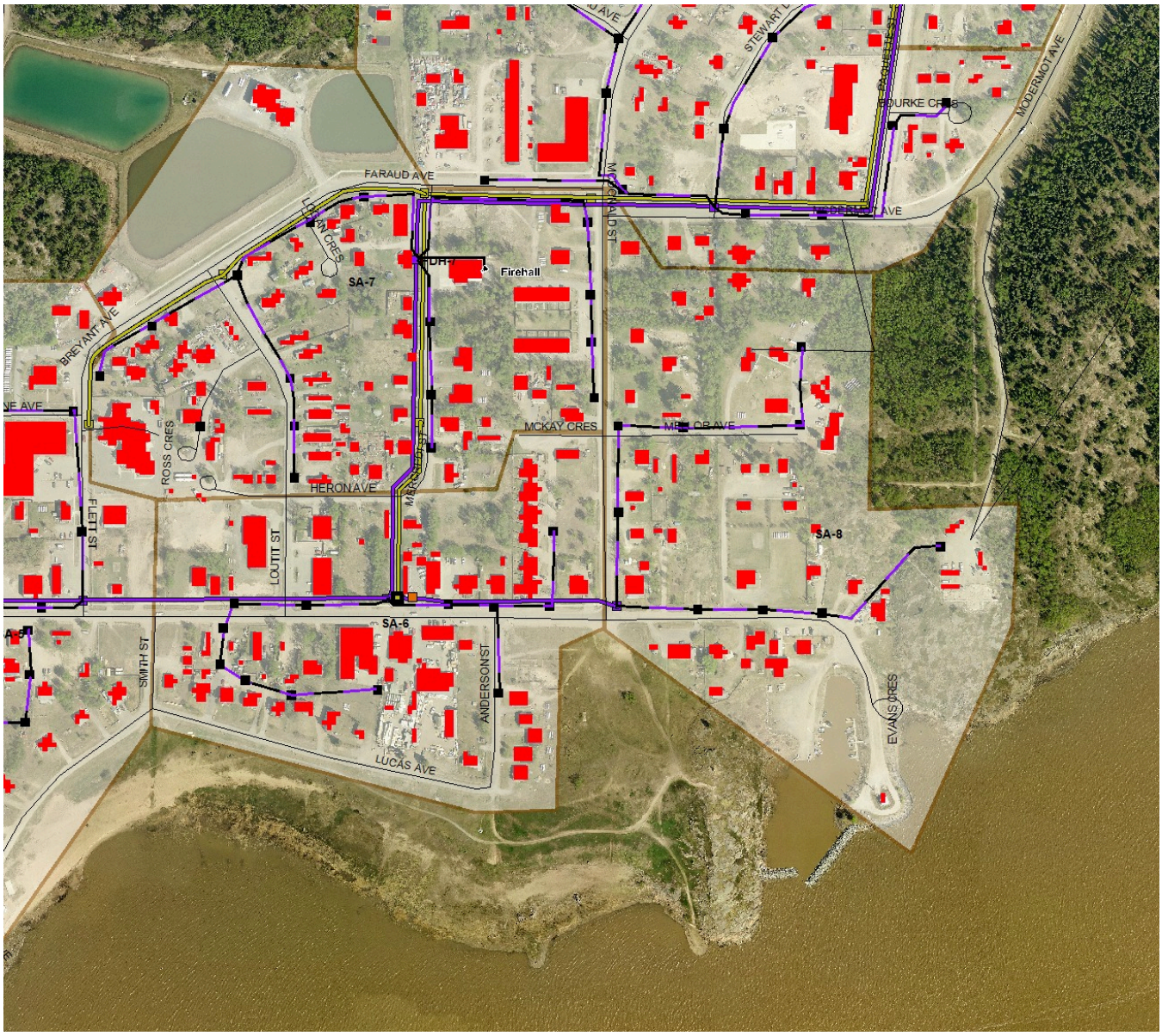
SA-1 & 2



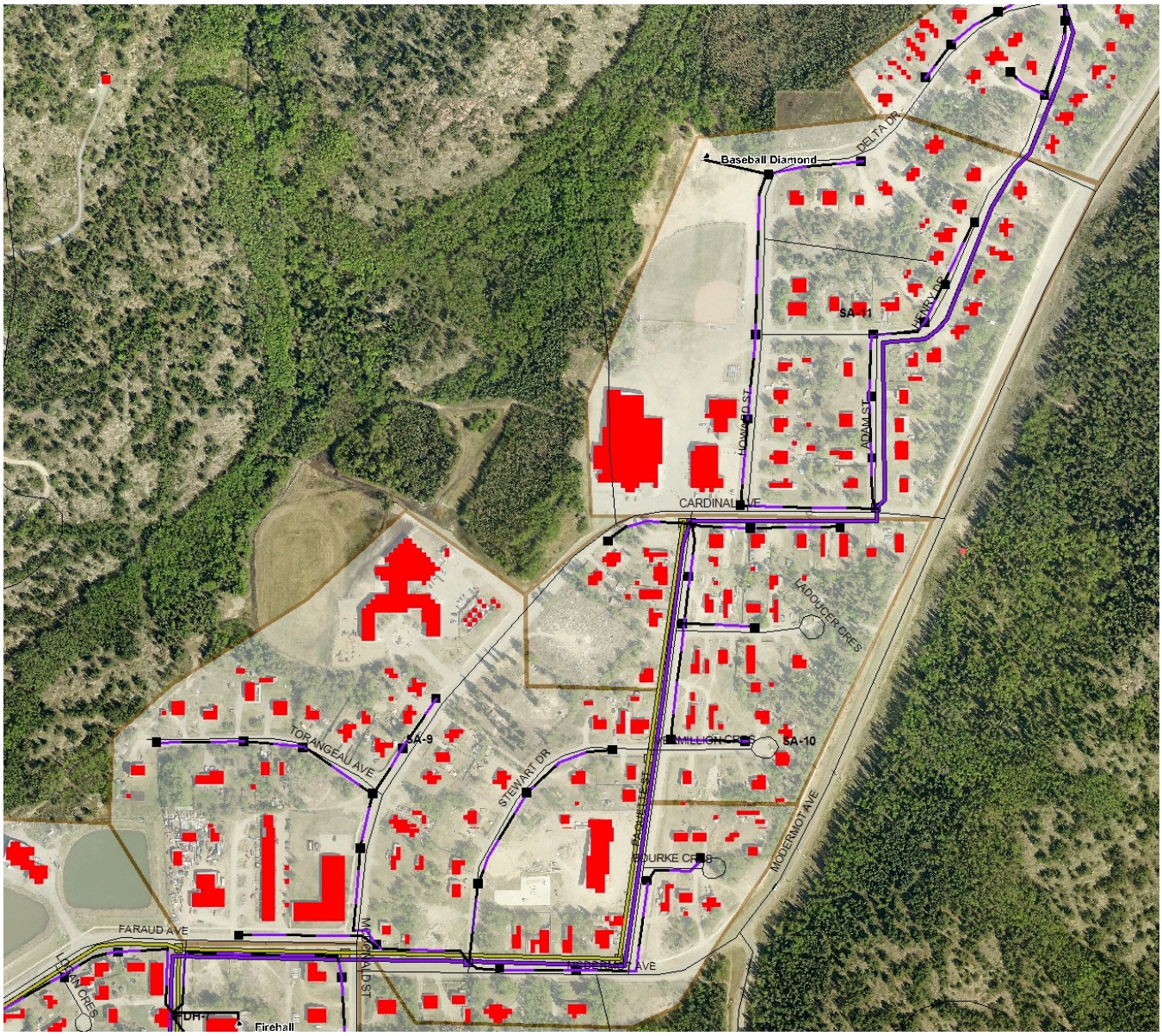
SA-3, 4, & 5


SA-3
SA-4
SA-5
LEGINE AVE
BREYANT AVE
FLETT ST
SIMPSON CRES
ROBERT AVE
MAYUE AVE

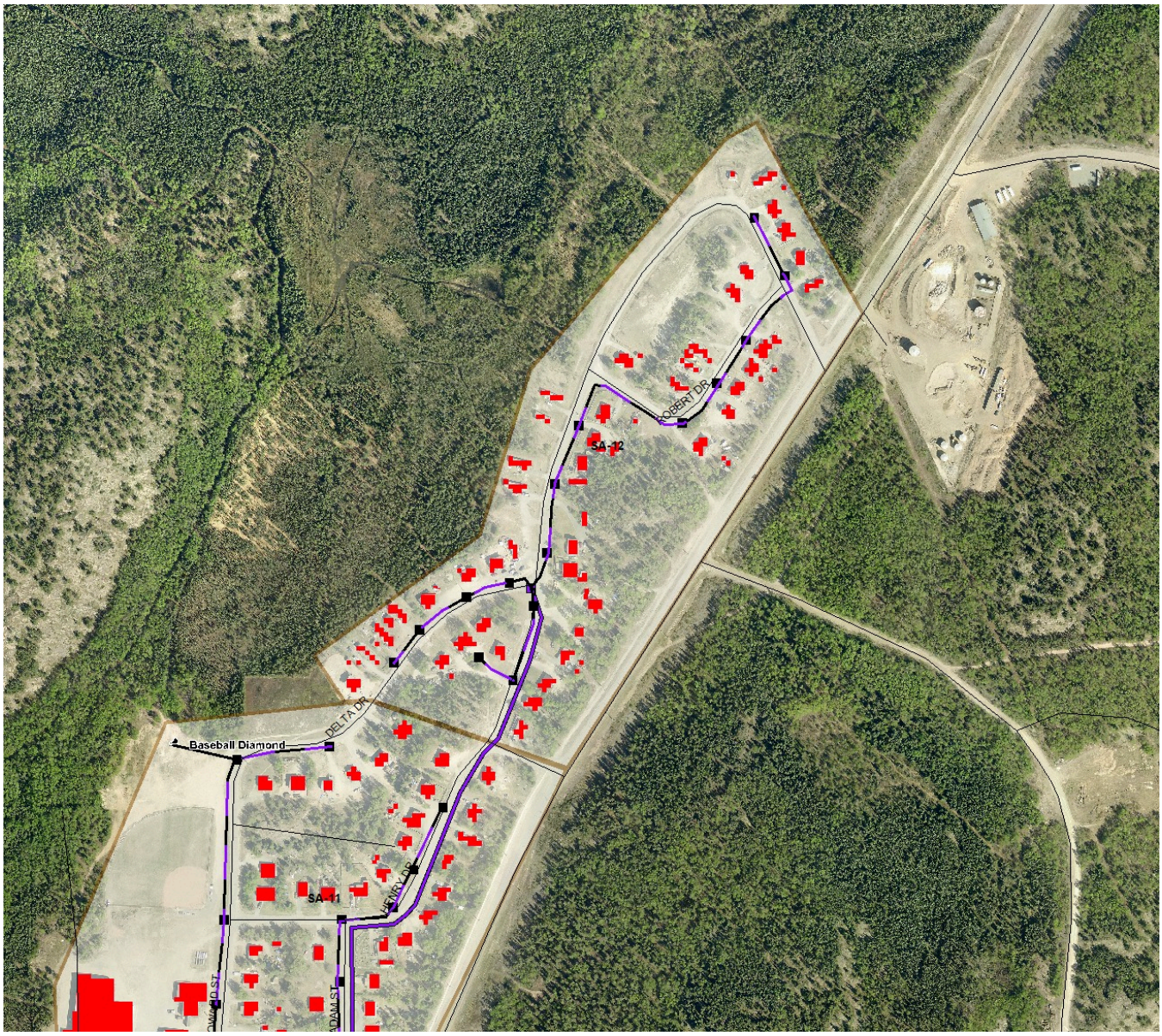
SA-6, 7, & 8


FARAUD AVE
STEWART L
MODERMOT AVE
FOURKE CRES
MCDONALD ST
LILLIAN CRES
SA-7
Firehall
BREYANT AVE
MCKAY CRES
ROSS CRES
HERON AVE
MARSHALL ST
FLETT ST
LOUTIT ST
SA-8
SA-6
SMITH ST
ANDERSON ST
LUCAS AVE
EVANS CRES

SA-9, 10, & 11

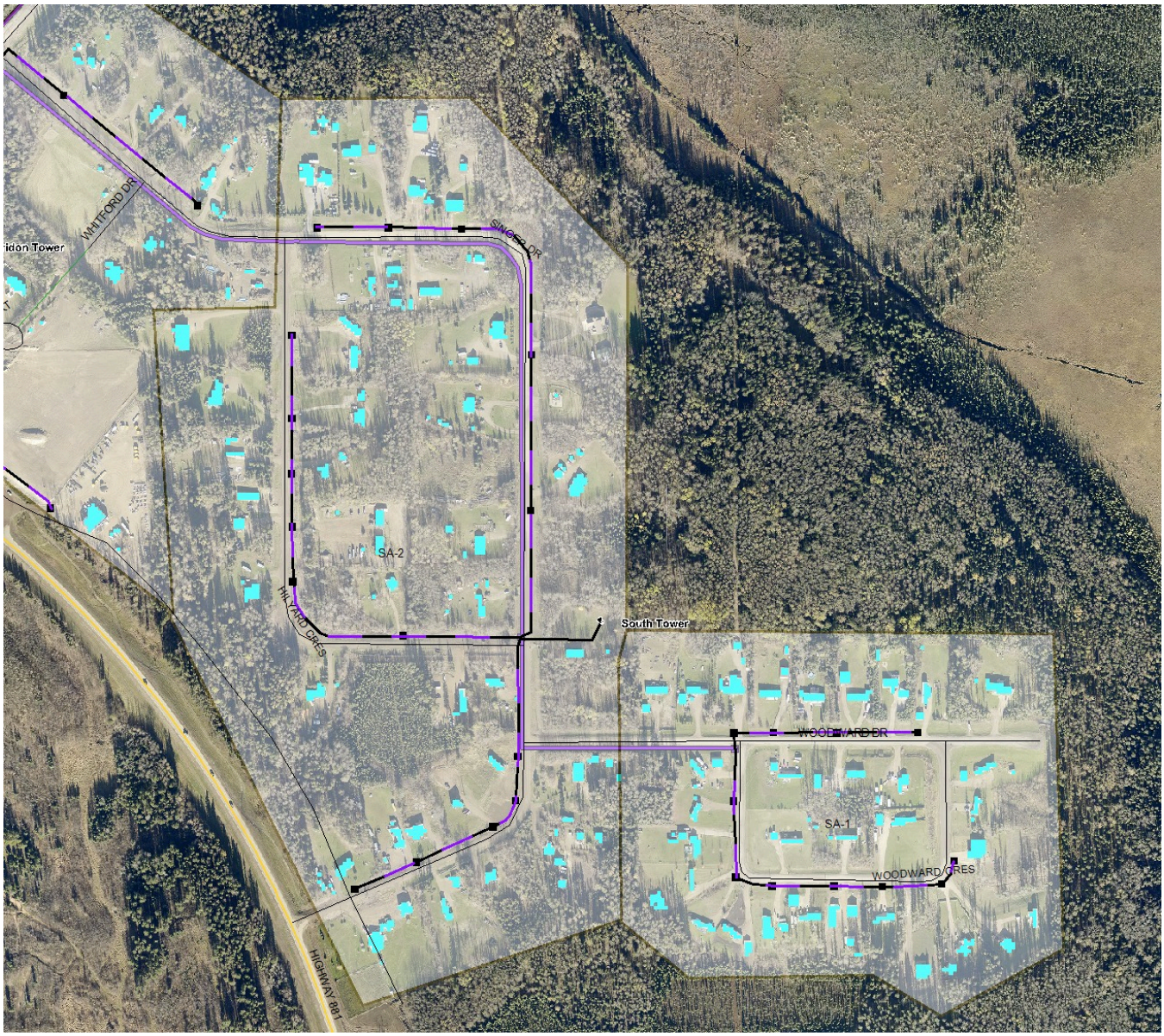

Baseball Diamond
DELTA DR
SA-11
HENRY DR
HOWARD ST
ADAM ST
CARDINAL AVE
LADOUCEUR CRES
SA-9
TOPANGEAU AVE
STEWART DR
SA-10
MODERMOT AVE
FARAUD AVE
MCDONALD ST
Firehall

SA-12

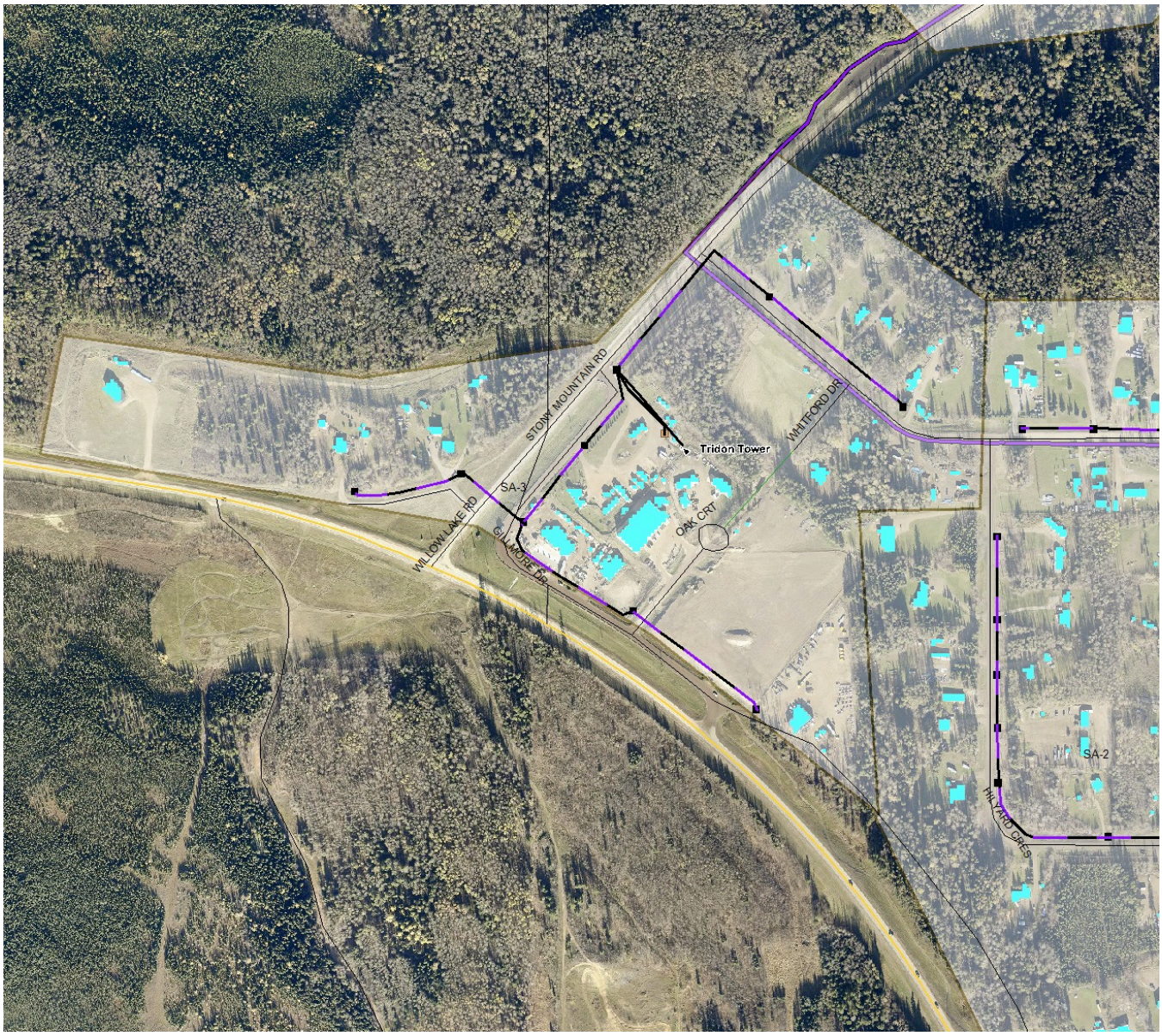


Anzac

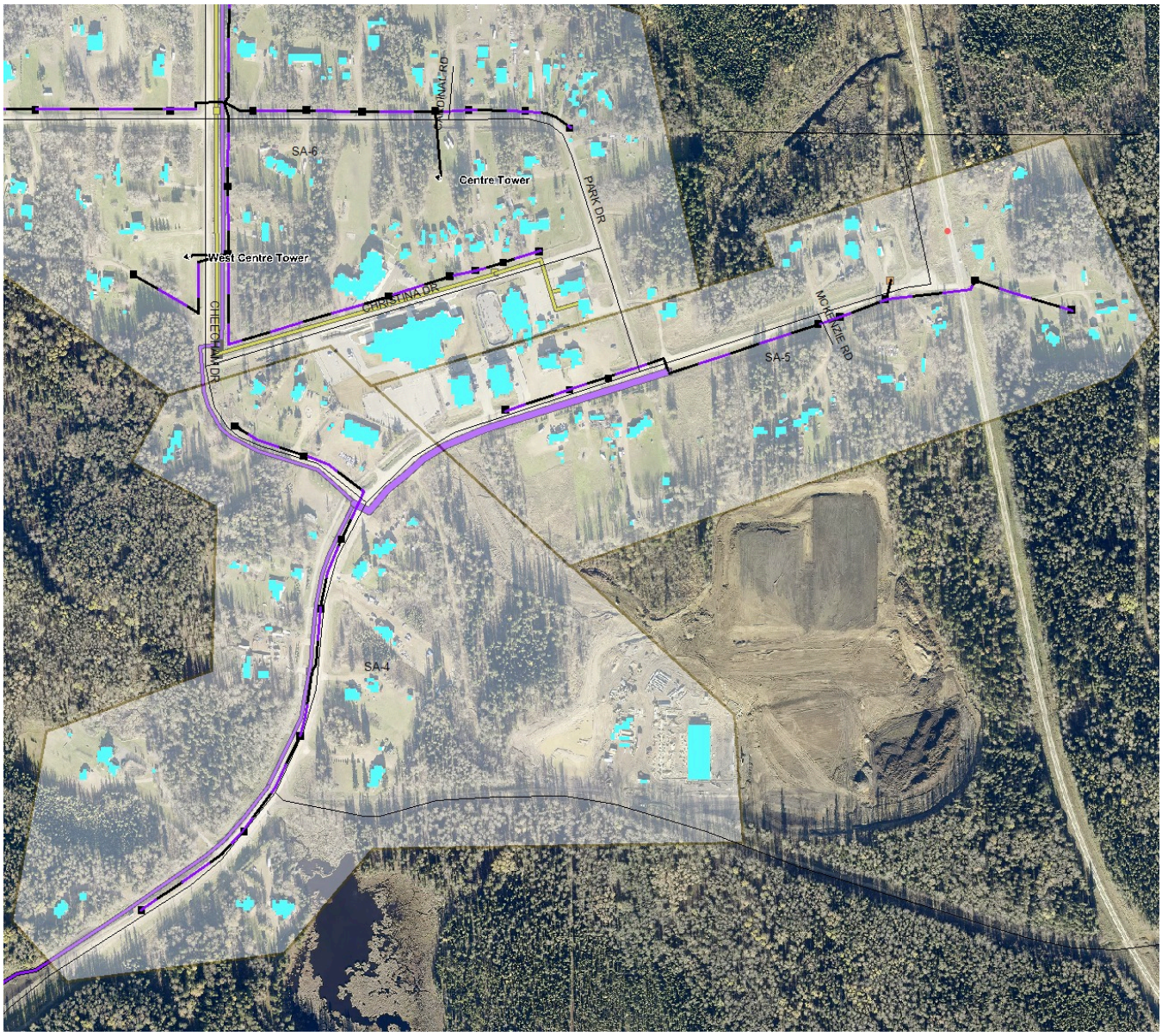
SA-1 & 2


WHITFORD DR
SINGER DR
SA-2
HILYARD CRES
South Tower
WOODWARD DR
SA-1
WOODWARD CRES
HIGHWAY 881

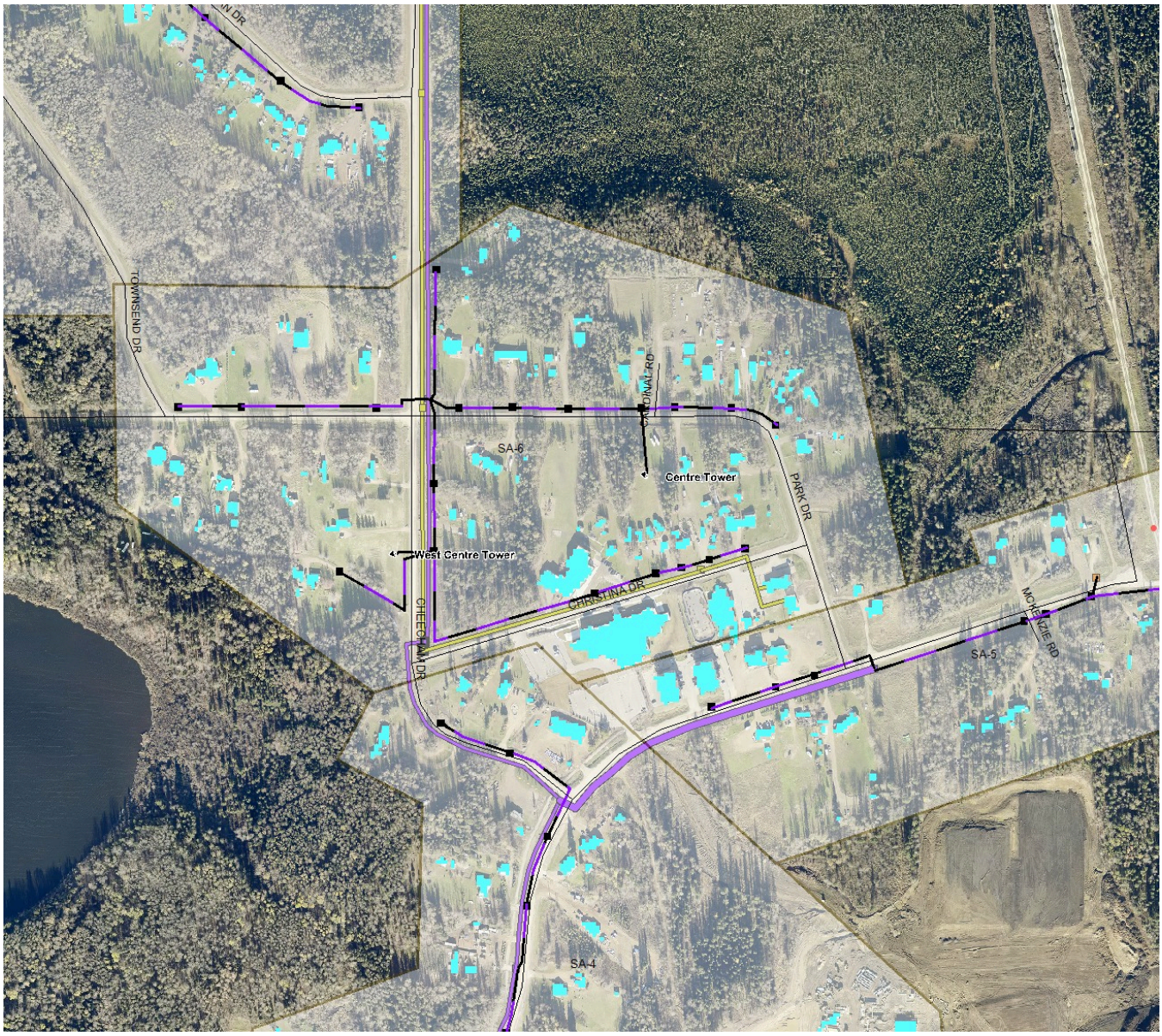
SA-3


STONY MOUNTAIN RD
Tridon Tower
WHITFORD DR
SA-3
WILLOW LAKE RD
GILMORE PL
OAK CRT
SA-2
HAYWARD CRES

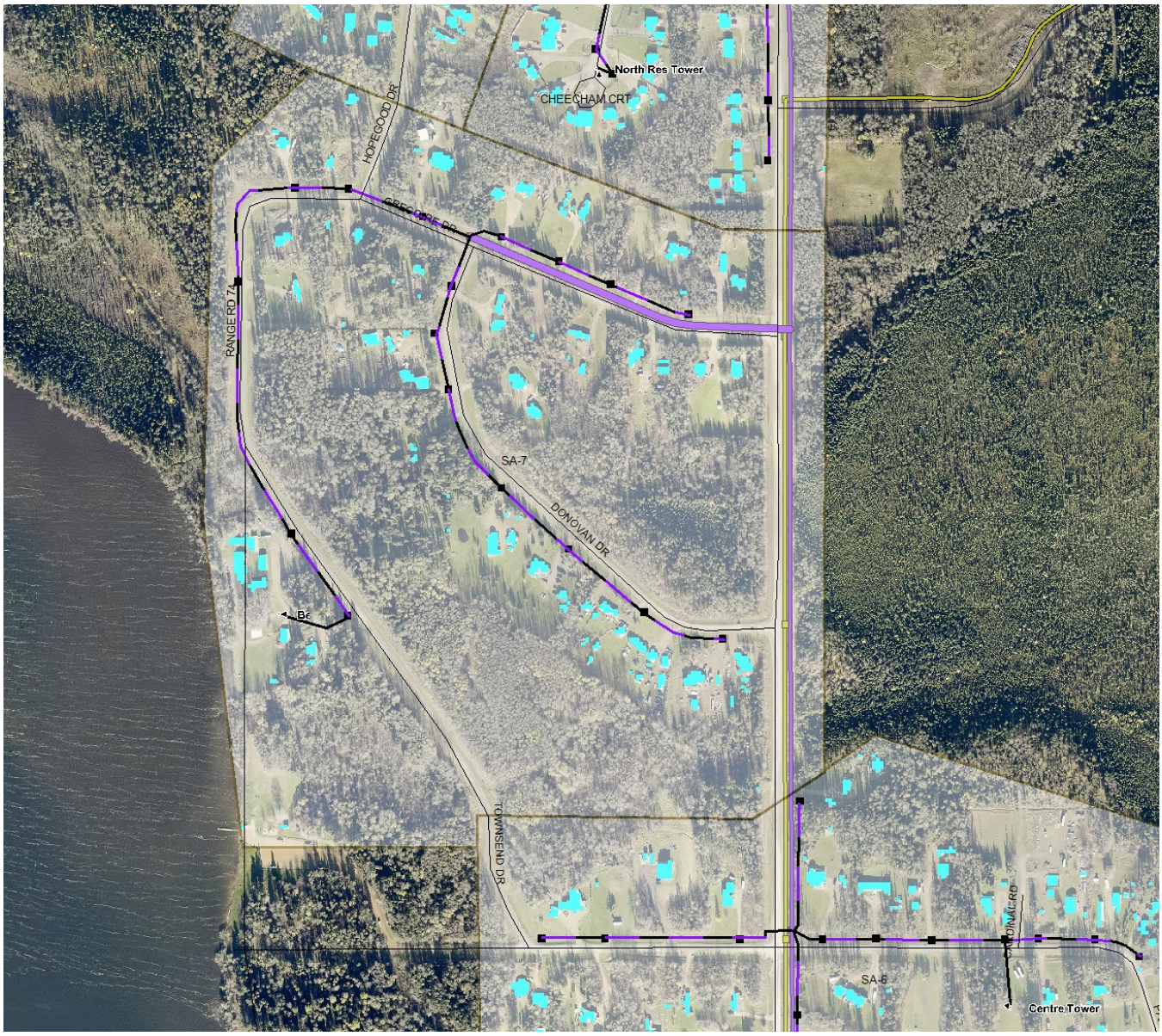
SA-4 & 5


SA-6
Centre Tower
West Centre Tower
CHRISTINA DR
CHEECHAM DR
PARK DR
MCKENZIE RD
SA-5
SA-4

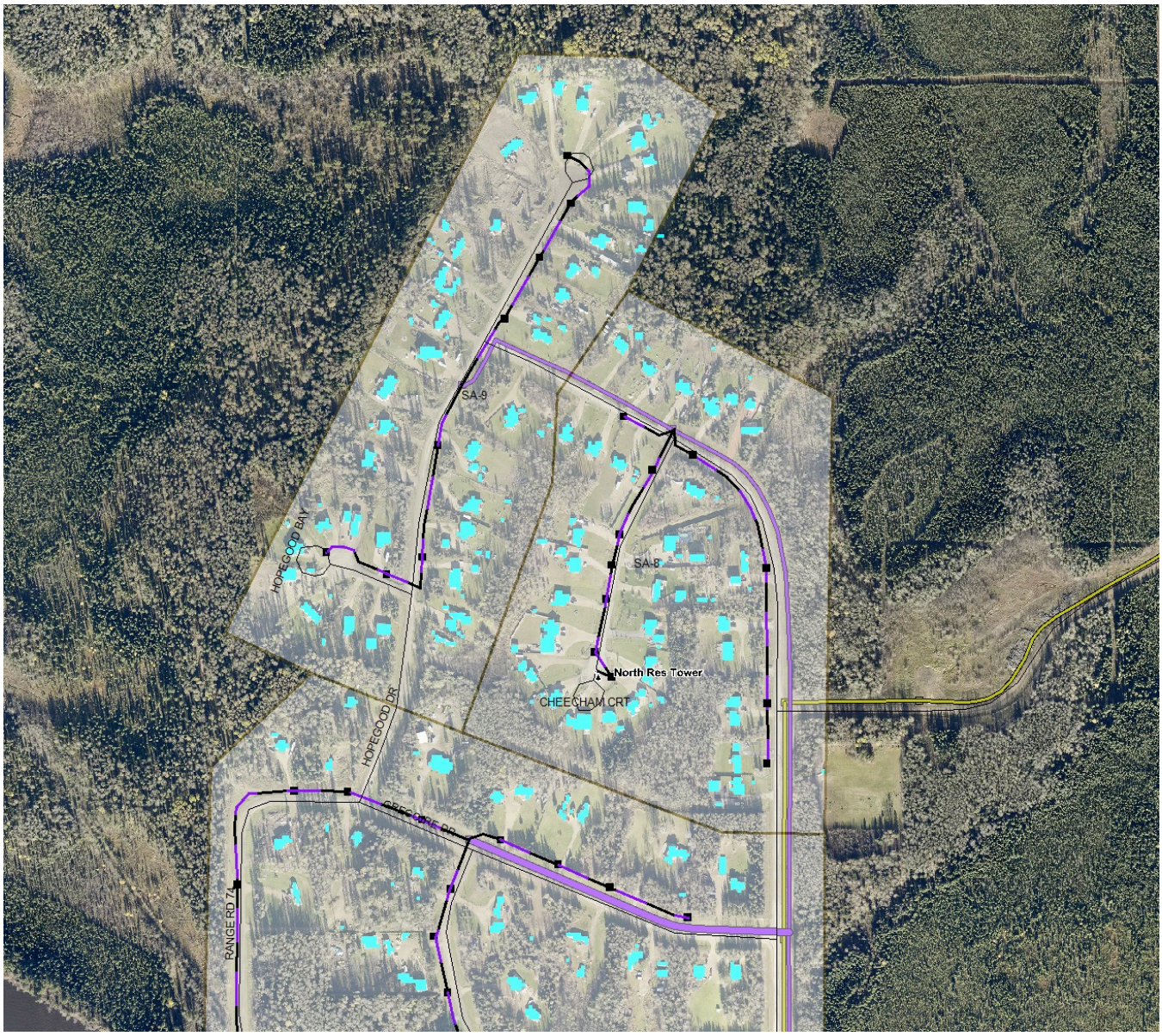
SA-6


TOWNSEND DR
SA-6
Centre Tower
West Centre Tower
CHRISTINA DR
CHEECHAM DR
PARK DR
SA-5
SA-4

SA-7


North Res Tower
CHEECHAM CRT
HOPEGOOD DR
RANGE RD 7A
SA-7
DONOVAN DR
TOWNSEND DR
SA-6
Centre Tower

SA-8 & 9


SA-9
SA-8
HOPEGOOD BAY
HOPEGOOD DR
North Res Tower
CHEECHAM CRT
RANGE RD 74

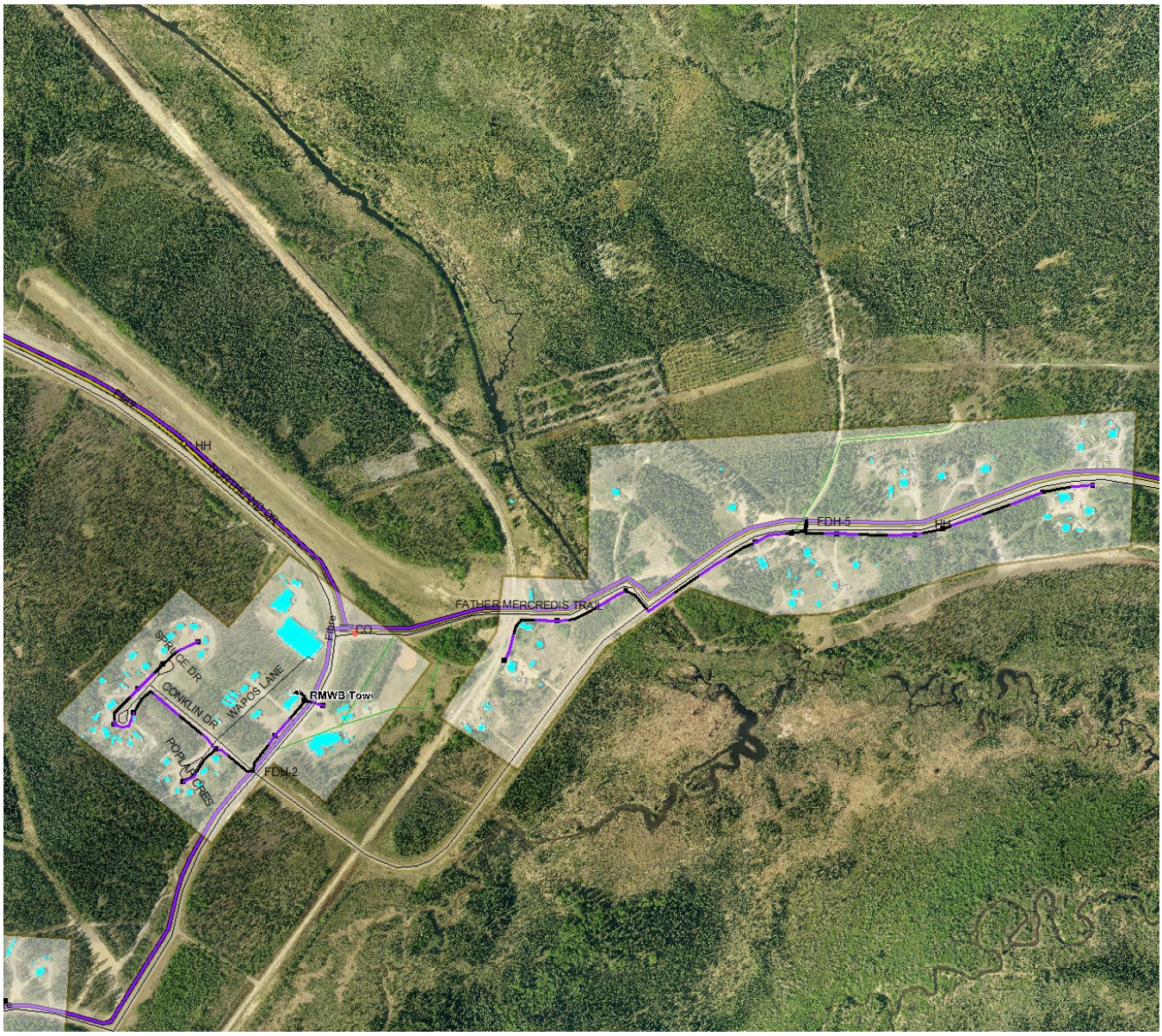
Conklin

SA-1, 2, & 3

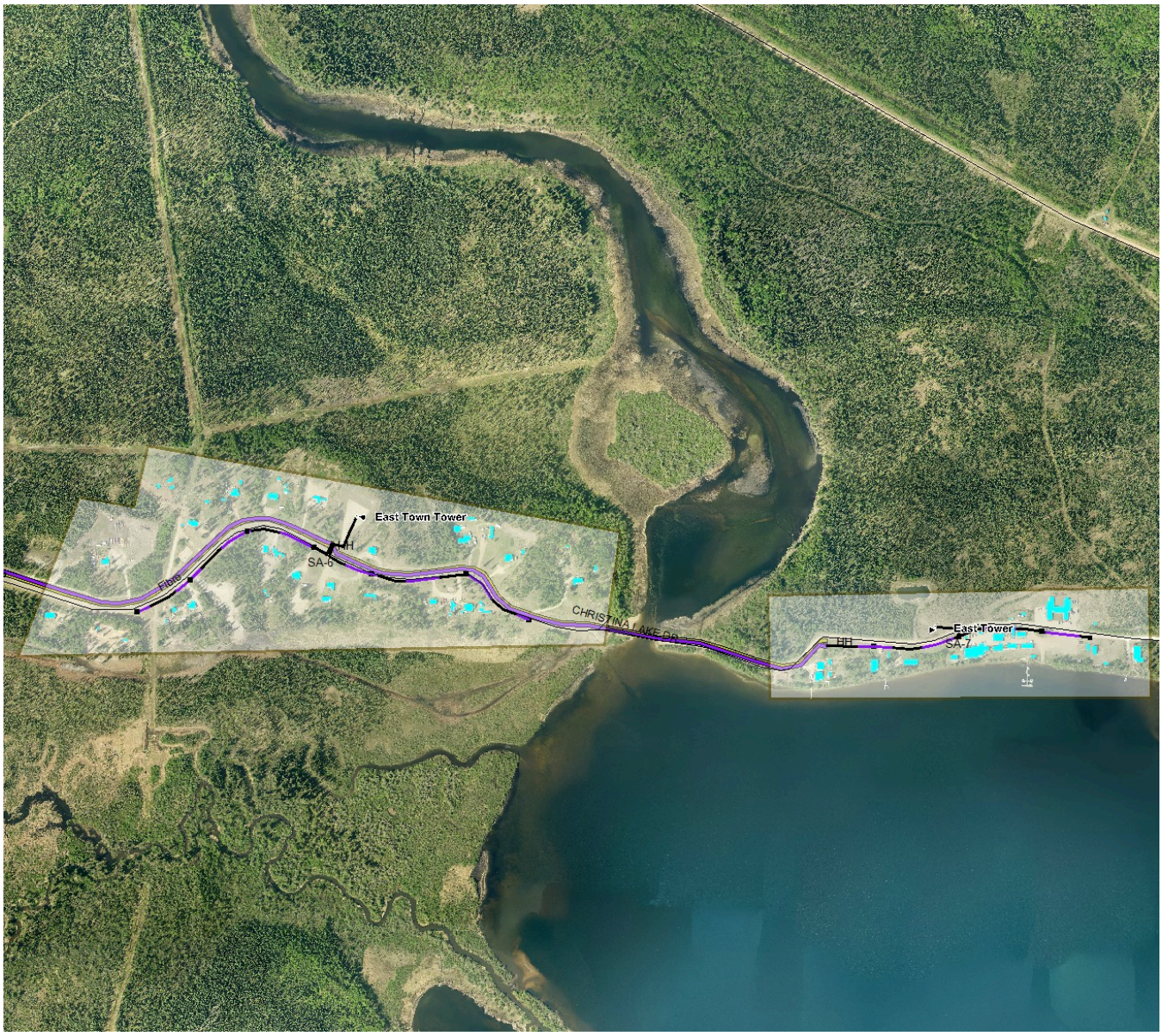
SA-4


TOWNSHIP RD 770A
HH
Fibre
HH
Tridon Tower
FDH-4
HH
PINE LANE
Fibre
FDH-3

SA-5

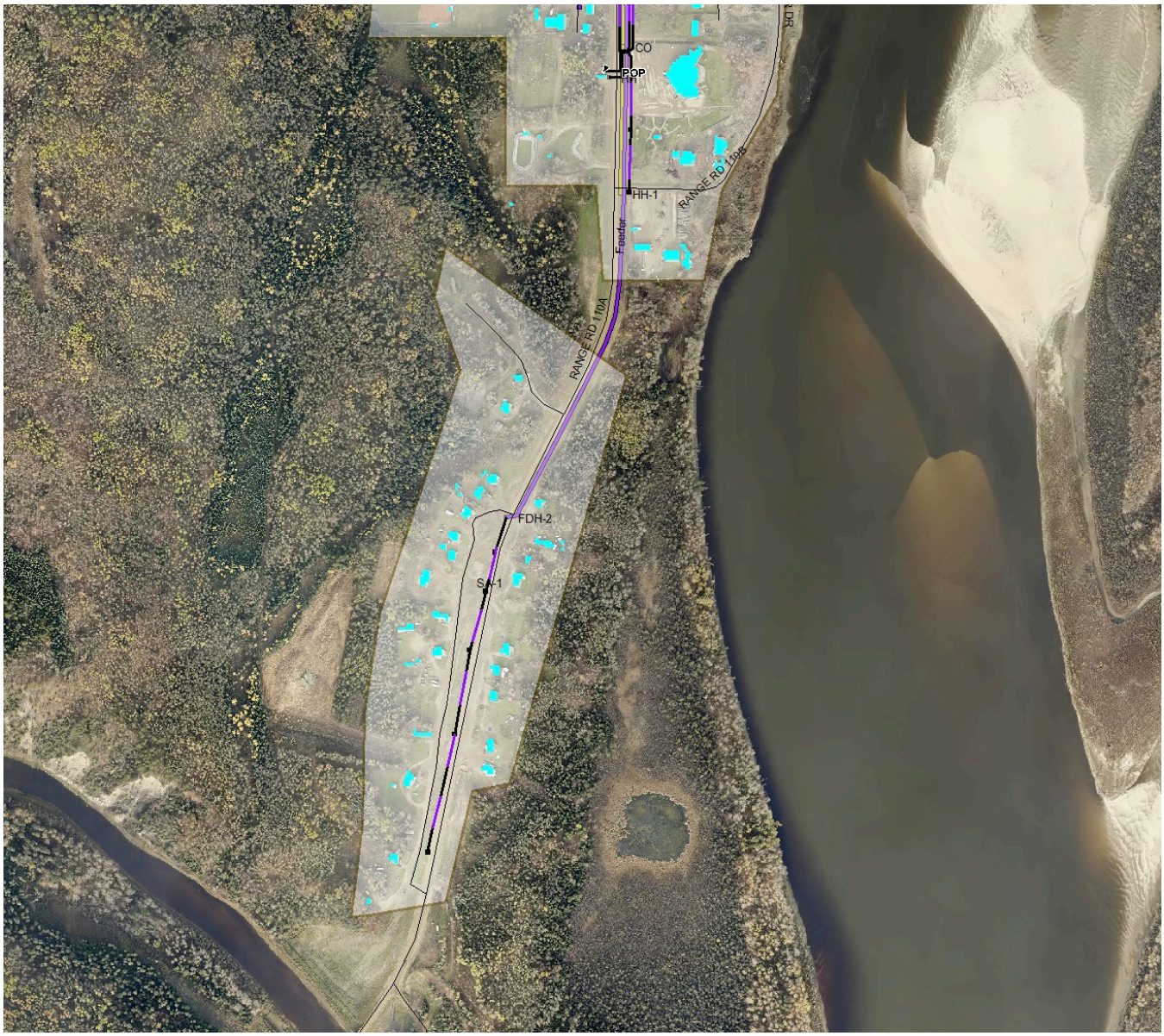

HH
FDH-5
FATHER MERCREDIS TRAIL
CO
SPRUCE DR
CONKLIN DR
WAPOS LANE
RMWB Town
POPLAR CRES
FDH-2

SA-6 & 7

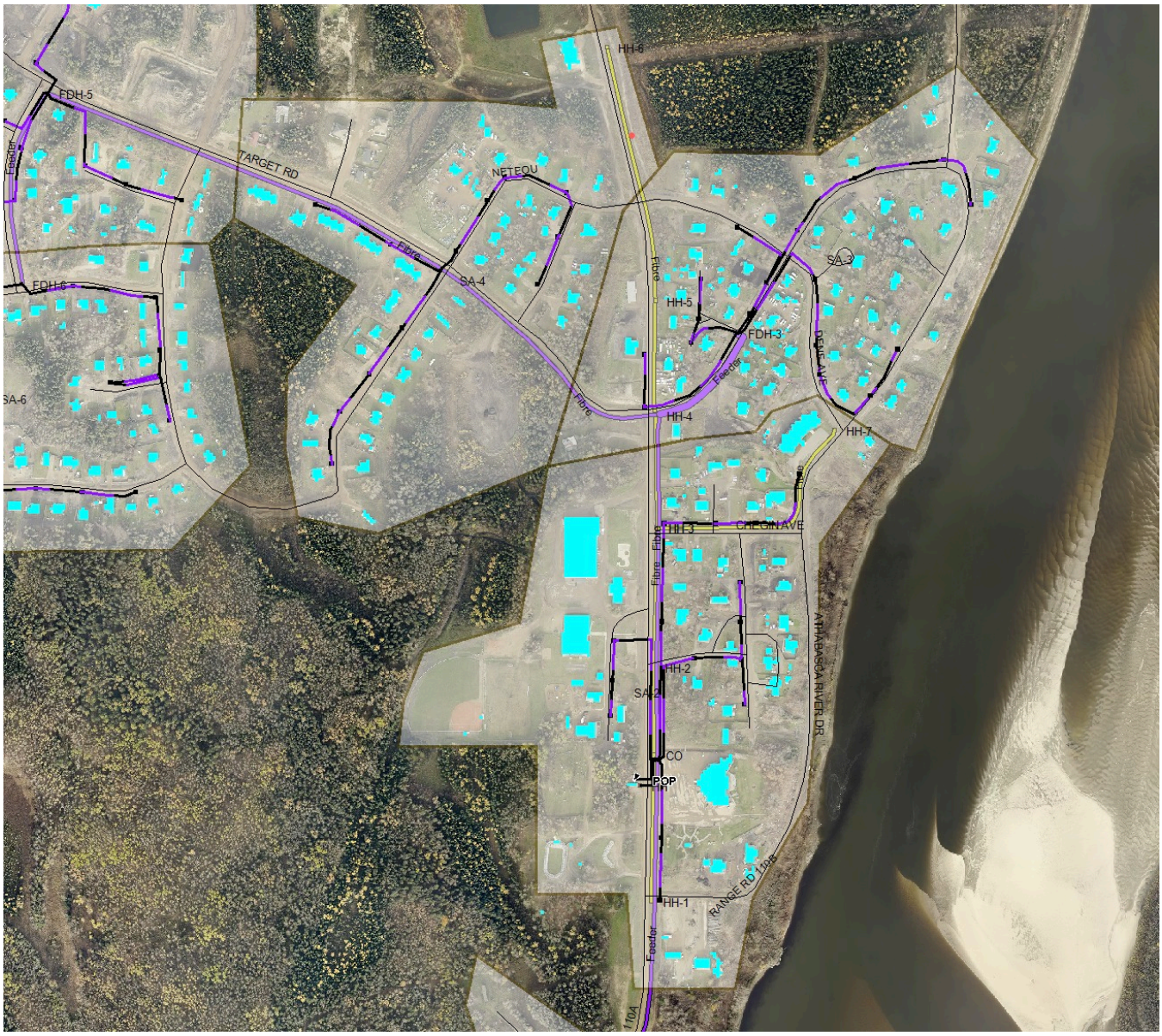

East Town Tower
HH
SA-6
Fibre
CHRISTINA LAKE DR
East Tower
HH
SA-7

Fort MacKay

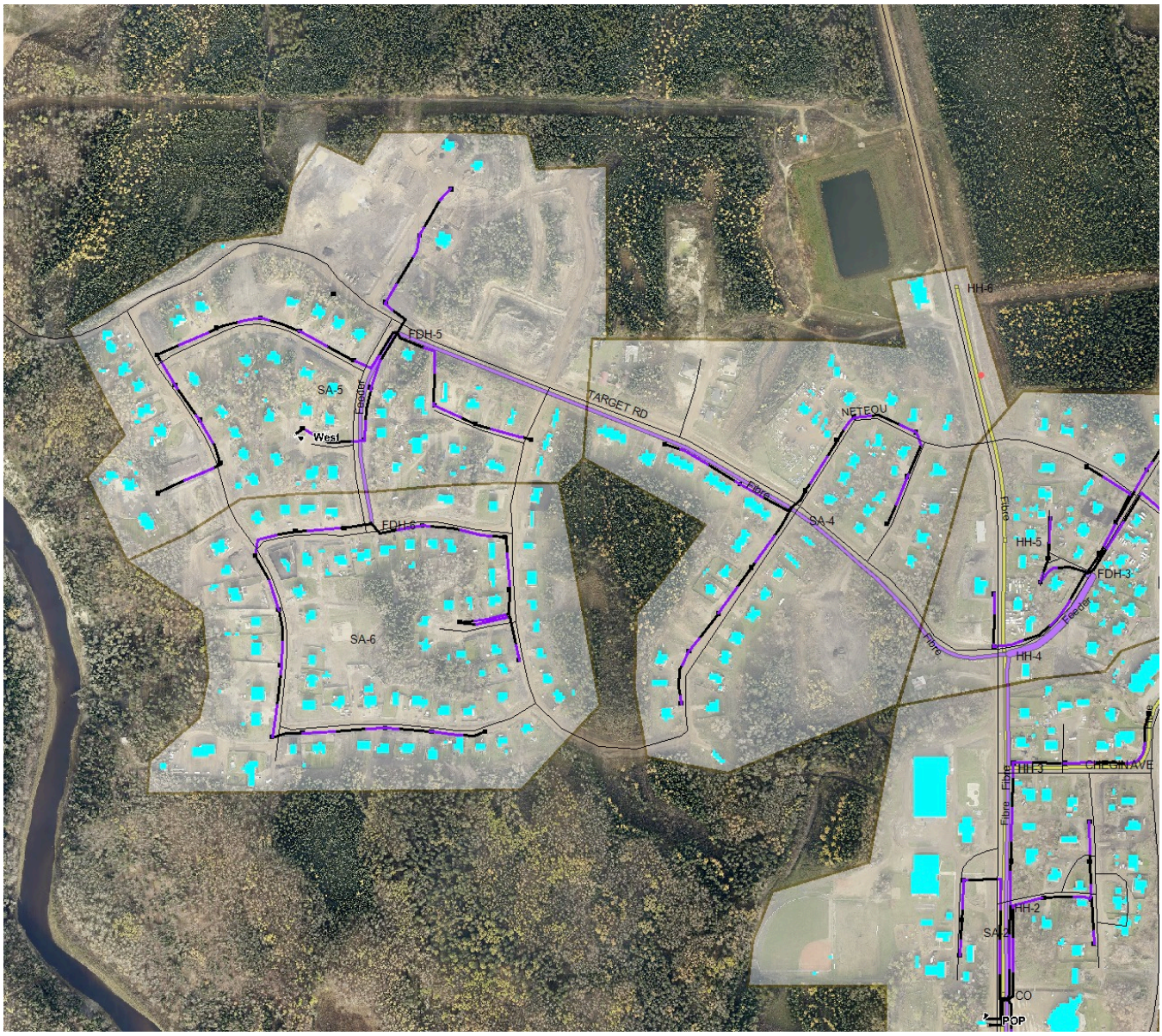
SA-1



SA-2, 3, & 4


HH-6
FDH-5
Feeder
TARGET RD
NETEQU
Fibre
SA-4
FDH-6
SA-6
Fibre
HH-5
FDH-3
SA-3
DENE AVE
Feeder
HH-4
HH-7
Fibre
HH-3
CHEGIN AVE
Fibre
Fibre
ATHABASCA RIVER DR
HH-2
SA-2
CO
POP
RANGE RD 720
HH-1
Feeder

SA-5 & 6


HH-6
FDH-5
SA-5
Feeder
West
TARGET RD
NETEQU
Fibre
SA-4
FDH-6
HH-5
FDH-3
Feeder
SA-6
HH-4
Fibre
Fibre
HH-3
CHEGWIN AVE
Fibre
Fibre
HH-2
SA-2
CO
POP

Gregoire Lake Estates

SA-1, 2, & 3