SUMMARY REPORT ON PROPOSED WATER WELL LOCATIONS FOR HALFWAY RIVER FIRST NATION AREA

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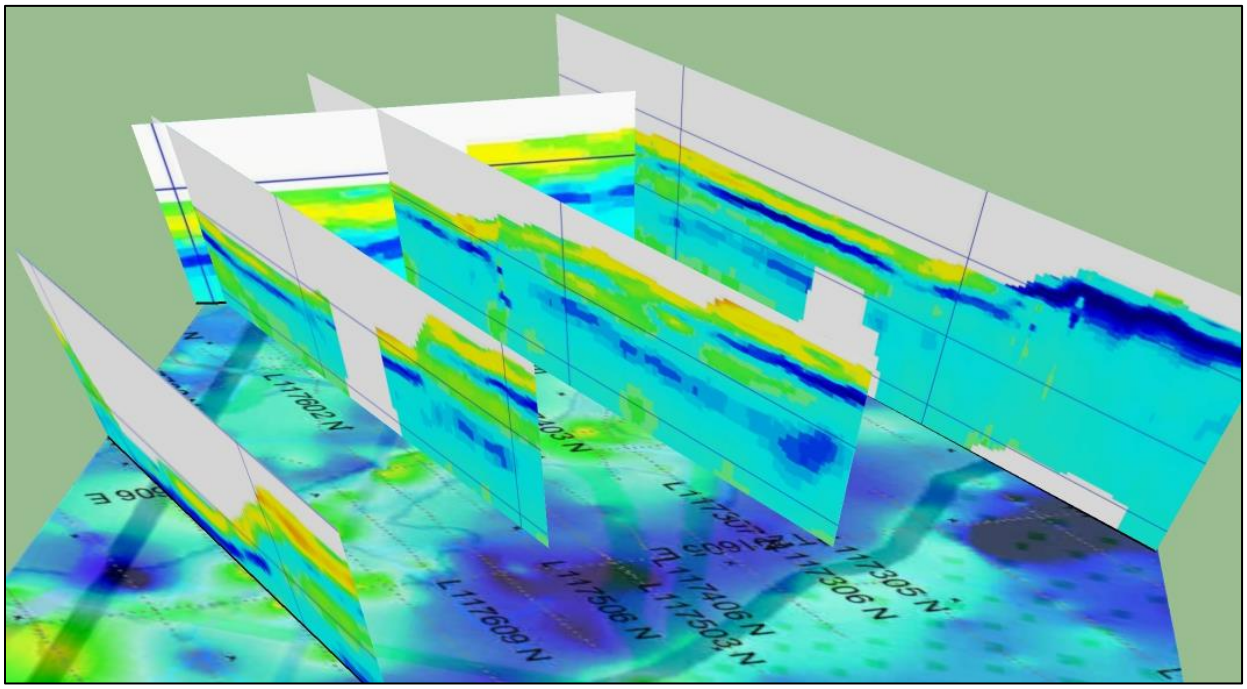

Report to Geoscience BC, November 17, 2017

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Contents

List of Figures

List of Tables

Introduction

At the request of GeoscienceBC, Quaternary Geosciences Inc. and Bemex Consulting International conducted an analysis of available geological and geophysical information in the vicinity of the Halfway River First Nation (HRFN) community. The objective of the analysis was to identify potential water well drill sites in the area that might help provide more groundwater for the community. Targets close to the community are the most economically feasible so the initial investigation focussed on the community area and then expanded outwards. The selected study area is shown by a red box on Figure 1. A regional Airborne Electromagnetic (AEM) survey was conducted in the area as well as a detailed infill AEM survey over the HRFN reserve area (Aarhus Geophysics, 2016).

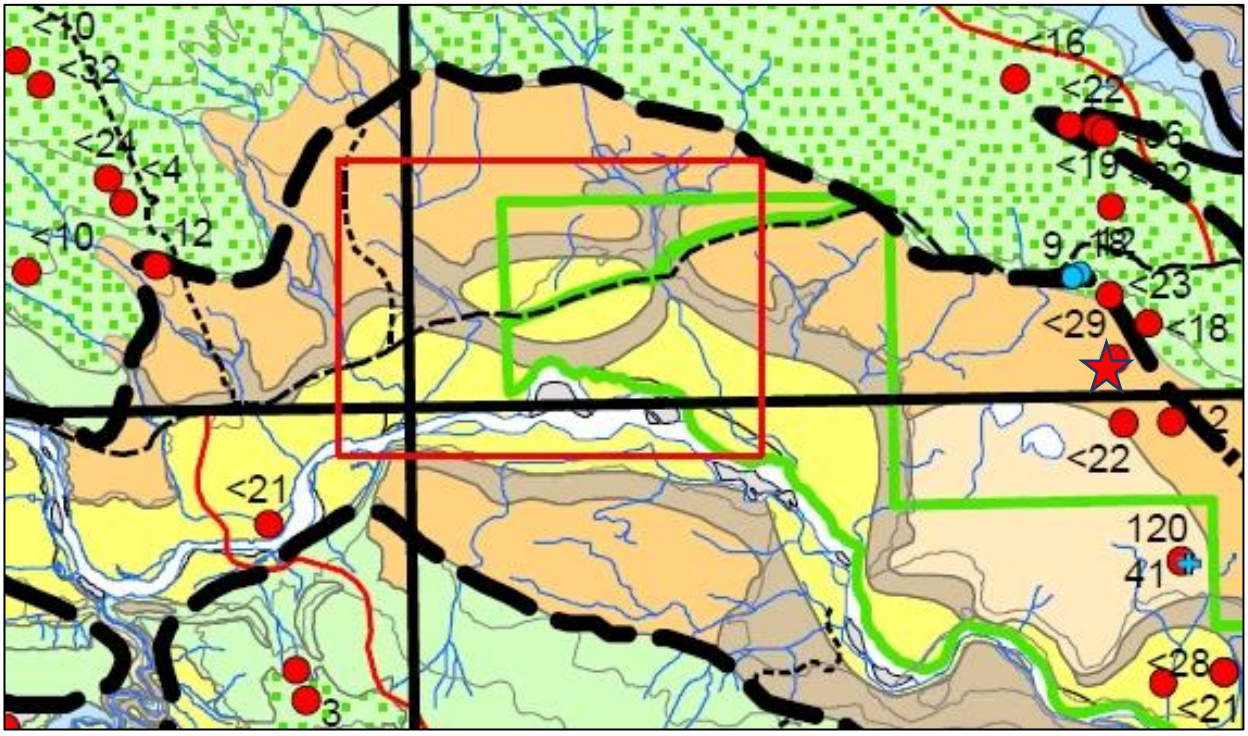

Figure 1. Location map of the HRFN study area (red outline) overlain on the regional surficial geology map. The area is centered on the HRFN community and bounded to the south by the Halfway River. Surficial geology units are described in the text but in the study area they mainly include alluvial floodplain and terraces (yellow) and glaciofluvial sands (orange). Red dots are gas wells with interpreted depth to bedrock in metres. The red star on the far right is the location of sonic hole 7. Thick dashed black lines outline the paleovalley margins (defined by >10 m depth to bedrock). The HRFN reserve is outlined in green.

Surficial Geology and inferred effects on groundwater

The surficial geology of the study area and surrounding region is shown in Figure 1. The study area is dominated by alluvial floodplain and terrace deposits (yellow area on Figure 1). The floodplain deposits include point bar, scroll bar, abandoned channel-fill and low terrace deposits. The water table in these areas is close to surface as indicated by standing water in ponds and abandoned channel lakes. Water wells in these fluvial sands and gravels on the floodplain most likely would be productive. However, these areas are open to surface contamination from local and upstream sources. In addition, the floodplain of the Halfway River is dynamic with relatively frequent channel migration and channel

shifting. Installation of permanent water well facilities on the floodplain would require careful site selection and would be subject to damage in the event of future channel shifts.

Intermediate alluvial terraces in the area above the modern floodplain generally consist of relatively coarse, fluvial gravels and sands deposited during the Mid to Late Holocene. Most of these terrace surfaces are characterized by well preserved channel and bar landforms and remnant cut-bank scarps (Figure 2). The gravels and sands are up to several metres thick and relatively well sorted and well bedded (Figure 3). The water table lies at or below the base of the terrace gravels in many locations as indicated by the local presence of ponds at the bottom of some gravel pits in the area, especially those at lower elevations closer to the river. However, the absence of ponded water in most parts of the gravels pits and a general riverward slope along the base of most of the terraces suggests that the gravels are generally free draining. Groundwater may be retained in low areas at the base of the terrace gravels such as in former channel bases.

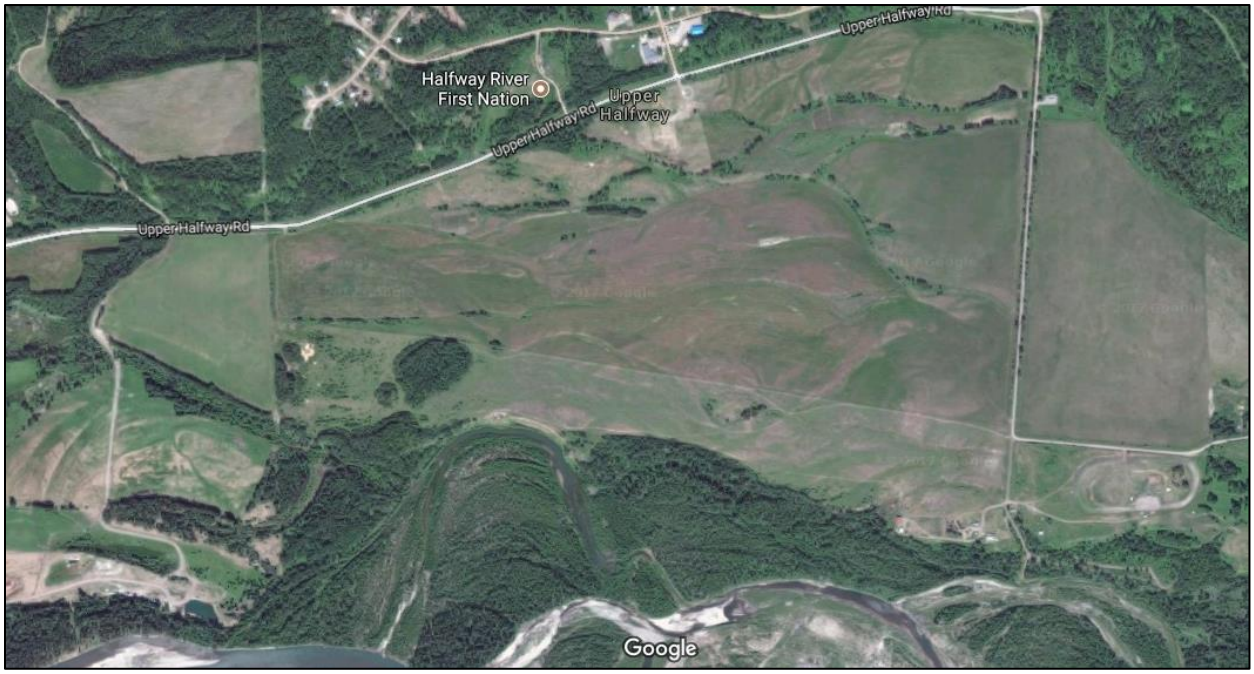

Figure 2. Air photo image of HRFN study area showing the community at the top of the figure and the Halfway River at the bottom (2017, Google Maps image). Note the abandoned channels, point bars and scroll bars along the Halfway River and remnant channel scars and longitudinal bars on the alluvial terraces south of the community

Glaciofluvial benches are separated from alluvial terraces by relatively steep slopes mapped as colluvial slopes (grey areas on Figure 1). The uppermost benches are typically 50 to 75 m higher than the alluvial terraces. Locally, such as in the area directly south of the HRFN community, Mathews (1979) also mapped colluvial slopes along the boundary between different levels of alluvial terraces (Figure 1). Above the glaciofluvial terraces, the surficial deposits are dominated by glacial deposits (green on Figure 1) or by till with a glaciolacustrine veneer (stippled green). Mathews mapped a shoreline of Glacial Lake Peace in these latter deposits several kilometres west of the study area at elevations of about 700 to 730 m. These types of surficial deposits are unlikely to host any significant groundwater resources.

Figure 3. Alluvial terrace gravels several kilometres west of the HRFN community. The gravels are pebble to cobble sized, mostly dry and moderately well stratified.

Bedrock Geology

The bedrock geology of the study area is shown in Figure 4, based on a regional bedrock geology map of northeast British Columbia (Okulitch et al., 2002). The map indicates that a relatively narrow belt of Sikanni Formation cuts through the west side of the study area and separates Sully Formation to the east from the Buckinghorse Formation to the west. The Sikanni Formation is mainly a fine-grained grey sandstone with lesser siltstone and shale whereas the Sully and Buckinghorse formations are mainly marine shale and siltstone with minor sandstone. Four water wells from the BC WELLS database are shown on Figure 4. The two wells overlying the Sikanni Formation both produced water while those over the Sully formation were all dry.

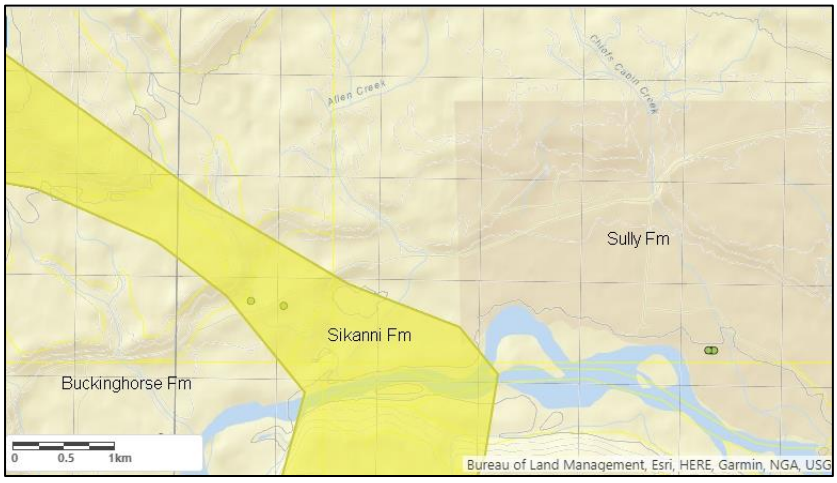

Figure 4. Bedrock geology of the study region. Dots are water wells in the BC WELLS database. Note that the two wells overlying the Sikanni Formation both produced water while those over the Sully formation were all dry.

Available water well and aquifer information in the region

There are several water wells in the region of the HRFN reserve that provide relevant information on the local subsurface geology (Figure 5). Five of these wells are shown on Figure 5 which also shows an outline of the Halfway River aquifer as mapped by the BC Ministry of Environment (2011).

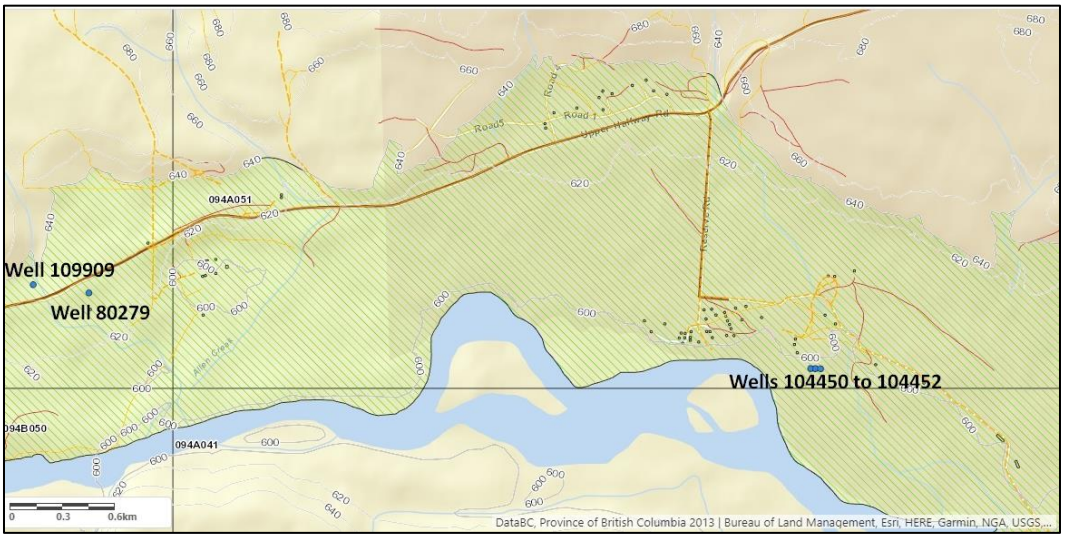

Figure 5. Eastern part of the Halfway River aquifer and water well locations in the study area.

Aquifer description

The Halfway River aquifer (aquifer reference # 0908) is described as an unconsolidated aquifer about 22.9 square kilometres in size (Figure 5). The southern aquifer boundary is defined as the Halfway River bank and the northern boundary as a topographic break in slope between the valley and the plateau to the north (BC Ministry of Environment, 2011). However, the northern boundary is mapped along the 640-m contour rather than along the main break in slope. Terrace deposits, consisting of gravel sheets less than 20 m (65 ft) thick covered with sand and/or silt, dominate the aquifer. The area is covered with thin, low permeable clay and silt but windows of high permeable sand occur in some places. Three of the 5 wells recorded in the aquifer do not have a confining layer.

The aquifer is described as moderately productive and moderately vulnerable (BC Ministry of Environment, 2011). The following statistics are based on an analysis of only 5 wells and all means are geometric (which dampens the effect of anomalous values). Reported well yields range from 0.6 to 0.9 L/s (10 to 15 US gpm) with a mean of 0.69 L/s (12 US gpm) and median of 0.76 L/s (11 US gpm). The mean depth to static water level is 7.6 m (25 feet); the median is 5.5 m (18 ft) and the range is 4.9 to 22.6 m (16 to 74 ft). The thickness of the confining layer in the well records ranges from 0 to 7.6 m (0 to 25 feet) with an average of 1.8 m (6 ft) but a geometric mean of only 0.2 m (0.6 ft). However, low permeability surface clay was identified in only 2 wells while gravels and sands were identified in 3, indicating that the aquifer has “windows” of highly permeable sediments and thus is moderately vulnerable. Well density in the aquifer is very low (0.17 wells/ km^2) and all reported wells are domestic. The five water wells have a mean depth of 11.9 m (39 ft), median depth of 12.5 m (41 ft) and range from 4.5 to 28.3 m (15 to 93 ft) deep. Only one well encountered bedrock (at 6.4 m or 21 ft). Two bedrock wells are reported just above the aquifer boundary.

The direction of groundwater flow is eastward, following the topographic gradient. Cross-sections indicate that the Halfway River recharges the aquifer in the west whereas the aquifer appears to feed the river in the east. Precipitation is another source of recharge and creeks flowing off the plateau to the north, such as Chief's Cabin Creek and Alley Creek (Figure 4), also likely provide fresh water to the aquifer (BC Ministry of Environment, 2011).

Existing Water wells

A summary of water well lithology logs in the study region is provided in Table 1. Lithologic logs from these water wells have been plotted on the closest EM resistivity cross-sections, the locations of which are shown in Figure 6 (UTM coordinates are shown on the top and left sides of Figure 6).

well 80279			
From (ft)	To (ft)	m	
0	12	3.7	silt and sand
12	42	12.8	gravel
42	45	13.7	sand, gravel, water
45	55	16.8	very soft sand and clay
55	70	21.3	dark gumbo clay
70	85	25.9	gravel and sand
85	90	27.4	sand and gravel
90	93	28.3	clay

Well 109909			
From (ft)	To (ft)	m	
0	12	3.7	very soft, brown
12	69	21.0	gravel and sand, dry, brown
69	85	25.9	very soft, dry, wet at 66.5 ft (20.3 m), brown
85	98	29.9	very soft, grey
98	104	31.7	sand with clay and gravel, wet, black
104	122	37.2	sand with some gravel, wet, grey
122	135	41.1	hard, wet, fractured, grey, 14 gal/minute

well 104450			
From (ft)	To (ft)	To (m)	
0	2	0.6	top soil
2	18	5.5	sand and gravel
18	80	24.4	cased
80	160	48.8	open hole

well 104451			
From (ft)	To (ft)	To (m)	
0	2	0.6	topsoil
2	18	5.5	silty sand (moist)
18	24	7.3	silty clay
24	29	8.8	clay silt
29	45	13.7	silty gravel
45	54	16.5	grey silt
54	89	27.1	silty gravels
89	360	109.7	siltstone
Note: Dry hole; produced some methane gas			

well 104452			
From (ft)	To (ft)	To (m)	
0	2	0.6	topsoil
2	12	3.7	dirty gravel
12	16	4.9	sand and gravels (water-bearing)
16	92	28.0	till
92	120	36.6	dirty gravels (dry)
120	132	40.2	sand (dry)
132	145	44.2	sand and gravels (dry)
145	154	46.9	clay
154	240	73.2	shale
Note: Dry hole			

well 75512			
From (ft)	To (ft)	To (m)	
0	58	17.7	clay
58	80	24.4	sandstone and shale, 7 gals/min

well 80281			
From (ft)	To (ft)	To (m)	
0	40	12.2	clay
40	100	30.5	shale, water, 5 gals/min

well 98361			
From (ft)	To (ft)	To (m)	
0	17	5.2	soft, brown
17	22	6.7	medium clay with boulders, brown
22	30	9.1	hard, brown
30	120	36.6	bedrock, hard, 3 gals/min, fracture at 86 ft (26.2 m)

well 102672			
From (ft)	To (ft)	To (m)	
0	30	9.1	gravel and sand
30	34	10.4	medium, water, grey
34	41	12.5	medium, grey shale and gravel

Table 3. Water well logs in the study region (records from BC Ministry of Environment WELLS database)

The two wells in the study area that are geologically most similar to the HRFN community area occur about 3 km west-southwest of the community near a western tributary to Allen Creek (wells 80279 and 109909, Figure 5). The wells occur on a terrace near the upper margin of the Halfway River aquifer at about the same elevation and topographic position as the HRFN community. Both wells have reasonably good lithology logs and they are plotted on EM resistivity cross-section (Figure 7). The log for well 80279, drilled in 1999, records 3.7 m of silt and sand overlying gravel and sand to a depth of 13.7 m, the lower metre being wet. These sediments are underlain by clay and sand to about 21 m depth and an additional 6 m of gravels and sands. The well base is in about 1 m of clay at 28.3 m (93 ft). The lower 6 m (74-93 ft) of the well was screened and produced 0.69 L/s (11 US gpm). Well number 109909 was drilled

recently (August, 2014) and shows about 7 m of basal wet sands with some gravel overlying presumed bedrock (described as hard, wet, fractured) that produced 14 gal/minute over a screened interval of 37-43 m (122-135 ft) depth. Both wells had a static water level of about 22 m. The lower sands and gravels were also reported to be wet from about 30 to 37 m whereas the overlying units of gravel, sand and silt were dry except for one wet unit at about 20 m depth.

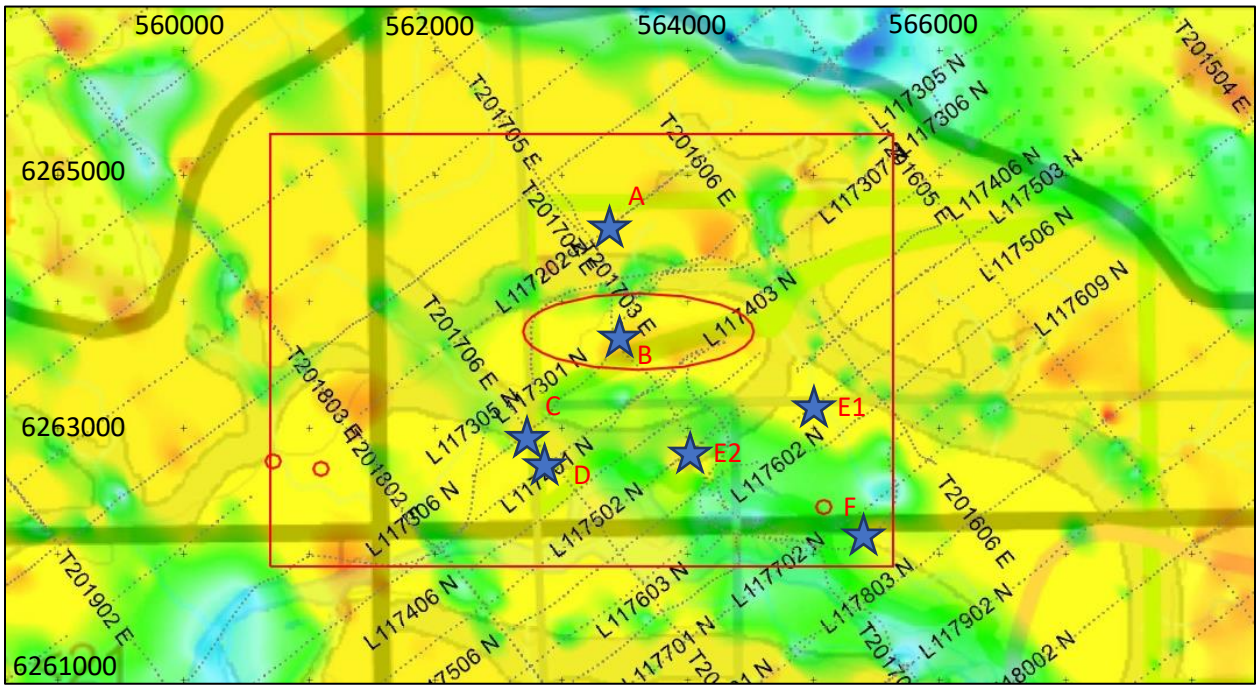

Figure 6. Location of EM flight lines overlain on the 10-15 m EM depth slice. The red circle outlines the area of the HRFN community and the red box outlines the primary study area. UTM easting and northing coordinates are shown on the top and left sides of the figure, respectively. Stars show target water well locations A to F.

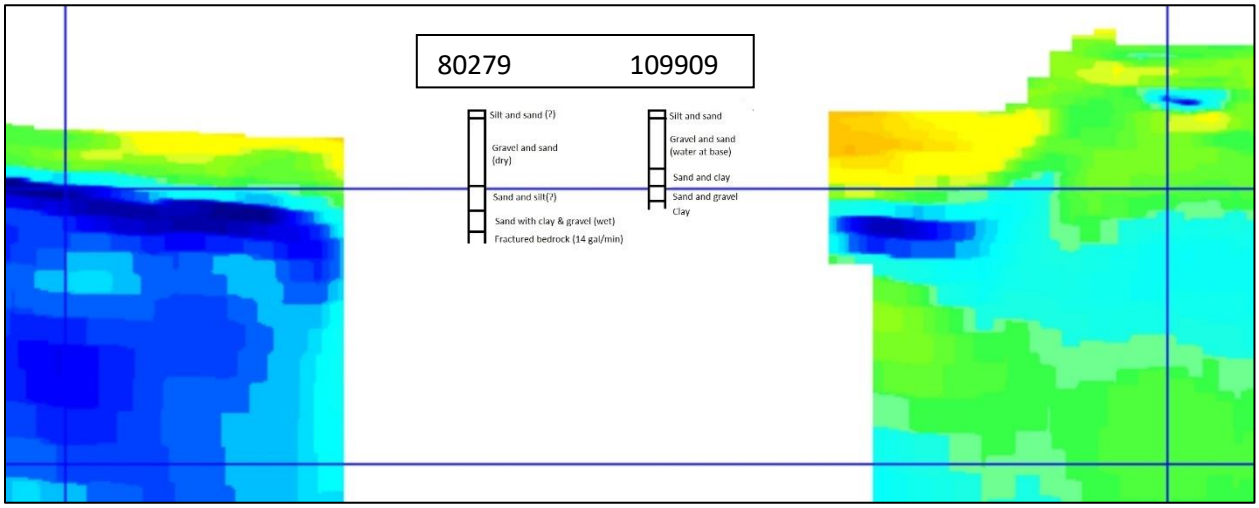

Figure 7. Lithology logs for water wells 80279 (left) and 109909 (right) plotted on EM cross-section L117202N.

Lithologic logs for water wells 80279 and 109909 are plotted on EM Line 117202N (Figure 7). Although there is a gap in the EM Line at the locations of the wells, the base of the sand and gravel sequence in

both wells corresponds reasonably well with the base of the more resistive units shown on both sides of the gap in the cross-section L117202N (Figure 7).

Three closely spaced water wells on the HRFN reserve were drilled close to the river by the former Department of Indian Affairs in late September, 1983 (Figure 5). All three wells were reported to be dry although moist or water-bearing sands and gravels were noted at shallow depths up to 5.5 m (18 ft). Original well records and lithologic logs for wells 104451 and 104452 were obtained from the Ministry of Environment as only incomplete logs were available in the WELLS database. The lithologic log for well 104451 (Table 1) records moist silty sand to 5.5 m depth, clay and silt to 8.8 m and mainly silty gravel to 27.1 m except for one silt bed from 13.7-16.5 m. The lower 82.6 m, to a bottom hole depth of 109.7 m, were in siltstone that produced some methane gas. The log for well 104452 (Table 1) records gravels and sands to 4.9 m depth (with the lower metre water-bearing) underlain by till to a depth of 28 m, dry sands and gravels to 44 m, clay to 47 m and then shale to the bottom of the hole at 73.2 m. Water wells 104451 and 104452 are plotted on EM Line 117701 in Figure 8. The two wells are plotted together as they are only 30 m apart. The uppermost unit of moderate resistivity corresponds to silty sands, clays and silty gravels in well 104451 and to a thin sand and gravel unit overlying till in well 104452. The lower resistivity zone on the EM section corresponds mainly to shale and siltstone as well as some clay, silt and till. However, some silty gravels and sub-till sand and gravels also show low resistivity. Interestingly, the two wells show significant differences even though they were drilled only 30 m apart within a few days of each other by the same drilling company.

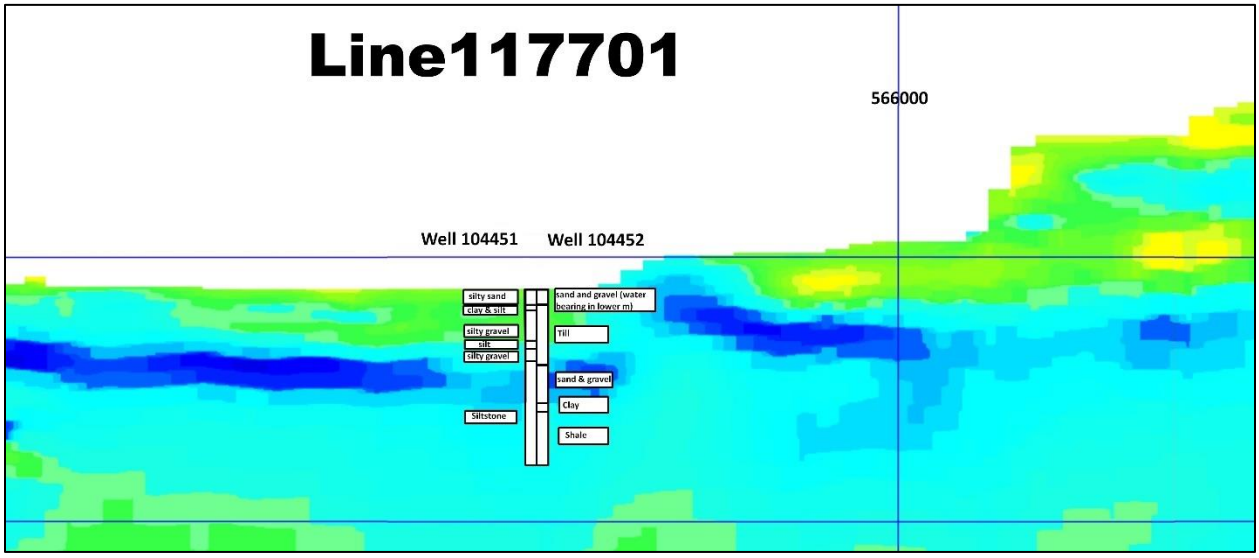

Figure 8. Lithologic logs for water wells 104451 and 104452 plotted on EM Line 117701

Other water wells in the general region are shown on Figure 9. These include three wells several kilometres northeast of the HRFN community on the northern margin of the uppermost glaciofluvial bench. Two of these wells, 75512 and 80281 (drilled in 1996 and 1999, respectively), are very close to one another and show similar lithologic logs. About 17.7 m of clay overlies sandstone and shale yielding 0.44L/s (7 gpm) with a static water level of 2.4 m in well 75512 and in well 80281, slightly closer to the valley side, 12.2 m of clay overlies about 18 m of shale yielding 0.31 L/s (5 gpm) with static water level at 6.7 m. A third well (98361) was more recently (2008) drilled higher up on the valley side in an area mapped as till with a veneer of glaciolacustrine sediments. The well log shows, as expected, about 5 m

of soft sediments (likely glaciolacustrine silts) underlain by clay with boulders interpreted to be till to a depth of about 9 m. Hard bedrock was then encountered to a depth of 36.6 m with fractures noted at about 26 m. The bedrock produced 0.19 L/s (3 gpm) and static water level was recorded at 5.2 m. The wells are plotted on EM Line 118001 (Figure 10).

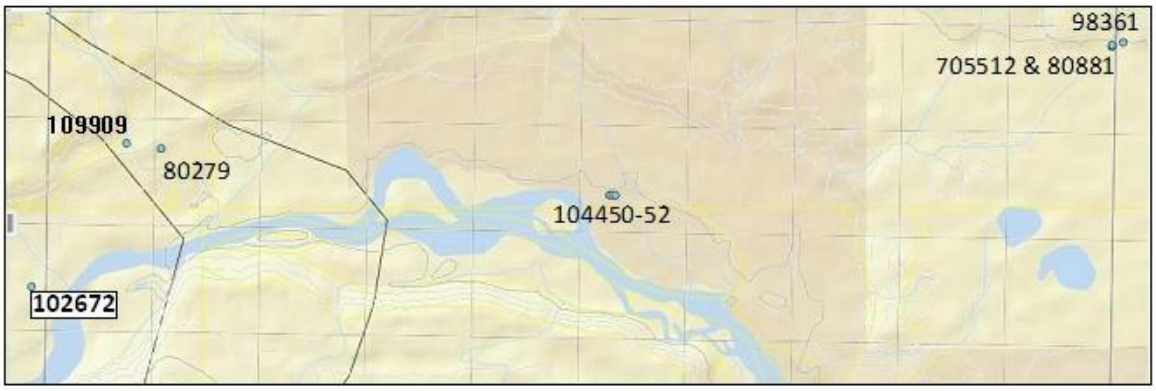

Figure 9. All recorded water wells in the study region and surrounding areas

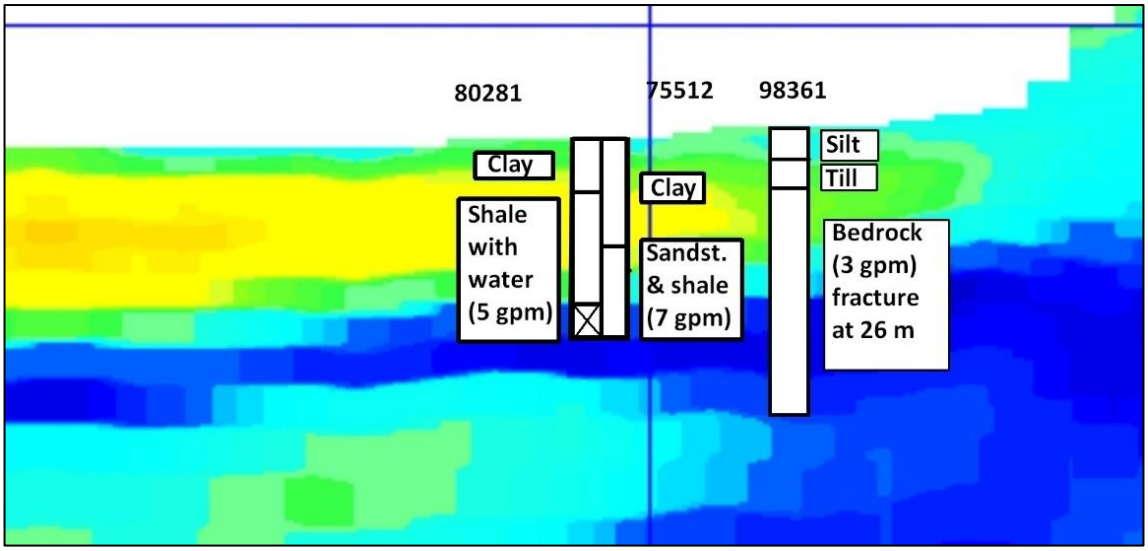

Figure 10. Lithologic logs for water wells 80281, 75512 and 98361 plotted on EM Line 118001.

The only other recorded well in the area is well # 102672, located about 4.5 km southwest of the HRFN community close to the Halfway River on a relatively low alluvial terrace (Figure 9). The lithologic log for the well, drilled in 1989, is incomplete but shows about 9 m of sand and gravel overlying shale. Water was encountered at about 10 m depth but a well yield was not provided. The static water level was reported to be about 5.5 m. The 9 m of terrace sands and gravels in this area corresponds well with an estimated thickness of 8 m of moderately resistive materials on nearby EM sections (e.g. Line 117301).

Discussion of EM Cross-sections and Potential water well target horizons

A location map of AEM lines flown over the study area overlain on an air photo image is provided in Figure 11. The locations of the EM resistivity cross-sections are also shown on Figure 6 where UTM coordinates are also available.

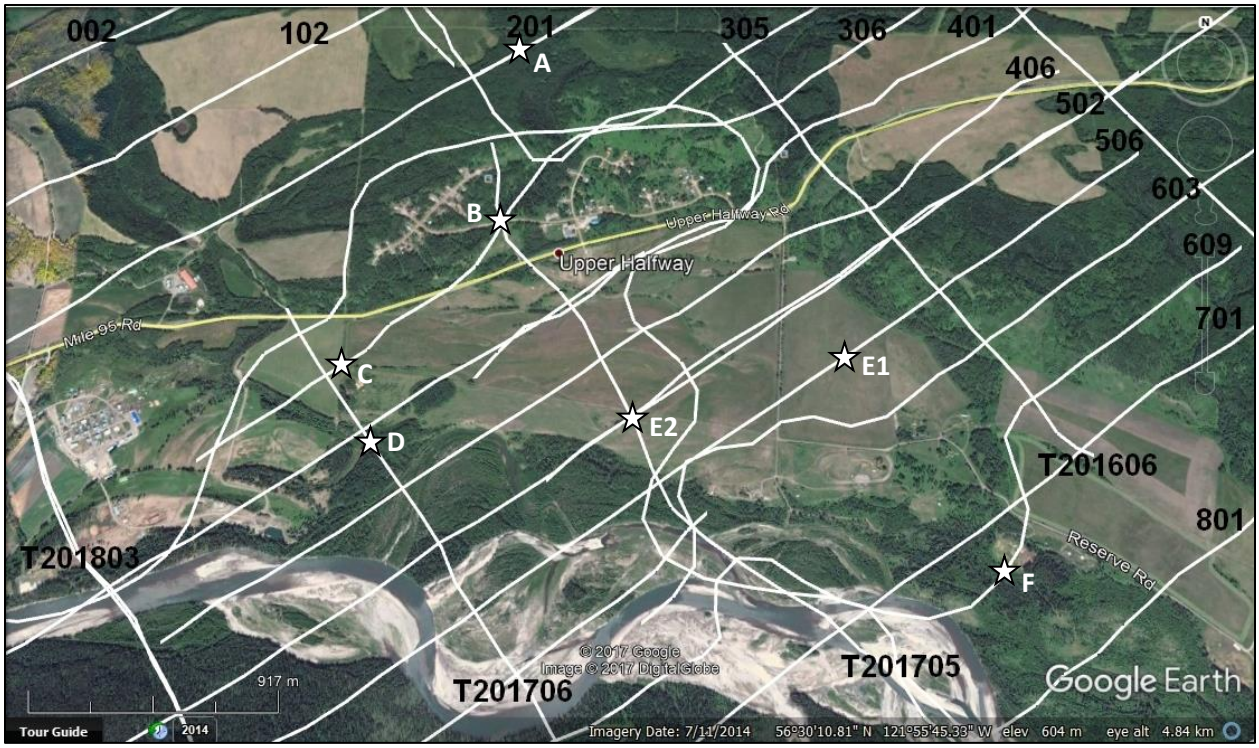

Figure 11. Location map of AEM lines flown over the study area and proposed drill targets (A-F). The erratic flight paths along some lines were necessary to avoid developed areas. Note that the density of flight lines in the study area is approximately double that in the regional survey.

A series of representative northeast-trending EM resistivity cross-sections are provided in Figures 12 to 14. Figure 12 shows four EM resistivity cross-sections in the northwest part of the study area extending downslope to the southwest from the high bench northeast of the HRFN community. Figures 12 and 13 each show three EM resistivity cross-sections in the central and southeast parts of the study area, respectively. Benches east of the HRFN community are shown on the right side of all the cross-sections in Figures 12 and 13. Three EM resistivity cross-sections along southeast-trending tie lines in the study area are shown on Figure 15. Glaciofluvial benches and upland areas east and north of the HRFN community are illustrated as well as lines from near the HRFN community to south of the river.

Till covered uplands and high glaciofluvial benches

The northeast (right) sides of cross-sections 117102 and 117201 (Figure 12) show upland areas north of the HRFN community. Low resistivity materials, close to the surface on the upland, are interpreted to be Sully Formation shales, with a thin cover of till and likely some localized, resistive glaciofluvial deposits. Relatively high (>650 m) glaciofluvial benches are shown on all the cross-section in Figure 12. They are capped with about 20-30 m of moderately high to high resistivity sandstone or silts and fine sands similar to the sediments encountered in the upper 30 m at sonic hole 7 (Levson and Best, 2017a), located in the same surficial geology map unit and at a similar elevation (Figure 1). Although these resistive materials likely have low permeability, one potential target for a water well has been identified on the glaciofluvial bench above the HRFN community at about 563500E on Line 117201 (Target A, Figure 12).

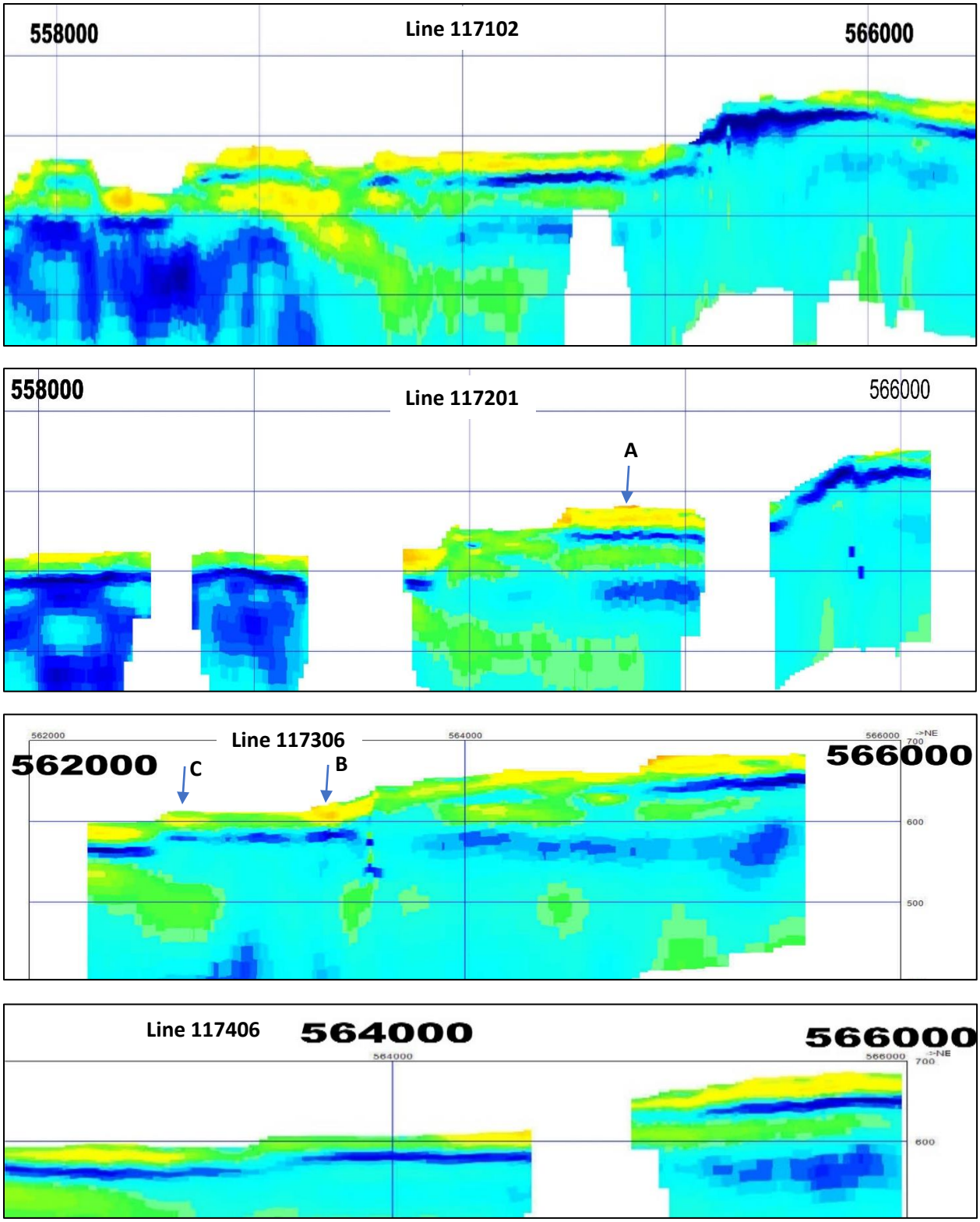

Figure 12. Northeast-trending EM sections in the northwest part of the study area: High bench northeast of the HRFN community is shown on the right side of each figure; view towards the northwest; vertical scale on all figures is about 1:5000 (2 cm = 100 m); horizontal scales shown.

High alluvial terraces

The alluvial terrace that the HRFN community is built on is relatively high compared to other alluvial terraces in the area but it occurs at a lower elevation (about 625 m) than the high glaciofluvial benches. This terrace was an original target for a water well because of its proximity to the community and because about 7 m of highly resistive (200-300 ohm-m) sediments, interpreted to be gravels and sands, were underlain by about 20 m of moderately resistive sediments (50-78 ohm-m), inferred to be silts and sands with some clay. These sediments were in turn underlain by a low resistivity section (<20 ohm-m) interpreted as shale bedrock, possibly fractured in the upper several metres (Levson and Best, 2017b). By comparison with water wells 80279 and 109909, which occur on a similar geological unit (see discussion above), the uppermost gravels were considered to be likely dry but the base of the silt and sand unit and underlying fractured bedrock were considered to be potential water-bearing horizons (Levson and Best, 2017b). However, according to information provided by the HRFN, a well drilled at the site (about 200 m east of site B on Line 117306, Figure 12) encountered "gravel/mud" to about 8.5 m (28 ft) "sitting on sandstone". Thus, the unit inferred to be silts and sands from about 7 to 27 m depth, appears to be sandstone. This result was unexpected as the uppermost resistive unit (yellow zone on Figure 12) occurs only on the alluvial bench and does not extend underneath the adjacent glaciofluvial bench. However, a slightly resistive unit (green on Figure 12) does occur discontinuously at about the same elevation under the alluvial bench suggesting that the HRFN terrace is a bedrock (strath) terrace with a comparatively thin gravel cap. The pronounced resistivity contrast between the terrace bedrock and the bedrock buried under the glaciofluvial bench (as indicated by the sharp yellow to green transition on Lines 117201 and 117306 on Figure 12, and all the lines on Figure 13) needs explanation. A possible explanation is that the terrace sands and gravels are resistive enough that, when averaged with the underlying bedrock, they produce a higher average resistivity value compared to the case where there is no overlying sand and gravel bed.

In contrast to the preceding, lithologic logs from water wells 80279 and 109909 (Figure 7, Table 1) clearly indicate that up to at least 37 m of mainly gravels and sands can occur locally on these alluvial terraces. For this reason, we have selected 3 potential well targets (targets B, C and E, Figures 12 and 13) on these high terraces. Target B is located near the intersection of Line 117306 and Tie Line T201705. Target B is just east of the intersection of Line 117306 and Tie Line T201706. Target C is just east of the intersection of EM Lines 117306 (Figure 12) and T201706 (Figure 15). Target E1 is located at about 6262805N on Line T201705. Target E2 is a lower priority alternate option for E1; it is located on a slightly lower terrace level than E1 and closer the community (6262805N on T201705), but is near to the terrace edge and the resistive zone is shallow. All of the targets are in resistive materials but, as discussed in the preceding paragraph, it is not possible to determine if they are in sands and gravels or sandstone. The former is preferred as the sandstones in the region are tight and have low permeability unless well fractured. One disadvantage of these alluvial terraces is that they generally slope towards the river and therefore may drain relatively freely suggesting low productivity depending on the rate of recharge. A gravel pit on the same terrace level as target D, on Reserve Road about 2 km to the southwest, shows ponded water on the east side of the pit suggesting that, at least locally, the gravels are water-bearing.

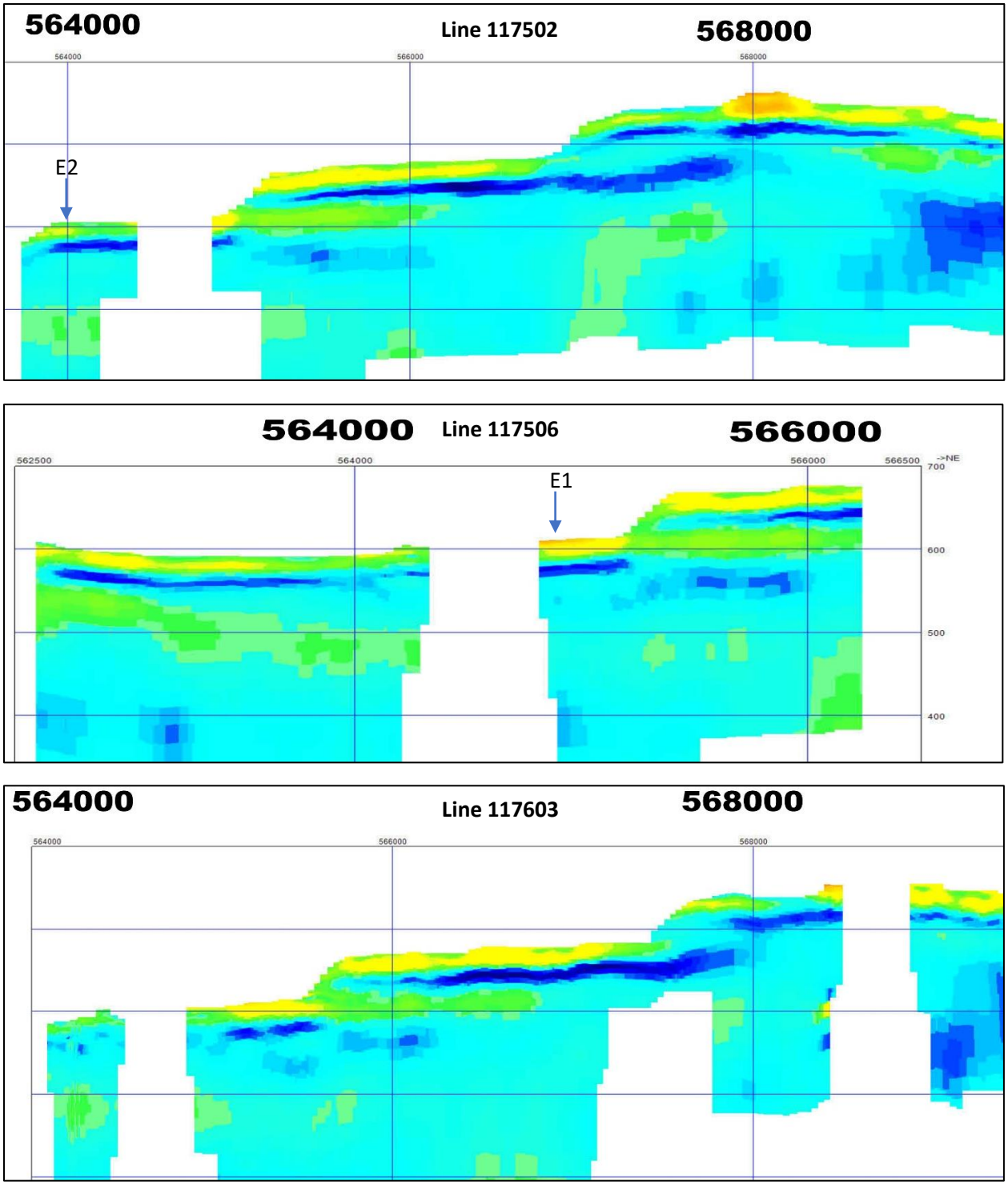

Figure 13. Northeast-trending EM sections in the central part of the study area: Upland areas and high glaciofluvial benches east of the HRFN community are shown on the right side of the figure; view towards the northwest; vertical scale on all sections is about 1:5000 (2 cm = 100 m); horizontal scales shown

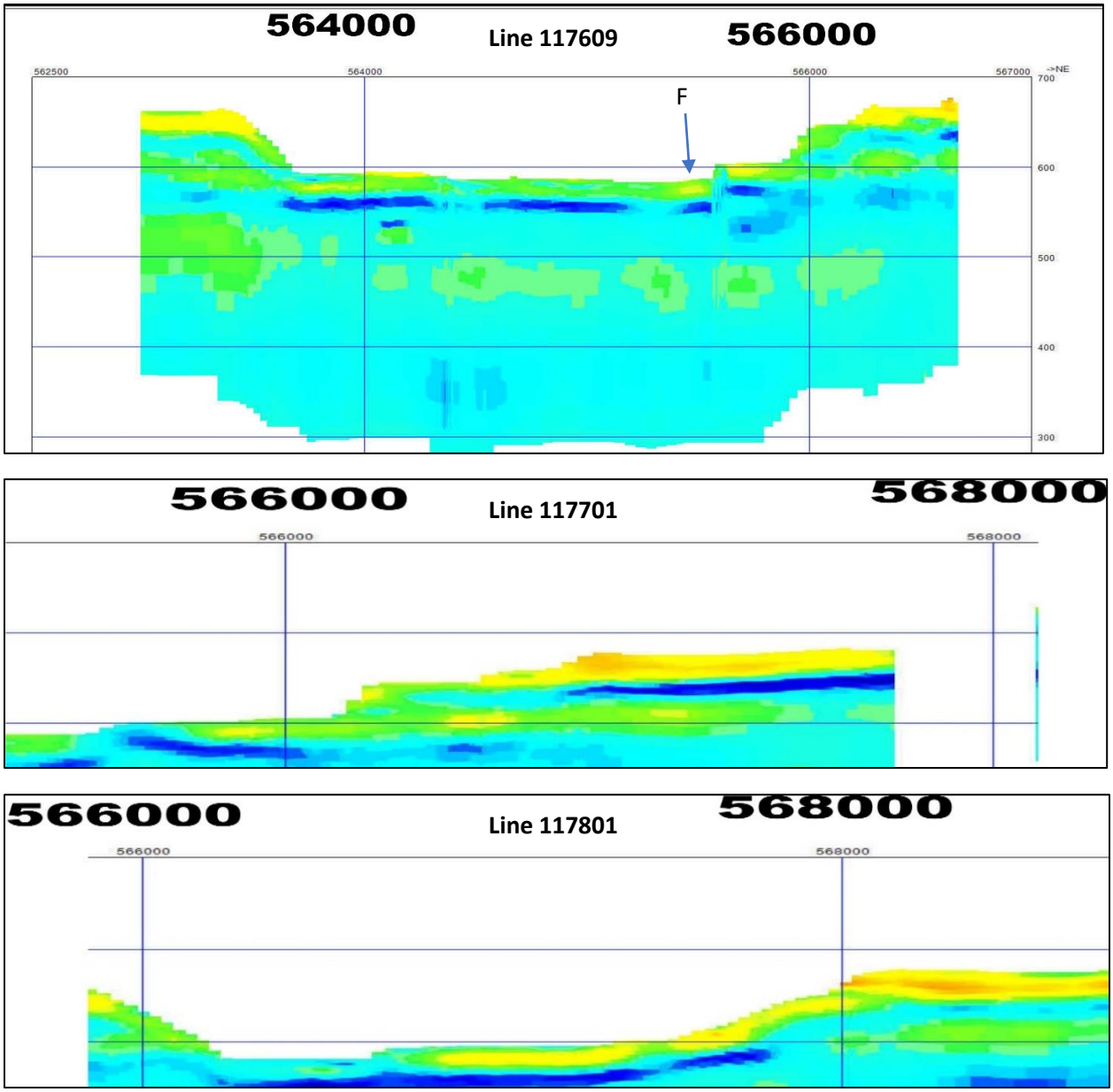

Figure 14. Northeast-trending EM sections in the southeast part of the study area: Benches east of the HRFN community are shown on the right side of each figure; view towards the northwest; vertical scale on all figures is about 1:5000 (2 cm = 100 m); horizontal scales shown

Low alluvial terraces

EM sections through low alluvial terraces can be seen on the southwest (left side) of lines 117306 and 117406 (Figure 12), 117506 (Figure 13) and 117701 (Figure 14). Complete sections across the Halfway River alluvial floodplain are presented on Lines 117609, 117801 (Figure 14) T201705, and T201706 (Figure 15). Two potential water well targets have been identified in low terrace settings: Target D occurs at about 6262650N on Tie Line 201706 (Figure 15) near the junction with Line 117403 at about 363000E. Target F occurs at about 565500E on Line 117609 (Figure 14). Two other possible targets just outside the study area include low terrace locations at about 566000E on Line 117701 and 567000E on Line 117801. Targets on low terraces have the highest risk of groundwater contamination from

upstream sources whereas targets on slightly higher terraces appear to be recharged mainly from the upper terraces. Low terraces are also subject to flooding and channel erosion. Targets E and F have been selected in locations that appear to be relatively stable and far enough away from the river to minimize surface contamination from upstream sources.

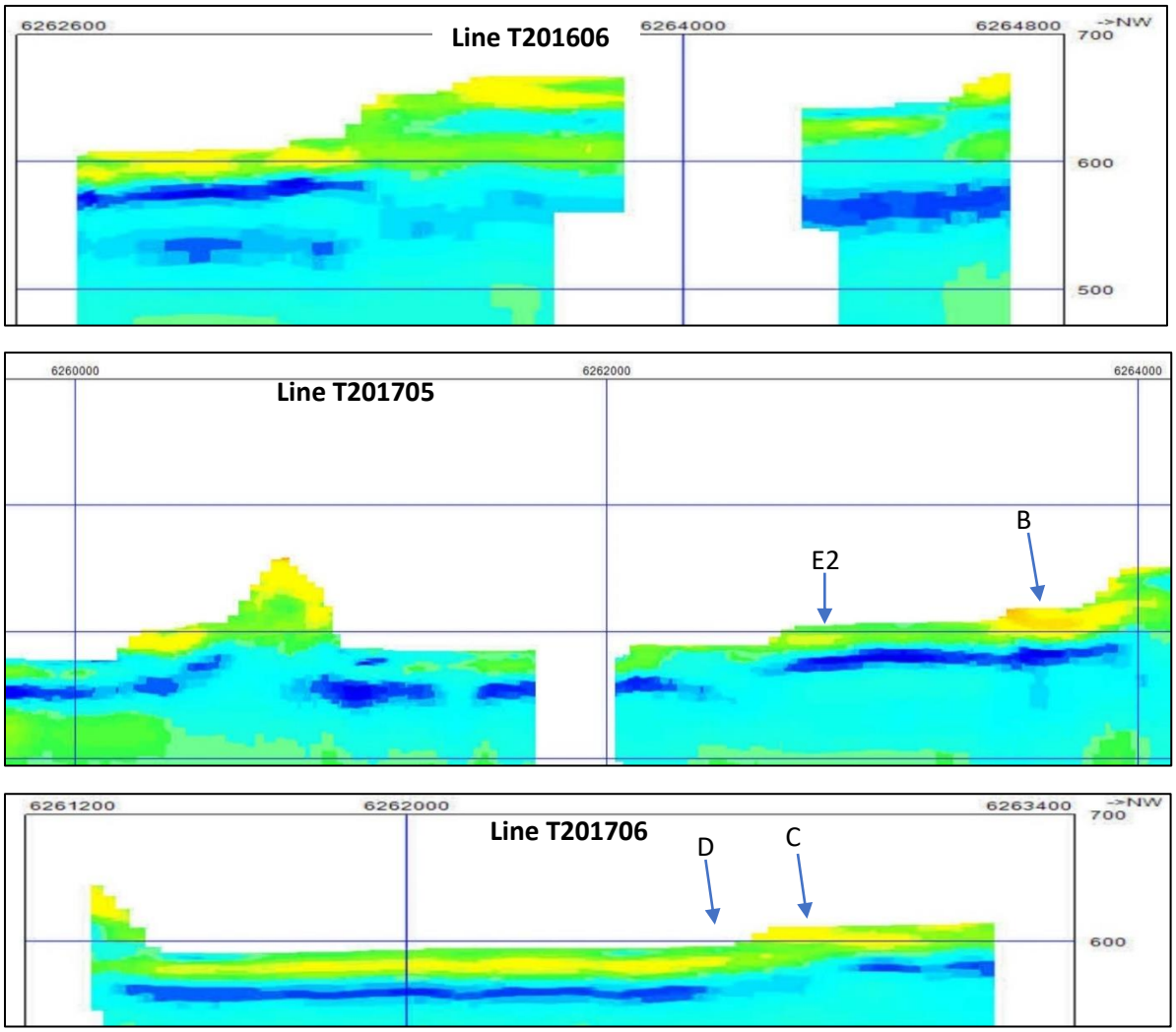

Figure 15. Southeast-trending EM sections (tie lines) in the study area: Line T201606 shows glaciofluvial benches east of HRFN community; Line T201705 extends from just north of the HRFN community to south of the river. Line T201706 is southwest of the community and extends to the south side of the river); vertical scale on all figures is about 1:4000 (2.5 cm = 100 m); horizontal scales as shown; view towards the southwest (NW on the right, SE on the left)

Depth Slices

Four EM resistivity depth slices are provided in Figures 16 and 17. The 5-10 m and 10-15 m depth slices (Figure 16) are quite similar and both show several high resistivity areas (orange to red in color) on the glaciofluvial bench above the HRFN. Most of these areas are relatively shallow and few remain visible on the deeper depth slices. The main exceptions are a few locations in southeast of the study area (>4 km from the community). These locations were investigated on the EM resistivity sections and on topographic maps and the most pronounced areas occur on topographic promontories and are most likely resistant sandstones with a thin glaciofluvial mantle. Also, the sites are fed by relatively small

drainage areas so recharge is likely small. None of these areas are recommended as water well drill targets. However, one high resistivity location occurs in the HRFN community on the high alluvial terrace at about 6263750N on Line T201705E. The site shows a high resistivity zone on the 10-15 and 15-20 m depth slices (Figure 16) and as a small, moderately high resistivity zone on the 20-30 and 30-40 m depth slides (Figure 17). The area is highlighted with a small red circle on Figures 16 and 17 and identified as target A. Although the high resistivity may simply be dry gravels overlying bedrock (see discussion above under high alluvial terraces), the area has the advantage of being at the mouth of an unnamed intermittent channel draining from the upland to the north of the community. This channel has a relatively small drainage area but is a potential source of recharge for the alluvial terrace.

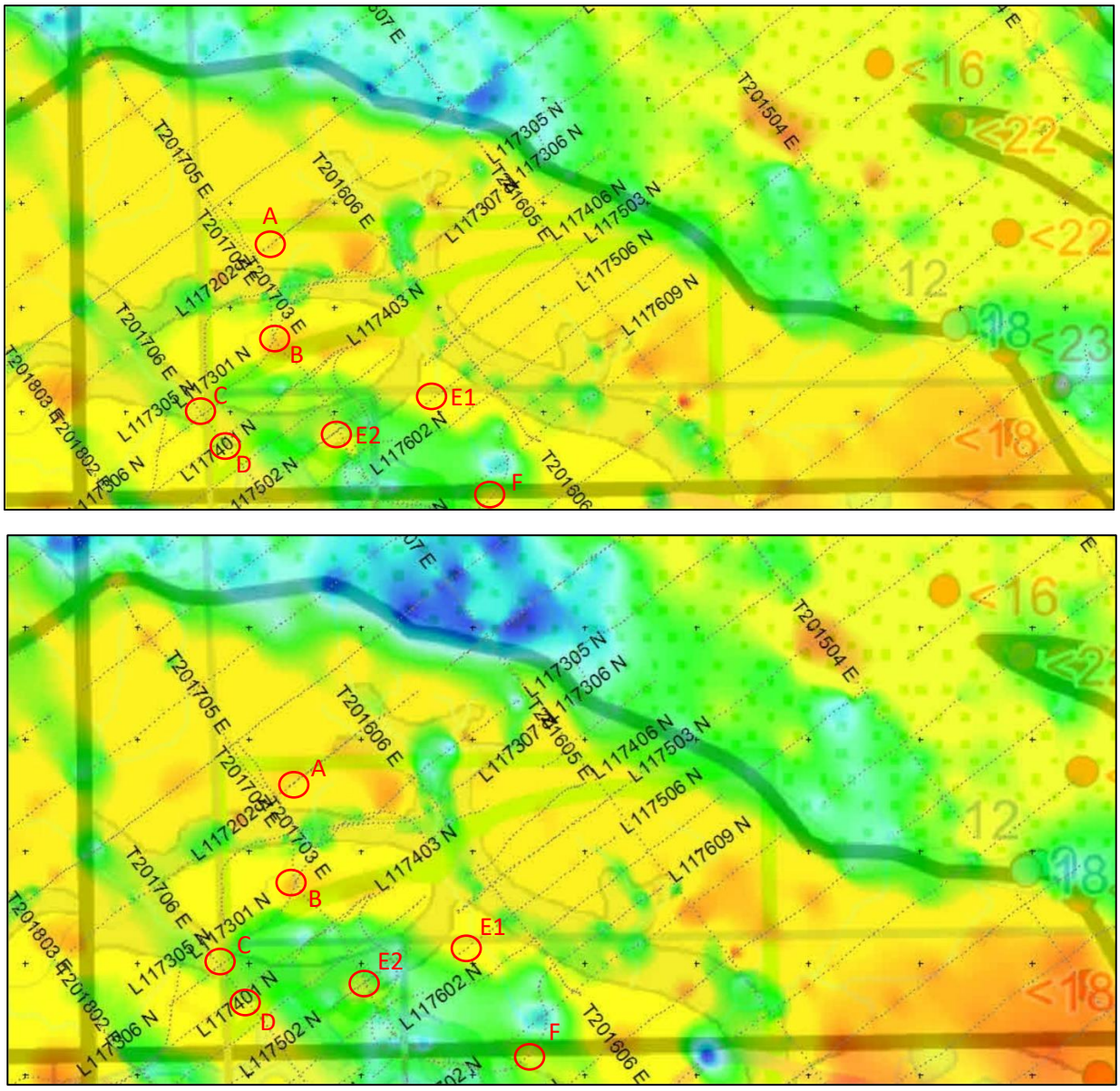

Figure 16. EM resistivity depth slices in the study area (top: 10-15 m; bottom 15-20 m) area and proposed drill targets (A-F)

The 20-30 and 30-40 m resistivity depth slices show an interesting pattern of moderately resistive zones that form a broad convex curve that approximately parallels the shape of the northern margin of the mapped paleovalley (dark curved line in the background of the images). This area of higher resistivity may reflect an old channel within the paleovalley and the relatively narrow, moderately resistive zone apparent on the 30-40 m depth slice may be the thalweg (deepest part) of the paleochannel. If so, target A lies within the thalweg of the paleochannel (although the possibility that this is a sandstone unit can't be ruled out).

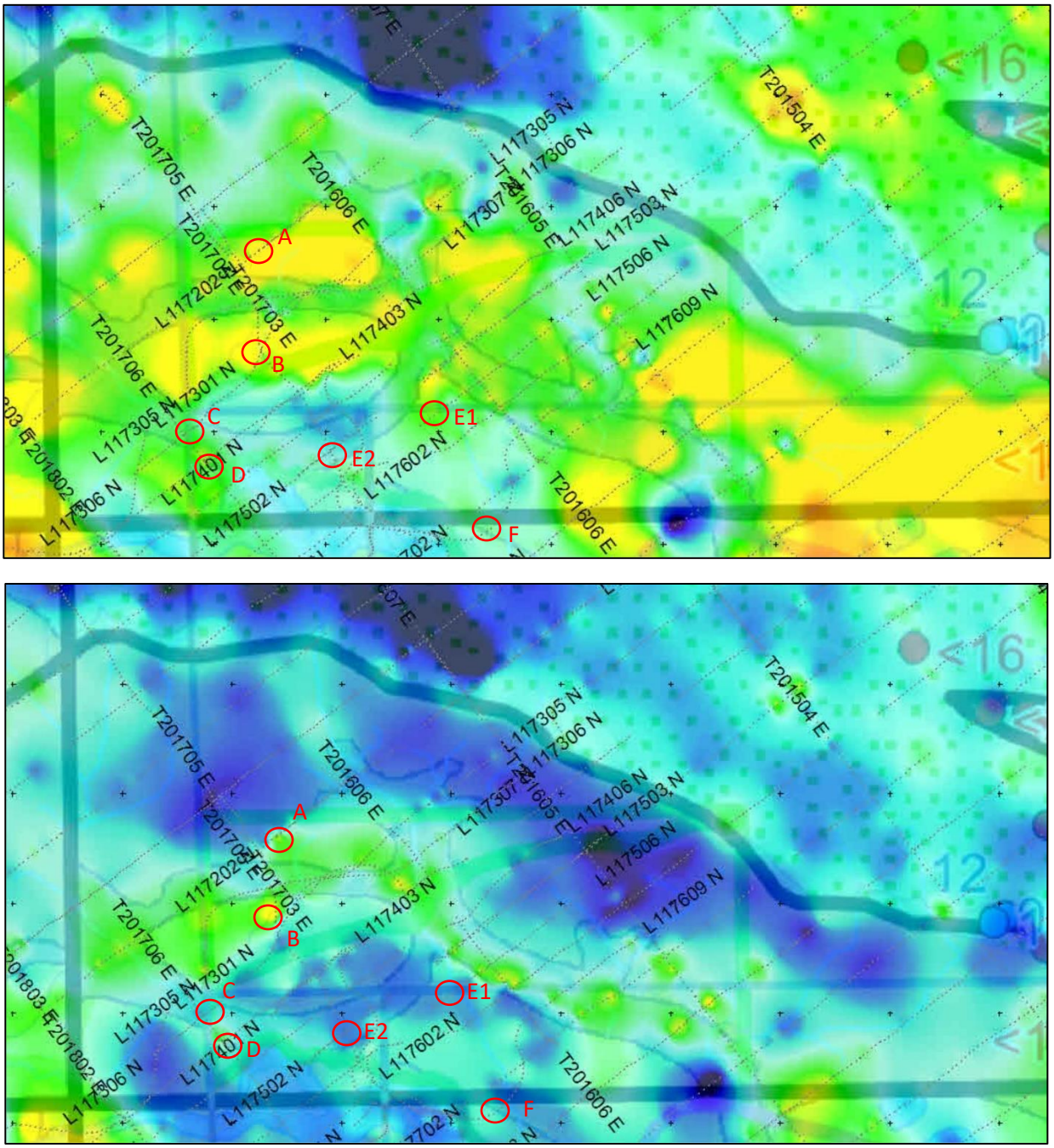

Figure 17. EM resistivity depth slices in the study area (top: 20-30 m; bottom 30-40 m) area and proposed drill targets (A-F)

Most other potential moderate resistivity targets on the 20-30 and 30-40 m depth slices occur above the alluvial terraces either on the slope rising up to the glaciofluvial bench or on the bench itself. The targets are interpreted to be mainly thin glaciofluvial sediments overlying sandstone and they are considered to have low aquifer potential.

Summary of water well targets

In the preceding sections a number of potential targets have been identified and discussed. Each of these is summarized here, organized by proximity to the HRFN community (except target B which is in the community). Table 2 provides UTM locations, a summary and the nearest EM resistivity line for each target.

Target	Easting	Northing	Advantages	Disdadvantages	Nearest EM Line
A	563500	6264720	Just N of community; resistive to ~25 m depth; potential recharge from uplands to the N; deeper bedrock targets at ~75 m and ~175 m	target zone may be tight sandstone or low permeability sands	117201
B	563390	6263750	In community; road access; resistive to ~35 m depth; potential recharge from bench to the N and intermittent channel	target zone may be tight sandstone	117306
C	562760	6263020	alluvial terrace; ~1.3 km from community; good access; resistive to ~25 m depth; also a deeper bedrock target at ~100-150 m depth	target zone may be tight sandstone	117306
D	562945	6262670	low alluvial terrace; ~1.34 km from community; access nearby; recharge from Allen Creek drainage likely	close to modern river; some potential for contamination from surface water sources; resistive to <20 m depth	T201706
E1	564865	6263100	high alluvial terrace; open field; ~1.4 km from the HRFN community; possible recharge from Chiefs Cabin Creek	high (potentially dry) terrace; sands and gravels may be thin; may be tight sandstone at depth; resistive to <20 m depth	117506
E2	564020	6262805	intermediate alluvial terrace; slightly lower elevation than E1 terrace; open field; ~1 km from the HRFN community; also a deeper bedrock target at ~100-150 m depth	near terrace margin (may be free draining); sands and gravels likely thin; may be tight sandstone at depth; resistive to <20 m depth	T201705
F	565500	6262225	low alluvial terrace; no signs of recent channel activity; resistive sediments potentiallyto ~25 m; access nearby	dry wells previously drilled about 300 m to the NW (but in low resistivity sediments); ~1.34 km from community; some potential for contamination from surface water sources	117609

Table 4. Locations (UTM Easting and Northing) of proposed drill target and advantages and disadvantages of each

A. This potential water well target occurs on the glaciofluvial bench above the HRFN community at about 563500E on Line 117201 (Figure 12). The location shows high resistivity materials from near surface to a depth of about 25 m depth. Although it is possible that these resistive materials are mainly sandstone, they may also be sands and gravels like those observed in sonic hole # 7. The location of this site, at 680 m elevation, is at a similar elevation to site # 7 (684 m) and also is in a similar geomorphic position near the northern margin of the mapped paleovalley. If the resistive materials at the site are sediments, they may be relatively fine-grained sands with low permeability as at sonic hole # 7. The uplands north of the site provide a relatively large potential source area groundwater recharge. The site is about 0.9 km northwest of the community.

B. This target is within the HRFN community and is located at about 563390N on Line 117306 (Figure 12) and about 6263750N on Line T201705E (Figure 15). The area shows moderate to high resistivity materials that appear to have good potential for hydraulic connectivity with

resistive units on the bench and upland above the target (Figure 12). The target also is apparent on all four EM depth slices (Figures 16 and 17) and is one of the deepest potential Quaternary targets in the study area. The target area occurs near an intermittent channel that drains a small area of the upland to the north. The target coincides with what may be the thalweg of a Quaternary paleochannel but the possibility that the resistive materials are sandstone and not sands and gravels, can't be ruled out.

C. This target is located on an alluvial terrace that is slightly lower in elevation than target B. It is located at about 6262890N on Line T201706 (Figure 15) close to the reserve boundary and south of 562760E on Line 117306 (Figure 12). The site is relatively close to the HRFN community (1.29 km southwest). The resistive target extends to a depth of about 25 m. A slighter better location for the site is a few hundred metres to the northwest where the resistive zone is deeper and farther from the terrace edge but this location is just outside of the reserve boundary near the intersection of line T201706 and 117306 (at about 562685E). A secondary target for the drill hole is a slightly resistive zone at about 100 to 150 m depth (Figure 12).

D. This target is located on a low alluvial terrace just southeast of target C. The site is located at about 6262670N on Tie Line T201706 on a low terrace just a few metres above river level. Although this site is just above the river elevation, it is located in a forested area about 0.5 km north of the current river bank. Sites closer to the river would likely be more productive but are more subject to river channel shifts and to potential contamination from upstream sources. The site is located on a small terrace and likely receives some recharge from the Allen Creek drainage. The location is about 1.34 km from the HRFN community.

E. Target E1 is a resistive feature located on a high alluvial terrace at about 565000 on Line 117506 (Figure 13). Like target B, it is possible that relatively thin terrace gravels overlie sandstone at this location but the resistive unit here has a distinctive channel-like geometry (Figure 13). A similar channel-like resistive feature occurs on Line 117609 at a northing of about 565600 (Figure 14). The recharge area for this location is not obvious but there may be some recharge from the drainage area of Chiefs Cabin Creek. Target E1 is located about 1.39 km from the HRFN community. Target E1 is located at about 6262805N on Line T201705. Target E2 is a lower priority alternate option for E1; it is located on a slightly lower terrace level than E1 and closer the community (about 1 km away at 6262805N on T201705). Unfortunately, the target is near to the terrace edge and the resistive zone is shallow so it not considered a high priority target.

F. This target is located on a low alluvial terrace of the Halfway River at about 565500E on Line 117609 (Figure 14). The terrace is only a few metres above river level but about 300 m northeast of the river bank. The terrace is relatively stable, well vegetated and has no signs of recent channel activity in the area of the target location. Moderate resistivity sediments occur at the site to a depth of about 25 m. The three dry wells drilled in 1983 were just west of this site but the resistivity of the sediments there (Line 117701 Figures 8 and 14) is lower than on Line 117609 (Figure 14). Sediments with similarly low resistivity occur on the low terrace crossed by EM Lines 117502/03 and 117506 but one shallow moderately resistive zone occurs on Line 117503 at about 563740E. Target F is about 2.35 km southeast of the HRFN community.

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