TOLKO Industries Ltd.

LOW ALTITUDE THERMAL IMAGERY OF THE COLDWATER RIVER

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1.0 PURPOSE

This represents a first attempt at measuring stream temperature at low altitude above the ground using a helicopter and forward- looking infrared (FLIR) camera technology. Therefore, the study was very exploratory in nature, with the following objectives:

1. To test the accuracy of aerial versus ground-measured stream temperature , and to,
2. To explore the utility of other features of aerial videographic technology to complement the existing Tolko stream temperature-monitoring project in the Coldwater River.

2.0 METHODS

We used FLIR - related articles by McIntosh (1999) and Torgersen et al (1999) to develop a helicopter flight plan and to guide use of equipment, however, no attempt was made to 'stitch' continuous thermal images of the Coldwater River as per Torgersen et al (1999).

The flight was carried out July 3, 2001 after several days of clear skies and warm weather, from approximately 2:30 pm to 3:45 pm (including shuttle time). At the time of the flight, the sky was clear and air temperature was 32°C. The helicopter was a Jet Ranger operated by Valley Helicopter equipped with an on-board GPS system and below- mounted camera that recorded continuous colour video and audio along with latitude and longitude.

Radiant heat was recorded using an infra-red (IR) ThermaCAM PM695 camera owned and operated by the Thermografix Consulting Corporation of Kelowna. Thermal images were taken along the Nicola River upstream of the confluence with the Coldwater River and the Coldwater River from the mouth upstream to Brook Creek. Images were stored on a PC card, and later removed to download information for viewing and storage.

The camera was hand-held, positioned downward approximately 30° above the nadir at the forward passenger side of the helicopter with the door removed to facilitate filming. Helicopter speed ranged from 40 to 80 km/hr at an altitude of 100m to 300m, depending on the wetted width of the channel, topography, wind and urban flying restrictions.

The PM695 camera created a series of near-simultaneous still thermal and digital images at 12 selected sites shown on the map. It was attempted to capture the mainstem of the Nicola or Coldwater River plus some or most of the floodplain on either side of the channel. Thermal and digital images are offset by approximately 5 seconds of time (required to switch image type) and by several lineal meters of distance depending on wind and helicopter hovering factors (e.g. weight).

To test for the accuracy of the aerial-measured temperature, ground surveyors measured stream temperature while the helicopter hovered at three locations:

1. Near the mouth of the Coldwater River;
2. At the POI of Brook Creek;
3. Kwinshatin Creek at a culvert above the Coquihalla Highway.

3.0 RESULTS

A map and embedded thermogram site files are contained in the CD ROM; a printed version is attached.

Twelve still images were produced, referenced to the ground using a combination of GPS co-ordinates and known reference points such as bridges, roads and confluence of streams. The GPS co-ordinates are approximate because the camera looks slightly ahead (30° above the nadir) of the helicopter. Using 100m and 300m elevations, the forward angle resulted in a ground location of approximately 116 m to 350m ahead of the helicopter. GPS data was not adjusted to an actual ground location in this exploratory flight.

Thermal images were transformed into Adobe Acrobat (PDF extension) files for examination and subsequent analysis in the office. Final images were then embedded to an Adobe-created map of the Coldwater River that covered the flight path. Mapping was by Drake Forestry, Kelowna.

Instructions to download the map and explore the embedded site files are explained in 'README FIRST'.doc file on the CD ROM (see attached hard copy). Double clicking a 'Thermogram Site' brings up the thermal and digital coverage for that location. Interpretation of a thermogram is provided in, 'HOW TO READ SITE INFORMATION', which is also attached as a hardcopy.

Two scale sets of images are presented for each of the 12 sites, *landscape and water thermograms*. *Landscape thermograms* are images with a broad temperature range that contrasts the thermals of water with the surrounding land or vegetation. The temperature range is from 10°C or less to more than 50°C, depending on site characteristics. An example is discussed at site 1. The two fallen trees in the foreground are yellow and red, indicating a warm surface temperature ranging from 42°C to 54°C. The bush behind the standing tree near the channel is pink with small red spots indicating a temperature in the high 30°C's to low 40°C. Slightly cooler temperatures are shown in dark and light blue's as 'shadow's' cast by bushes and trees on the floodplain. Coolest temperature below 20°C is in the stream itself, shown as a lighter tone of blue. Channel bars at the bottom left and upper right of the image are pink and red colours depicting warmer surface temperatures up to over 50°C.

The colour scale of the *water thermogram* images have been adjusted to a much narrower temperature range, for example 17.3°C to 22.5°C at site 1, to emphasize the variation in water temperature. Using site 1 as an example, cool blue, light green and pink colours enhance and contrast longitudinal and horizontal variations in stream temperature that range from 17°C to over 20°C. Temperatures greater than 22.5°C on the adjacent floodplain or channel bars show as a yellow colour.

The data box to the right of the images lists the date and time of the photo, air temperature and relative humidity. Most importantly, there are temperature values that correspond to specific locations in the thermal image. Refer to the attachment for more details on spot, line and area temperature symbols, as well as information on the temperature graph.

3.1 Accuracy of Aerial-Measured Infrared Temperature

Aerial- recorded stream temperature was within 0.4°C or less of in-stream temperature (Table 1) when comparing the same spot. This is the same accuracy as reported by Torgensen et al. (1999). We did not compare the accuracy at multiple locations in the same image. A thermal image may capture the surface temperature of rocks, vegetation or still water at the channel edge, all of which would record a higher temperature than in the main body of a mixed, flowing stream. Therefore, it is probably more representative to use the average of several thermal spot temperatures in the stream thalweg at each still image to develop a longitudinal temperature profile along a stream system.

Table 1:Comparison of Aerial and Ground Measured Stream Temperature

Site #	Location	Aerial °C*	Stream °C	Ground surveyor
3	Coldwater River near mouth	20.7	21.1	Ken
10	Brook Creek at P.O.I.	12.6	13.0	Will
12	Kwinshatin Creek at Highway	10.1	10.1	Chris

* water temperature at spot close to measurement by ground- surveyor.

3.2 Features Of The Aerial Thermographic Technique

Longitudinal Stream Temperature

The images provide a snapshot of stream temperature along and across a stream. When complemented with in-stream sensors (such as in the Coldwater River), the longitudinal temperature variation from the headwaters, at the Tolko forestry operating area and then downstream to the mouth of the Coldwater River can be mapped in a rapid fashion and archived in a permanent record. Multiple flights can document seasonal stream temperature change in the mainstem and the dynamic effects of tributaries.

The in-stream Coldwater River sensors are useful for an accuracy check of the aerial-measured data and also to note stream temperature change during the aerial flight. We recorded close to a 0.5°C temperature increase at the mouth of Coldwater River during this first flight. Flying from the headwaters to the mouth from 2:00 pm – 3:00 pm should capture the near-peak daily stream temperature in the summer months.

Horizontal Variation

The landscape scale photo images help visualize the dynamics of stream temperature around the main channel of the Coldwater River. At sites 7 and 8 for example, cooler temperatures are near the right bank. At site 11, there are cool slope temperatures at the top of the image, suggesting sub-surface inflow to the DFO fish channel. Note that the fish and main channels are nearly the same surface temperature, around 18.5°C, but an intermediate channel is cooler by nearly 2°C, suggesting the possibility of a spring.

Landscape scale images provide opportunities to map locations of cool inflow to the Coldwater River from slopes or tributaries, while the water-scale image of the same site can isolate cool pools within a channel. This information can be evaluated on the ground to confirm aerial results. For example, in the case of Torgensen et al. (1999) the authors were able to correlate fish populations to locations of cool pools in streams in Oregon. The same could be done on the Coldwater River, or to identify restoration opportunities for new fish habitat, back channels, etc.

3.3 Advantages And Limitations

Advantages

Aerial thermal imagery can quickly map stream temperature over large areas. Thermal infrared stream temperature compared well (within 0.4°C) to in-stream temperature measurements. Mapping can be carried out in most weather types, day or night. Helicopter rental costs are $1,000/hr: at a flight speed of 40km/hr, the entire mainstem of the Coldwater could probably be mapped in point form approximately every 0.5 kilometer in 2.0 hours (some hovering time may be needed at key sites). Camera personnel, and pre and post flight time are additional and highly dependent on project objectives, but this provides a base for budget calculations. With multiple flights, thermal images can reveal seasonal variations in stream temperature.

Many of the logistics related to operating a thermal camera from a moving helicopter have been solved and subsequent flights will become progressively more efficient. Depending on project objectives, thermal imagery is useful for rapidly establishing longitudinal stream temperature profiles at the watershed scale, and to identify areas of cool and warm inflow from slopes and tributaries, and within-channel sections of cool water. These features are useful for identifying potential in-channel restoration opportunities related to fish habitat.

Limitations

Thermal imagery is a snapshot of stream temperature in time and space and may or may not capture the daily temperature maximum. Accuracy is within approximately 0.4°C of a certified in-stream thermometer. Rain can affect accurate radiant temperatures. A view of the channel is also needed to measure stream temperature. Therefore the technique is limited to streams not obscured by canopy cover.

Care is needed in interpretation of average stream temperature to avoid rocks, bars, or near shore values. Camera calibration to a correct emissivity is required to compensate for ground reflection. Aerial temperature measures are best used in conjunction with in-stream monitors to confirm accuracy, and a ground survey is suggested to follow up at areas of interest or to help place additional in-stream sensors.

3.4 Other Forestry Applications of Infrared Imagery

The usefulness and richness of data revealed by the FLIR technology has potential forestry applications wherever surface temperature is an important indictor. Examples include:

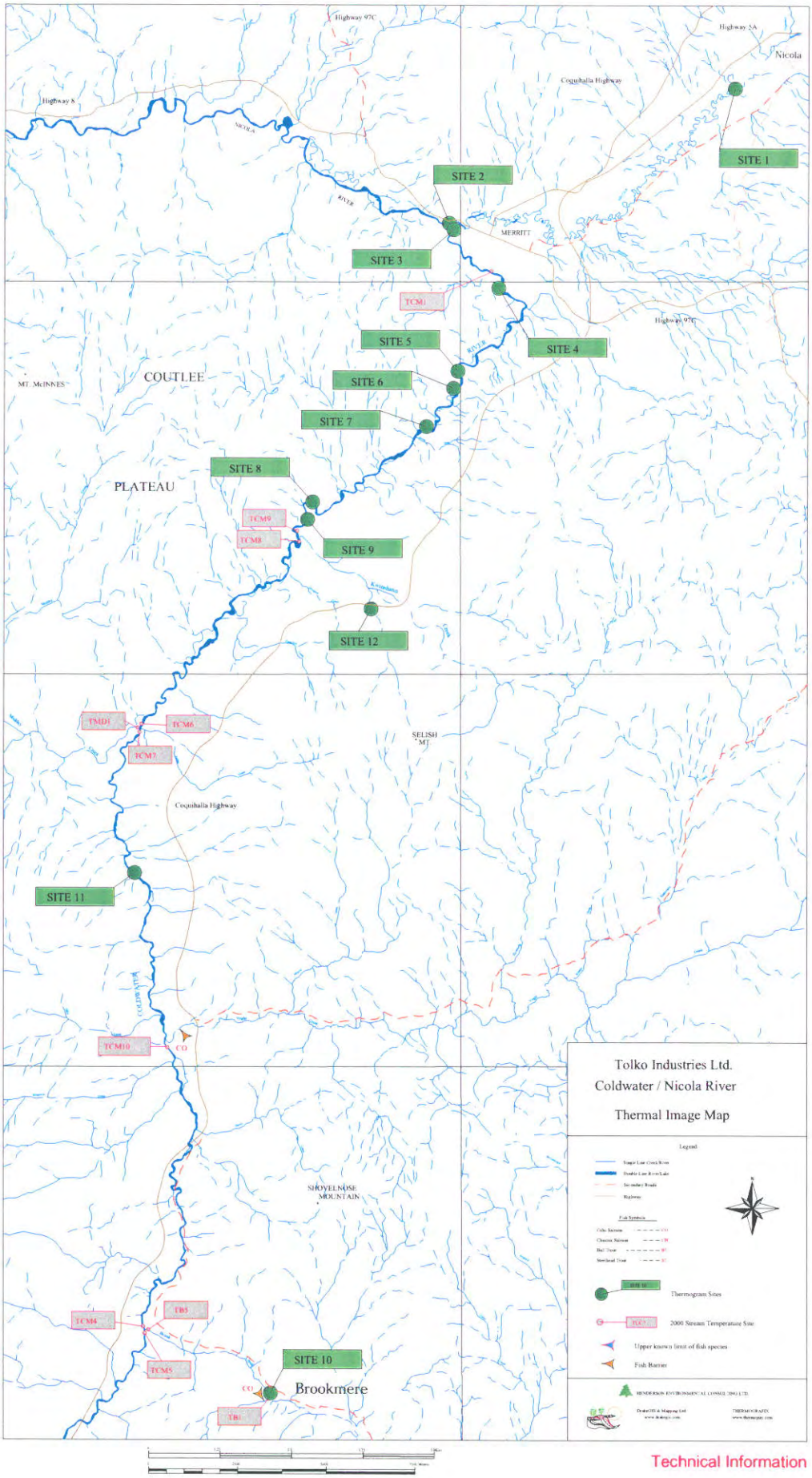
1. Forest health surveys (e.g. foliar damage from insects or fungus);
2. Ground-based stream shade temperature (e.g. conifer versus deciduous cover);
3. Temperature emissions from kilns and mills;
4. Mammal surveys;
5. Fish counts.

4.0 REFERENCES

Torgersen, Christian E., David M. Price, Hiram W. Li, and Bruce A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of chinook salmon in Northeastern Oregon. Ecological Applications, 9(1), pp. 301-319.

McIntosh, Bruce A., Russell Faux and James R. Sedell.1999. Aerial survey of the Applegate River. Thermal infrared and color videography. Unpublished. Department of Forest Science, Forestry Sciences Laboratory, Oregon State University, Corvalis, OR 97331. pp.27.

Coldwater/Nicola River Thermogram Sites



Technical Information

HOW TO READ SITE INFORMATION

Each file presents an output page formatted with a thermal and digital image on the left, data box at the top right and temperature graph at the bottom right.

The thermal image is a representation of the surface temperature of a target object. A camera that measures emitted infrared (IR) radiation produces the image. Thermal patterns show as a rainbow palette of colours to visually enhance temperature differences. A scale that relates colour to temperature is to the right of the thermal image.

The digital picture below the thermal image is the same site shown in colours visible to the eye. This image is useful to relate known features such as water, bridges, gravel bars, or trees to a corresponding colour temperature in the thermal image.

The data box provides reference information such as date and time of the photo, air temperature and relative humidity, and temperature that corresponds to specific points or areas on the thermal image. Symbols are:

IR- infrared
SP- spot
LI-line
AR- area

IR max and min reflects the maximum and minimum temperature on the image. For ease of viewing, the minimum temperature has been set for each site at the cross for SPO1, or spot 1, on the thermal image. Temperature at other spots, such as SPO2, SPO3, et cetera is also listed in the data box.

A line drawn across the creek on the thermal is represented as LIO1 for line 1, or LIO2 for line 2. The temperature in the data box is at the cursor along the line, whose location is also shown as a vertical line on the temperature graph at the bottom right of the page.

The graph depicts the temperature for the entire line drawn on the thermal image starting from the 'LI' marker and traversing to the end of the line. A small data box below the graph summarizes the range of temperature along the line.

Finally, some thermal images also outline an area as a box. The maximum, minimum and average temperature data for the outlined area is presented in the data box as ARO1, ARO2, et cetera.

For further information contact:

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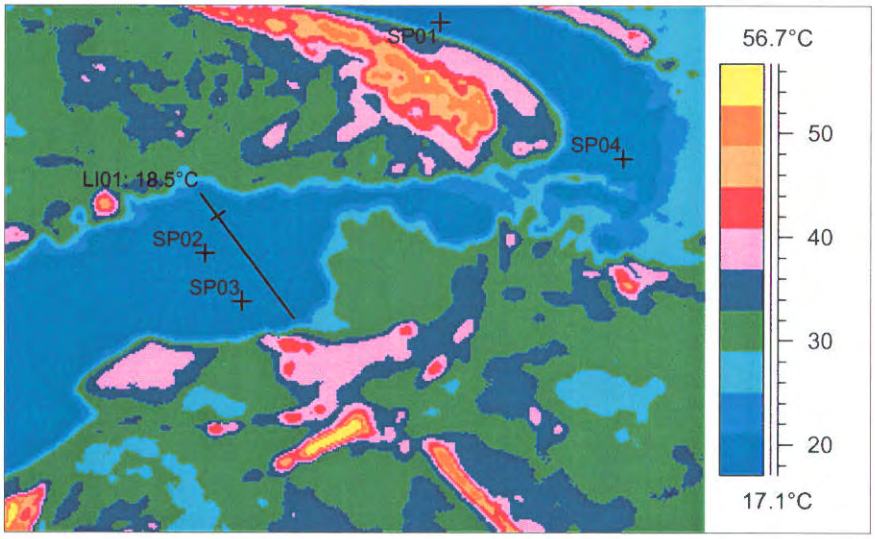
(250) 860-7266
ghenderson@telus.net

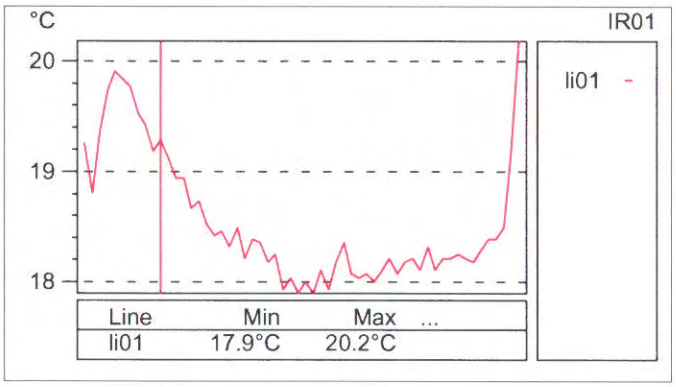
Site 1 - Landscape Thermogram

Nicola River between Nicola Lake and confluence with Coldwater River.

IR Text Comment	Value
Approximate GPS	N5008.94 W12041.65



IR information	Value
Date of creation	7/3/01
Time of creation	2:48:13 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	57.3°C
IR : min	17.0°C
SP01	17.0°C
SP02	18.1°C
SP03	18.0°C
SP04	18.1°C
LI01 : cursor	19.3°C

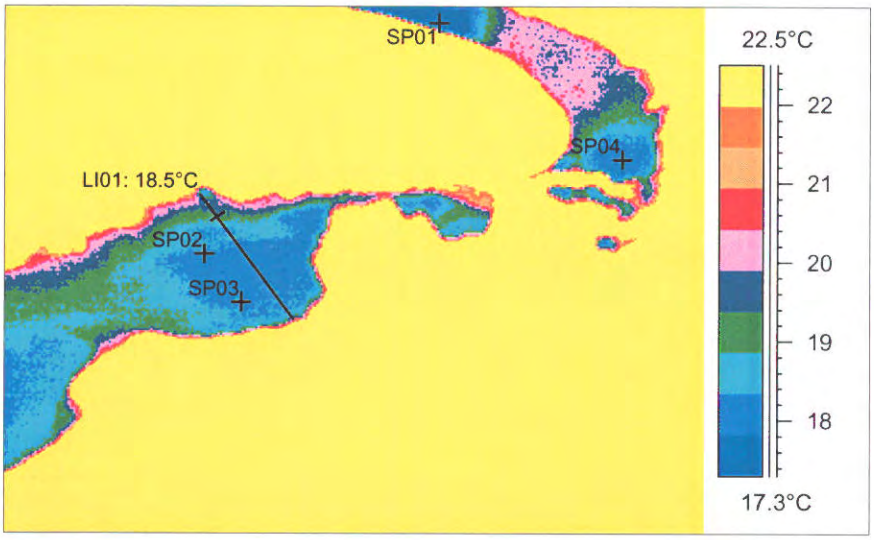


Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 1 - Water Thermogram

Nicola River between Nicola Lake and confluence with Coldwater River.

IR Text Comment	Value
Approximate GPS	N5008.94 W12041.65



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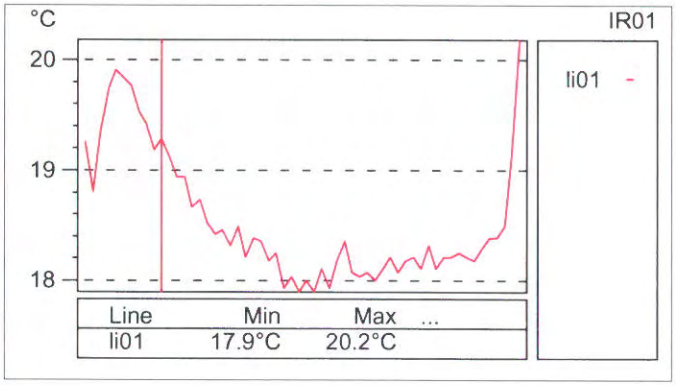
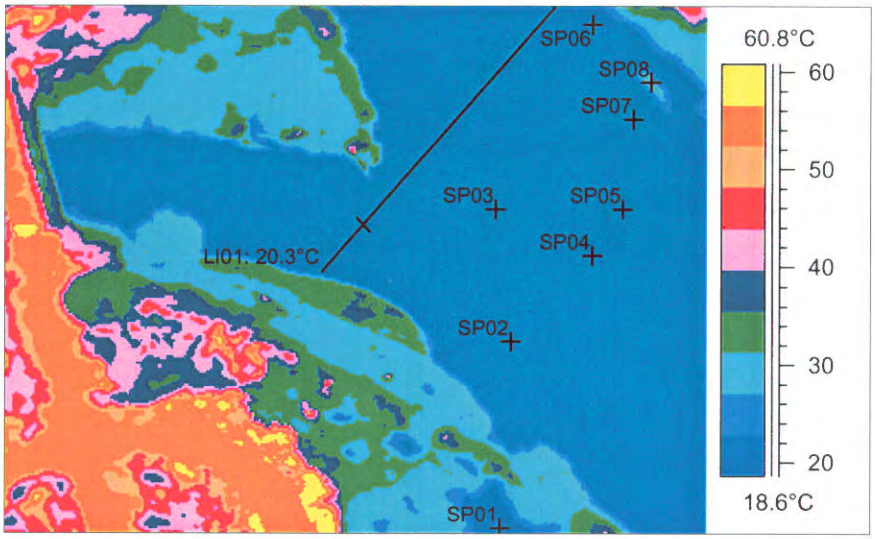
Date of creation	7/3/01
Time of creation	2:48:13 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	57.3°C
IR : min	17.0°C
SP01	17.0°C
SP02	18.1°C
SP03	18.0°C
SP04	18.1°C
LI01 : cursor	19.3°C



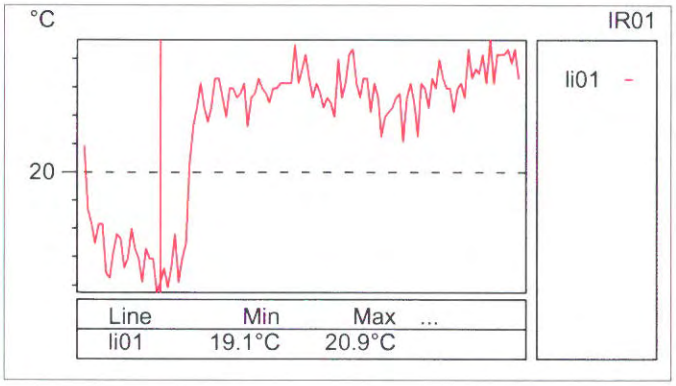
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 2 - Landscape Thermogram

Nicola River entering left, Coldwater River at right



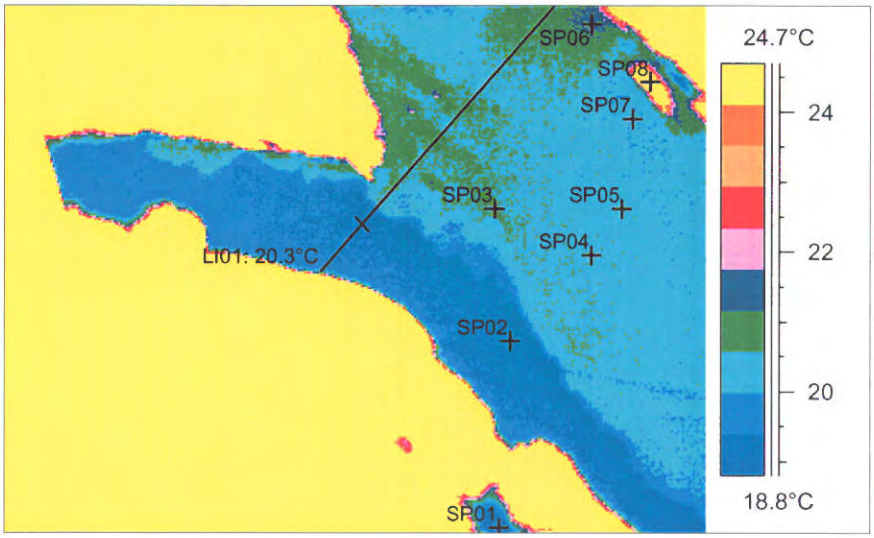
IR information	Value
Date of creation	7/3/01
Time of creation	3:00:55 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	61.5°C
IR : min	18.5°C
SP01	18.5°C
SP02	19.3°C
SP03	20.6°C
SP04	20.4°C
SP05	20.4°C
SP06	21.4°C
SP07	20.1°C
SP08	29.8°C
LI01 : cursor	19.2°C



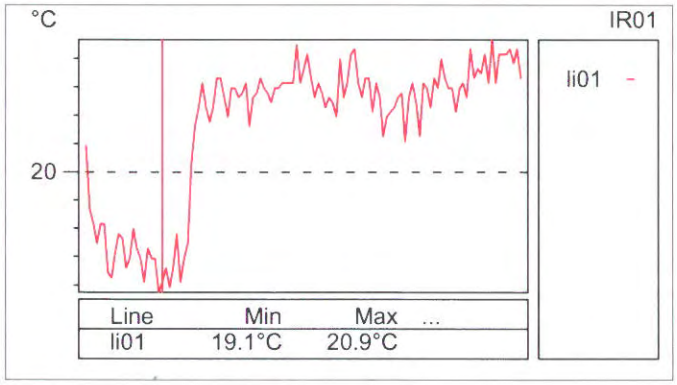
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 2 - Water Thermogram

Nicola River entering left, Coldwater River at right



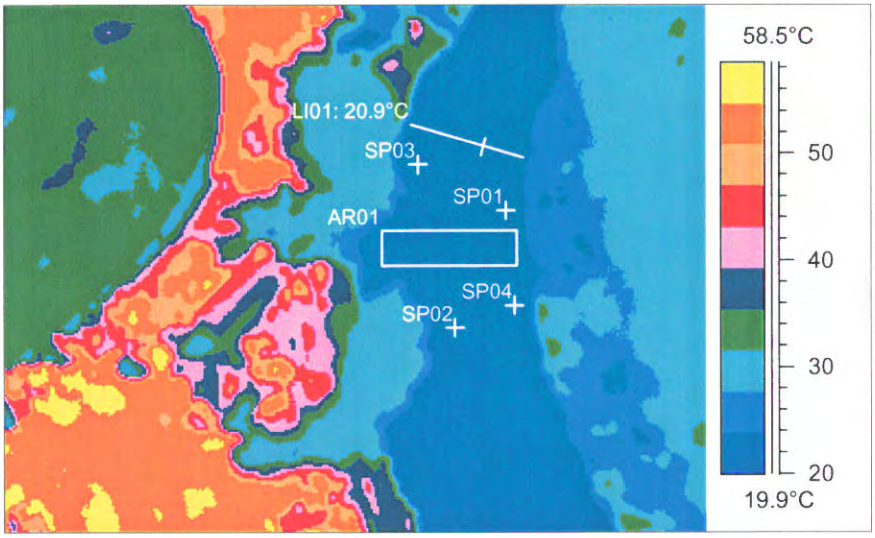
IR information	Value
Date of creation	7/3/01
Time of creation	3:00:55 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	61.5°C
IR : min	18.5°C
SP01	18.5°C
SP02	19.3°C
SP03	20.6°C
SP04	20.4°C
SP05	20.4°C
SP06	21.4°C
SP07	20.1°C
SP08	29.8°C
LI01 : cursor	19.2°C



Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 3 - Landscape Thermogram

Location: Coldwater River near confluence with Nicola River



IR information	Value
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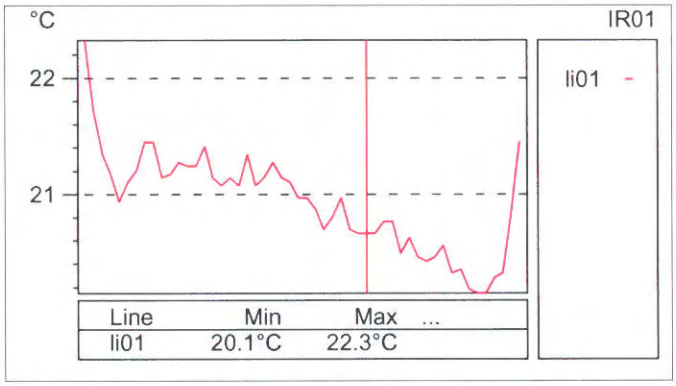
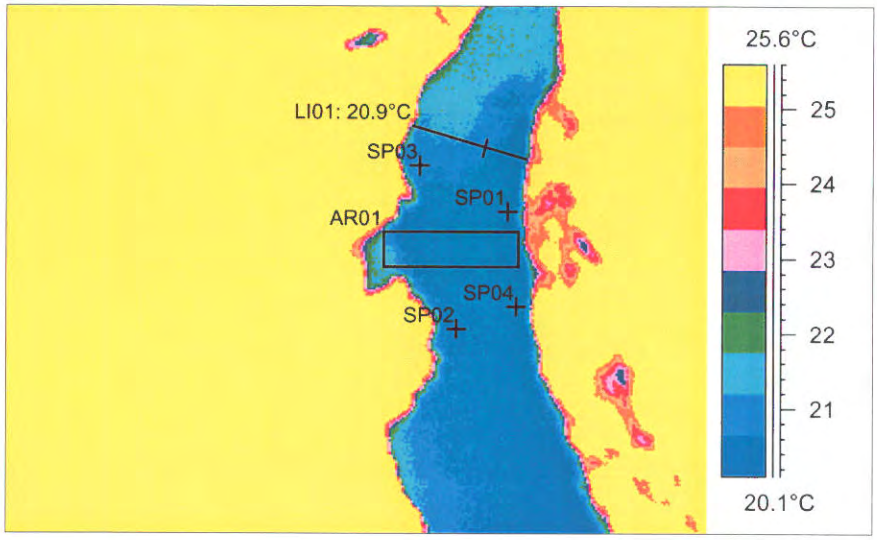
Time of creation	3:04:39 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	60.3°C
IR : min	19.8°C
SP01	19.9°C
SP02	20.5°C
SP03	20.7°C
SP04	20.2°C
LI01 : cursor	20.7°C
AR01 : max	21.8°C
AR01 : min	19.8°C
AR01 : avg	20.4°C



Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.
Ground-measured water temperature near Spot 03 was 21 degrees (Surveyor: Ken)

Site 3 - Water Thermogram

Location: Coldwater River near confluence with Nicola River



IR information	Value
Date of creation	7/3/01
Time of creation	3:04:39 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	60.3°C
IR : min	19.8°C
SP01	19.9°C
SP02	20.5°C
SP03	20.7°C
SP04	20.2°C
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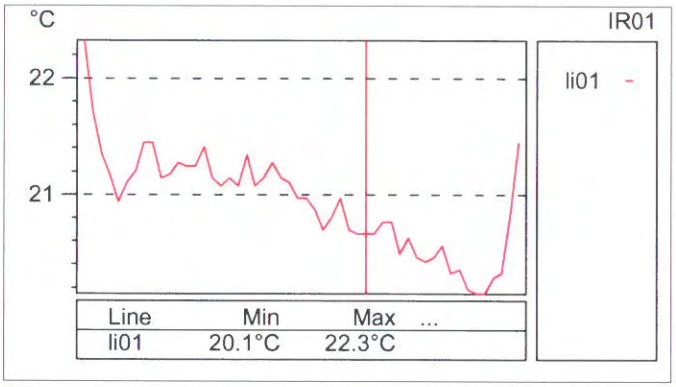
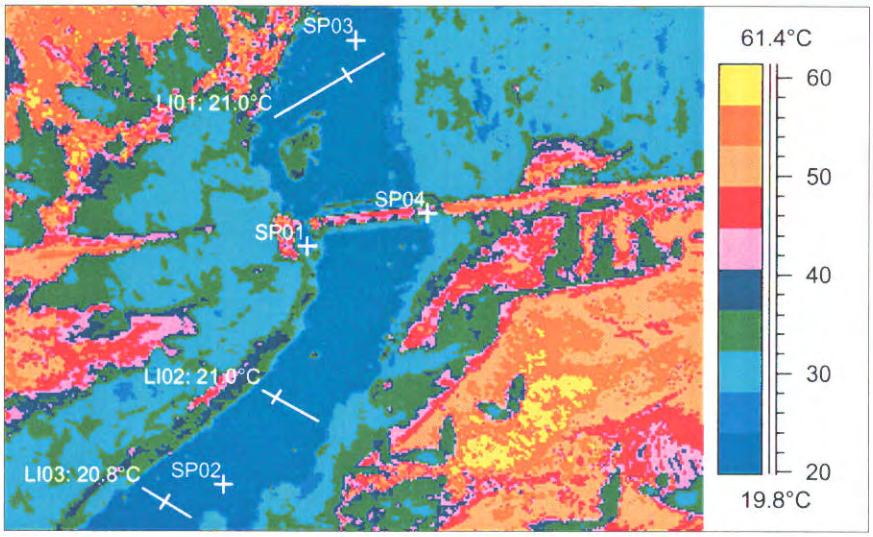
AR01 : min	19.8°C
AR01 : avg	20.4°C



Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.
Ground-measured water temperature near Spot 03 was 21 degrees (Surveyor: Ken)

Site 4 - Landscape Thermogram

Coldwater River @ KVR line approx. 750 m upstream of Tolko Mill



IR information	Value
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Time of creation	3:12:08 PM
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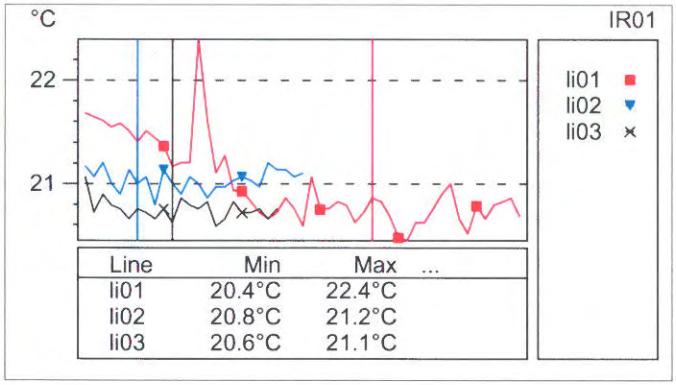
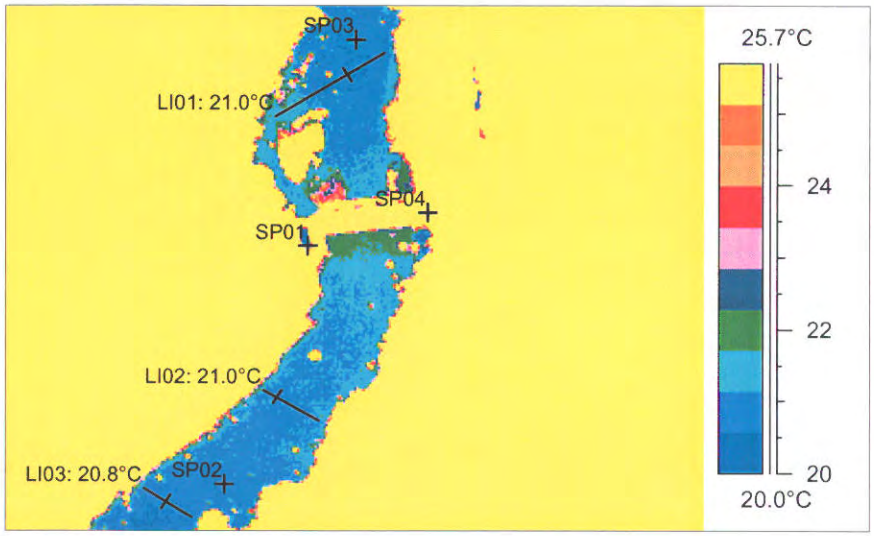
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	63.4°C
IR : min	19.0°C
SP01	19.2°C
SP02	20.9°C
SP03	20.6°C
SP04	40.8°C
LI01 : cursor	20.9°C
LI03 : cursor	20.6°C
LI02 : cursor	21.0°C



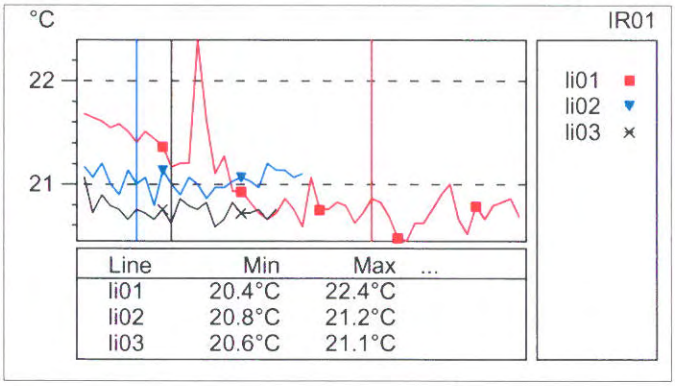
Spot 01 on the thermogram is located close to the coldest temperature associated with the thermogram.

Site 4 - Water Thermogram

Coldwater River @ KVR line approx. 750 m upstream of Tolko Mill



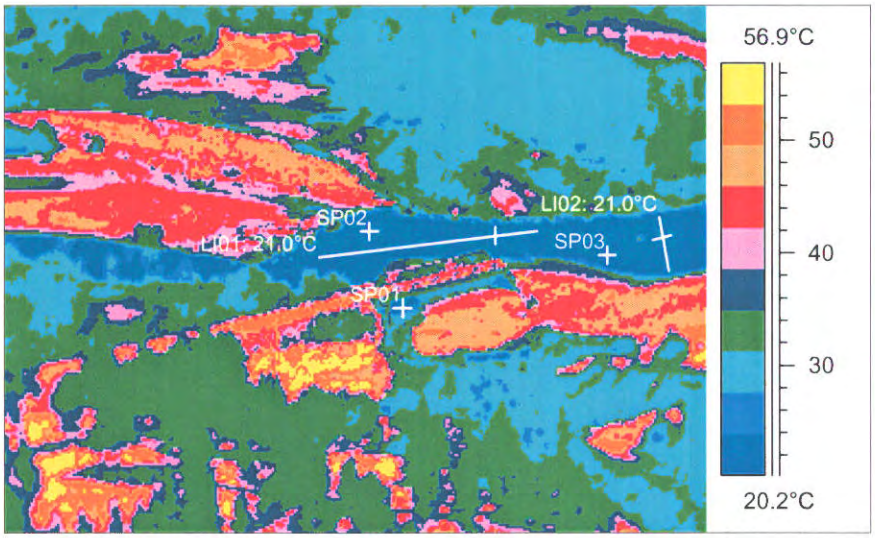
IR information	Value
Date of creation	7/3/01
Time of creation	3:12:08 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	63.4°C
IR : min	19.0°C
SP01	19.2°C
SP02	20.9°C
SP03	20.6°C
SP04	40.8°C
LI01 : cursor	20.9°C
LI03 : cursor	20.6°C
LI02 : cursor	21.0°C



Spot 01 on the thermogram is located close to the coldest temperature associated with the thermogram.

Site 5 - Landscape Thermogram

Coldwater at KVR Bridge approx. 4.1 km upstream of the Tolko Mill



IR information	Value
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Time of creation	3:13:35 PM
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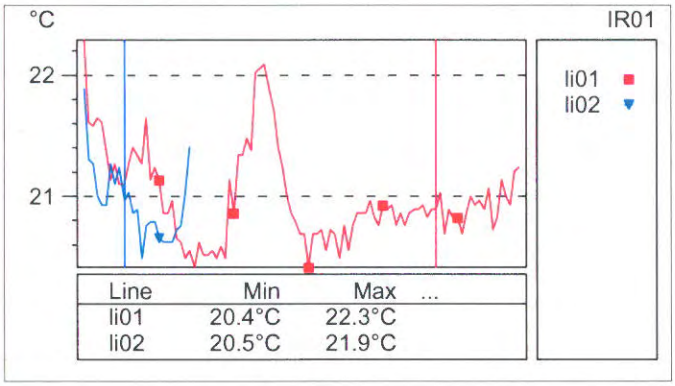
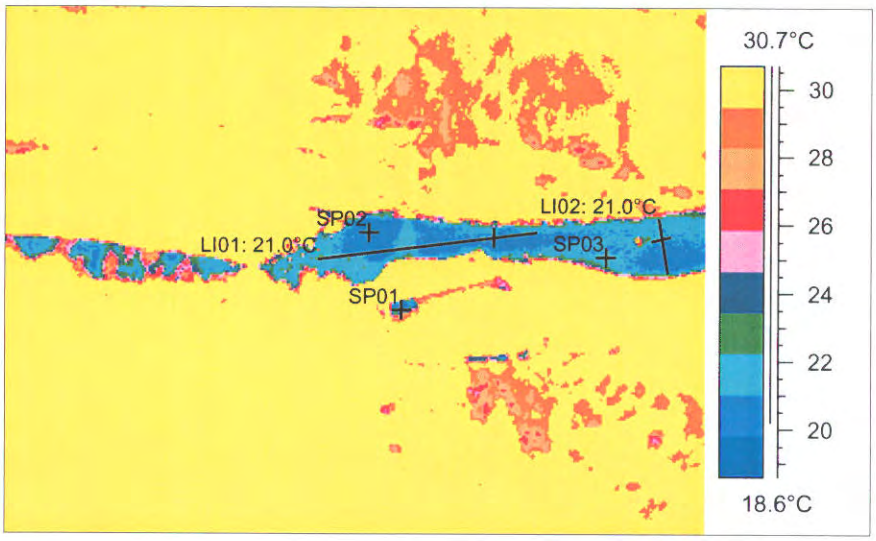
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	60.4°C
IR : min	19.4°C
SP01	19.4°C
SP02	20.7°C
SP03	21.1°C
LI01 : cursor	20.9°C
LI02 : cursor	21.0°C



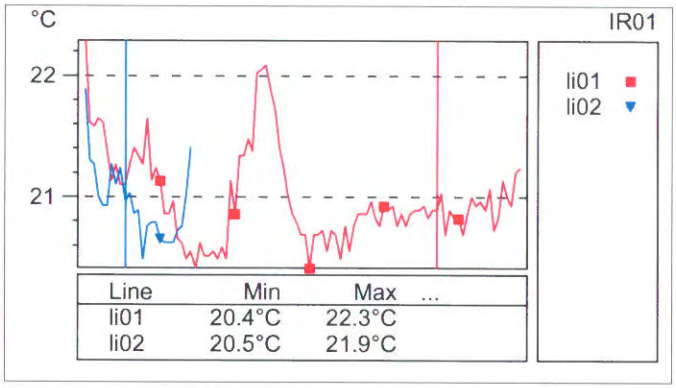
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 5 - Water Thermogram

Coldwater at KVR Bridge approx. 4.1 km upstream of the Tolko Mill



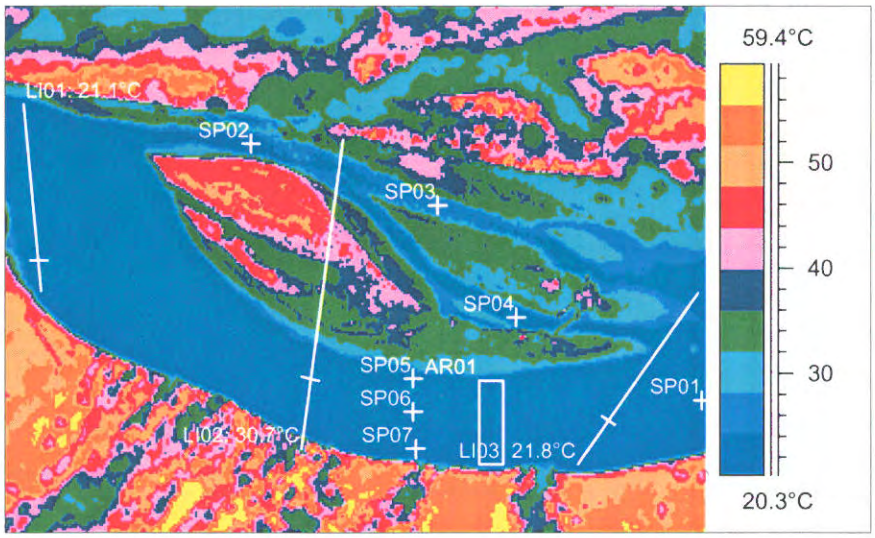
IR information	Value
Date of creation	7/3/01
Time of creation	3:13:35 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	60.4°C
IR : min	19.4°C
SP01	19.4°C
SP02	20.7°C
SP03	21.1°C
LI01 : cursor	20.9°C
LI02 : cursor	21.0°C



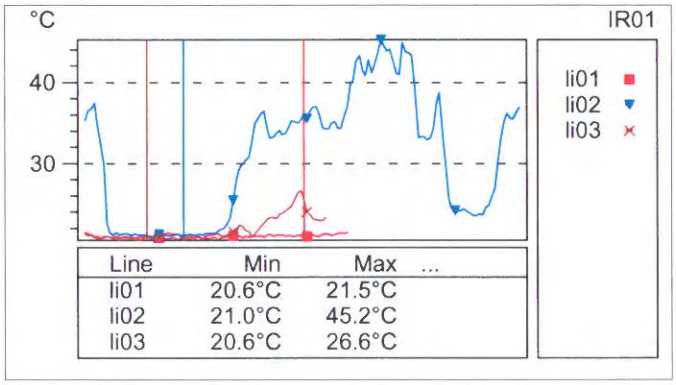
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 6 - Landscape Thermogram

Coldwater River approx. 300 m upstream of site 5



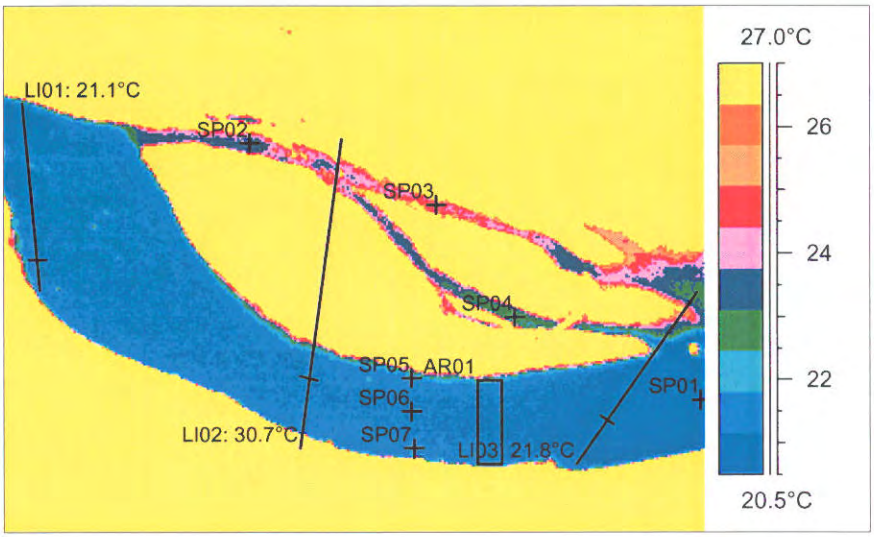
IR information	Value
Date of creation	7/3/01
Time of creation	3:13:57 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	60.0°C
IR : min	20.1°C
SP01	20.2°C
SP02	23.5°C
SP03	24.9°C
SP04	22.6°C
SP05	21.8°C
SP06	21.2°C
SP07	21.3°C
LI01 : cursor	21.3°C
LI02 : cursor	21.1°C
LI03 : cursor	21.1°C
AR01 : max	22.7°C
AR01 : min	20.8°C
AR01 : avg	21.2°C



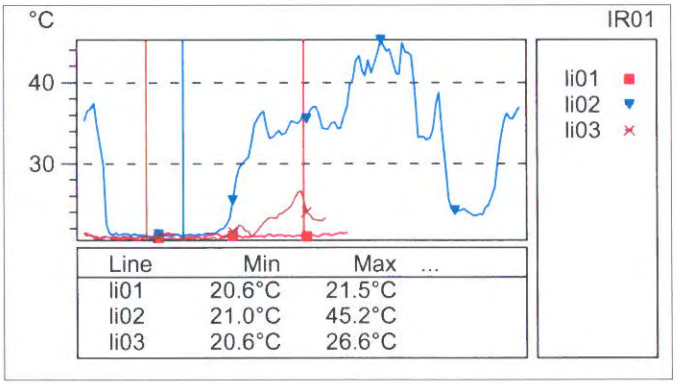
Spot 01 on the thermogram is located close to the coldest temperature associated with the thermogram.

Site 6 - Water Thermogram

Coldwater River approx. 300 m upstream of site 5



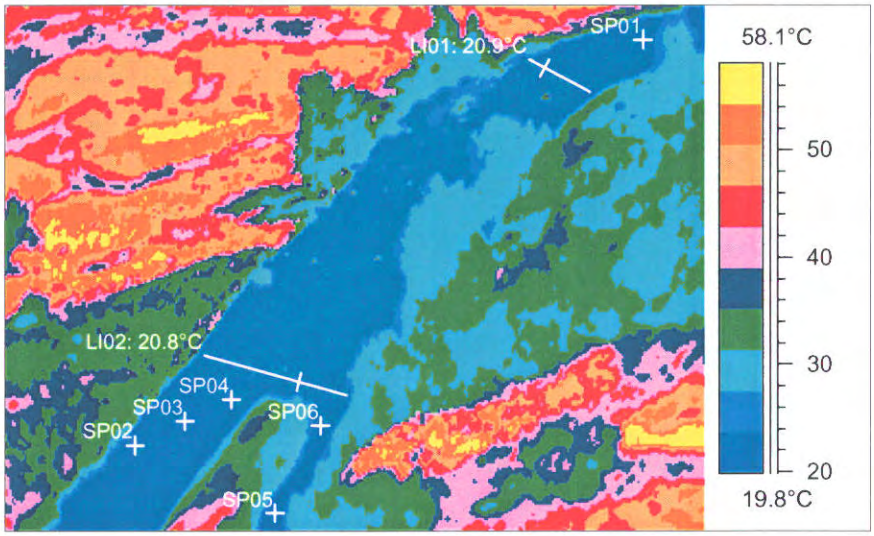
IR information	Value
Date of creation	7/3/01
Time of creation	3:13:57 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	60.0°C
IR : min	20.1°C
SP01	20.2°C
SP02	23.5°C
SP03	24.9°C
SP04	22.6°C
SP05	21.8°C
SP06	21.2°C
SP07	21.3°C
LI01 : cursor	21.3°C
LI02 : cursor	21.1°C
LI03 : cursor	21.1°C
AR01 : max	22.7°C
AR01 : min	20.8°C
AR01 : avg	21.2°C



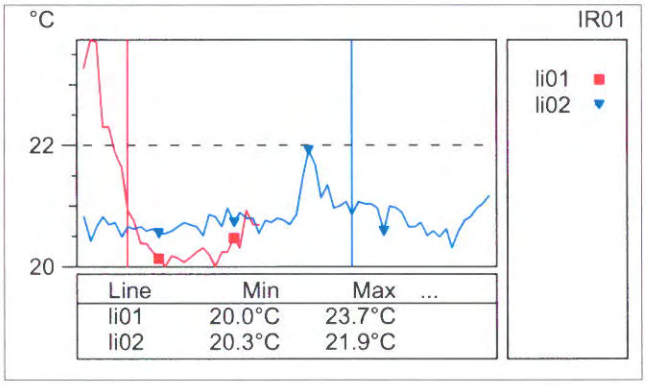
Spot 01 on the thermogram is located close to the coldest temperature associated with the thermogram.

Site 7 - Landscape Thermogram

Coldwater River between sites 6 and 8



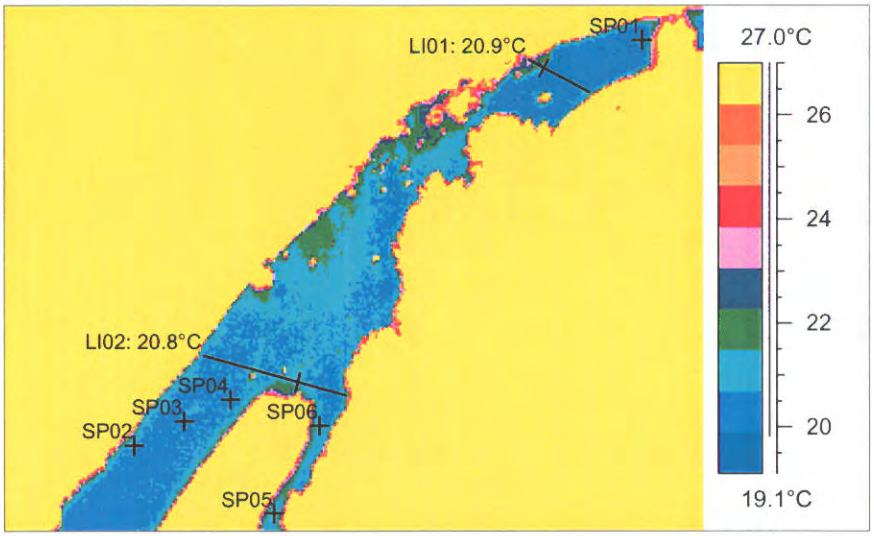
IR information	Value
Date of creation	7/3/01
Time of creation	3:15:27 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	59.2°C
IR : min	19.6°C
SP01	19.6°C
SP02	20.8°C
SP03	20.7°C
SP04	20.7°C
SP05	20.9°C
SP06	21.0°C
LI01 : cursor	20.9°C
LI02 : cursor	20.9°C



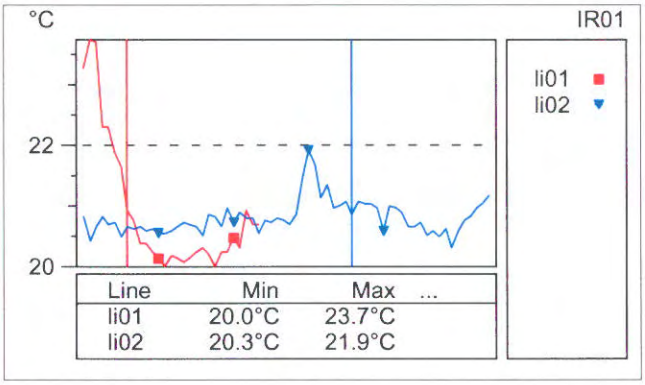
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 7 - Water Thermogram

Coldwater River between sites 6 and 8



IR information	Value
Date of creation	7/3/01
Time of creation	3:15:27 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	59.2°C
IR : min	19.6°C
SP01	19.6°C
SP02	20.8°C
SP03	20.7°C
SP04	20.7°C
SP05	20.9°C
SP06	21.0°C
LI01 : cursor	20.9°C
LI02 : cursor	20.9°C

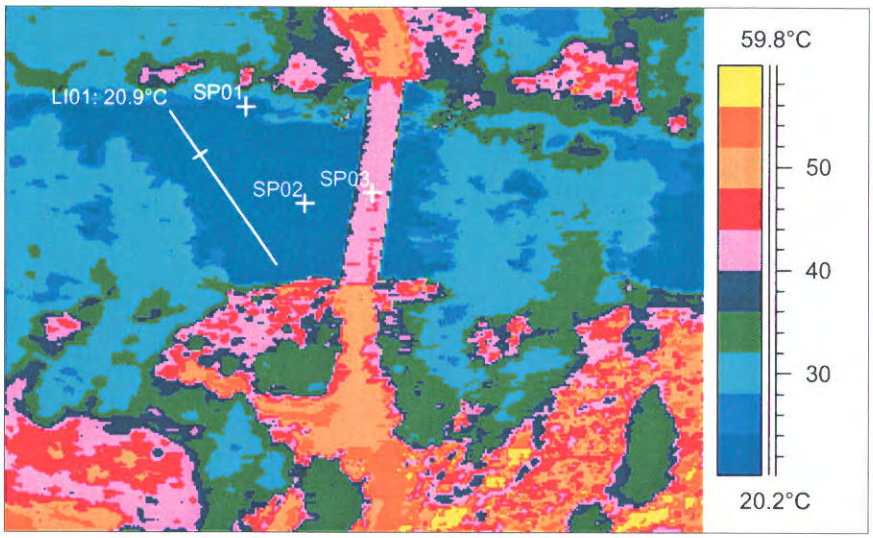


Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

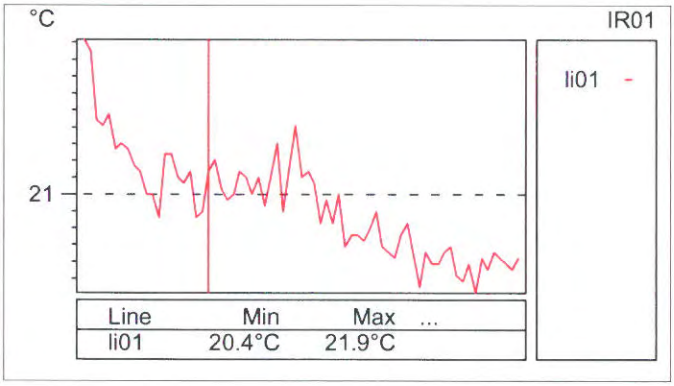
Site 8 - Landscape Thermogram

Coldwater River near (downstream) of confluence with Kwinshatin Creek

IR Text Comment	Value
Approximate GPS	N5002.72 W12051.66



IR information	Value
Date of creation	7/3/01
Time of creation	3:17:29 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	61.8°C
IR : min	19.3°C
SP01	19.4°C
SP02	20.6°C
SP03	43.1°C
LI01 : cursor	21.1°C

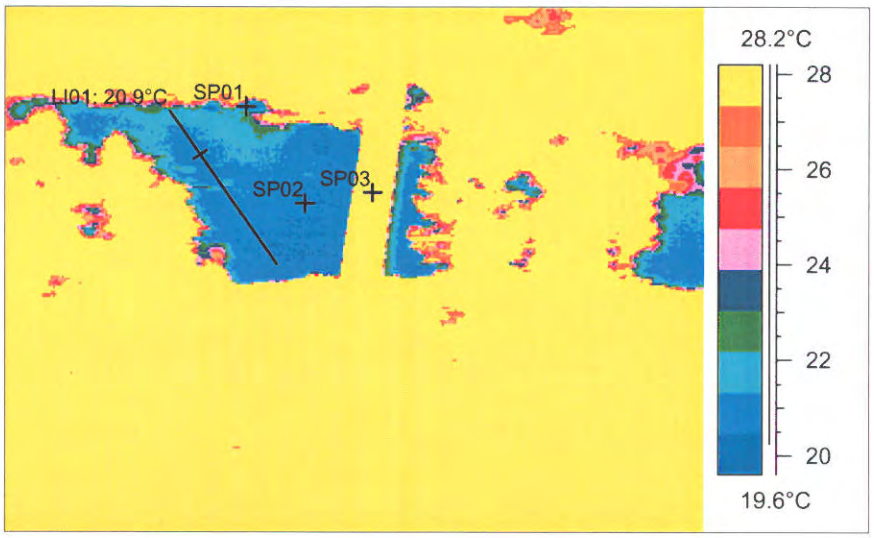


Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

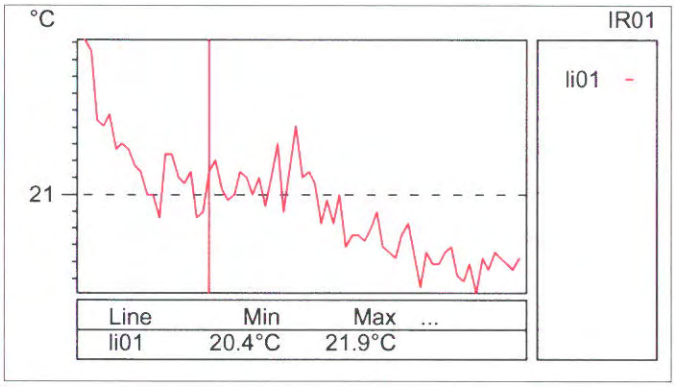
Site 8 - Water Thermogram

Coldwater River near (downstream) of confluence with Kwinshatin Creek

IR Text Comment	Value
Approximate GPS	N5002.72 W12051.66



IR information	Value
Date of creation	7/3/01
Time of creation	3:17:29 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	61.8°C
IR : min	19.3°C
SP01	19.4°C
SP02	20.6°C
SP03	43.1°C
LI01 : cursor	21.1°C

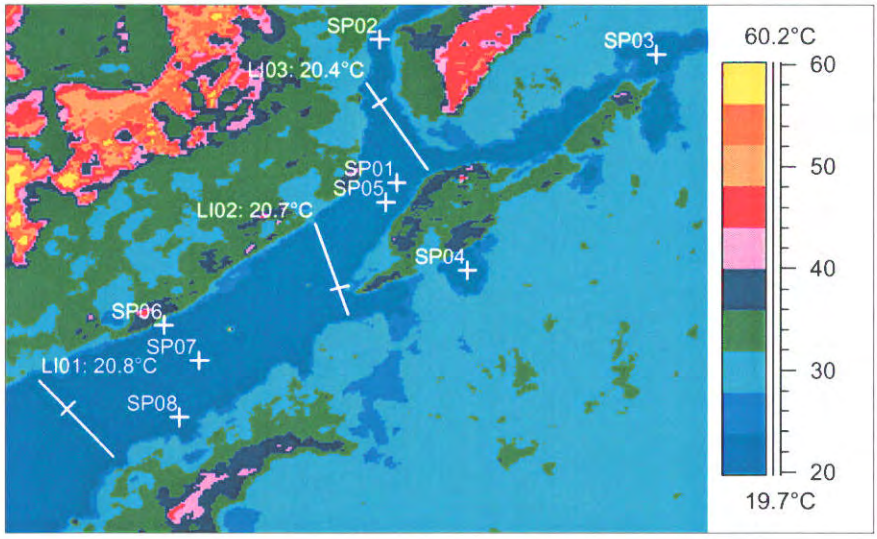


Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

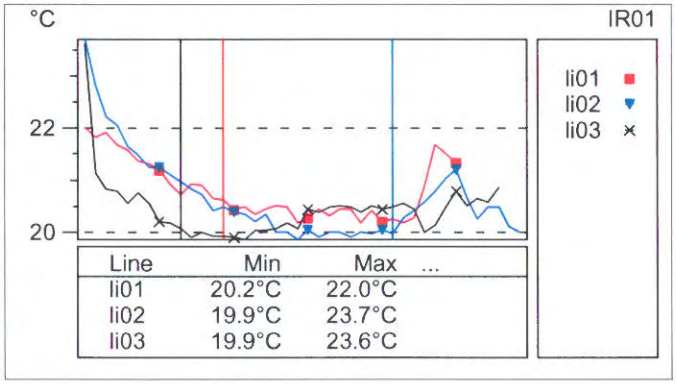
Site 9 - Landscape Thermogram

Coldwater River near(downstream) confluence with Kwinshatin Creek

IR Text Comment	Value
Approximate GPS	N5002.40 W12051.74



IR information	Value
Date of creation	7/3/01
Time of creation	3:18:04 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	62.4°C
IR : min	19.6°C
SP01	19.6°C
SP02	22.5°C
SP03	21.5°C
SP04	20.1°C
SP05	19.9°C
SP06	22.3°C
SP07	20.0°C
SP08	20.4°C
LI01 : cursor	20.6°C
LI02 : cursor	20.0°C
LI03 : cursor	20.1°C

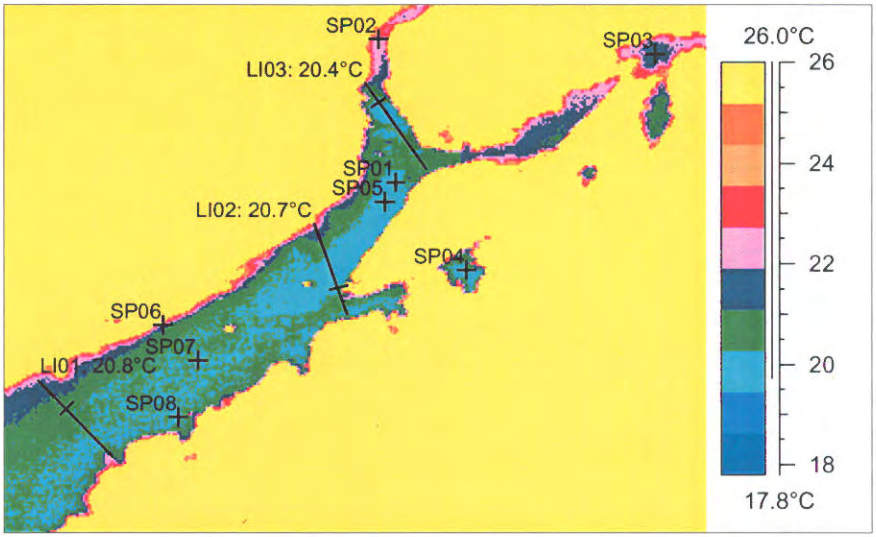


Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

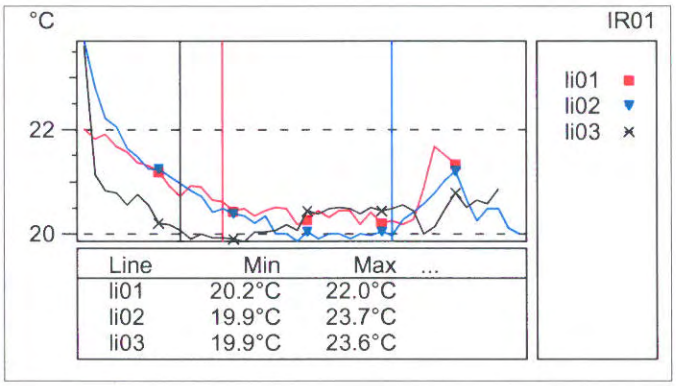
Site 9 - Water Thermogram

Coldwater River near(downstream) confluence with Kwinshatin Creek

IR Text Comment	Value
Approximate GPS	N5002.40 W12051.74



IR information	Value
Date of creation	7/3/01
Time of creation	3:18:04 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	62.4°C
IR : min	19.6°C
SP01	19.6°C
SP02	22.5°C
SP03	21.5°C
SP04	20.1°C
SP05	19.9°C
SP06	22.3°C
SP07	20.0°C
SP08	20.4°C
LI01 : cursor	20.6°C
LI02 : cursor	20.0°C
LI03 : cursor	20.1°C

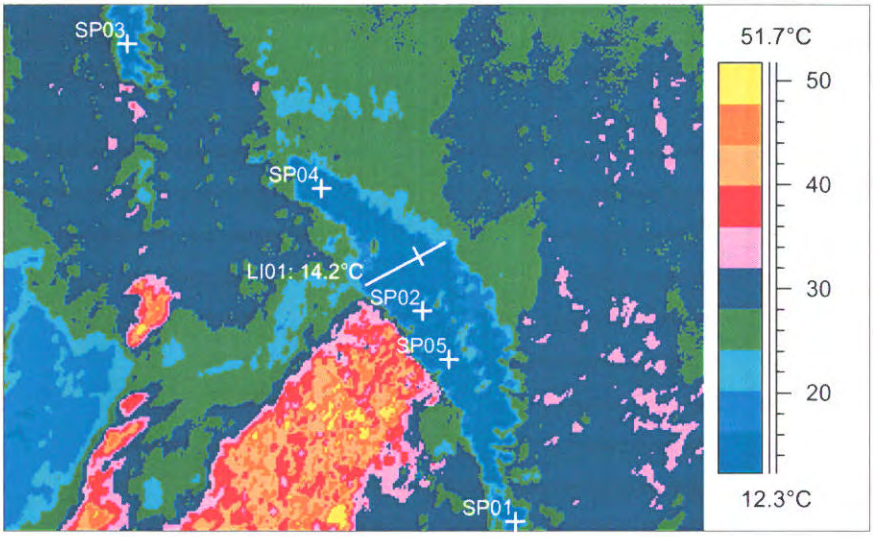


Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

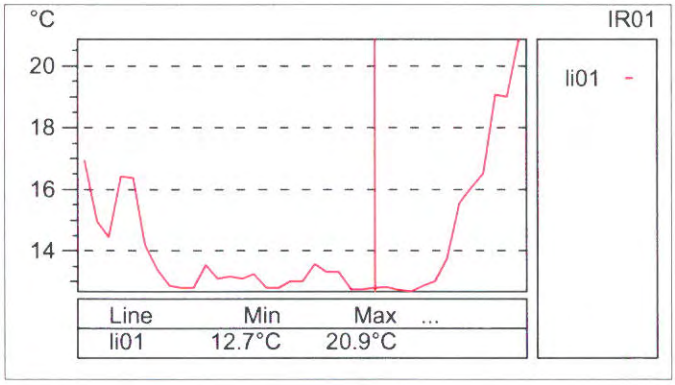
Site 10 - Landscape Thermogram

POI at Brook Creek

IR Text Comment	Value
Approximate GPS	N4949.00 W12052.52



IR information	Value
Date of creation	7/3/01
Time of creation	3:37:38 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	53.7°C
IR : min	9.6°C
SP01	12.3°C
SP02	12.7°C
SP03	13.1°C
SP04	12.7°C
SP05	12.6°C
LI01 : cursor	12.8°C

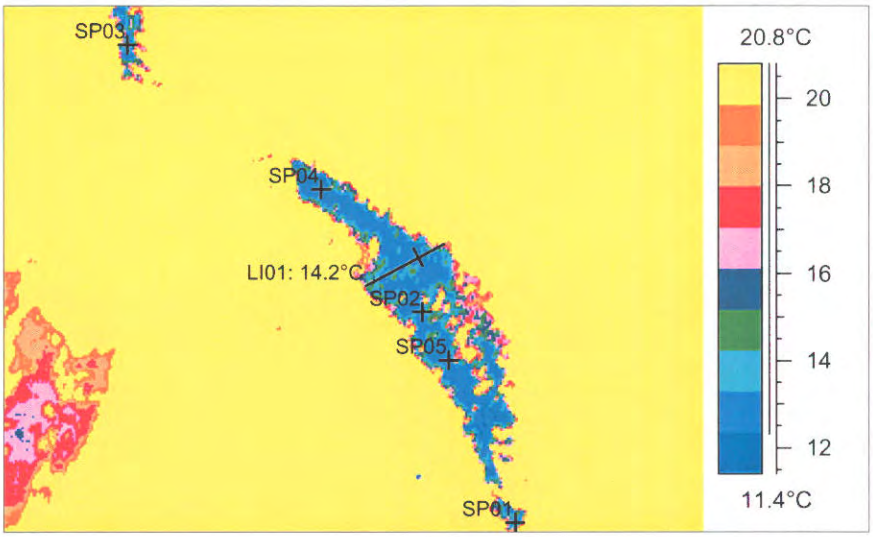


Spot 01 on the thermogram is located close to the coldest temperature associated with the thermogram.
Ground measured water temperature close to Spot 02: 13.0 degrees(Surveyor: Will)

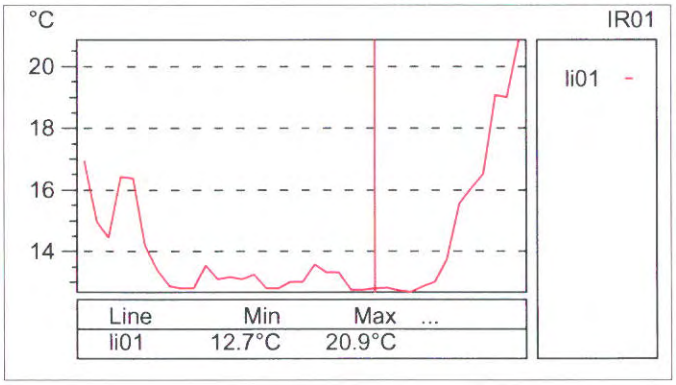
Site 10 - Water Thermogram

POI at Brook Creek

IR Text Comment	Value
Approximate GPS	N4949.00 W12052.52



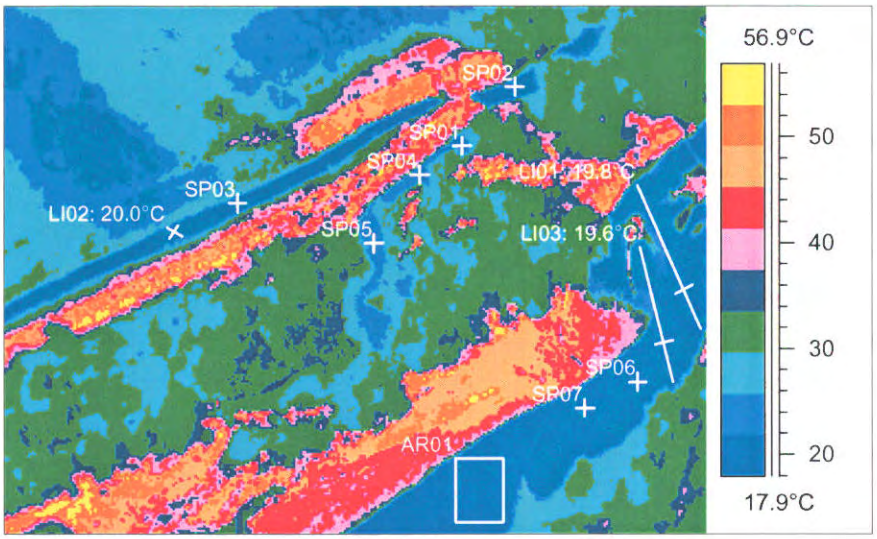
IR information	Value
Date of creation	7/3/01
Time of creation	3:37:38 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	53.7°C
IR : min	9.6°C
SP01	12.3°C
SP02	12.7°C
SP03	13.1°C
SP04	12.7°C
SP05	12.6°C
LI01 : cursor	12.8°C



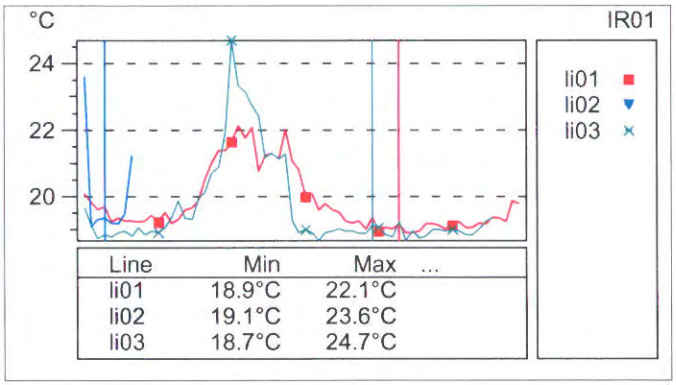
Spot 01 on the thermogram is located close to the coldest temperature associated with the thermogram.
Ground measured water temperature close to Spot 02: 13.0 degrees(Surveyor: Will)

Site 11 - Landscape Thermogram

Coldwater River at DFO Fish Channel (downstream of Brook) Creek)



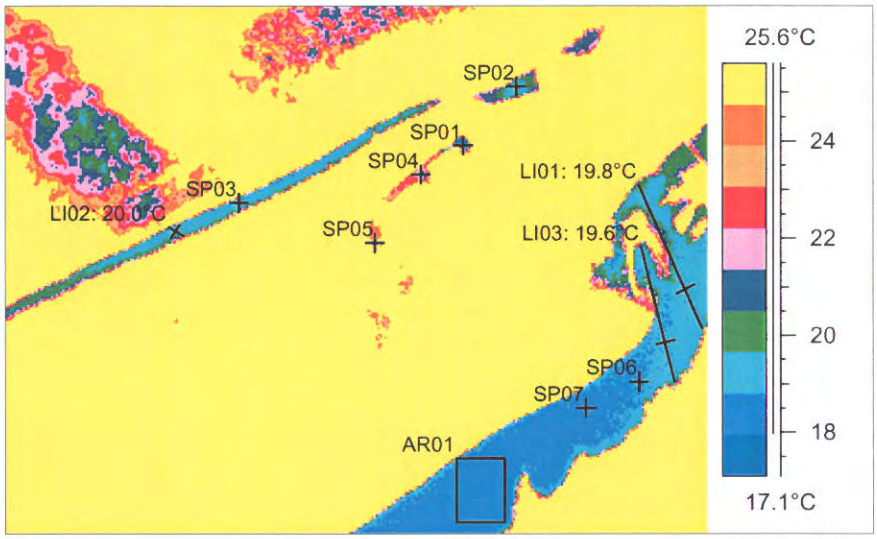
IR information	Value
Date of creation	7/3/01
Time of creation	3:46:49 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	59.1°C
IR : min	16.3°C
SP01	16.3°C
SP02	18.6°C
SP03	19.2°C
SP04	22.2°C
SP05	24.6°C
SP06	18.8°C
SP07	18.5°C
LI01 : cursor	19.2°C
LI02 : cursor	19.3°C
LI03 : cursor	19.1°C
AR01 : max	20.8°C
AR01 : min	18.0°C
AR01 : avg	18.4°C



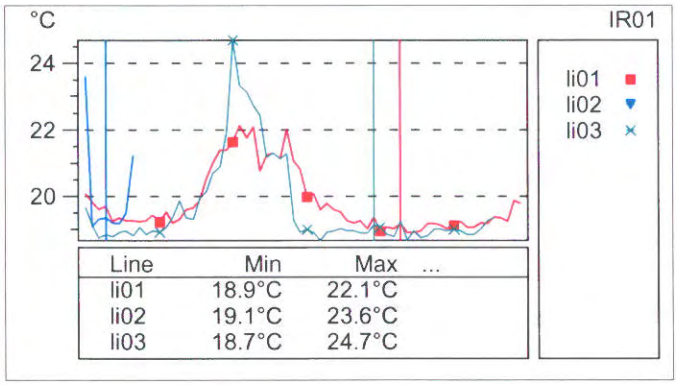
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 11 - Water Thermogram

Coldwater River at DFO Fish Channel (downstream of Brook) Creek)



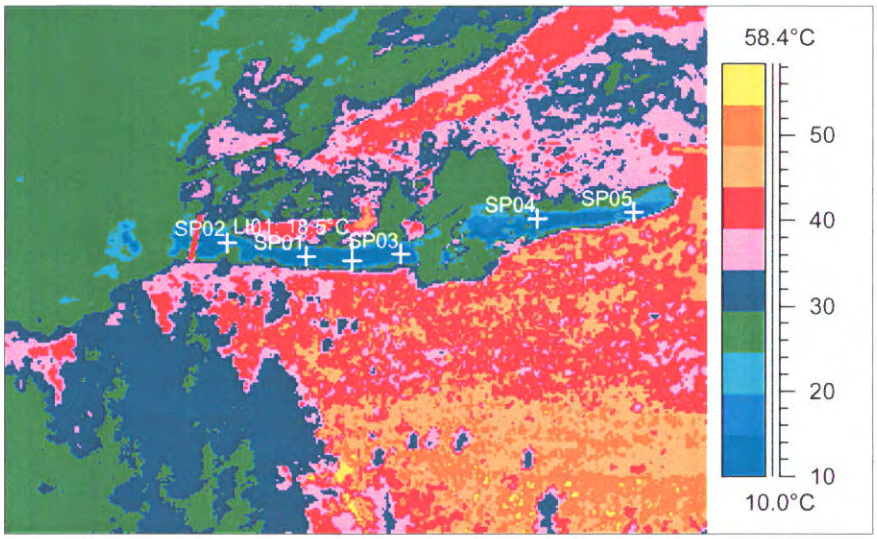
IR information	Value
Date of creation	7/3/01
Time of creation	3:46:49 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	59.1°C
IR : min	16.3°C
SP01	16.3°C
SP02	18.6°C
SP03	19.2°C
SP04	22.2°C
SP05	24.6°C
SP06	18.8°C
SP07	18.5°C
LI01 : cursor	19.2°C
LI02 : cursor	19.3°C
LI03 : cursor	19.1°C
AR01 : max	20.8°C
AR01 : min	18.0°C
AR01 : avg	18.4°C



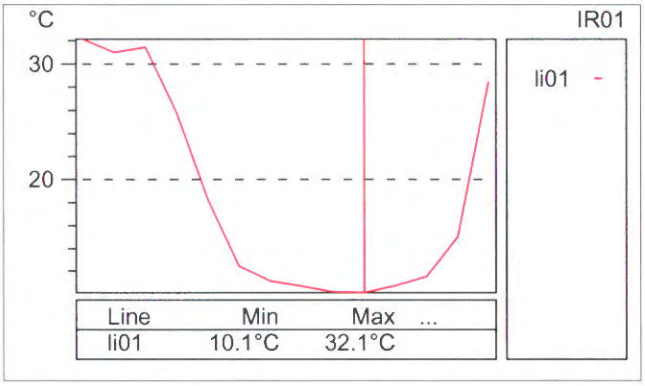
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.

Site 12 - Landscape Thermogram

Kwinshatin Creek at Coquihalla Highway



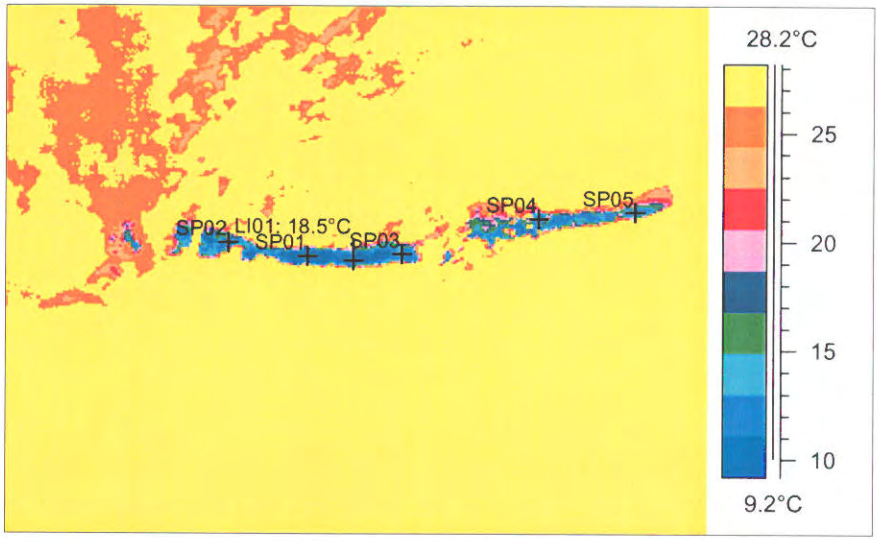
IR information	Value
Date of creation	7/3/01
Time of creation	3:54:51 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	61.5°C
IR : min	9.8°C
SP01	9.9°C
SP02	10.1°C
SP03	11.7°C
SP04	10.7°C
SP05	11.4°C
LI01 : cursor	10.1°C



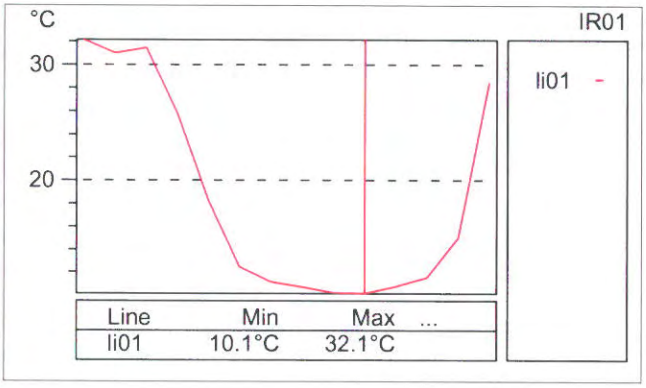
Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.
Ground-measured water temperature 10.1 degrees (Surveyor: Chris)

Site 12 - Water Thermogram

Kwinshatin Creek at Coquihalla Highway



IR information	Value
Date of creation	7/3/01
Time of creation	3:54:51 PM
Object parameter	**Value**
Atmospheric temperature	32.0°C
Relative humidity	0.27
Label	**Value**
IR : max	61.5°C
IR : min	9.8°C
SP01	9.9°C
SP02	10.1°C
SP03	11.7°C
SP04	10.7°C
SP05	11.4°C
LI01 : cursor	10.1°C



Spot 01 on the thermogram is located at the coldest temperature associated with the thermogram.
Ground-measured water temperature 10.1 degrees (Surveyor: Chris)