Blackfoot River Groundwater Detection Infrared Study

By

Ron Pierce

and

Don Peters

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Montana Department of Fish, Wildlife and Parks
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INTRODUCTION

The objective of this study was to evaluate the potential for using infrared scanning equipment to detect groundwater influenced stream sections while geo-referencing the data collections. Bull trout, a species of special concern in the state of Montana and being considered for petitioning for endangered status by several organizations, is known to use groundwater influenced areas for spawning. Since some known historical spawning areas are not currently being used and re-introductions to historical spawning sites is being considered, identification of all potential re-introduction sites need to be identified. Visual observation with aircraft could be used to identify potential sites by identifying stream areas devoid of ice. The lack of mid-winter ice cover probably is sufficient evidence of a groundwater influenced stream section. Thermal infrared scanning has the potential to obtain accurate water temperatures and quickly identify the area of influence. Geo-referencing of the infrared data could provide for increased accuracy of ground locations and provide analysis capability via computer based geographic information systems (GIS).

METHODS

A Model 525 Forward Looking Infrared (FLIR) line scanner manufactured by Inframetrics (North Billerica, Ma.) was used for infrared wave length detection. The hand-held FLIR was filled with liquid nitrogen during scanning flights. Several different modes of operation were available with this FLIR. The two most useful modes we found were the image mode and the line mode. The image mode produced a full screen picture similar to TV of thermal emissions of scanned objects. Line scan mode gave a video output of the average value of intercepted infrared wave lengths across the horizon for the entire field of view. The resultant TV image was a line with peaks and troughs of those average values with warmer areas appearing as the peaks and cold areas the troughs.

The FLIR needed to be calibrated with a level control and scale dial to the desired temperature ranges. Some operator experience was necessary to become proficient at setting the level for good image production. FLIR scan data was routed to a small Sony portable VCR/TV. The portable VCR/TV produced a high resolution line scan or image scan on the screen. A smaller camcorder size viewing monitor was mounted on the FLIR to help the FLIR operator with viewing output from the FLIR. Image mode setting of the level was difficult with the camcorder size monitor and communications with the computer/vcr/tv operator was helpful for this calibration.

Two geo-referencing techniques were considered for referencing infrared scan data. The first was a helicopter mounted Apollo

model 604 Loran-c receiver and the satellite based Global Positioning System (GPS). The GPS was to be run independently for post flight error correction of Loran readings at some later date. Loran data was routed through a caption generator and then into an 8 mm video recorder, as well as, into a laptop 286 portable personal computer. The function of the caption generator was to add time and location data (lat/long) in the form of a caption to the video image from the FLIR. Helicopter Loran data sent to the laptop pc were interpreted by a software program called LORAN written by the USFS. The program is configurable to various loran systems, several plotters, time between lat/long data saves, data review, screen mapping and the ability to flag individual lat/long locations during collection. Location data,time and flags are stored in standard ASCII format in an operator designated file.

The 28 volt aircraft power source was used to power all equipment via a transformer box.

The flight crew that we used included the pilot, FLIR operator, and computer/vcr/tv operator. The front passenger side door of the helicopter was removed for the FLIR operator to scan from. The computer operator sat in the back seat. Audio communications to the video recording equipment was accomplished by sliding a small microphone into the helicopter communications headset a bad headset resulted in essentially no useable audio on the video tape. The audio would have helped in identifying stream locations on the video recordings of the FLIR scans.

The temperature at the mouth of Nevada Creek and the Blackfoot river were measured with a hand held laboratory thermometer.

RESULTS

On March 4 we mounted the FLIR and peripheral devices into the Hughes 500 helicopter. Approximately 2 hours of flight time in the pre-dusk evening hours gave us the opportunity to field test the FLIR over the Blackfoot River and Cottonwood Creek. The caption generator did not work so was removed from the aircraft. A ground crew made rounds to local streams to check for water temperature conditions in the groundwater influenced area of Monture Creek. Fair weather had eliminated the differences in groundwater temperature compared to the basin fed ambient temperatures in Monture Creek. This would make detection of groundwater impossible. Since the key to success of this effort was the detection of water temperature differences with the FLIR, we began looking for sites in the vicinity that had temperature differences. The mouth of a small unnamed spring creek on the North Fork of the Blackfoot River and the mouth of Nevada Creek and the Blackfoot River provided another site. We landed the helicopter at each of the sites to collect water temperatures after scanning them with the FLIR.

Water temperature of Nevada Creek and the Blackfoot River were respectively 1.0° C and 4.5° C. The line and image scans in

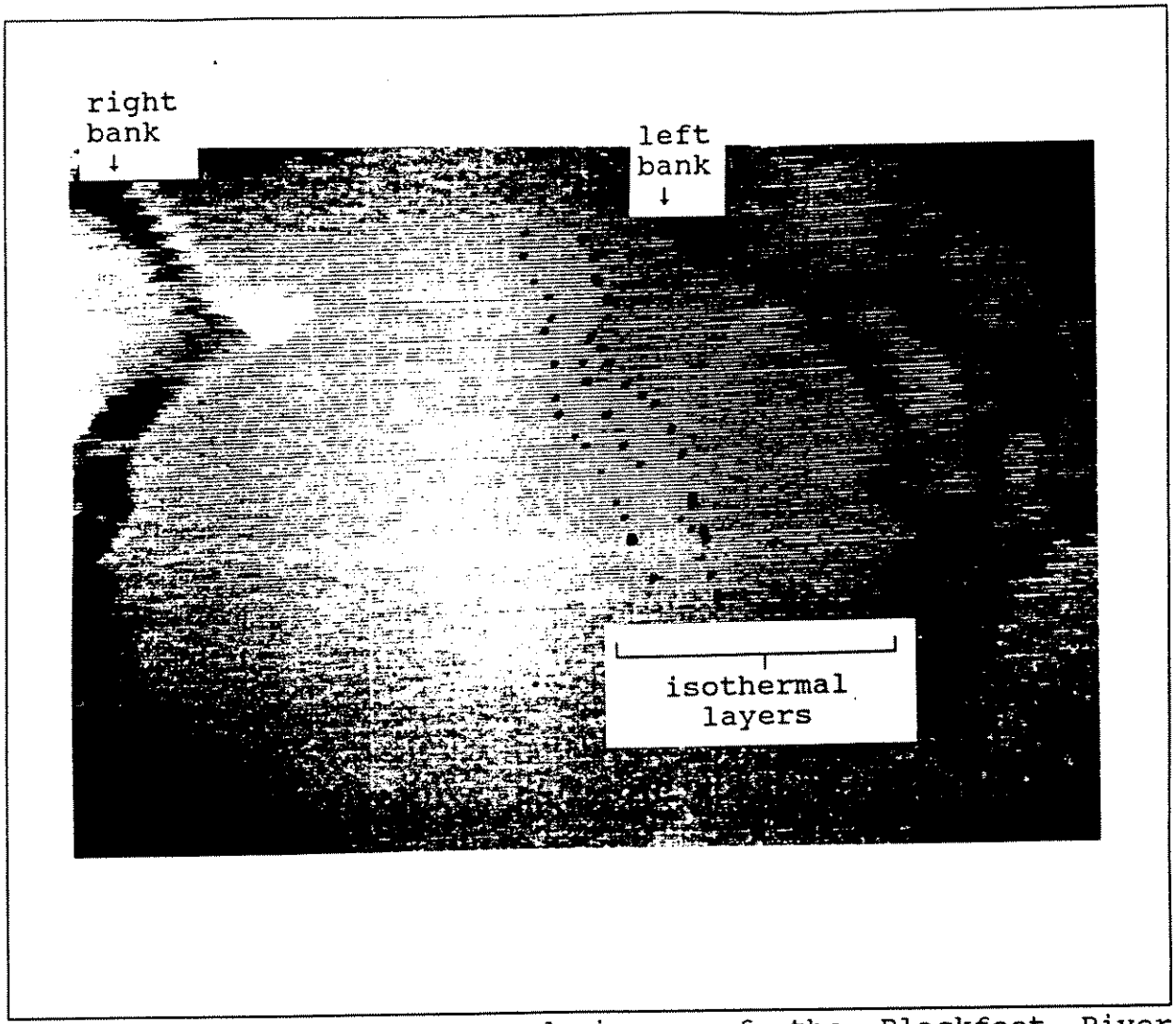

Figure 1. Infrared scanned image of the Blackfoot River approximately 150 feet below the mouth of Nevada Creek, March 5, 1992.

Figures 1 and 2 clearly show the temperature mixing zone below the mouth of Nevada Creek.

The isothermal layers are visible along the left bank of the Blackfoot River in Figure 1.

DISCUSSION

Due to mild weather, we were unable to determine groundwater influence within a stream section. However the infrared scanner clearly defined thermal variation within streams at tributary junctions. At tributary junctions stream temperatures ranged from 1.0° C to 4.5° C. The 3.5° C temperature range differential

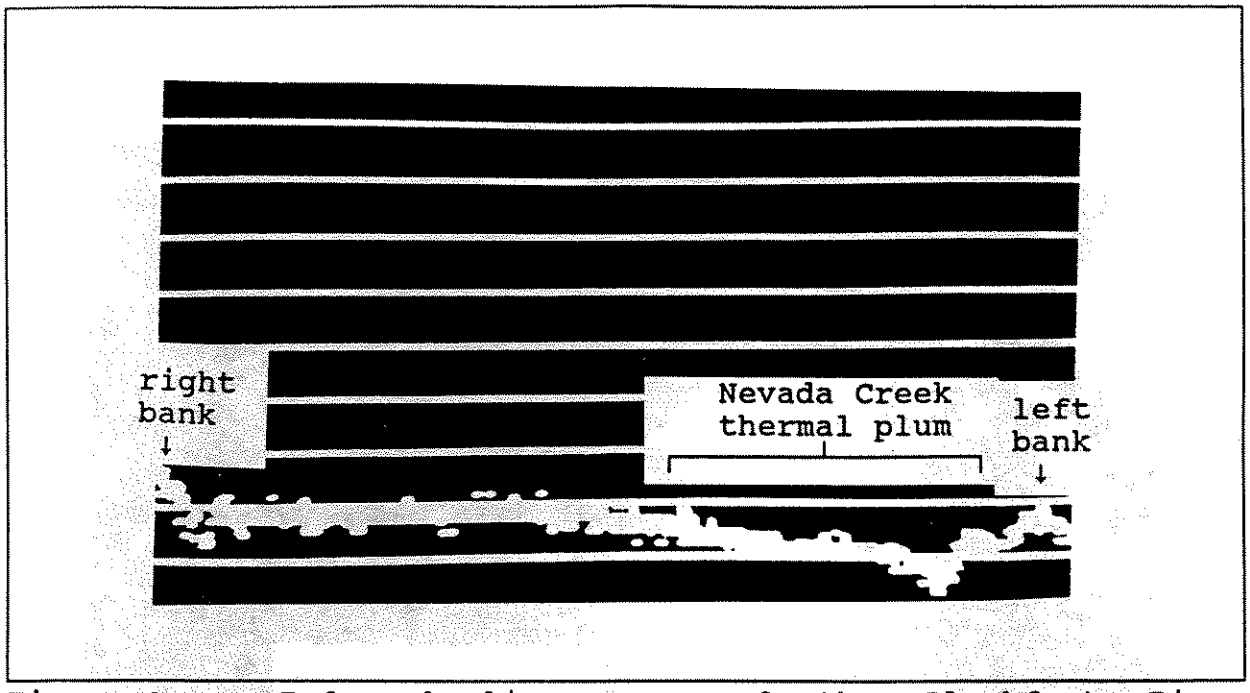

Figure 2. Infrared line scan of the Blackfoot River approximately 150 feet below the mouth of Nevada Creek, March 5, 1992.

approximates the range found in groundwater fed reaches during mid-winter periods. Therefore we conclude that the FLIR technology would adequately detect groundwater influenced zones during the mid-winter periods when stream temperatures are near 0° C. The amplitude of the line scan data also seems to indicate that temperatures can be differentiated down to the 0.5° C range. This technology has great potential in the study of thermal problems associated with over-heated systems. The technology lends itself to easily identifing sources, mixing zones, and spatial dynamics of the thermal problems.

The equipment we used is currently about three generations old in product design improvements according to the manufacturer. Several of the difficulties we had with calibration, level control, and geo-referencing are now integrated into the system much better.