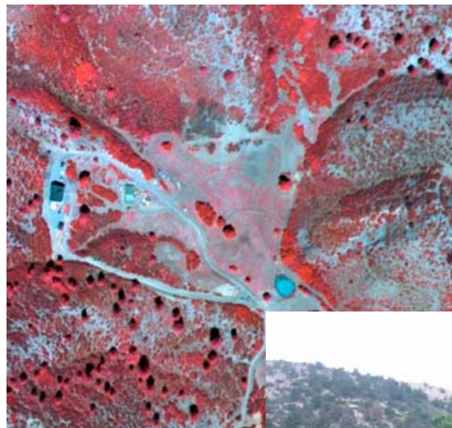
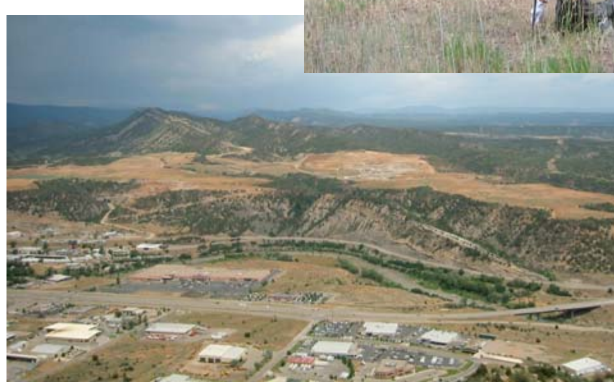
FRUITLAND OUTCROP MONITORING REPORT

LA PLATA COUNTY, COLORADO





OCTOBER 2003

Prepared for:

THE GROUP
Durango, Colorado

FRUITLAND OUTCROP MONITORING REPORT
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EXECUTIVE SUMMARY

Since 1998, LT Environmental, Inc. (LTE) has conducted methane seep monitoring on the Fruitland Formation (Kf) outcrop in La Plata County, Colorado (Figure 1). The study area is located along the north rim of the San Juan Basin, north of the Southern Ute Indian Reservation. The objectives of the monitoring program are to observe and document the relative change in methane seepage from the Kf outcrop over time and space. The overriding goal of the program is to ensure the safety of the public and the environment.

The three objectives of the scope of work as described in this report are as follows:

- Continued monitoring of the existing flux chamber systems;
- Perform detailed seep mapping in known methane seep areas; and
- Expansion of the previously reported pilot study to evaluate the entire outcrop area using infrared (IR) imagery coupled with field verification to document present day conditions.

Gas Flux Chambers

Overall, Pine River, Texas Creek, and, to a lesser extent, Basin Creek are more active seep areas than that observed at the Animas River (Carbon Junction), Florida River, and East Pine. Increased radius of capture has provided higher volumes of gas for land positioned flux chambers in Texas Creek, Carbon Junction, and Pine River thereby allowing for more accurate recording of flow rate when gas is present. For long term trend monitoring of seep flow, all chambers are capable of measuring rate changes over time.

The Basin Creek flux chamber has been removed and is no longer active due to construction of the Animas La Plata Project (ALP) dam.

Gas flow rates recorded by the flux chambers have decreased during the last four months of the reporting period which is likely due to decreases in water levels in the alluvial aquifers. As water levels in alluvial aquifers drop, the effect of dilution and dispersion of seeping gas increases. Increases in the effects of dilution and dispersion in the vadose zone appear to affect the flux chambers ability to capture seeping gas at measurable levels.

The flow rates measured at the land based chamber and creek chambers in Texas Creek appear to be proportional to each other. Similar declines in gas flow were observed in both chambers over the same time period. This data suggests that land based chambers have the capability to monitor changes in seepage flow rate over time. Over time, the land-based chambers should be capable of detecting changes in seepage flow rate as effectively as the chambers located directly within creeks.

As previously observed, daily methane flow rates peak during the afternoon when the ambient air temperature is the highest. There appears to be some comparison between lower barometric pressure readings and increased flow rates.

Detailed Seep Mapping

Detailed mapping of known seep areas occurred in late May 2003. The seep mapping areas included Basin Creek, Carbon Junction, Florida River, and Texas Creek.

The seep trends observed are similar to those trends previously identified with the most active seeps occurring in the lower portions of the Kf, based on surface geology, in areas where a surface drainage feature transects the geologic contact between the Pictured Cliffs Formation (Kpc) and Kf.

A methane seep area was identified along the Florida River near the Florida Farmers Canal Headgate. The area was not included in previous surveys along the outcrop. This location is stratigraphically positioned over the Lewis Formation (Kl) based on surface geology. A sample was collected and analyzed from these visible seeps in July 2003. The results indicate that the methane detected is from a near-surface microbial fermentation source rather than a thermogenic source.

Drought has influenced the detailed mapping results, particularly during the October 2002 mapping event where more dead and/or dormant vegetation was observed. Dr. Jacobi, a tree pathologist from Colorado State University, stated that trees are highly stressed due to drought conditions that have been present in the region for the past four to five years.

The presence of dead or stressed vegetation does not imply that methane has caused the condition. In many areas mapped, particularly east of the Carbon Junction area, dead or stressed vegetation was observed with no detectable concentrations of methane noted. Another example is in the Carbon Junction area where numerous dead pine trees from Ips beetle kill was observed and subsurface methane was not detected.

Dr. Jacobi noted that vegetation mortality in methane seep areas appears to include all types of plants such as grasses, forbes, bushes, and trees rather than individual species. Mortality of piñon pine trees is commonly a result of black stain root disease and Ips bark beetle. Mortality of juniper trees is not common in the study area and could be an indicator of subsurface methane. Mortality of ponderosa pine is not as common as piñon mortality but also appeared to be a result of Ips beetle in most cases. At first glance, most of the woody plant mortality observed in the main seep areas appeared to have occurred within the last five to 15 years but more in-depth analysis is needed to document this observation.

Based on the results of the detailed seep mapping, it appears that the mapping methodology utilized by LTE will be effective for monitoring changes over time and space since more features are being monitored. In addition, the features that were mapped have been located and defined more accurately as compared to previous surveys. The distribution of methane relative to vegetation will be better observed in the spring (May time frame).

Inferences to the extent of the seep areas can also be made from the results of the detailed mapping and IR imagery analysis activities, although specific boundaries are difficult to define. The methane distribution has been established in the seep areas. Subsequent mapping events will provide data to determine if the methane seeps are intensifying, remaining the same, or decreasing.

Regional Reconnaissance

The IR imagery from along the entire 23 mile Kf outcrop area has been viewed and evaluated, and the images have been incorporated into LTE's ongoing Geographic Information System (GIS) project. One hundred and one (101) suspect areas were identified along the outcrop based on vegetative conditions or other chromatic anomaly observed in the imagery. LTE's field crew visually inspected and manually collected subsurface methane measurements at 80 of the 101 suspect polygons. Of the 80 areas visited, 20 suspect areas contained subsurface methane above 25 parts per million (ppm) and 12 of these areas were located outside the previous detailed seep mapping study areas performed in October 2002 and May 2003. Most of the suspect areas that were not inspected were located on land where access was not granted.

The majority of the suspect areas identified in the imagery contained dead vegetation that was not associated with subsurface methane. The predominant cause of mortality and/or stress observed at these areas was related to natural die back as a result of drought conditions or Ips beetle infestation.

The IR imagery was effective in identifying relatively small and isolated areas of dead vegetation that were confirmed to exhibit methane seepage through field verification. The value of the photo-documentation will increase as future IR imagery is captured. Comparison of the suspect areas where methane has been observed will demonstrate changes in both time and space.

The newest previously undefined area which contains methane is the Hoier property located on the Kf outcrop approximately 1.25 miles west of Pine River.

LTE recommends that the next detailed mapping occur in May 2004 and the next IR imagery reconnaissance flight be performed during late Spring 2005, field verification of the IR imagery can occur in early Summer 2005.

Finally, LTE recommends that the ORDER established by the Colorado Oil and Gas Conservation Commission (COGCC) be modified to incorporate the new technologies and methods used to monitor the outcrop.

SECTION 1.0

INTRODUCTION

Since 1998, LT Environmental, Inc. (LTE) has conducted methane seep monitoring on the Fruitland Formation (Kf) outcrop in La Plata County, Colorado (Figure 1). The study area is located along the north rim of the San Juan Basin, north of the Southern Ute Indian Reservation. The objectives of the monitoring program are to observe and document the relative change in methane seepage from the Kf outcrop over time and space. The overriding goal of the program is to ensure the safety of the public and the environment.

This program is being conducted on behalf of BP, Inc. (BP); XTO Energy, Inc. (XTO); Pure Resources, Inc (Pure); ChevronTexaco Production Company (ChevronTexaco); the Bureau of Land Management (BLM); the Colorado Oil and Gas Conservation Commission (COGCC); and La Plata County. These companies and governmental agencies are collectively referred to as "The Group".

1.1 OBJECTIVES

Based on the results of the modifications detailed in LTE's *Fruitland Outcrop Monitoring and Data Acquisition Modification Report* dated January 2003, LTE performed the following tasks:

- Continued monitoring of the existing flux chamber systems;
- Performed detailed seep mapping in known methane seep areas; and
- Expansion of the previously completed pilot study to evaluate the entire outcrop area using infrared (IR) imagery coupled with field verification to document present day conditions.

1.2 ORGANIZATION OF REPORT

This report is organized into six sections including this introduction, which presents the objective of the study and discusses background information related to the project. The field methods used to complete the scope of work are described in Section 2.0. Section 3.0 presents the results of the flux chamber monitoring. The results of the detailed mapping activities are summarized in Section 4.0. The results of the IR imagery evaluation and field verification activities are presented in Section 5.0. Section 6.0 presents the conclusions and recommendations for continued monitoring. Figures and appendices follow the text in separate sections. Pertinent photographs have been included in the text.

1.3 BACKGROUND INFORMATION

The study area consists of approximately 23 miles of the Kf outcrop extending from the Southern Ute Indian Reservation northern boundary north and eastward to an area three miles east of Pine River (Figure 1). There have been a number of previous and ongoing studies, which support the overall methane seepage evaluation. Some of the previous studies include:

- Ongoing detailed mapping, methane seepage data collection, and mitigation in the Pine River area by BP since 1994;

- Reconnaissance survey by BLM/Stonebrooke in 1995, which consisted of collection of over 1,100 surface and/or subsurface methane sample points. This survey identified four additional primary methane gas seepage areas besides Pine River including Basin Creek, Carbon Junction, Florida River, and South Fork Texas Creek (Texas Creek);

- Installation of 162 permanent soil gas monitoring probes by LTE in 1998 and ongoing monitoring of the points by the BLM. The probes are sampled approximately six to eight times per year;

- Installation and ongoing monitoring of seven flux chambers in the primary seepage areas. The gas flux chambers measure gas flow on 10-minute intervals. Data are downloaded from the flux chambers every 45 days;

- Reconnaissance surveys of the outcrop by LTE since 1998; and

- Flux chamber system modifications, detailed seep mapping, and IR pilot study performed in August 2002. The pilot study demonstrated that the IR imagery is useful in identifying suspect areas based on vegetation impacts, which can be subsequently field verified for the presence or absence of methane.

These studies have noted the variability of the methane seepage both in time and space as a result of changes in rainfall, barometric pressure, temperature, and data collection techniques.

SECTION 2.0

FIELD METHODS

This section describes the approach and procedures used during flux chamber monitoring; the detailed seep mapping; and the IR imagery review and associated field verification event. Photographic documentation of the modifications is included throughout the report and in the appendices.

2.1 GAS FLUX CHAMBER MONITORING

Throughout the period from July 2002 to July 2003, LTE continued data collection and operation and maintenance (O&M) activities at the seven gas flux chambers. Data are collected on 10-minute intervals and stored in a Datataker remote datalogger. Data are downloaded from each of the dataloggers approximately every 45 days and transferred to a database for evaluation. LTE personnel inspected each of the chambers for operational issues and made the necessary adjustments to maximize data collection. Power supply issues and mechanical problems are remedied during each inspection, as required. The modified flux chamber locations are presented in Figure 1.

The data from the chambers are stored in a Microsoft® Access database to facilitate data retrieval using specified queries.

In late August 2003, LTE received notice that the gas flux chamber located in the Basin Creek study area will soon impede construction work on the Animas La Plata Project (ALP). On August 29, 2003, LTE personnel were on site to remove the flux chamber and associated equipment from the area. With the cooperation of the COGCC, the equipment was transported to a storage unit located in Durango, Colorado for temporary storage.

2.2 DETAILED METHANE GAS SEEP MAPPING

Detailed seep mapping was completed in the areas of Basin Creek, Carbon Junction, Florida River, and South Fork Texas Creek. Detailed seep mapping was not performed in the Pine River area since BP frequently maps this area. A small area west of Pine River (Hoier Property) was mapped by LTE personnel following a recent report from the landowner citing the presence of large areas of dead vegetation on the property.

The detailed seep mapping was performed May 20, 2003 through May 27, 2003. The detailed mapping on the Hoier Property was performed on August 17, 2003. The LTE field crew was equipped with the aerial photographs (orthoquads and uncorrected IR imagery), topographic maps, digital camera, sampling equipment (slide-hammer and probe), global positioning system (GPS), and an MSA GasPort® capable of detecting methane, hydrogen sulfide (H_2S), oxygen (O_2), and carbon monoxide (CO).

The scope of the detailed seep mapping program was based on the previous surveys performed by BP in the Pine River area (Paul Oldaker) and in the Texas Creek area (Rusty Riese). The procedure involved walking the known seep areas and vicinity and noting dead, stressed, and non-vegetated areas. Areas where visible seeps were occurring within surface water bodies were also identified and mapped. LTE mapped the dead or stressed trees, areas of dead or impacted grass using the GPS. Subsurface measurements of methane, H_2S, and O_2 were collected, where appropriate.

Previous studies identified the most active seep areas to be in lowland areas where a creek or river transects the Kf outcrop. The seep mapping was conducted within 0.5 miles of the creek/river banks along the strike of the outcrop. LTE mapped beyond the upper and lower surface contacts of the Kf outcrop to define the seep area and account for faulting, inter-fingering, or other potential geologic anomalies.

When the surface water flow was relatively low enough, LTE waded through the creeks and walked along the banks looking for methane seep bubbles and dead or stressed vegetation. Since this mapping event was performed during spring runoff, visible seeps within the surface water bodies were limited. If wading was not possible, the banks of each waterway were traversed. Pertinent features on each side of the waterway were mapped in areas where property access was granted.

Digital Orthophoto Quarter Quadrangles (DOQQs) and uncorrected IR Imagery were used as preliminary field guides to locate suspect areas, such as clusters of dead or stressed trees, patches of dead or stressed grass, or bare ground in the seep areas. This preliminary review of the aerial photographs was conducted as a mechanism to help with the initial mapping.

2.2.1 Types of Features Observed

The types of features noted during the mapping survey included the following:

- non-vegetated areas;
- dead vegetated areas;
- stressed vegetated areas;
- pertinent live vegetated areas;
- dead trees;
- pertinent live trees;
- stressed trees;
- bifurcated trees;
- methane seep points within surface water bodies;
- methane seep areas within surface water bodies; and
- general seep trend lines.

In the lowland areas, LTE focussed on non-vegetated areas that were adjacent to live vegetation areas. These areas were commonly located in the valley lowlands and appear to have been vegetated in the past but have since died off. The dead vegetated areas were observed as patches of dead bushes and/or grass. Stressed vegetation areas were defined as co-mingled sparsely vegetated areas and non-vegetated areas. The small dead or non-vegetated areas were mapped independently at each mapping area. Pertinent live vegetation features were mapped when they appeared as mappable surface areas coexisting with dead or non-vegetated areas.

Dead, stressed, and bifurcated trees were mapped, as practicable, in each of the mapping areas. LTE initially attempted to map tree stumps but dropped these features from the mapping program due to time constraints. The trees were divided into scrub oak, pine, aspen, juniper, and cottonwood.

In some instances, bifurcated trees were also mapped although mapping of this feature was limited compared to the mapping procedures used during the 2002 detailed seep mapping. These trees were characterized by trunks that have split or forked due to genetic reasons or some type of damage to the leader.

LTE mapped individual seeps observed within surface water bodies. In some cases, visible methane seeps were often closely spaced and therefore mapped as seep areas or seep trends, especially if the flow in the rivers was high. When linear stressed or dead features where noted they were also mapped as seep trend lines.

The mapping results are presented in figures, which are contained in a separate section following the text. The subsurface methane measurement location symbols were graduated based on concentration. While the lowest concentration range depicted is from 0.0 parts per million (ppm) to 25 ppm, the majority of these locations were actually measured to be 0.0 ppm. In many cases, subsurface methane concentrations were collected in dead and stressed areas and at dead and stressed trees. The results of the subsurface measurements for these features were presented using text labels rather than graduated symbols.

2.2.2 Use of GPS

LTE used a Trimble ProXR® GPS with a real-time correction processor to map observed dead, bifurcated, and pertinent live trees; dead, stressed, and non-vegetated patches; and obvious methane seeps in the creeks/rivers. Specifications of the unit are included in Appendix A. The methane measurements and other relevant field notes were stored as attributes in the GPS unit with the associated GPS mapped positions. The GPS data were later downloaded to a computer and manipulated using Trimble GPS Pathfinder Office® version 2.90. The data was converted to shape files and grouped according to the type of feature, as points, lines, or polygons.

The data were collected with GPS in the WGS 84 coordinate system and converted to decimal degrees NAD 83 for use in the Durango Methane ArcView® project file developed by LTE in 2001. Trees were mapped as point locations and vegetation patches were mapped as polygons. On average, 20 GPS readings were collected for each point feature in order to obtain more accurate positioning. The perimeter of each mapped area was slowly traversed collecting positioning data at a rate of approximately one logged point per foot.

2.2.3 Gas Measurement Collection

A slide hammer was used to advance a half-inch diameter steel rod (probe) to a depth of approximately 36 inches during the seep mapping. Some probe holes were shallower than 36 inches due to the density of the ground surface. One-quarter inch diameter polyethylene tubing perforated at the bottom six inches was inserted into each probe hole to collect subsurface gas measurements. The MSA GasPort® field meter was utilized to measure the concentration of methane, H_2S, and O_2 in each probe hole. After recording the gas reading, the tubing was removed and the probe hole was backfilled with native soil.

The MSA GasPort® is capable of detecting methane in concentrations from 0.0 ppm to 100 percent (%) methane. Specifications for the unit are included in Appendix A. The field meter was calibrated to methane and H_2S each morning and again at midday to ensure the equipment was working properly.

Subsurface methane measurements were recorded at selected dead, stressed, or bifurcated trees. Probe holes were advanced adjacent to the trees to collect the measurements. If the stressed or dead trees were grouped together a representative number of measurements were recorded inside the cluster to depict the entire area.

2.3 REGIONAL OUTCROP MONITORING

The regional outcrop monitoring consists of IR imagery acquisition and evaluation followed by field verification of suspect areas identified in the imagery.

2.3.1 Aerial Photograph and Infrared Imagery Review

The purpose of the IR imagery is to assist in long term reconnaissance monitoring of the entire outcrop to identify changes in methane seepage over time and space. While the imagery cannot identify specific seep areas, it is useful in identifying areas of dead and/or stressed vegetation that may or may not be attributable to methane seepage. Therefore, LTE contracted Mr. Kevin Lee Hayes, a digital IR imaging expert from Colorado State University (CSU), to assist in identifying suspect areas along the outcrop.

Suspect areas are defined as areas observed within the IR image that appear anomalous when compared to the surrounding areas. For example, a light gray colored area surrounded by bright red colored areas would be considered a suspect area. The natural features that often produce such suspect areas include areas of dead vegetation, shadows, rock outcrops, and patches of stressed vegetation.

Through field verification processes, the suspect areas are inspected to determine if methane gas is present. In addition, the photo-documentation record will provide a baseline to monitor changes in vegetative conditions across the entire outcrop and with subsequent flights over time.

<u>Acquisition of Aerial Imagery</u>

Imagery acquisition by Agro Engineering (Agro) of Alamosa, Colorado, was selected based on image quality, availability, logistical considerations, and cost. This decision was reinforced by the 2002 Missionary Ridge fire, which occurred a few miles north of the pilot study area. Agro successfully captured the outcrop imagery, despite flying restrictions due to the wildfire, periodic air quality problems, and turbulent flying conditions over topographic ridges. Agro was able to follow the GPS flight path supplied by LTE accurately and completely. The aerial imagery of the entire outcrop was collected as part of the pilot test activities performed in August 2002.

The photo-mission traversed the entire 23 mile long outcrop three times, collecting three different resolutions (0.5 meters, 1.0 meters, and 1.5 meters). Photography was acquired between 9:30 AM and 1:00 PM on August 14, 2002. Note that 1.5 meter images were taken nearly three hours before the higher resolution images. The time differences significantly affect the impact of shadows within the imagery. The flying altitude varied from approximately 10,500 to 15,400 feet, over rugged terrain with elevations between 7,300 to 8,200 feet. A total of 237 images were acquired and quickly reviewed for quality. The interpretation and analysis for the entire outcrop was performed using the 1.5 meter resolution images since they were determined to be useful for identifying suspect areas and also require fewer images to rectify and evaluate across the entire outcrop area.

Image Georectification

In order to present the data and aerial IR imagery, it is first necessary to georectify the imagery. This process assigns a coordinate system to the IR imagery so that geographic features can be mapped and presented on the imagery as a map base.

LTE contracted Agro to process and georectify the 54 images collected at 1.5 meter resolution during the August 14, 2002 flight of the entire outcrop area. The images were tiled together into three groups and imported into the GIS for the project area.

The accuracy of a georectified base map is proportional to the number of control points available and the time and effort exerted during the rectification process. Agro used DOQQs as the reference map and rectified the IR image to the DOQQ. Therefore, the accuracy of the IR base map image is limited but still provides a frame of reference for the field mapping data collected. In some cases the IR image is accurate to within one meter of the actual location because a control point is available nearby. In certain portions of the same image, accuracy can be skewed as much as 10 meters to 15 meters due to lack of control. When viewing the data presented in this report, remember that GPS data is accurate to within one meter and the actual position of the feature mapped should be trusted over the position of the features observed within the IR image. Ultimately, the rectified images are accurate enough to assist the field personnel in identifying the area in question.

Analysis of Imagery

A variety of software imaging packages were used. Microsoft Photo Editor®, Adobe Photoshop®, Kodak Photo Imager®, and ACDSee® proved helpful for cursory examination on a color computer monitor. All of these imaging packages are not appropriate for viewing pixel-level detail (i.e. zoomed in or enlarged).

As described in LTE's January 2003 report summarizing the IR pilot study, Spectral analysis using ERDAS Imagine® further refines the utility of the imagery but the effort involved in obtaining the data outweighs the usefulness of the result. Therefore, LTE decided that the "heads-up" method of image evaluation would be best suited to identify areas with significant vegetation mortality. Field verification of these suspect areas could then determine if the mortality was a result of methane seepage.

The images acquired within the pilot study area were evaluated by Mr. Hayes using simple visual techniques. Based on professional experience in evaluating IR imagery and knowledge gained during the pilot test process, Mr. Hayes was able to identify suspect areas across the entire 23 outcrop that appeared to contain vegetation mortality or, in some cases, vegetative stress.

2.3.2 Field Verification

Field verification of the IR imagery was performed by LTE from July 21, 2003 through July 31, 2003. Using a GPS, slide hammer, and methane meter, LTE visited each of the suspect areas where accessible and collected subsurface methane measurements within each polygon and outside the perimeter of each polygon. LTE also collected photographs of the area and describe the features observed. The field verification data has been relayed to Kevin Hayes to refine future evaluations of IR imagery.

During a portion of the field verification activities, LTE contracted to Dr. William Jacobi from CSU. Dr. Jacobi, a tree pathologist, was contracted to observe the condition of vegetation in the study area and provide information concerning plant mortality.

2.4 LIMITATIONS

The type of terrain that exists along the Kf outcrop presents difficulties for both the GPS unit and collection of subsurface methane samples with the slide hammer.

North-facing slopes and heavily wooded areas are difficult to obtain accurate positioning by the GPS. Satellite signals are frequently bounced among the trees or lost completely. When satellite signals are limited, positioning accuracy decreases. In some cases, it is not possible to map by GPS. Readings collected with the GPS unit can be located within one-meter radius of accuracy. However, in heavily wooded areas and north-facing slopes the unit’s accuracy will decrease.

Soil probing in consolidated materials along the outcrop was limited. LTE used the slide hammer to probe to a maximum depth of 36 inches below ground surface (bgs). In some cases, probing depths of 18 inches bgs were laborious to achieve. If refusal occurred, measurements were taken at the depth bored. All probe holes were advanced to a depth ranging from 6 inches to 36 inches bgs depending on the type of surface cover present.

Methane measurements of the visible seeps within surface water bodies were not recorded because of the inaccuracy associated with collecting the readings. Ambient air mixing with the methane and dispersion caused skewing of the measurement. The funnel was used in areas where gas seeps were unexpected to determine whether methane was the gas seeping through the surface water. Some portions of the waterways had too many bubbles to map separately so they were grouped together as seep areas or seep trends.

Aerial imagery varies greatly depending on the type of terrain, angle of the sun, time of day, and atmospheric conditions at the time of acquisition. In some cases the full potential usefulness of the image could not be achieved due to one or more of the factors described above. In particular, north facing slopes and morning time images cast shadows that make IR interpretation difficult in some areas.

Finally, LTE was restricted by property owners from accessing several areas with noted irregularities observed on the IR images or during previous surveys. These areas are denoted on the maps presented in this report.

SECTION 3.0

FLUX CHAMBER MONITORING RESULTS

This section describes the results of the O&M and data collected at each of the flux chamber locations from November 2002 through July 2003. Flux chamber data is presented in Appendix C. Flux chamber monitoring locations are illustrated on Figure 1.

3.1 BASIN CREEK

The repositioning of the flux chamber from the original location down into the creek in August 2002 effectively increased the volume of gas captured and recorded by the monitoring unit. Flow rates prior to modifications were sporadic and rarely exceeded 200 standard cubic centimeters per minute (sccm). Once repositioned, flow rates remained sporadic but were higher ranging from approximately 500 sccm to as high as 5,000 sccm. Daily flows were generally in the 500 sccm to 2,000 sccm range.

During the early part of July 2003, the Basin Creek area apparently experienced heavy rain followed by localized flooding within the creek. As a result, the high water worked the chamber loose from its original position. Fortunately, the tubing and cable fixed on the top of the chamber to the control box and solar panel tethered the unit and prevented it from floating downstream. The unit was repaired and placed back into operation on August 20, 2003.

Recently, the Bureau of Reclamation notified The Group that construction of the Animas La Plata (ALP) water project will encroach upon the current Basin Creek monitoring location. At the direction of the COGCC, LTE removed the Basin Creek chamber from the monitoring location on August 29, 2003. The monitoring chamber has been stored the COGCC's storage unit in Durango, Colorado indefinitely.

3.2 CARBON JUNCTION

The relocation of the flux chamber from the hillside to a position adjacent to the Animas River in August 2002 increased the volume of gas captured and recorded by the unit. However, flow rates remain sporadic over time. Flow rates measured at the previous location were frequently less than 25 sccm with peak flow rates ranging from 200 sccm to 400 sccm. Currently, flow rates are generally around 50 sccm but peak flow rates range from 400 sccm to greater than 1,100 sccm. As expected, the peak flows are also occurring more frequently than measured at the previous location.

3.3 FLORIDA RIVER

The relocation of the flux chamber from the hillside to a position within the Terry Palmer Ranch pond near the Florida River increased the volume of gas captured and recorded by the unit. Previous flow rates were typically less than 10 sccm with peak flows near 25 sccm. Currently, flow rates are consistently measured at rates above 20 sccm with peak flows approaching 75 sccm.

One difficulty that we have experienced at this location is drops in pond water levels. During the period from August 2002 through March 2003, water levels in the pond were below the bottom of the flux chamber, which is placed directly within the pond. Therefore, recorded flow rates during the low water periods are markedly lower than when the base of the unit is sealed by the pond water level. LTE will attempt to lower the unit during the low water periods observed in late fall and early winter months.

3.4 TEXAS CREEK

The flux chamber within Texas Creek has typically recorded the highest flow rates within the monitoring system. However, the data from the past year has shown significant decline in recorded flow rate. This decline is likely associated with the drought conditions in the area. The low flow rates observed during most of 2002 and into February 2003 and again from late March 2003 to the present appear to correlate with observed low or no stream flow rates within the South Fork of Texas Creek. The peak methane flows observed during the period between February 2003 and late March 2003 are lower than peak methane flows observed in 2001.

When comparing the data collected from the chamber located directly in the creek to the data collected from the chamber located on land, it appears that there is a proportional relationship between the two units. During the period between May 2003 and July 2003, both units recorded a declining methane flow rate trend. A similar trend can be observed at Basin Creek. These declines are likely associated with seasonal decline in water levels observed in the creeks.

3.5 PINE RIVER

The larger capture zone of the Pine River flux chamber located on land has resulted in an increase in the maximum flow rates recorded. However, the flow recorded at the chamber appears to remain highly variable with sporadic peak flows rather than a consistent flow as compared to the BP Pyramids located directly within the Pine River.

3.6 EAST PINE

The flow rates recorded at the East Pine flux chamber appear to be consistent with previous measurement periods. Flow is sporadic with peak flow rates rarely exceeding 50 sccm. In general, methane flow appears to be slightly more active during the period from March through October in comparison to the winter months. Concentrations of methane collected during O&M activities ranged from 0.0 ppm to 1,500 ppm.

3.7 WEATHER STATION DATA COMPARISON

LTE compared the flow data collected from the chambers to the barometric pressure data and temperature data collected by the weather station at Pine River. The comparison suggest a slight relationship between methane flow and daily temperature changes in that most peak flows occur in the afternoon hours when the temperature is highest. Flow rates decrease as temperatures decrease. This is not always consistent but proportional relationships are observed frequently throughout the data collection period. Charts illustrating the comparison between temperature and gas flow are included in Appendix C.

Based on the data collected, any relationship between gas flow and barometric pressure is difficult to determine because gas flow is not constant. There is some indication from the Texas Creek flux chamber data that suggests gas flows are relatively higher during period of low pressure. Charts illustrating the comparison between barometric pressure and gas flow are included in Appendix C.

3.8 FLUX CHAMBER MONITORING SUMMARY

Overall, Pine River, Texas Creek, and, to a lesser extent, Basin Creek are more active seep areas than that observed at the Animas River (Carbon Junction), Florida River, and East Pine. Increased radius of capture has provided higher volumes of gas for land positioned flux chambers in Texas Creek, Carbon Junction, and Pine River thereby allowing for more accurate recording of flow rate when gas is present. For long term trend monitoring of seep flow, all chambers are capable of measuring rate changes over time.

The Basin Creek flux chamber has been removed and is no longer active due to construction of the ALP dam.

Gas flow rates recorded by the flux chambers have decreased during the last four months of the reporting period which is likely due to decreases in water levels in the alluvial aquifers. As water levels in alluvial aquifers drop, the effect of dilution and dispersion of seeping gas increases. Increases in the effects of dilution and dispersion in the vadose zone appear to affect the flux chambers ability to capture seeping gas at measurable levels.

The flow rates measured at the land based chamber and creek chambers in Texas Creek appear to be proportional to each other. Similar declines in gas flow were observed in both chambers over the same time period. This data suggests that land based chambers have the capability to monitor changes in seepage flow rate over time. The major difference between the two is that the land based chambers are more influenced by changes in the shallow groundwater level. Over time, the land based chambers should be capable of detecting changes in seepage flow rate as effectively as the chambers located directly within creeks.

As previously observed, daily methane flow rates peak during the afternoon when the ambient air temperature is the highest. There appears to be some comparison between lower barometric pressure readings and increased flow rates.

SECTION 4.0

DETAILED SEEP MAPPING RESULTS

The following sections summarize the observations made during the detailed seep mapping carried out from May 20, 2003 through May 27, 2003. This is the second detailed seep mapping event conducted in these areas with the initial event completed in early October 2002.

The mapping followed the procedures outlined in Section 3.0. The sections are grouped by study area and frequently reference figures for illustration purposes. Figures are included in a separate section following the text. For each figure reference, LTE has designated a text reference label to easily identify the location discussed. Each label consists of a two letter abbreviation for the mapping area followed by a number (i.e. BC-1).

4.1 BASIN CREEK

The detailed seep mapping for Basin Creek was completed on May 24, 2003. The mapping area was centered on Basin Creek and was approximately 0.45 miles in the east-west direction and 0.20 miles in the north-south direction. Figure 2 illustrates the results of the mapping in the Basin Creek area.

4.1.1 Observed Methane Seeps in Surface Water

The Basin Creek flux chamber is located in the creek bed of Basin Creek (BC-1, Figure 2). Visible methane seeps were noted within the creek intermittently for one-tenth of a mile east of the flux chamber location. Additional methane seeps were observed within the creek approximately one-quarter of a mile downstream at location BC-2 (Figure 2).

4.1.2 Lowland Areas

The area in Basin Creek demonstrating the highest subsurface methane concentration was encountered along the creek bed where the current gas flux chamber is located (BC-1, Figure 2). The concentrations detected ranged from less than 25 parts per million (ppm) to 490,000 ppm or 49 percent (%). The more active methane seeps identified in the mapping area were stratigraphically located in the lower sections of the Kf, though direct correlation to stratigraphy is difficult due to surface coverage. The area denoted as BC-2 correlates stratigraphically to the transition zone between the Kf and the Kirtland Formation (Kk) based on surface geology. Methane concentrations reported in the eastern end of the mapping area were less than 25 ppm. Subsurface H_2S concentrations were not detected in the lowland areas of Basin Creek.

4.1.3 Upland Areas

Subsurface methane was detected at location BC-3 (Figure 2) at a concentration of 39,500 ppm or 3.95%. All other mapped areas of dead and stressed pine, juniper, and scrub oak trees tested did not report methane concentrations at the time of sampling.

Figure 2 also illustrates data collected during the outcrop assessment in upland areas (BC-4). Elevated concentrations of methane were detected in upland areas south of Basin Creek ranging from less than 25 ppm to 20%. Subsurface H_2S concentrations were not detected in the upland areas of Basin Creek.

4.1.4 Comparison to Previous Surveys

Approximately five additional methane seeps in surface water were mapped during this event as compared to the mapping event performed in October 2002. This is likely due to the increased ability to observe methane seeps in surface water bodies during spring runoff conditions compared to dry conditions observed in the fall. Methane seeps are able to be observed more readily during saturated surface soil conditions or in surface water bodies such as slow moving creeks and rivers, standing pools of water, and small ponds. Although more locations were measured during this most recent detailed mapping event compared to the October 2002 event, the concentrations measured were relatively similar. Areas mapped as stressed vegetation areas during the October 2002 detailed mapping event were mapped as dead vegetation areas during the May 2003 mapping event. Subsurface H_2S was not detected at the Basin Creek study area during the 2002 and 2003 detailed mapping events.

Three subsurface methane measurements lines were collected in 1995 within the Basin Creek mapping area. In general, the concentrations detected in those locations were less than 25 ppm with the exception of six locations reporting concentrations ranging from 25 ppm to 500 ppm and two locations reporting methane concentrations ranging from 500 ppm to 5,000 ppm. Subsurface methane concentrations measured during the May 2003 detailed mapping event and July 2003 field verification event are generally higher than the concentrations reported in 1995 for the same area (BC-1, Figure 2). Maps illustrating the comparison between the 1995 and 2003 subsurface methane concentration data for the Basin Creek area is presented in Figures J through L in Appendix F.

4.2 CARBON JUNCTION

The mapping area at Carbon Junction is centered on the Animas River by the Wal-Mart shopping center on Highway 160 and extends approximately one-mile in the northeast direction and one-quarter of a mile in the northwest direction. The detailed mapping activities occurred on May 21, May 23, and May 24, 2003. The field data are illustrated on Figures 3 and 4.

4.2.1 Observed Methane Seeps in Surface Water

The Animas River is a major river in Colorado, and therefore only the banks were mapped due to the high water flow rates within the river at the time of mapping. Also, the high water flow rates and high turbidity made it difficult to observe methane bubbles within the river. The majority of the visible seep activity appears to be located over the lower portions of the Kf based on observed surface geology as mapped by the Colorado Geological Survey (CGS). However, several areas with visible seeps were noted in the upper portion of the Kf based on surface geology.

Observable methane seeps were sparsely distributed along both banks of the river downstream from the boat launch area for a distance of approximately 600 feet. Water in the Animas River was at its highest level due to snowmelt, so subsurface measurements were not recorded along the banks of the river.

4.2.2 Lowland Areas

Tree stumps, dead cottonwood, pine, aspen, and juniper trees, and stressed cottonwood, pine, juniper, and scrub oak trees were noted along the banks of the Animas River during the detailed seep mapping conducted in May 2003. The majority of the subsurface readings collected at the base of these trees did not report the presence of methane.

A dead scrub oak area located south of the gas flux chamber reported a subsurface methane concentration of 27,500 ppm (2.75%). A subsurface methane concentration of 320,000 ppm (32%) was recorded in a dead vegetation area (100 feet by 150 feet) on the west side of the Animas River that corresponds with the middle portion of the Kf (CJ-2, Figure 3). Directly west from location CJ-2 a smaller dead vegetation area (30 feet by 75 feet) reported a subsurface methane concentration of 950,000 ppm (95%). A dead vegetation area (75 feet by 175 feet) at location CJ-3 reported subsurface concentrations as high as 120,000 ppm (12%) methane (Figure 3). Subsurface H_2S concentrations ranged from two to nine ppm along the west side of the Animas River.

View of west side of Animas River (Location CJ-2)

4.2.3 Upland Areas

Dead and stressed pine and juniper trees, stressed scrub oak trees, and two dead scrub oak areas were mapped in the upland area west of the Animas River (CJ-6, Figure 3). The subcrop in this area corresponds with the basal portion of the Kf. Concentrations of subsurface methane ranged from 16,000 ppm (1.6%) to 810,000 ppm (81%) in this area.

Numerous dead pine trees mapped individually and grouped into areas were observed during the 2003 detailed mapping event on the east side of the Carbon Junction study area. The majority of the dead trees were not associated with subsurface methane at the time of sampling.

Concentrations of subsurface methane were detected closer to the bottom of the drainage in the lower section of the Kf. A dead pine tree area reported methane concentrations of 190,000 ppm (19%) at location CJ-4 (Figure 4). Subsurface methane concentrations in a dead vegetation area ranged from 39,500 ppm (3.95%) to 80,000 ppm (8%) (CJ-5, Figure 4). Dead pine trees located along the basal contact of the Kf were associated with subsurface methane readings ranging from 21,000 ppm (2.1%) to 100,000 ppm (10%). Subsurface H_2S was not detected in the upland areas on the west side of the Animas River during the 2003 detailed mapping event. In the upland area on the east side of the Animas River subsurface H_2S concentrations ranged from two to three ppm during the 2003 detailed mapping event.

Location CJ-5
View northeast

4.2.4 Comparison to Previous Surveys

Fewer methane seeps in surface water were observed during this detailed mapping event when compared to the detailed mapping event that occurred in October 2002. The Animas River was at its highest water level in May 2003 as a result of snowmelt runoff. Seeps were more difficult to observe because of the higher velocity of the water within the Animas River.

Methane concentrations noted in the western portion of the study area during the detailed mapping conducted in May 2003 were equivalent to those recorded in October 2002. Dead vegetation areas were easier to identify in May 2003 because of spring growth. Additional dead pine and cottonwood trees were mapped along the east and west banks of the Animas River, and additional dead vegetation areas were mapped at location CJ-3 and west of location CJ-2. Higher subsurface methane concentrations were recorded at CJ-2 in October 2002, even though more readings were taken in the area in May 2003.

East of the Animas River, LTE noted a higher number of dead pine trees during the July 2003 event than were noted during the October 2002 detailed mapping event. Subsurface methane was not detected in the areas of new mortality but Ips beetle infestation was observed on most of these trees (CJ-7, Figure 4).

Subsurface H_2S concentrations in 2002 ranged from two to 16 ppm in the Carbon Junction study area and were noted in the upland areas on the east and west sides of the river in addition to the lowland areas. Subsurface H_2S was detected in lower concentrations in 2003 and only on the east side of the river and in the lowland area.

When comparing similar collection areas in the May 2003 data to the data collected in 1995, higher methane concentrations are observed in the May 2003 data. Comparisons with the BLM probe data were not completed. Comparisons for the Carbon Junction area between 1995 and 2003 data are illustrated in Figures H and I of Appendix F.

4.3 FLORIDA RIVER

The Florida River mapping area is approximately two-thirds of a mile in the northeast direction by 0.25 miles in the northwest direction from where the river transects the Kf. The mapping area included the Florida River from the bridge crossing at the Terry Palmer Ranch northward to the Florida Farmers Canal headgate. The headgate is located upstream of the Kf outcrop and stratigraphically lower in geologic section within the Lewis Formation (Kl). LTE mapped the river for methane seeps on May 22, 2003. The east and west sides of the Florida River were mapped on May 26, 2003. Figures 5 and 6 illustrate the results of the detailed seep mapping performed at the Florida River mapping area (note scale changes on maps).

4.3.1 Observed Methane Seeps in Surface Water

Numerous visible methane seeps and methane seep trends were noted in the private pond located at Terry Palmer Ranch. The pond corresponds with the middle and upper portions of the Kf based on surface geology. Methane seeps were identified in the river north of the private pond, which stratigraphically correlates with the lower portion of the Kf. Methane seeps were noted for approximately 0.10 mile upstream of the private pond.

Water was observed in the ditch along the east side of County Road 234 (Figure 6). Visible seeps were mapped in the ditch for approximately 400 feet due west of the private pond. One visible methane seep was observed in the ditch on the south side of County Road 237 (Figure 5). The seeps noted in the ditches correspond stratigraphically with the lower portion of the Kf based on surface geology. No visible seeps were observed in the canal system along the west side of County Road 234.

During the October 2002 detailed seep mapping event, visible methane seeps were observed near the Florida Farmers Canal headgate. The high water and swift velocity of the river prevented the observation and collection of gas samples for analysis in May 2003. In July 2003 samples were collected from the Florida Farmers Canal headgate and submitted for analysis to identify the gas. Results of the analysis conducted on the sample indicate methane was detected at a concentration of 800,000 ppm (80%). Isotope analysis of the sample indicates that the methane detected is from a near-surface microbial fermentation source rather than a thermogenic source. Laboratory analytical reports are included in Appendix D.

4.3.2 Lowland Areas

Stressed, non-vegetated, and dead vegetated areas were mapped on the west, north, and east sides of the pond. Subsurface methane concentrations on the east side of the pond were as high as 50,000 ppm (5%). Several stressed and non-vegetation patches were mapped northwest of the pond with reported subsurface methane concentrations ranging up to 230,000 ppm (23%) (Figure 6). This area correlates stratigraphically with the middle Kf based on surface geology. Access issues prevented additional detailed seep mapping north of the private pond.

The lowland area near the farm house located south of the primary seep area was investigated during field verification activities. Methane was detected at one location at a concentration of 10,000 ppm (1%) (FR-3, Figure 5). Addition information concerning this area is discussed later in this report. Subsurface H_2S was not detected in the lowland areas of the Florida River study area.

4.3.3 Upland Areas

Due west of the Terry Palmer Ranch private pond and canal system, numerous dead pine, dead cottonwoods, stressed scrub oak, and stressed pine trees were observed in a cluster (FR-1). Subsurface methane measurements were collected in this area next to the dead and stressed trees and in non-vegetated areas between the trees. No subsurface methane was detected at the dead cottonwood trees adjacent to the canal. Concentrations of subsurface methane at the dead and stressed pine, and stressed scrub oak trees ranged from 6,500 ppm (0.65%) to 950,000 ppm (95%). Existing gas monitoring probes monitored by the BLM are located in this area. This cluster of trees is located stratigraphically on the contact of the upper Kpc and the lower Kf.

Approximately 0.15 miles southwest of location FR-1, a second cluster of dead and stressed pine trees, tree stumps, and stressed vegetation areas were observed (FR-2, Figure 5). The stressed vegetation areas were located in a small open meadow bordered mostly by pine trees. Subsurface methane measurements recorded in the meadow ranged from 1,500 ppm to 470,000 ppm (47%). The subsurface readings surrounding the dead pine trees recorded no methane except the locations in close proximity to the meadow at location FR-2 (Figure 5). The group of dead pine trees is located stratigraphically over the lower Kf based on surface geology.

Dead and stressed pine trees and tree stumps were observed for approximately 0.15 miles due west of location FR-2 (Figure 5). Only one of the 21 subsurface measurements collected reported a methane concentration of 500 ppm. The remaining 20 measurements collected did not detect subsurface methane.

A third cluster of dead and stressed pine trees was mapped approximately 0.15 miles southeast of location FR-2 (Figure 5). Subsurface methane gas was not detected within this area.

Numerous tree stumps, dead cottonwood and dead scrub oak trees were mapped on the east side of the Florida River that correspond with the middle and upper portions of the Kf based on surface geology. Subsurface methane measurements were collected at the base of each of these trees and in open areas. Subsurface methane was not detected at the base of any of the cottonwood trees. Of the nine tree stumps, three subsurface methane points, and one dead scrub oak mapped, only two tree stumps reported subsurface methane concentrations of 500 ppm and

1500 ppm. The remaining dead or stressed vegetation observed did not have subsurface methane gas reported at the time of sampling.

Subsurface H_2S was not detected in the upland areas of the Florida River detailed mapping area.

4.3.4 Comparison to Previous Surveys

Fewer seeps were observed in the Florida River in May 2003 than in October 2002 because of the higher water level resulting from spring snowmelt, and therefore higher velocity of the water. However, seeps were observed in the ditch containing standing water along the east side of County Road 234 and south side of County Road 237, which were not observed in October 2002.

Lower subsurface methane concentrations were recorded near the private pond in the May 2003 subsurface mapping event. In addition, areas that were mapped as stressed vegetated in October 2002 were mapped as non-vegetated areas in May 2003.

More dead and stressed pine trees, and dead cottonwood trees were mapped on the west side of County Road 234 in May 2003 than in October 2002. Higher subsurface methane concentrations were reported at locations FR-1 and FR-2 during the May 2003 detailed mapping event. Stressed vegetation areas with associated subsurface methane readings were mapped in the most recent detailed mapping event in May 2003 at location FR-2 that were not noted in the October 2002 survey.

Additional dead cottonwood trees and tree stumps were mapped on the east side of the Florida River in the May 2003 detailed seep mapping event. Very low concentrations of subsurface methane (500 ppm and 1,500 ppm) were recorded in two of the 42 measurements collected in May 2003. Methane concentrations on the east side of the river are similar to concentrations observed during the October 2002 detailed seep mapping event.

Subsurface H_2S was detected in 2002 near the location of FR-1 at a concentration of six ppm. In 2003 subsurface H_2S was not detected in the Florida River study area.

In comparison to the 1995 reconnaissance data, the May 2003 mapping event identified the presence of methane at concentrations higher than those detected in 1995 in the same area with the exception of the area immediately adjacent and east of the Florida River and, to a lesser extent, the area adjacent and northwest of the pond. The area west of location FR-2 reported methane concentrations in May 2003 that were lower than those methane concentrations reported in 1995. Figure A in Appendix F illustrates the comparison between the 1995 data and 2003 data in the Florida River area.

4.4 SOUTH FORK TEXAS CREEK

The Texas Creek mapping area is located where the south fork of Texas Creek transects the Kf. A large alluvial grass covered valley parallels the strike of the outcrop and eventually transects the contact between the Kf and Kpc. The detailed mapping area was approximately one mile in the east to west direction and 0.2 miles in the north to south direction. The most recent detailed seep mapping at the Texas Creek area occurred on May 22, 25, and 27, 2003. The field data are illustrated on Figures 7 and 8 (note scale changes on maps).

4.4.1 Observed Methane Seeps in Surface Water

The creek water level was relatively high but not turbulent during the time of mapping making methane seeps within the creek more visible. Numerous methane seeps were noted in the creek surrounding the gas flux chamber for approximately 100 feet north and south of the flux chamber (TC-1, Figure 8). Approximately 0.34 miles west of location TC-1, a seep area (100 feet by 200 feet) was observed where the creek had flooded the meadow (TC-3, Figure 7).

View east facing location TC-1

4.4.2 Lowland Areas

Non-vegetated and stressed vegetated patches were mapped throughout the valley floor of the Texas Creek study area. Linear trends can be found linking these patches in the east-southeast direction, paralleling the strike of the Kf.

The largest stressed and non-vegetated areas were noted in the center of the mapping area where the creek transects the Kf and Kpc contact (Figure 8). The linear trend of the stressed and dead vegetation follows the river abruptly north in this area which may indicate that the seepage trends along a fault in this area. These stressed and non-vegetated areas are nearly continuous along a suspected fault line and are commonly associated with subsurface methane gas. Subsurface methane concentrations ranged from 12,500 ppm (1.25%) to 1,000,000 ppm (100%) in the stressed and non-vegetated areas in the northeast portion of the study area surrounding the gas flux chambers. The majority of these vegetation patterns were irregular in shape. Twenty-six of the 44 subsurface measurements collected in these areas exhibited detectable concentrations of methane gas in May 2003.

Circular non-vegetated patterns, commonly containing a concentric patch of live grass, are intermingled with the irregular dead and stressed vegetation shapes but are not associated with subsurface methane. These circular shapes may be the result of a type of fungus impacting the surface grasses rather than subsurface methane gas, but LTE was unable to determine the specific cause of the pattern during the field mapping.

Tree stumps, non-vegetated and stressed vegetated areas, and a dead pine tree were mapped where the valley floor extends south. These features correlate to the middle portion of the Kf based on surface geology. Sixteen of the 19 subsurface measurements collected surrounding location TC-2 (Figure 8) did not detect reportable quantities of methane. Three of the 19 measurements reported subsurface methane quantities ranging from 120,000 ppm (12%) to 490,000 ppm (49%). These three measurements are aligned in a northwest to southeast linear feature.

One dead vegetation area and one stressed vegetation area are located due east of the seep area labeled TC-3 (Figure 7). This area was flooded from the creek, no visual seepage was noted, and subsurface methane measurements were not obtained. One of the two subsurface measurements collected east of these features reported methane concentrations of 840,000 ppm (84%) which is located near one of the existing permanent monitoring probe lines.

A subsurface methane concentration of 225,000 ppm (22.5%) was recorded at the base of a dead pine tree located along the south side of the valley west of location TC-2 (Figure 8). Stressed and non-vegetated areas were mapped in the east-west direction for approximately 0.20 miles west of location TC-2 (Figure 8). Eight of the 18 subsurface measurements ranged in methane concentrations from 25,500 ppm (2.55%) to 840,000 ppm (84%). The remaining 10 subsurface measurements collected did not report detectable levels of methane. Subsurface H_2S concentrations collected in the lowland areas at Texas Creek ranged from one ppm to 34 ppm during the detailed mapping event conducted in 2003.

4.4.3 Upland Areas

Access issues prevented mapping of upland areas during the 2003 detailed seep mapping event. A map illustrating access restrictions is presented in Figure 21.

4.4.4 Comparison to Previous Surveys

The water level observed in Texas Creek was higher in May 2003 than in October 2002 making the creek bed seeps more visible. Seeps mapped at location TC-2 were not visible during the 2002 mapping event because of the low water level in the creek.

More subsurface methane measurements were collected in the valley in the May 2003 detailed mapping event than in the October 2002 detailed mapping event. The concentrations of subsurface methane were similar between the 2002 and 2003 mapping events. Additional non-vegetation and stressed vegetation areas were mapped further west of location TC-2 than in 2002.

Subsurface H_2S was measured in the lowland areas in 2002 ranging in concentration from two to seven ppm during the detailed mapping event. Higher concentrations of subsurface H_2S were collected during the most recent detailed mapping event.

Subsurface methane data collected in 1995 in the Texas Creek area includes three lines of probe measurement locations that can be used in comparison to the May 2003 subsurface methane data. On the western end of the mapping area, 1995 data indicates that subsurface methane was generally not detected above 25 ppm with the exception of three locations which reported concentrations ranging from 25 ppm to 500 ppm. Data collected at two nearby locations indicated that methane was not detected above 25 ppm during the May 2003 mapping event indicating no change since 1995. The remaining two lines of 1995 subsurface methane data indicated methane was generally not detected above 25 ppm. In the primary seep area located near the flux chambers, the highest methane concentrations detected in 1995 ranged from 25 ppm to 500 ppm. Data collected by LTE in May 2003 in these same areas reported many areas containing subsurface methane concentrations greater than 10,000 ppm (1%). The comparison between the 1995 and 2003 data sets are illustrated on Figures B and C in Appendix F.

4.5 DETAILED MAPPING SUMMARY

Detailed mapping of known seep areas occurred in late May 2003. The seep mapping areas included Basin Creek, Carbon Junction, Florida River, and Texas Creek.

The seep trends observed are similar to those trends previously identified with the most active seeps occurring in the lower portions of the Kf, based on surface geology, in areas where a surface drainage feature transects the geologic contact between the Kpc and Kf.

A methane seep area was identified along the Florida River near the Florida Farmers Canal Headgate. This area was not included in previous surveys along the outcrop. This location is stratigraphically positioned over the Kl based on surface geology. A sample was collected and analyzed from these visible seeps in July 2003. The results indicate that the methane detected is from a near-surface microbial fermentation source rather than a thermogenic source.

Drought has influence the detailed mapping results, particularly during the October 2002 mapping event where more dead and/or dormant vegetation was observed. Dr. Jacobi stated that trees are highly stressed due to drought conditions that have been present in the region for the past four to five years.

The presence of dead or stressed vegetation does not imply that methane has caused the condition. In many areas mapped, particularly west of the Texas Creek area, dead or stressed vegetation was observed with no detectable concentrations of methane noted. Another example is in the Carbon Junction area where numerous dead pine trees from Ips beetle kill was observed and subsurface methane was not detected.

Dr. Jacobi noted that vegetation mortality in methane seep areas appears to include all types of plants such as grasses, forbes, bushes, and trees. While mortality of piñon pine trees is commonly a result of black stain root disease and Ips bark beetle. Mortality of juniper trees is not common in the study area. Mortality of ponderosa pine is not as common as piñon mortality but appeared to be a result of Ips beetle in most cases. At first glance, most of the woody plant mortality observed in the main seep areas appeared to have occurred within the last five to 15 years but more in depth analysis is needed to document this observation.

Based on the results of the detailed seep mapping, it appears that the mapping methodology utilized by LTE will be effective for monitoring changes over time and space since more features are being monitored. In addition, the features that were mapped have been located and defined more accurately as compared to previous surveys. The distribution of methane relative to vegetation will be better observed in the spring (May time frame).

Inferences to the extent of the seep areas can also be made from the results of the mapping and IR imagery activities, although specific boundaries are difficult to define. The methane distribution has been established in the seep areas. Subsequent mapping events will provide data to determine if the methane seeps are intensifying, remaining the same, or decreasing.

SECTION 5.0

REGIONAL OUTCROP RECONNAISSANCE

The regional outcrop monitoring programs have evolved during the past six years from a pedestrian survey with the collection of surface methane concentration and qualitative observations of vegetative condition to an IR imagery aerial reconnaissance, image evaluation, followed by field verification including the collection of subsurface methane measurements in suspect areas.

The goal of this reconnaissance is to provide long term monitoring across the entire 23-mile outcrop area in an effort to quantify changes in methane seepage over time and space. The IR imagery aerial reconnaissance of the entire outcrop was performed in August 2002. The following sections discuss the image evaluation and field verification activities performed in 2003.

5.1 IMAGE EVALUATION

Following geo-rectification of the IR images across the outcrop area, the images were evaluated to identify suspect areas containing disturbed, stressed, or dead vegetation.

A total of 101 suspect areas were identified across the outcrop area using heads-up digitizing techniques. In most cases, the dead or stressed vegetation was readily identifiable within the image. In some instances, it was difficult to determine the exact identity of the anomalous feature. The suspect areas are illustrated on Figures 9 through 26 as blue polygon features. Some of the suspect areas correspond to impacted areas identified during the detailed seep mapping. Future evaluation of IR imagery will allow for more accurate remote sensing interpretation using previous field verification data.

5.2 FIELD ACTIVITIES

Results of the field verification activities are illustrated on Figures 9 through 26 using graduated symbols to present the concentration of methane measured at each subsurface measurement location in and around the suspect area. Specific areas discussed in the text are noted on the maps with a designation of "M03" followed by a number (i.e. M03-1). The results are discussed by geographic location in the following subsections.

5.2.1 Basin Creek Area

The large suspect area adjacent to the Southern Ute Indian Reservation boundary was identified because mortality or stressed vegetation patterns mimicking the stratigraphy is clearly evident in the IR image (see location M03-1, Figure 9). LTE collected seven subsurface methane measurements in the vicinity of this suspect area but did not detect methane. It is possible that the vegetation patterns observed are more related to moisture variation or varying soil types. Much of this area is covered with Gamble's Oak (scrub oak) which experienced significant die back due to the drought conditions.

Location M03-1.

Approximately 800 feet east of the large suspect area previously discussed, a relatively small area (100 feet by 100 feet) that contained several dead trees within the shadows on the image (M03-2) was identified. Upon inspection, LTE confirmed the presence of methane at elevated concentrations within the center of the area but concentrations of methane diminished as the field crew moved away from the center of the suspect area.

Four other suspect areas were noted south of the Basin Creek road but most did not contain detectable concentrations of methane at the time of the visit. One location in particular, noted dead grass or low shrub area in which the presence of elevated concentrations of methane were detected (M03-17, Figure 9 and BC-4 on Figure 2).

Dead vegetation north of Basin Creek road.

Dead vegetation was noted in the three suspect areas identified north of the Basin Creek road. Two of the three areas contained detected concentrations of methane up to 1%. Coal outcrops and large dead trees were noted in these two areas (M03-3, Figure 10).

5.2.2 Carbon Junction Area

Four suspect areas were identified on the IR images west of the Animas River near Carbon Junction. This area is known locally as "moving mountain" due to a historic landslide. The suspect area on the top of "moving mountain" contained dead vegetation and methane was detected in two locations within the suspect area at concentrations less than 1%.

The largest suspect area on "moving mountain" consists of a large area of dead scrub oak, sage, and other vegetation on a steep hillside (M03-4, Figure 11). LTE initiated field activities in this area with methane detected at concentrations ranging from less than 25 ppm to 1% when weather conditions forced the field crew off the mountain. Unfortunately, field crews were unable to return to this area during the July 2003 field event. The presence of methane was detected at this location during the October 2002 detailed mapping event.

Location M03-4

A relatively small suspect area (100 feet by 200 feet) close to the shooting range noted a large area of dead scrub oak. Methane was detected in this area at a concentration of 81% (M03-5, Figure 11).

The east side of the Animas River in the Carbon Junction area has typically exhibited evidence of methane seepage. The large suspect area adjacent to the gravel quarry was identified on the IR image because of extensive vegetation damage. This area also contains the BLM permanent monitoring probes. Methane concentration data collected in this area has been highly variable. Many dead pine trees mapped as part of the Carbon Junction detailed seep mapping did not report detectable concentrations of methane in the subsurface at the tree location. Where methane concentrations were detected in this area, the values typically range from less than 25 ppm to nearly 100%. The field verification data collected during this 2003 monitoring event indicate methane concentrations ranging from less 25 ppm to 19% east of the highway (M03-6, Figure 12).

The suspect area identified from the IR image on the top of the gravel capped plateau is not obvious on the maps printed in this report (M03-7, Figure 12). But based on the subtle variability observed on the computer screen, the area warranted field verification. Upon inspection, methane was not detected in this area. It appears that the IR image anomaly may be associated with a slight variation in soil conditions in this area.

The two suspect areas located stratigraphically on the Kk contained areas of dead pine trees (M03-8 and M03-9, Figure 12). Upon inspection, the mortality appears to be a result of Ips beetle infestation. Methane was not detected in these two areas.

5.2.3 Northwest of Florida Mesa

Eleven suspect areas were identified in the upland areas along the Kf between Carbon Junction and the Florida River (Figures 13 and 14). Upon inspection, these areas predominantly consisted of scattered pine tree mortality and or scrub oak die back. Much of the pine tree mortality was associated with Ips beetle infestation. The scrub oak mortality appeared to be associated with natural die back common to scrub oak, especially in dry years. LTE collected 87 subsurface methane measurements across this 2.6 mile long area focussing on the suspect areas identified. Subsurface methane was not detected above 25 ppm at any of these 87 locations (Figure 13).

5.2.3 Florida River

Seven suspect areas were identified within the immediate Florida River area. These areas were inspected as part of the detail seep mapping program. In general, these areas did not contain detectable concentrations of methane with the exception of the areas located adjacent to the Terry Palmer Ranch pond. Concentrations detected around the pond were typically less than 1% methane during this sampling event. The area west of County Road 234 was not identified during the image evaluation but is known to contain subsurface methane since the Florida River BLM probe line is located in this area. LTE's detailed seep mapping in this area identified subsurface methane at concentrations ranging from 10% to 50%.

A suspect area was identified in close proximity to the house and barns on the Terry Palmer Ranch. LTE investigated these areas during the field verification activities and determined that methane was detected in only one location at a concentration of 10,000 ppm (1%).

Two large suspect areas were identified in the upland areas east of the Florida River but west of Edgemont Ranch (Figure 16). These suspect areas are in the valley which parallel the strike of the outcrop. It appears that the suspect area is associated predominantly with die back of scrub oak. Subsurface methane measurements in these areas did not identify the presence of methane above 25 ppm.

5.2.4 Edgemont Ranch

Figure 17 illustrates the location of suspect areas identified east of the Edgemont Ranch area. Many of the features identified in the IR image consist of shrub mortality. Upon inspection, LTE noted die back on scrub oak and outcrops of exposed coal seams. Methane was not detected above 25 ppm at these areas with the exception of the westernmost polygon (M03-10, Figure 17). Subsurface methane concentrations at this location ranged from 0.0 ppm to 5% methane. The higher concentrations were associated with coal outcrops near the basal portion of the formation.

5.2.5 Vosburg Pike Area

This upland area of the outcrop is approximately half way between the Florida River seep area and the Texas Creek seep area. Ten relatively small suspect areas were identified due to the condition of the shrub and grass mortality as well as the presence of coal outcrops. During the field inspection of these suspect areas, LTE confirmed the presence of die back among many of the scrub oak throughout the area. The absence of methane detected in this area during this mapping event and previous mapping events indicates that the stress/mortality is not due to methane but more likely due to effects of drought.

Two suspect areas were identified at the western end of the South Fork of Texas Creek valley (referred to as Vosburg Pike - Central on Figure 19). Inspection and sampling of these areas identified dead and stressed grass but no methane in the subsurface. Scattered mortality of pine trees was noted in a suspect area south of the valley on a small hill and a small area north of the valley. Inspection of these trees identified the presence of Ips beetle infestation.

5.2.6 Texas Creek Area

On the western end of the Texas Creek mapping area, five suspect areas were identified in the IR imagery. One of the suspect areas was inspected during detailed seep mapping activities in May 2003 and identified the presence of dead vegetation and methane gas (M03-11, Figure 20).

LTE was not granted access to two areas located west of the mapping area (M03-12 and M03-13, Figure 20). However, the northern most suspect polygon appears to be positioned along a linear trend of detected methane in the area. It is likely that the mortality observed in this area is associated with methane but cannot be confirmed without sampling. It is difficult to determine if the dead and/or stressed vegetation to the south (M03-12, Figure 20) is associated with methane without field verification.

The suspect areas identified on the north side of the road were inspected by LTE. Methane was not detected in the area but it appears that pattern pine tree mortality noted in the area is associated with Ips beetle infestation.

The suspect areas identified in the main Texas Creek seep area were investigated during the detailed seep mapping event performed in May 2003 (Figure 21). Nearly all of these areas were associated with the presence of elevated concentrations of methane in the subsurface.

One suspect area located approximately 800 feet east of the main seep area (M03-14, Figure 21) noted pattern pine tree mortality. LTE was not granted access to this area during either of the field inspection events. Previous inspection of this area during the October 2002 detailed mapping event detected elevated concentrations of methane as high as 90% at the base of dead or stressed pine trees.

Three suspect areas identified further east of the main mapping area were relatively small in size but contained significant vegetation mortality. Methane measurements in the area reported concentrations ranging from less than 25 ppm to 76% (M03-15, Figure 22).

Location M03-15

The area along the outcrop between Texas Creek and the location identified as M03-15 consists of three alluvial valley lowland areas separated by upland areas. The alluvial valleys are oriented roughly north to south and transect the entire outcrop. The westernmost alluvial valley is the main Texas Creek seep area containing the flux chambers. The valley to the east has detected surface and subsurface methane during previous mapping and monitoring events. The third valley (near location M03-15) has also detected methane in surface samples during the 1999 and 2000 surface reconnaissance studies. The October 2002 detailed mapping also detected the presence of elevated subsurface methane in the upland areas between the western most valley and the central valley. Until this field reconnaissance in July 2003, subsurface methane measurements in the upland area between the central valley and the valley at M03-15 have not been collected since 1995. No subsurface methane was reported at that time. Although at lower concentrations and smaller areas, the Texas Creek seep may extend to the east to M03-15.

5.2.7 Hoier Property

Prior to commencement of the field activities, BP requested that our field inspection include the Hoier Property following reports from the landowner of dead vegetation. LTE reviewed the location information and determined that portions of the Hoier Property were already cited as a suspect area and that field plans already included a visit to this area.

Upon arrival, LTE noted one specific area of significant vegetation mortality including pine trees, grass, scrub oak, and juniper trees (M03-16, Figure 23). Measurements collected in this area indicated elevated concentrations of methane. The highest methane concentration measured on the Hoier property was 91%. Other suspect areas noted on the IR image were determined to be areas of dead grass but not associated with methane seepage.

Hoier Property
Location M03-16

Upon return from the initial field activities, it was determined that the data file generated during inspection of the Hoier Property was corrupted and data were lost. Shortly following this discovery, BP contacted LTE and informed them that the Hoier family is now reporting the presence of methane within their drinking water well. LTE promptly returned to the property to recollect the corrupted data on August 17 and 18, 2003.

Previous surface reconnaissance in this area identified dead vegetation area approximately 20 feet in diameter but no associated surface concentrations of methane. Surface methane was detected on the Hoier property in 1999 in an upland area northeast of the residence near the basal coal unit of the Kf. A comparison of data collected in 1995 indicated higher methane concentrations during the July 2003 in one area and similar concentrations in two other areas. Areas east of the Hoier property also indicate higher concentrations detected in the 2003 mapping event as compared to the 1995 mapping event. Figures D and E in Appendix F illustrates the comparison between the 1995 data and the 2003 data.

5.2.8 Pine River and East

The area west of Pine River was mapped during the revisit to the Hoier Property. Subsurface methane was detected at concentrations ranging from 500 ppm to 22% (Figure 24). Areas of dead and stressed vegetation were noted in the image and confirmed during field activities.

The Pine River area was not visited during the field verification activities since this area is mapped and monitored by BP directly. In addition, the suspect areas identified within the Pine River area and eastward to the area immediately west of the East Pine flux chamber are predominantly owned by Mr. Williams, who generally restricts access to his properties.

The suspect areas identified by the IR imagery in the Pine River area and eastward are presented in Figures 24 through 26.

5.3 VEGETATION SUMMARY

As stated in Section 4.6, Dr. Jacobi made observations in the Carbon Junction, Florida River, and Texas Creek study areas. The major types of vegetation observed include piñon pines, ponderosa pines, junipers, narrow leaf and plains cottonwoods, elms, willows, Gamble's oak, aspen, cheatgrass, and box elders/maples. Beetles, both Ips and Borer, bacteria wetwood/slime flux, witches broom, and black stain root disease were all types of diseases noted by Dr. Jacobi during the field investigation. A key observation made by Dr. Jacobi is that vegetation mortality in methane seep areas appears to include all types of plants such as grasses, forbes, bushes, and trees, rather than individual species.

Appendix E includes a summary of Dr. Jacobi's observations made at the study area. Also attached is a summary of the various types of vegetation and their characteristics, including information regarding their different causes of mortality.

5.4 SUBSURFACE HYDROGEN SULFIDE SUMMARY

Subsurface H_2S concentrations have been detected sporadically in the Carbon Junction, Edgemont Ranch, and Texas Creek mapping areas. Concentrations were generally low and ranged from two ppm to nine ppm in most areas. The highest concentration measured during the 2003 mapping event was 34 ppm and was detected in the lowland areas at Texas Creek. On the Hoier property, one subsurface H_2S measurement of 10 ppm was detected during the July 2003 mapping event.

5.5 COMPARISON TO PREVIOUS SURVEYS

On a regional basis, the only pre-existing data set containing subsurface measurements of methane concentration in areas outside the detailed mapping areas are the data collected in 1995. This data was collected through a series of temporary probe lines that transected the outcrop at a relatively consistent spacing. The lines were primarily located around the main seep areas but lines were also advanced into the upland areas away from each of the major rivers (Animas River, Florida River, Texas Creek, and Pine River). The subsurface methane concentration was measured using a flame-ionization detector (FID) which was only capable of measuring up to 10,000 ppm (1%).

LTE utilized the existing GIS to compare the subsurface data collected in 1995 to the subsurface data collected in July 2003 in all areas where both data sets were present. The comparison indicated that the subsurface methane concentrations measured in 2003 are higher in most areas than the concentrations measured in 1995. This observation holds true for the primary seeps in the lowland areas but also in the upland areas between primary seeps. Figures illustrating the two data sets are included in Appendix F.

Comparison with the 1995 data sets suggests areas with higher concentrations, areas with lower concentrations, and areas where no change has occurred. As has been demonstrated with the flux chamber data and the probe data, the change in methane flow rate and concentration in the subsurface is variable. Methane levels also appear to be influenced to a limited extent by temperature, barometric pressure, and/or rainfall. Therefore direct comparison between one set of data from 1995 and a single sample event in 2003 may not demonstrate a trend.

5.6 REGIONAL RECONNAISSANCE SUMMARY

The IR imagery from along the entire monitoring area has been viewed and evaluated, and the images have been incorporated into LTE's ongoing GIS project. One hundred and one suspect areas were identified along the outcrop based on vegetative conditions or other chromatic anomaly observed in the imagery. LTE's field crew visually inspected and manually collected subsurface methane measurements at 80 of the 101 suspect polygons. Of the 80 areas visited, 20 suspect areas contained subsurface methane above 25 ppm and 12 of these areas were located outside the previous detailed seep mapping study areas performed in October 2002 and May 2003. Most of the suspect areas that were not inspected were located on land where access was not granted.

The majority of the suspect areas identified in the imagery contained dead vegetation that was not associated with subsurface methane. The predominant cause of mortality and/or stress observed at these areas was related to natural die back as a result of drought conditions or Ips beetle infestation.

The IR imagery was effective in identifying relatively small and isolated areas of dead vegetation that were confirmed to exhibit methane seepage through field verification. The newest previously undefined area which contains methane is the Hoier property.

SECTION 6.0

CONCLUSIONS AND RECOMMENDATIONS

6.1 GAS MONITORING SYSTEM

LTE recommends that monitoring of the flux chamber system continue as planned. The new locations and increased capture zones have resulted in more consistent recording of flow rates; however, methane flow captured at Carbon Junction, Florida River, Texas Creek Land, Pine River, and East Pine is still lower than flow rates observed at Basin Creek, Texas Creek, and the BP Pyramids. Due to the ability to observe more consistent flow, continued monitoring at the available areas with relatively lower flow will allow for documenting changes in seepage rates over time, if they occur.

Based on data collected at the Texas Creek flux chamber and the Texas Creek Land flux chamber, it appears that the two data sets are comparable to a limited extent. Similar declines in gas flow were observed in both units during the same time period. This suggests that the flux chambers positioned over the outcrop can be used to determine changes over time, despite the masking effects of dilution and dispersion in the vadose zone. When gas is present, all of the chambers are capable of recording the gas flow rate.

Flux chamber monitoring at Basin Creek has ceased pending completion of the ALP dam. According to the Bureau of Reclamation, dam construction is scheduled to be completed in 2008. Replacement of the unit may be possible at that time.

6.2 DETAILED SEEP MAPPING

The seep trends observed are similar to those previously identified with the most active seeps occurring in the lowlands where drainages transect the Kf.

Drought has influenced the detailed mapping results. Dr. Jacobi stated that many of the trees are highly stressed due to the drought conditions present over the last four to five years.

The presence of dead or stressed vegetation does not equate directly to the presence of methane. In many areas mapped, particularly west of Texas Creek, dead or stressed vegetation was not accompanied by subsurface methane. Vegetation mortality in seep areas appears to include all types of plants including the grasses, forbes, bushes, and trees. Mortality of piñon and ponderosa pine trees is commonly the result of Ips beetle or black stain root disease. Mortality of juniper trees is not common and may be an indicator of subsurface methane.

Results of the gas sampling of seeps identified at the Florida Farmer's Canal Headgate indicated the presence of biogenic methane rather than the thermogenic methane commonly associated with Kf seeps. LTE recommends that this area be excluded from subsequent detailed mapping programs. In addition, LTE recommends that compositional and isotopic analyses be performed, if possible, if new seep areas are identified.

LTE recommends continuing the detailed seep mapping program as described in this report. It appears to be effective at identifying and broadly delineating the known seeps. Over time, continued mapping should provide an indication of the changes in the seep dimensions and effects on vegetation. Detailed mapping in conjunction with the IR imagery program will allow for the ability to document the lateral extent of the seep areas.

In comparing the results of the detailed seep mapping performed in the late Fall 2002 with the detailed seep mapping performed during the Spring 2003, LTE recommends that future detailed seep mapping activities be performed during spring months rather than fall months. While fall conditions are conducive to identifying seeps in surface waters due to less turbulent water flow conditions, it is difficult to distinguish stress and mortality to vegetation from methane between stress and mortality due to drought and seasonal die back. During spring conditions, most plants appear healthy and it becomes much easier to distinguish stressed and/or dead vegetation areas. Identifying stressed and dead vegetation has evolved as the most effective means by which to identify areas of seep activity.

LTE recommends detailed seep mapping of the current known active seep areas on a yearly basis. These areas include Basin Creek, Carbon Junction, Florida River, Texas Creek, and Pine River. Since BP currently maps the Pine River area, LTE does not intend to include this area in future detailed mapping. However, LTE does recommend that detailed mapping of this area performed by BP also include portions of the Williams property, if possible, since IR imagery has identified many suspect areas on that property. LTE also recommends detailed mapping on the Hoier Property in conjunction with the other detailed mapping areas.

Additional efforts should be made to gain access to properties in the Texas Creek area. It appears that the seep area extends to the east approximately 0.75 miles east of the creek. This area includes the BP property; the Ward property; and the Varcoe, Yoretski, and Marion property. The Ward property has granted access in the past but recently denied requests during the 2003 mapping programs. LTE is requesting additional assistance from BP and the COGCC to persuade the owners of the Ward property to allow future mapping events to be performed on a yearly basis.

Prior to the next detailed mapping event, LTE will develop a vegetation flow chart for determining methane damage versus other issues on major plants in the region. This flow chart will be developed with the assistance of Dr. Jacobi and will be used during subsequent mapping events to assist in more thorough descriptions of vegetative conditions. In addition, LTE will develop a simple key to common plants seen in the region with the assistance of Dr. Jacobi. The next detailed seep mapping event is scheduled for early May 2004.

6.3 REGIONAL OUTCROP RECONNAISSANCE

The entire 23 mile Kf outcrop area was viewed and evaluated using the IR imagery with 101 suspect areas identified. Eighty of the 101 suspect areas were visited by LTE field crews to obtain subsurface methane concentration levels. Twenty of the 80 areas contain reportable concentrations of methane during the July 2003 field event. Twelve of these areas are located outside the previous detailed seep mapping study areas.

It appears that the IR imagery is an effective tool to monitor vegetative conditions along the outcrop over time. It is clear that dead and stressed vegetation over a large area can be readily identified with a relatively low level of effort using this technology. In addition, the value of this photo-documentation will increase as future IR imagery is captured across the study area. Comparison of suspect areas in which methane has been detected can be demonstrated.

While the technology is not capable of determining the presence or absence of methane, it does focus field efforts to suspect areas as demonstrated. Verification of the presence or absence of methane can then be performed and monitored over time.

Due to the relatively slow changing processes involved in the methane seepage and associated effects, LTE recommends that IR aerial reconnaissance followed by field verification along the entire outcrop occur at an interval of once every two to three years rather than annually. This sampling frequency for a broad look at the outcrop, coupled with annual detailed mapping in the known seep areas, and continued flux chamber monitoring will provide The Group with a cost-effective means to gather data and make prudent judgements concerning the effect that methane seepage is having on human health and the environment.

Comparison of the 1995 subsurface methane data to the 2003 subsurface methane data suggest higher concentrations at many of the areas in 2003 than in 1995. Since there are only two data points during this time frame, it is too early to determine if the higher concentrations noted represents a general increasing trend. It is not possible to determine the cause of higher concentrations at this time but it may be related to the drought conditions experienced in the region over the past four to five years. As has been observed, the variability of the methane reading can be influenced by temperature, barometric pressure, and rainfall.

LTE recommends that the next IR imagery reconnaissance flight be performed during the late Spring of 2005 with field verification occurring during the early Summer 2005. The 2005 field reconnaissance will include revisiting each of the 20 suspect areas identified during the 2003 survey that contained detectable concentrations of methane in the subsurface. LTE will inspect each area and install temporary probe holes to collect subsurface measurements both inside and around the perimeter of the suspect area. New suspect areas, if identified during evaluation of the new imagery, will be investigated in a manner similar to the July 2003 survey.

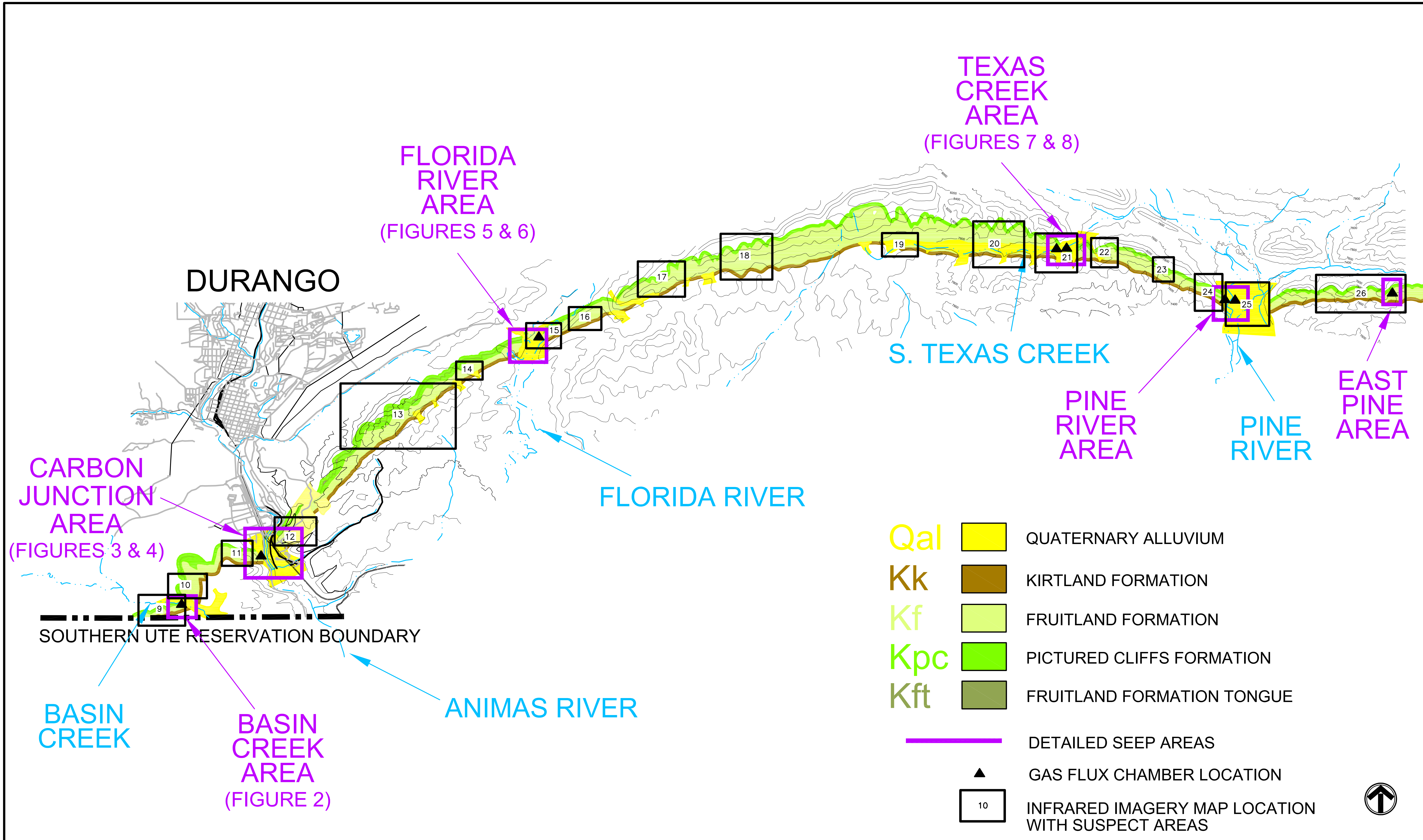
The 2005 aerial IR image will be compared to the 2002 aerial IR image to define changes in suspect area size and to identify potential new suspect areas. Field verification activities for the 2005 regional outcrop monitoring will include the suspect areas identified in the 2005 IR image and the suspect areas containing methane identified in the 2002 IR image.

6.4 ORDER MODIFICATIONS

The current ORDER established by the COGCC specifies an outcrop monitoring program that has significantly changed in scope since the ORDER was issued. There has been growing concern by The Group members that these modifications during the past three years may not meet the requirements as written in the ORDER and may compromise operating permits in the area.

LTE recommends that the ORDER be modified to incorporate the new technologies and methods developed under this project. The ORDER should incorporate the current methods used, monitoring frequencies, and mapping area extents as they have been specified in this report and in the LTE report dated January 2003.

FIGURES



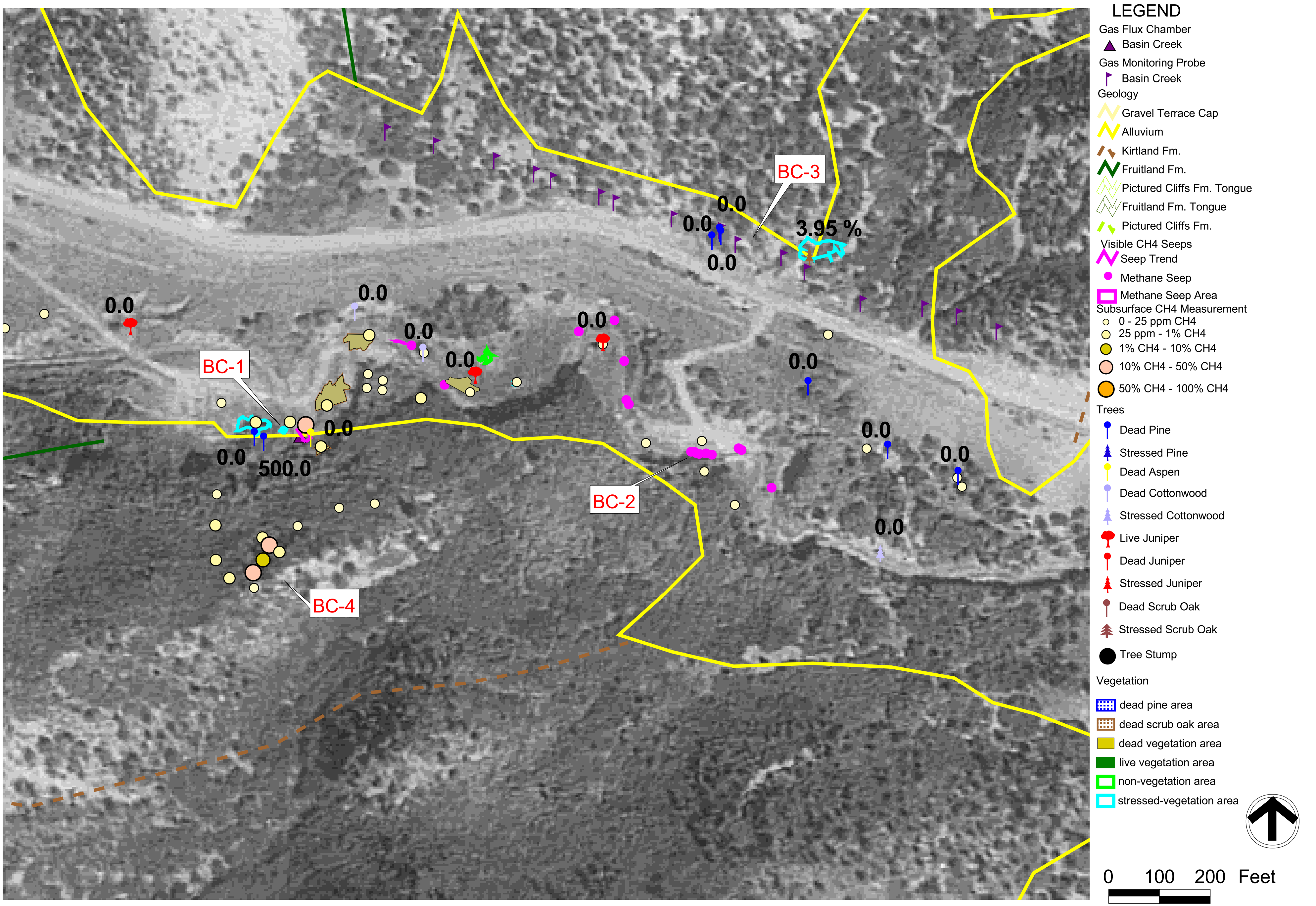
SOURCE: TOPODEPOT INC
USGS VECTOR 7.5' QUADRANGLE TOPOGRAPHIC MAPS

GEOGRAPHIC COORDINATE SYSTEM
(LATITUDE/LONGITUDE) NAD 83

FIGURE 1
METHANE SEEP MONITORING AREA
LA PLATA COUNTY, COLORADO

THE GROUP

METHANE SEEP 12/2002

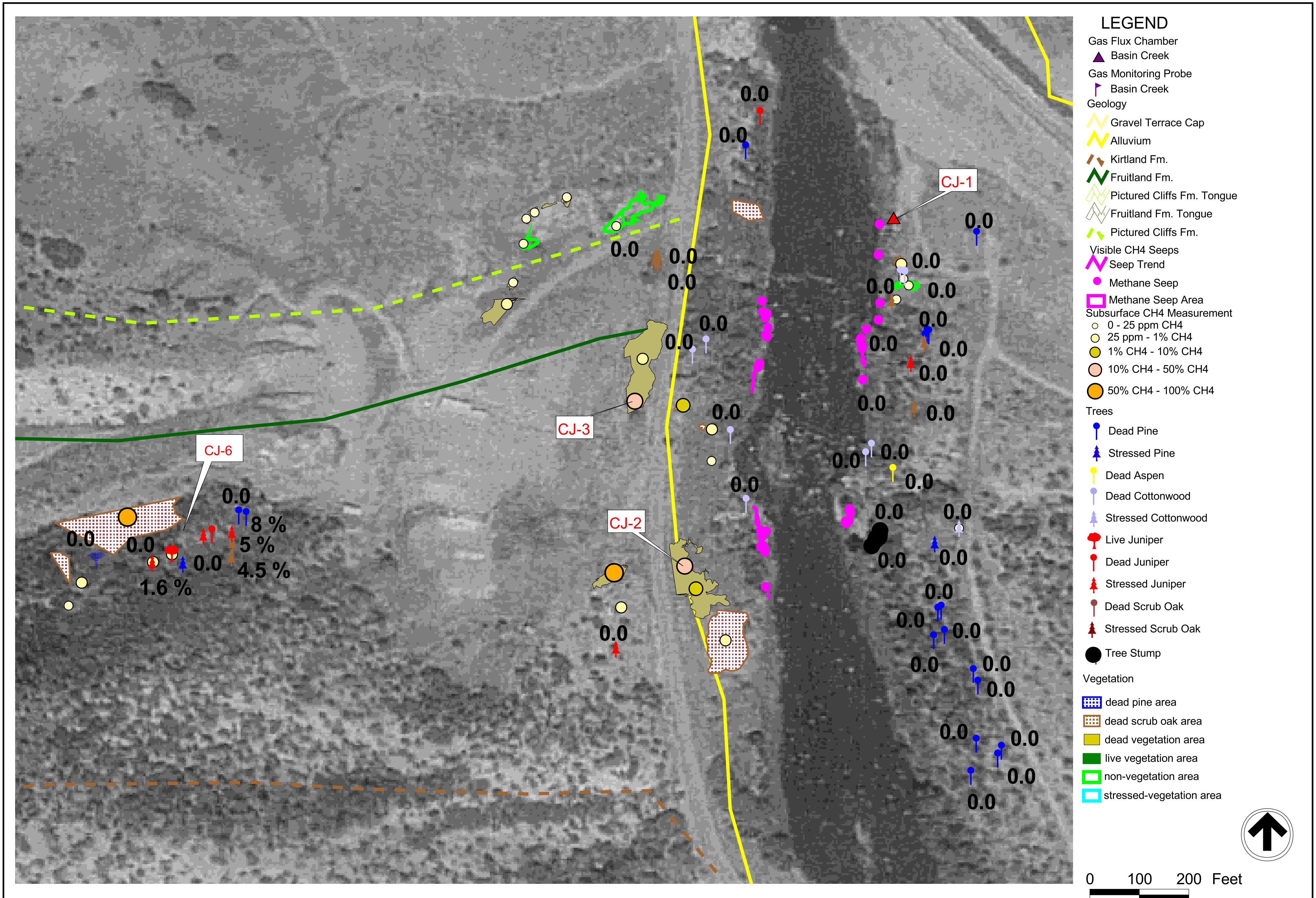


Mapping data collected on May 24, 2003.

FIGURE 2
BASIN CREEK
LA PLATA COUNTY, COLORADO
2003 MAPPING EVENT

THE GROUP

dgomethane.apr



CJ-1 Text Reference

8 % = Methane concentration at tree

Mapping data collected on May 21, May 23 and 24, 2003.

FIGURE 3
CARBON JUNCTION - WEST
LA PLATA COUNTY, COLORADO
2003 MAPPING

THE GROUP

dgomethane.apr

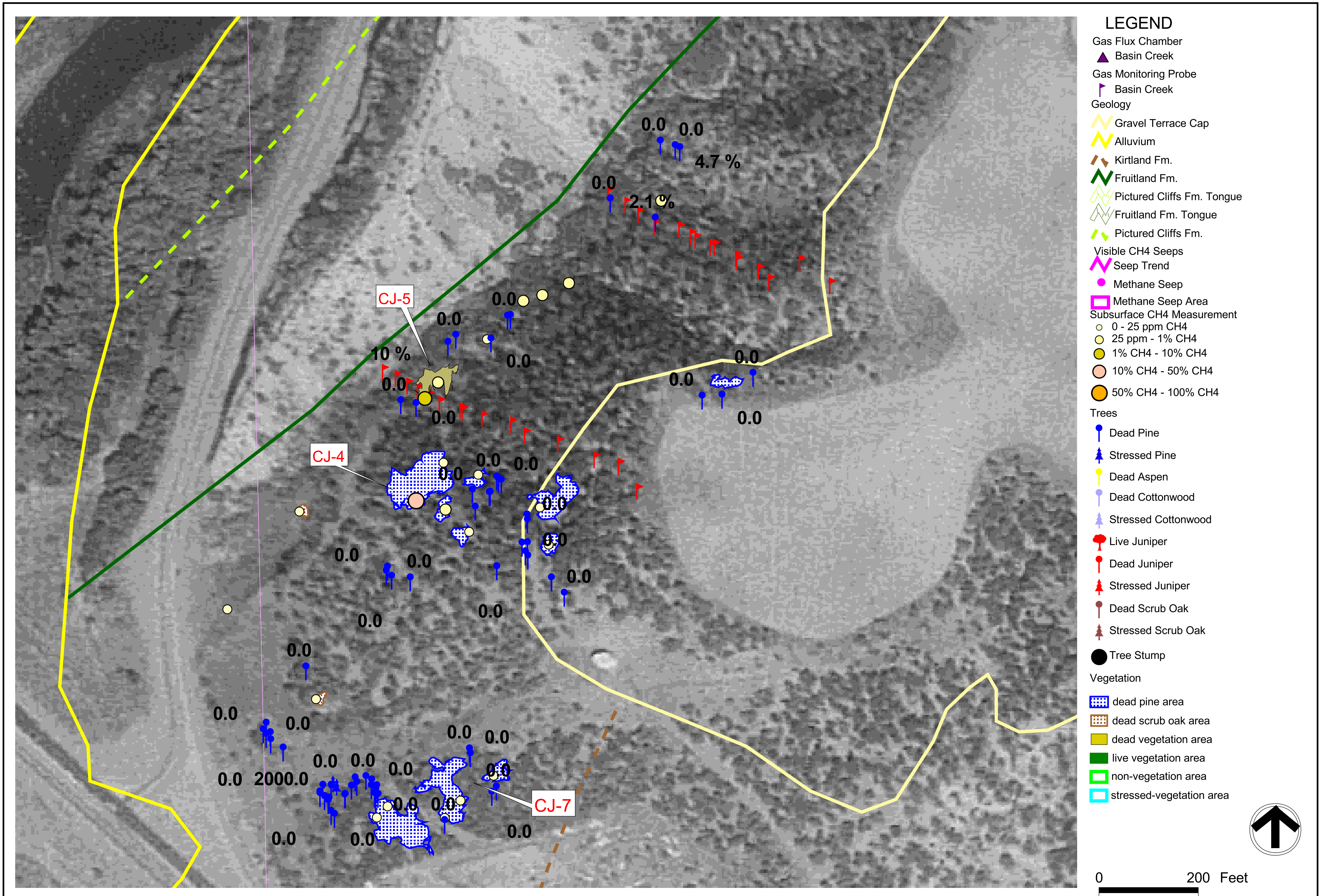
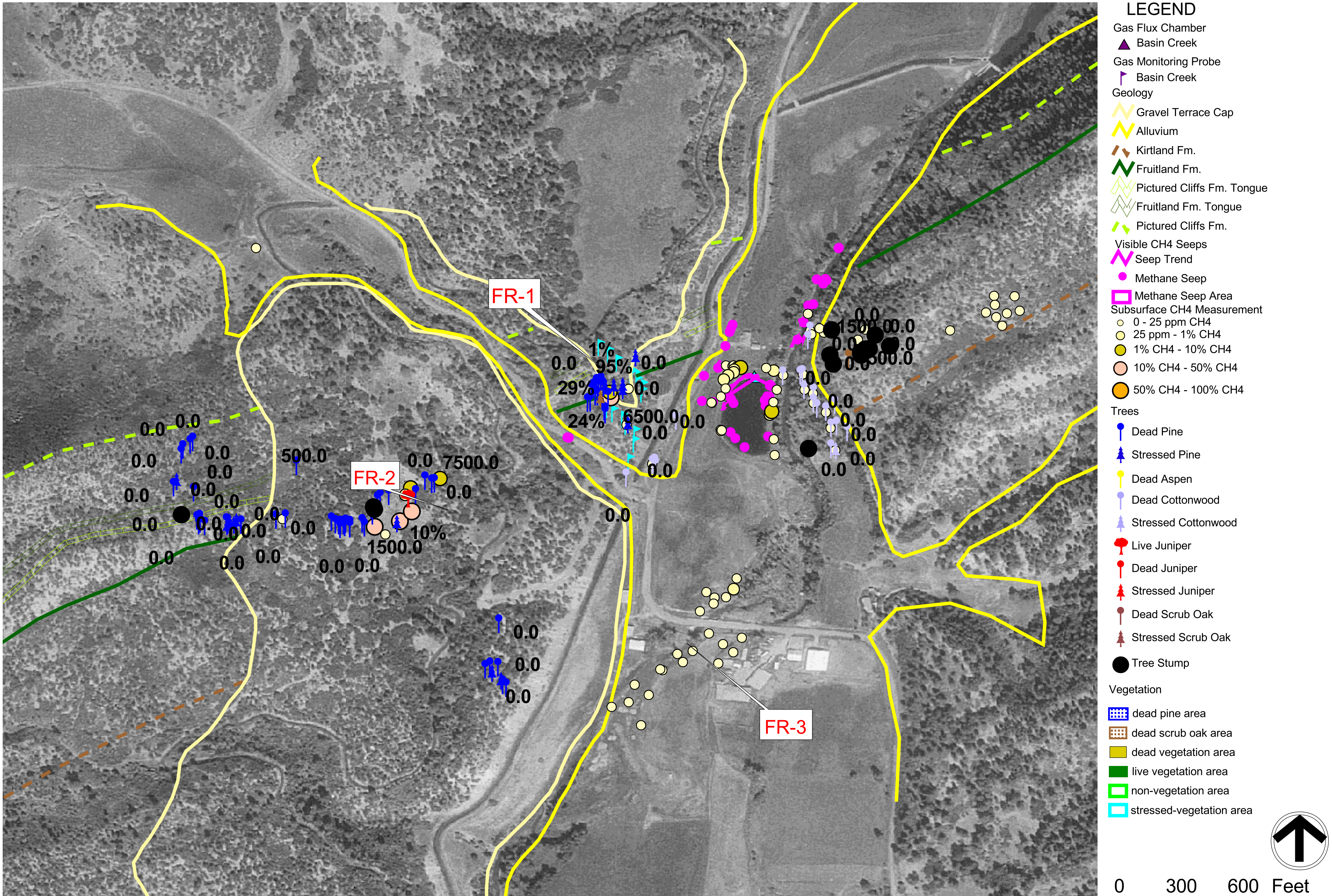


FIGURE 4
CARBON JUNCTION - EAST
LA PLATA COUNTY, COLORADO
2003 MAPPING

THE GROUP

dgomethane.apr



BC-1 Text Reference

500 ppm = Methane concentration at tree

Mapping data collected on May 22 and 26, 2003.

FIGURE 5
FLORIDA RIVER - WEST
LA PLATA COUNTY, COLORADO
2003 MAPPING

THE GROUP

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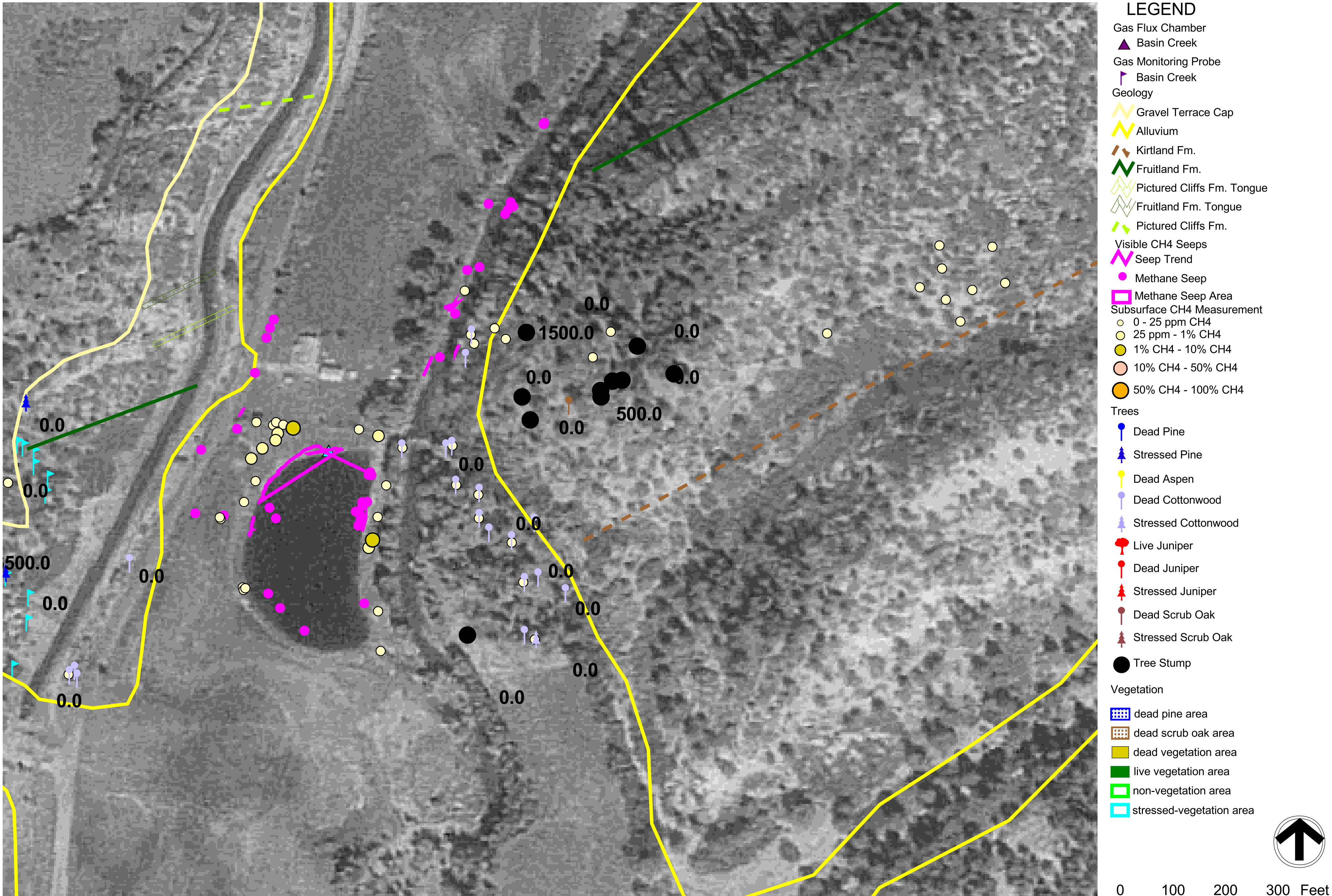


Mapping data collected on May 22 and 26, 2003.

BC-1 Text Reference

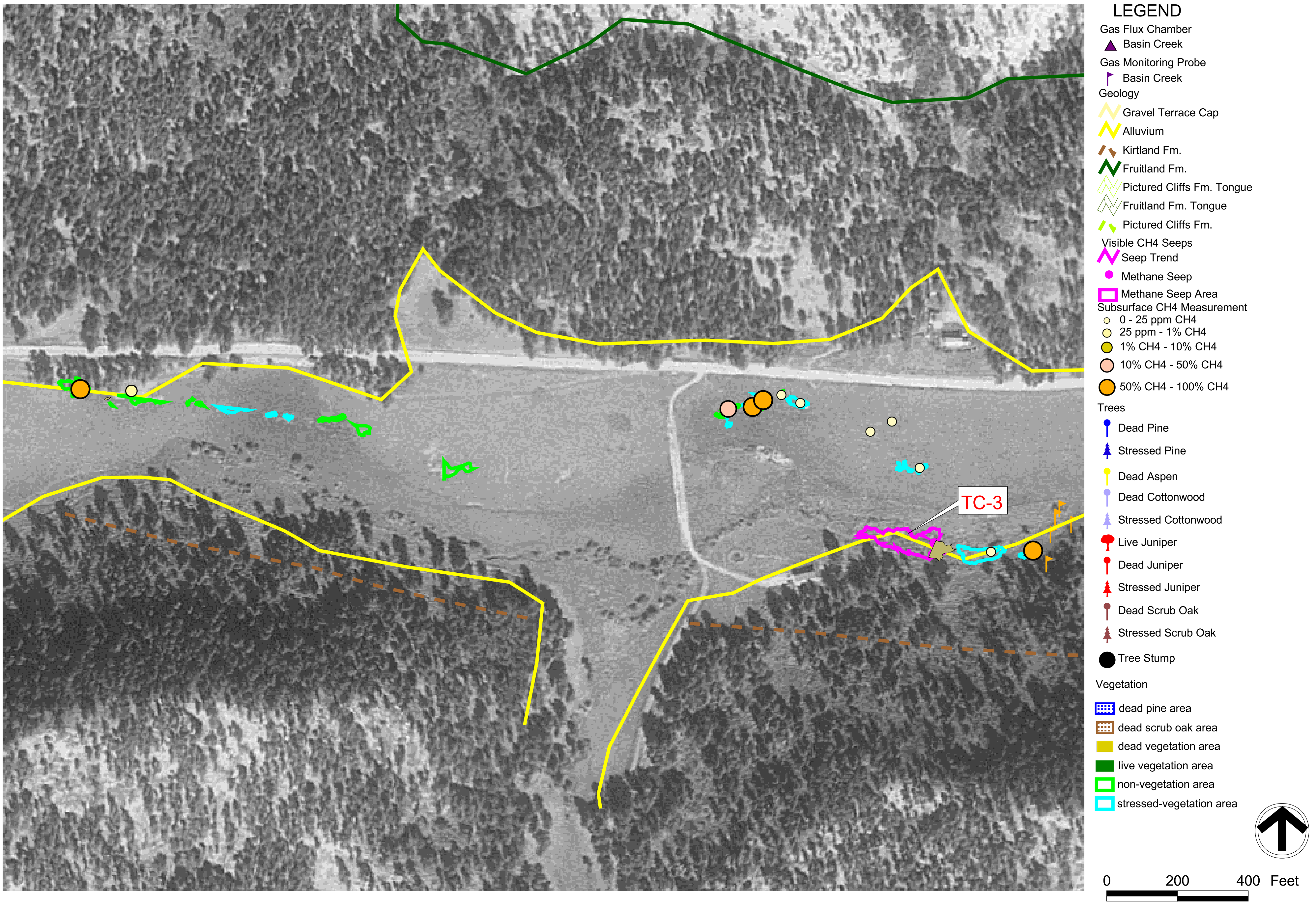
500 ppm = Methane concentration at tree

FIGURE 6
FLORIDA RIVER - EAST
LA PLATA COUNTY, COLORADO
2003 MAPPING

THE GROUP

LTE

dgomethane.apr



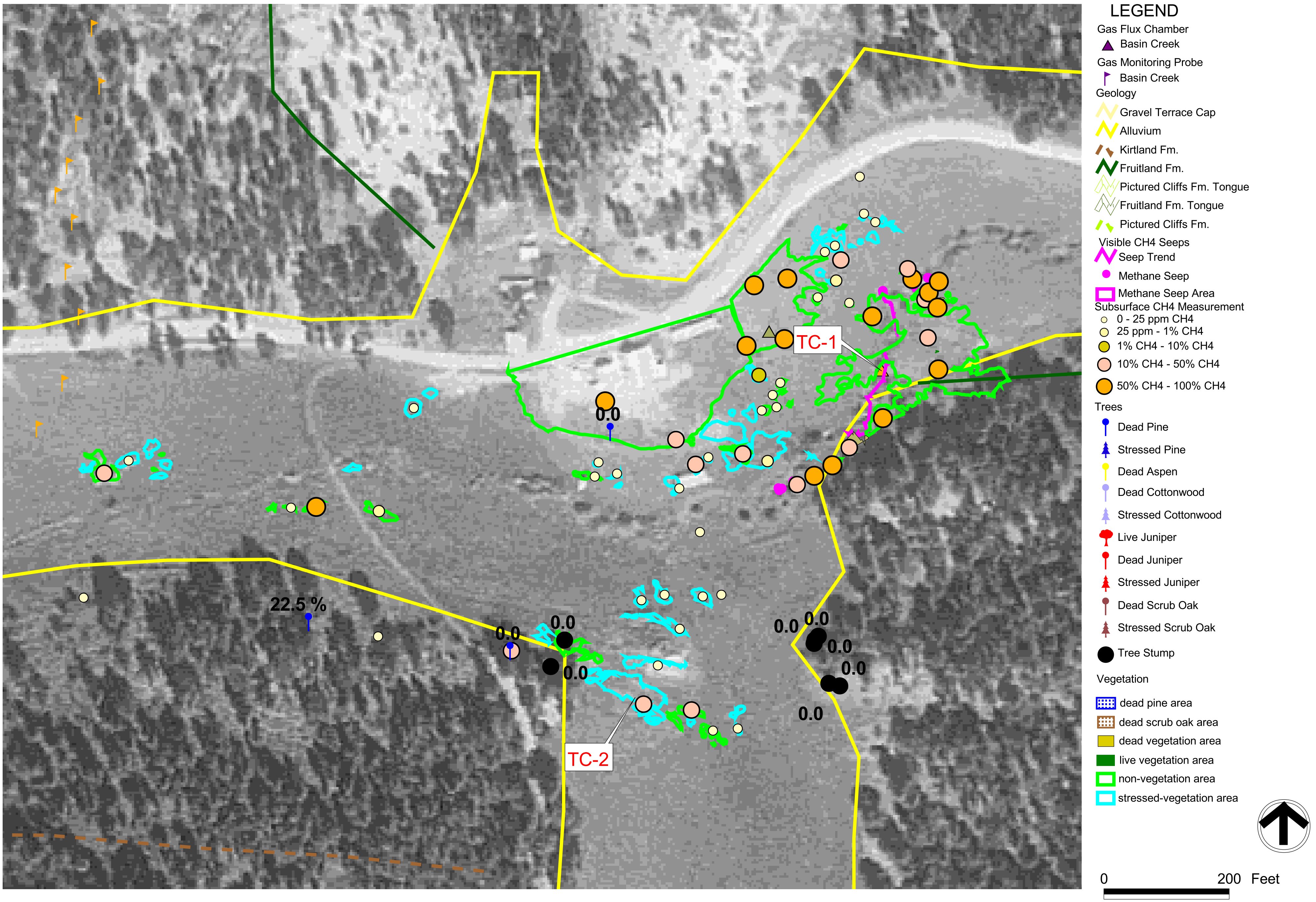
Mapping data collected on May 25 and 27, 2003.

BC-1 Text Reference

FIGURE 7
TEXAS CREEK - WEST
LA PLATA COUNTY, COLORADO
2003 MAPPING

THE GROUP

dgomethane.apr



Mapping data collected on May 25, 2003.

BC-1 Text Reference

22.5 % = Methane concentration at tree

FIGURE 8
TEXAS CREEK - EAST
LA PLATA COUNTY, COLORADO
2003 MAPPING

THE GROUP

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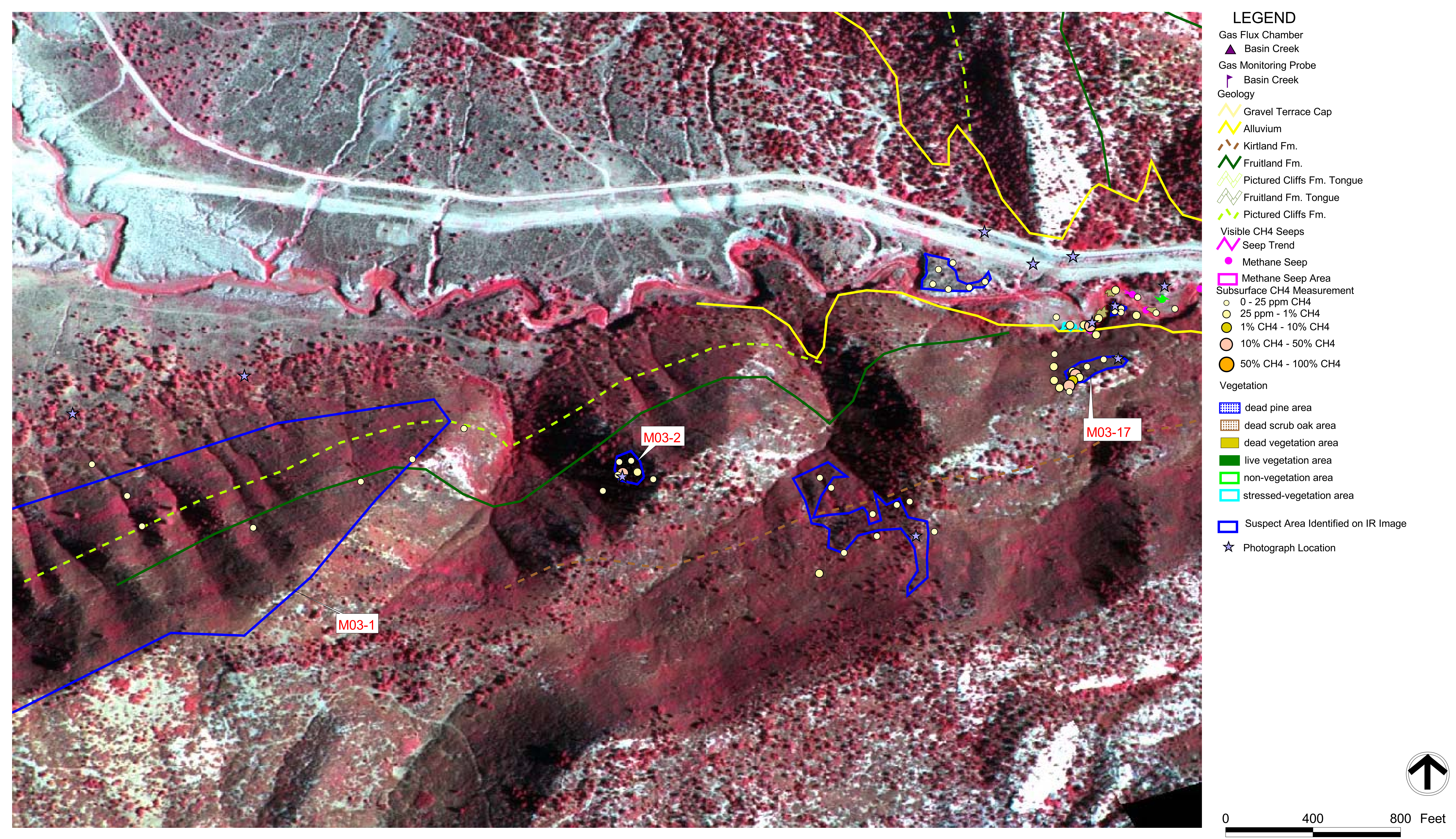

IR imagery taken on August 14, 2002.
Mapping data collected on July 29, 2003.

FIGURE 9
BASIN CREEK - WEST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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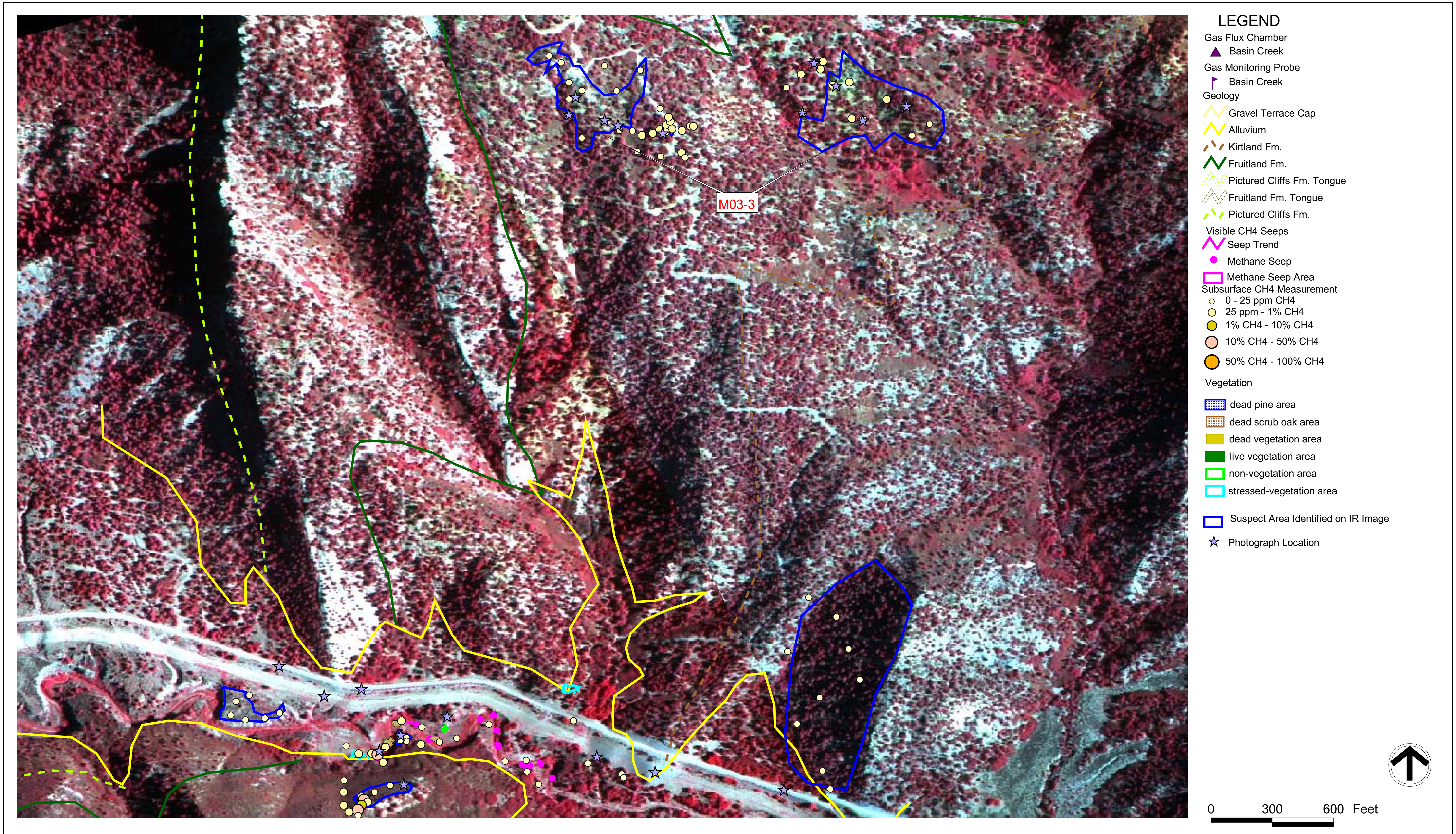

IR imagery taken on August 14, 2002.
Mapping data collected on July 27 and 30, 2003.

FIGURE 10
BASIN CREEK - EAST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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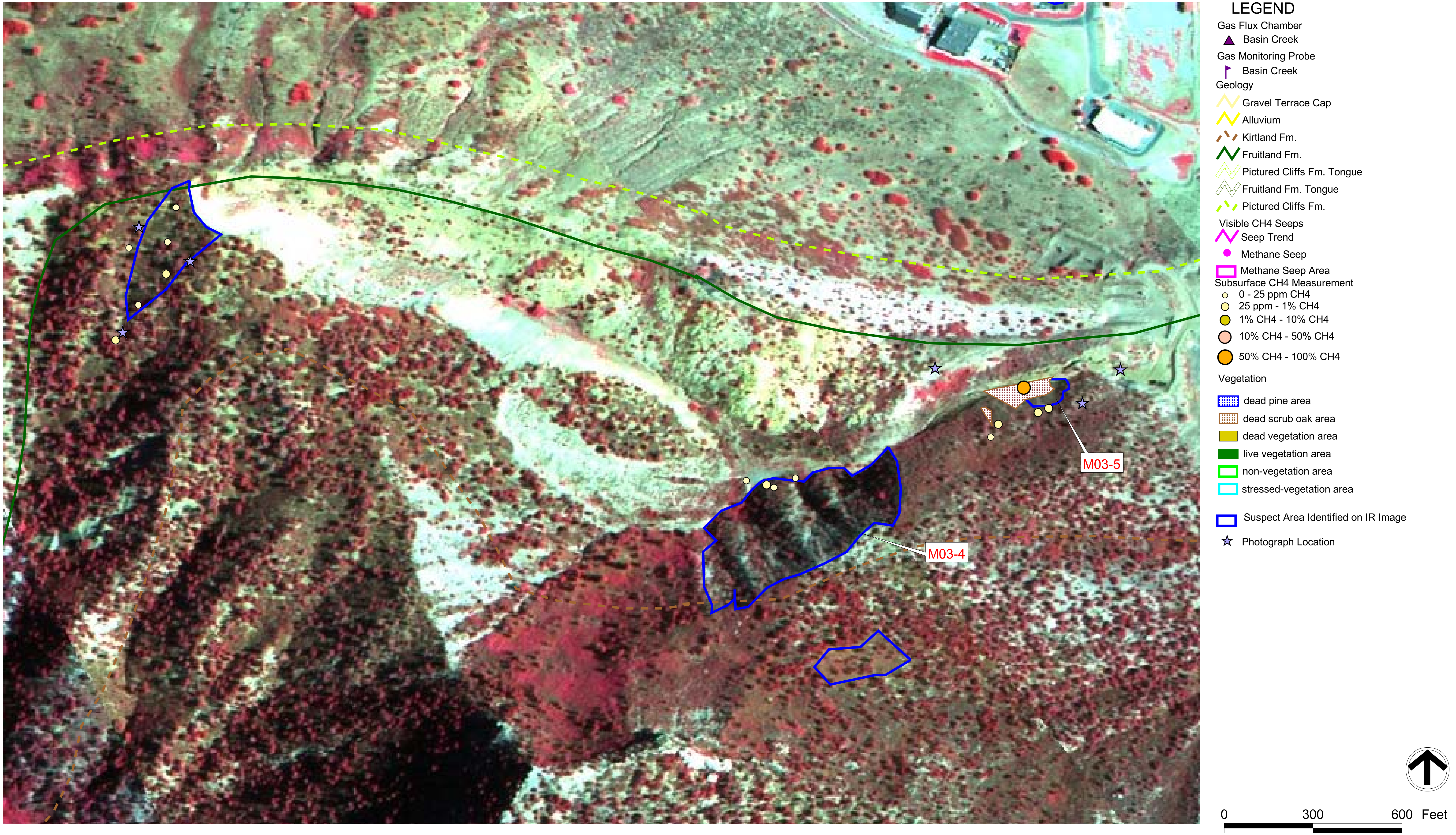

BC-1 Text Reference

IR imagery taken on August 14, 2002.
Mapping data collected on July 27, 2003.

FIGURE 11
CARBON JUNCTION - WEST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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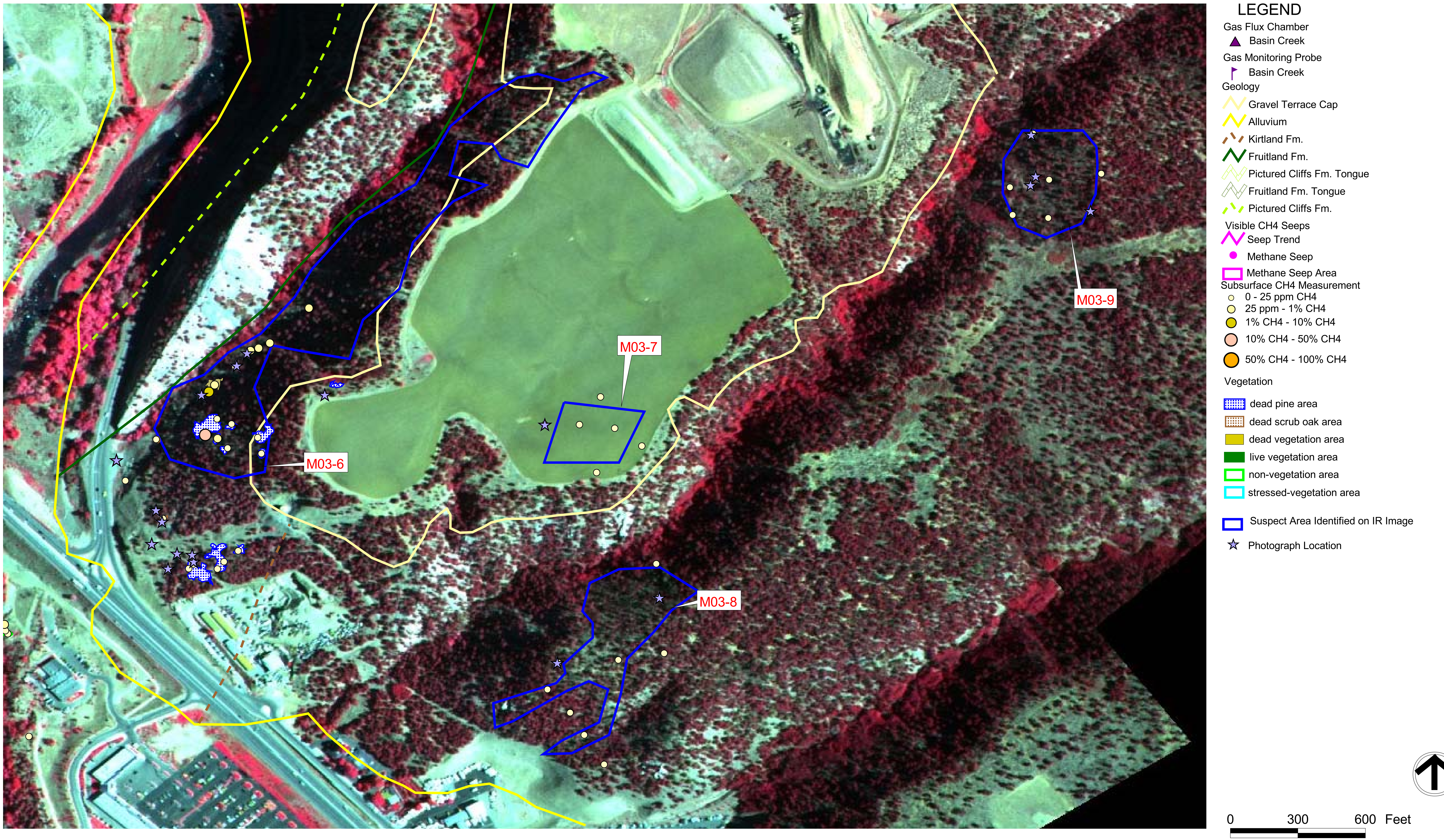

BC-1 Text Reference

IR imagery taken on August 14, 2002.
Mapping data collected on July 25, 2003.

FIGURE 12
CARBON JUNCTION - EAST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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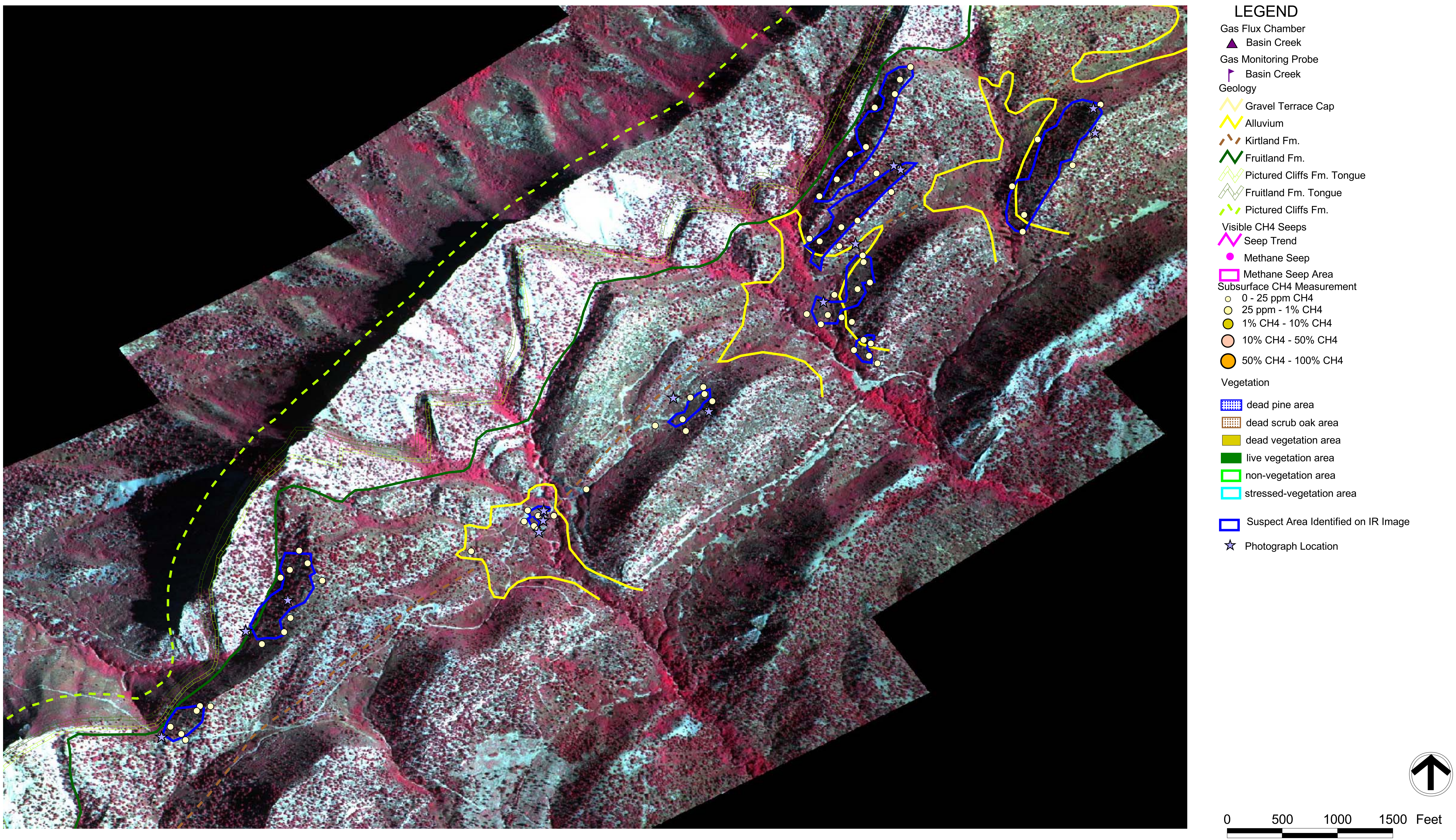

BC-1 Text Reference

IR imagery taken on August 14, 2002.
Mapping data collected on July 21 and 22, 2003.

FIGURE 13
NORTHWEST OF FLORIDA MESA
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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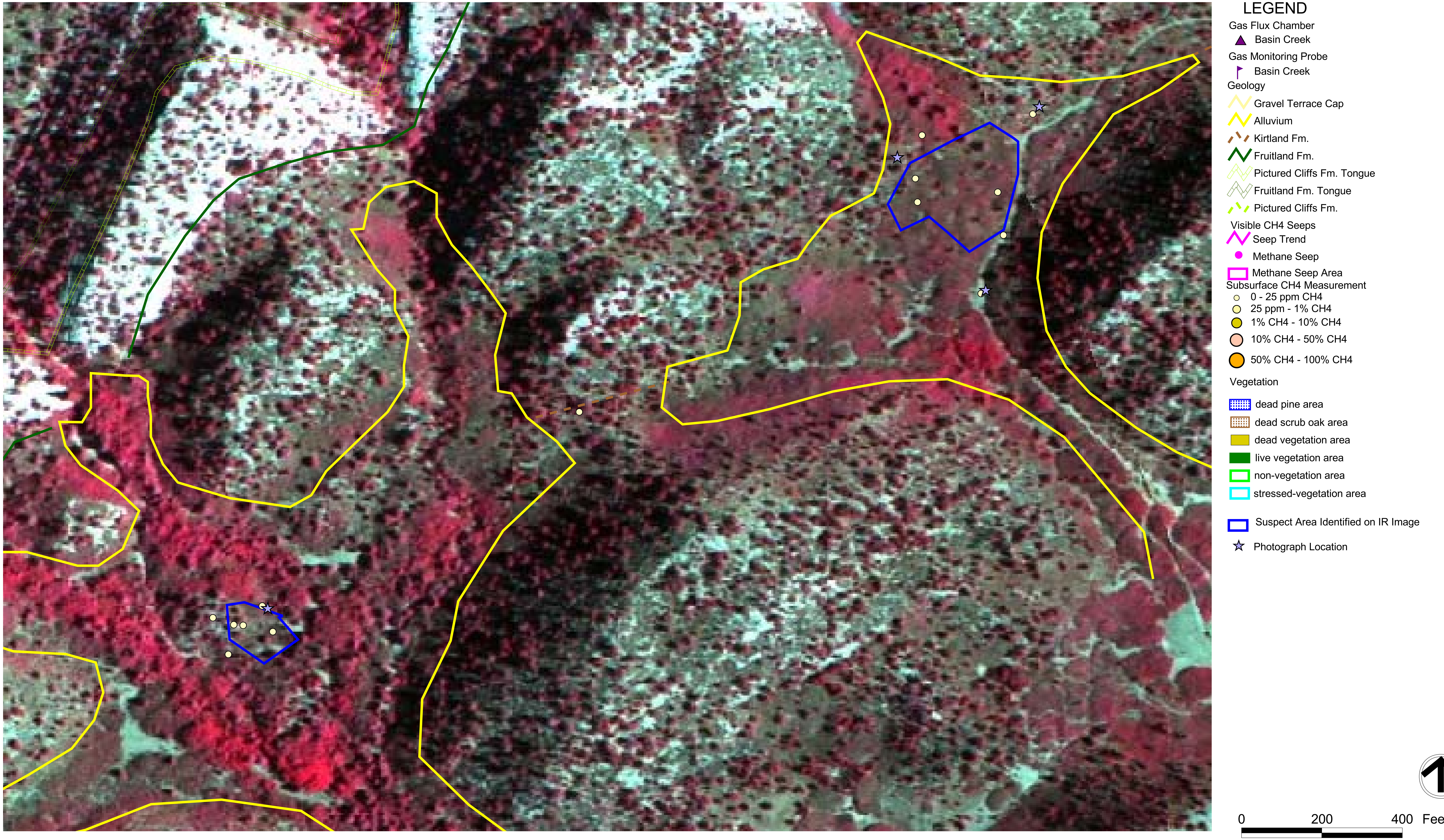


BC-1 Text Reference

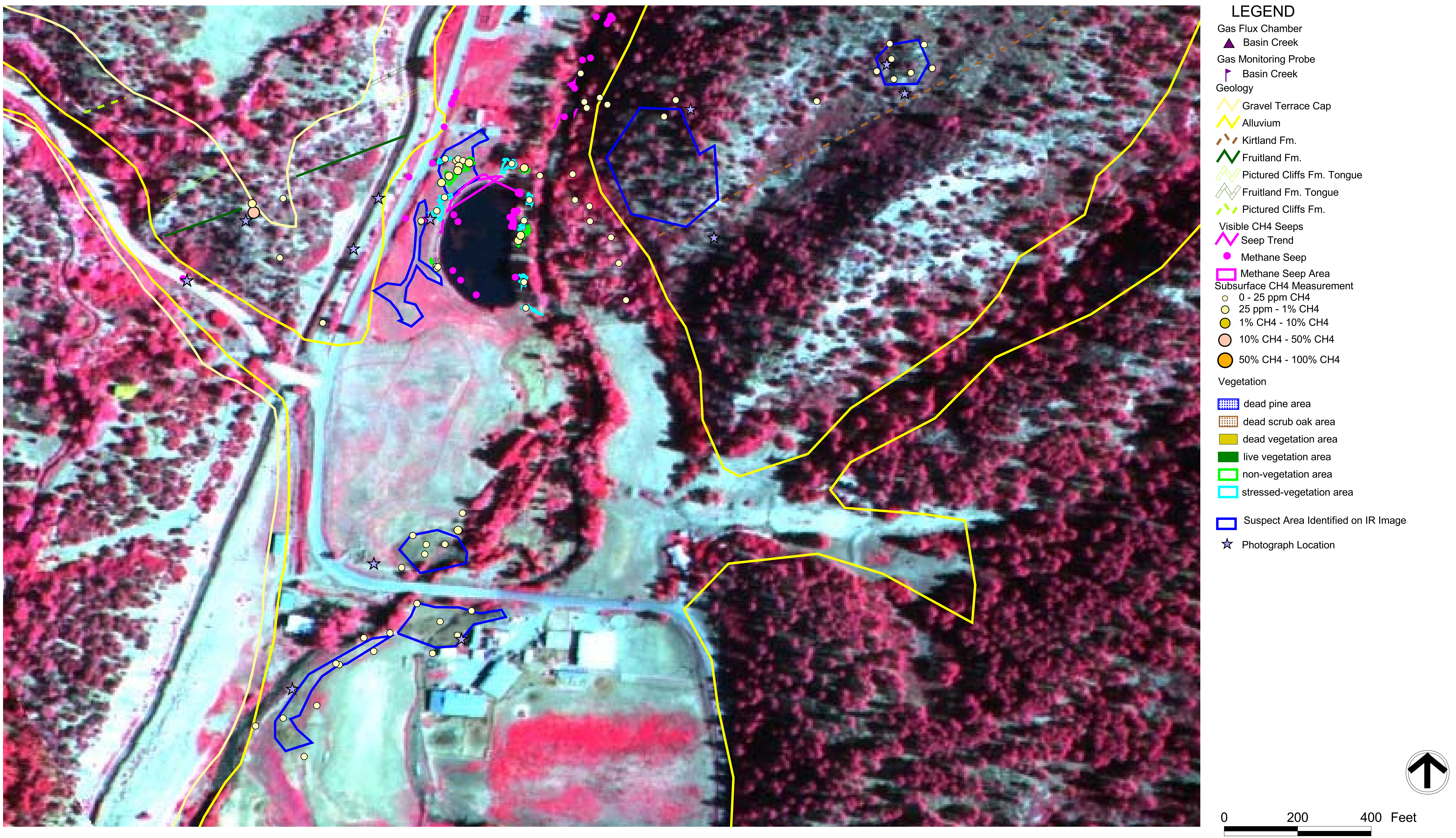
IR imagery taken on August 14, 2002.
Mapping data collected on July 22, 2003.

FIGURE 14
FLORIDA RIVER - WEST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

LTE

dgomethane.apr



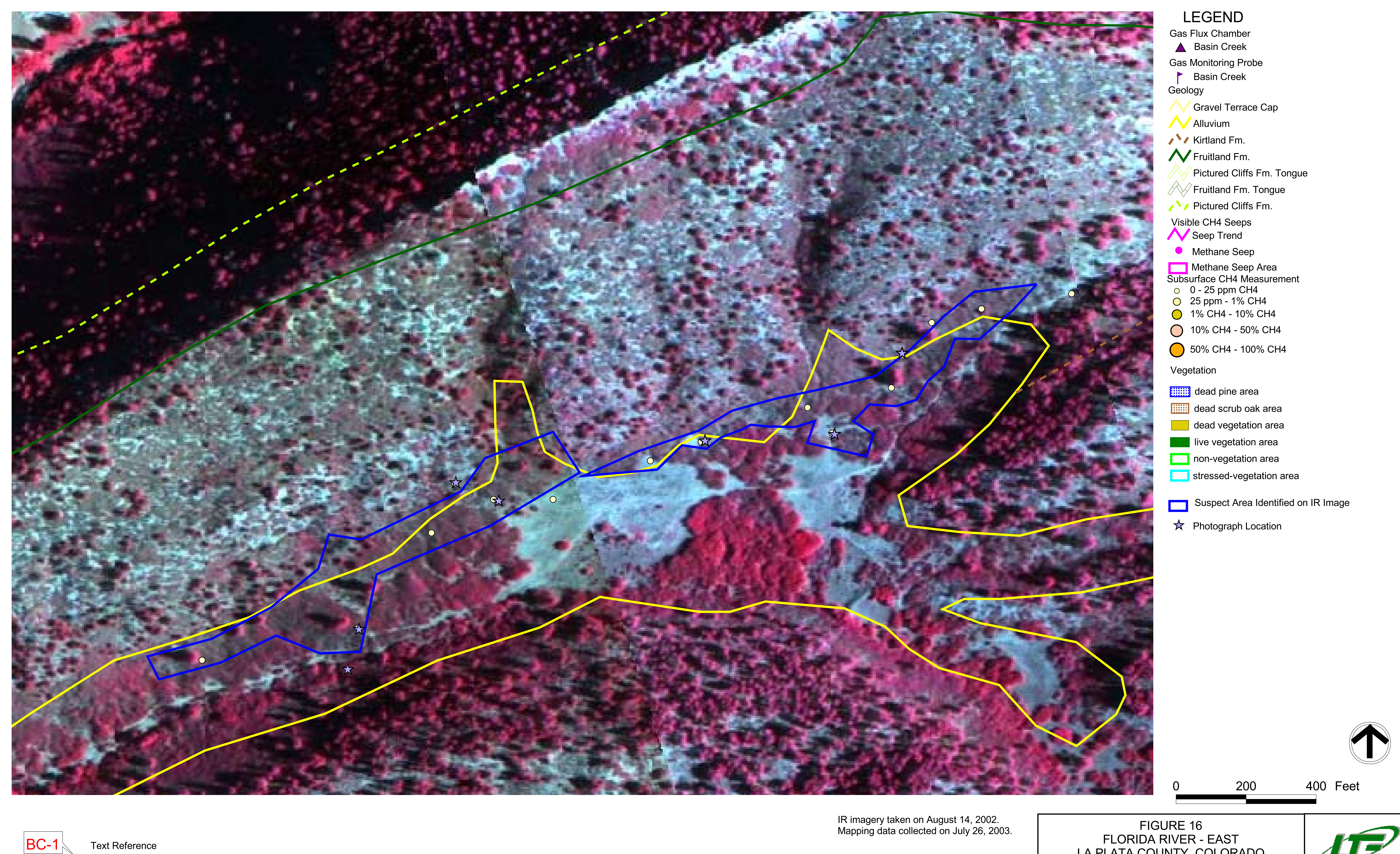
BC-1 Text Reference

IR imagery taken on August 14, 2002.
Mapping data collected on July 23, 2003.

FIGURE 15
FLORIDA RIVER AREA
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr

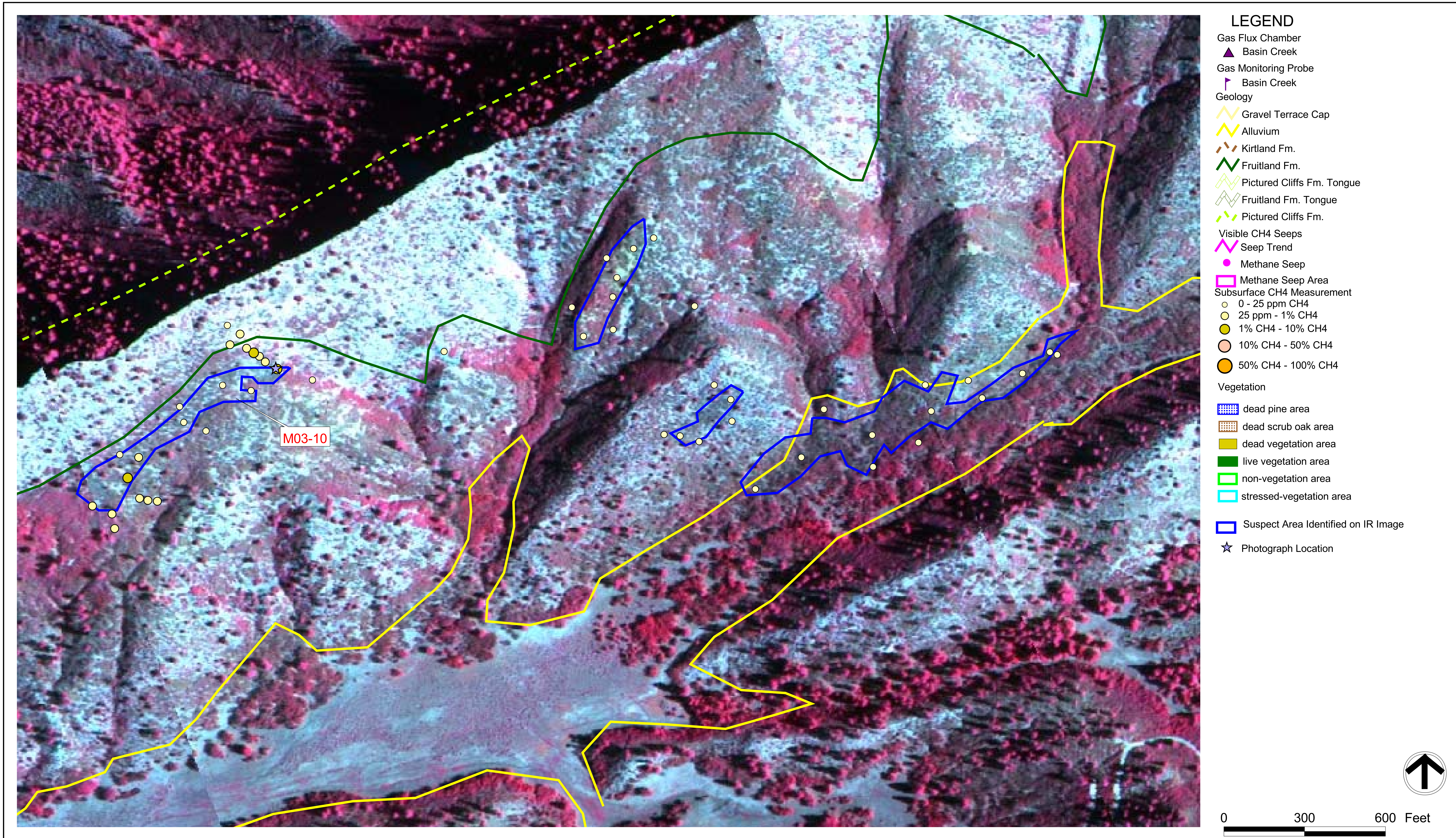


IR imagery taken on August 14, 2002.
Mapping data collected on July 26, 2003.

FIGURE 16
FLORIDA RIVER - EAST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr

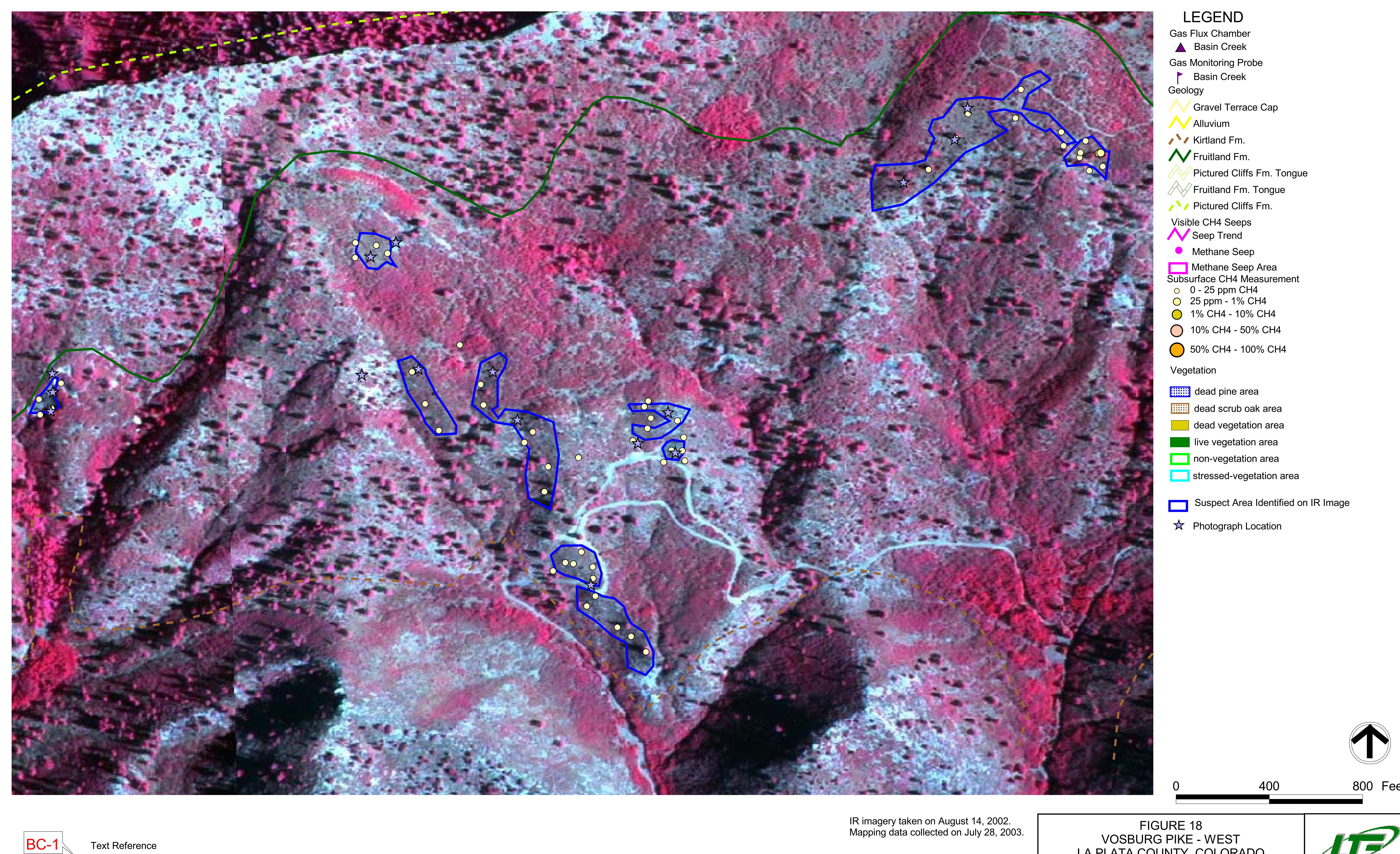


IR imagery taken on August 14, 2002.
Mapping data collected July 24, 2003.

FIGURE 17
EDGEMONT RANCH - EAST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr

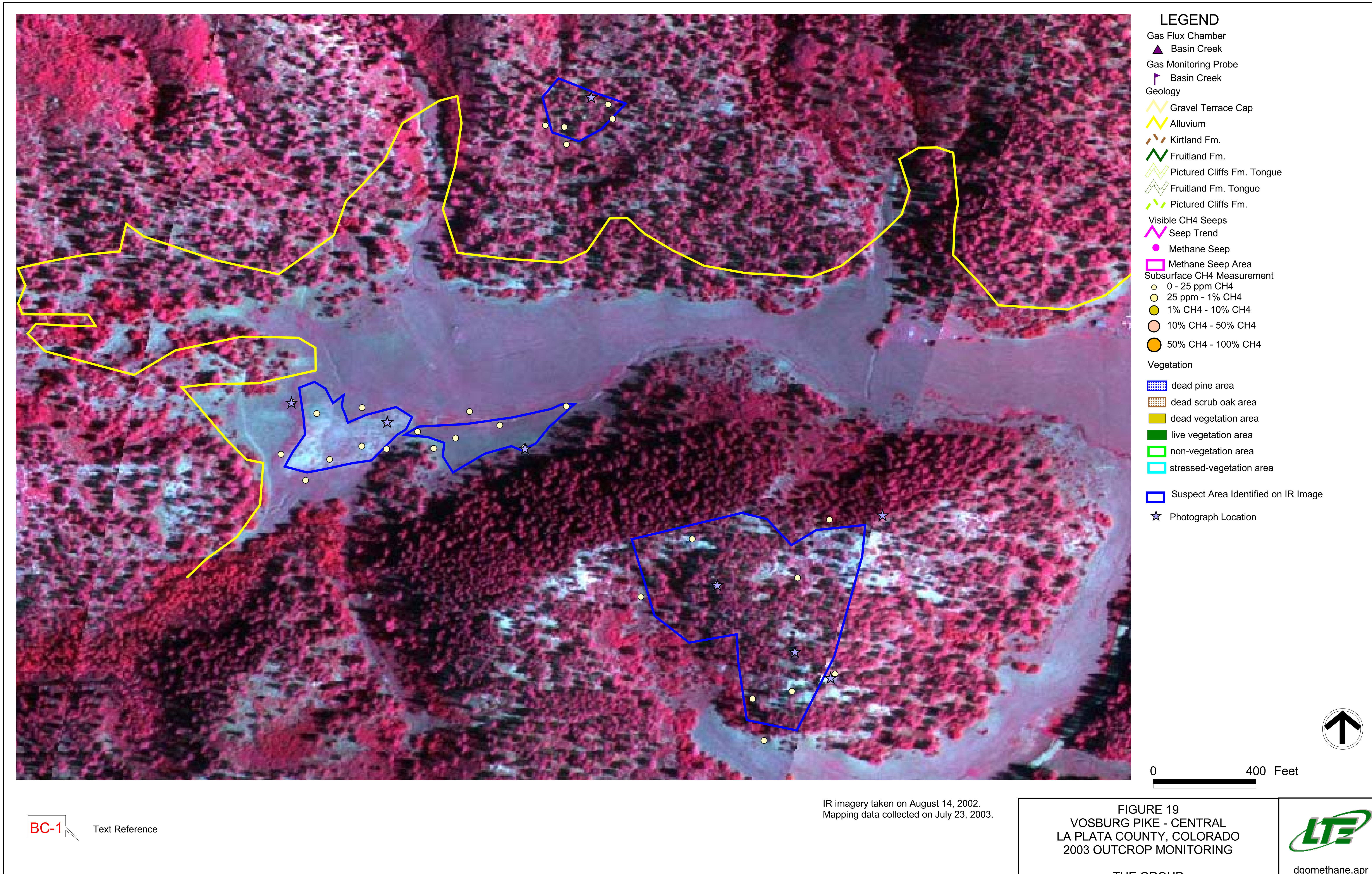


IR imagery taken on August 14, 2002.
Mapping data collected on July 28, 2003.

FIGURE 18
VOSBURG PIKE - WEST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr

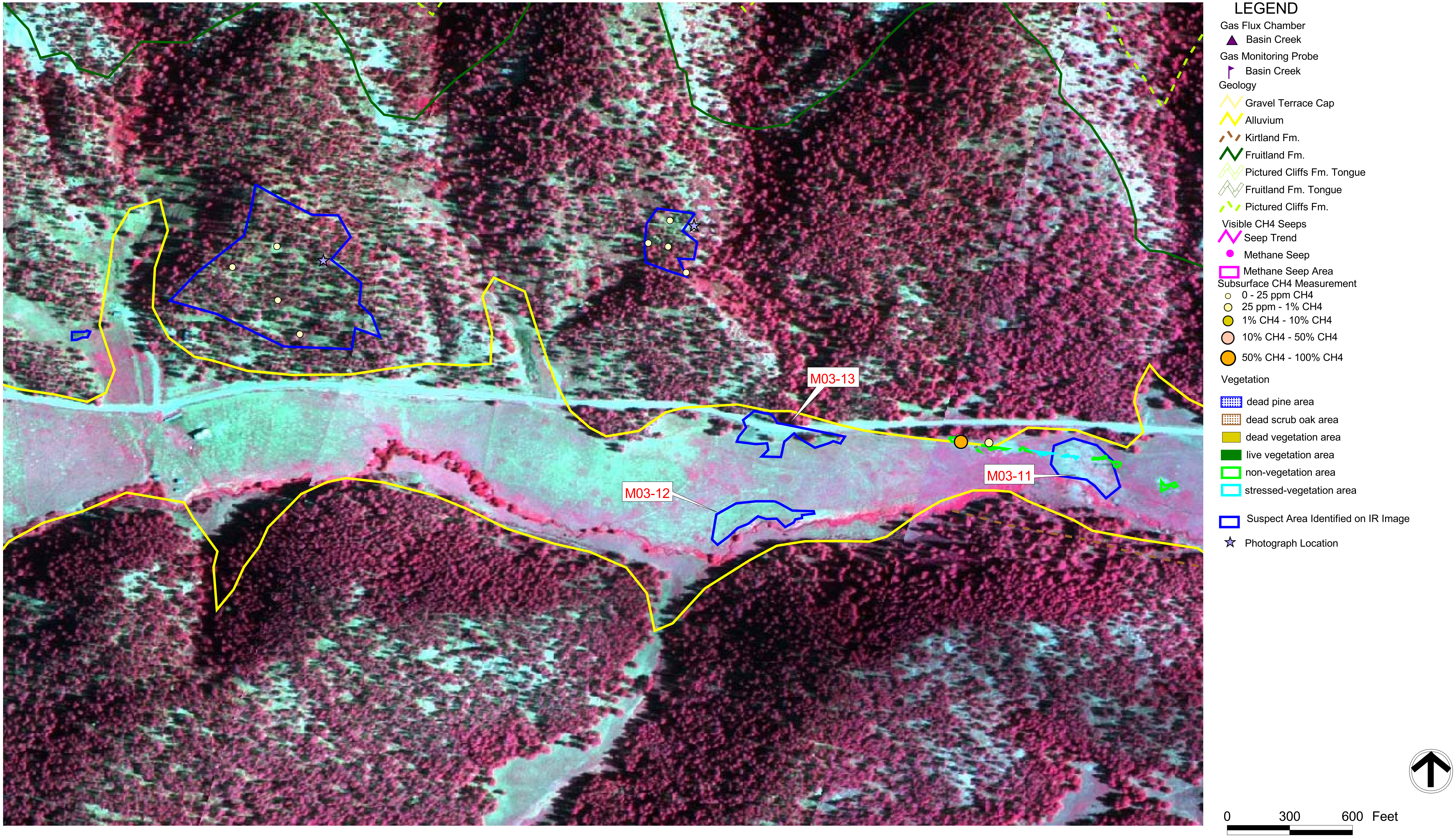


IR imagery taken on August 14, 2002.
Mapping data collected on July 23, 2003.

FIGURE 19
VOSBURG PIKE - CENTRAL
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr



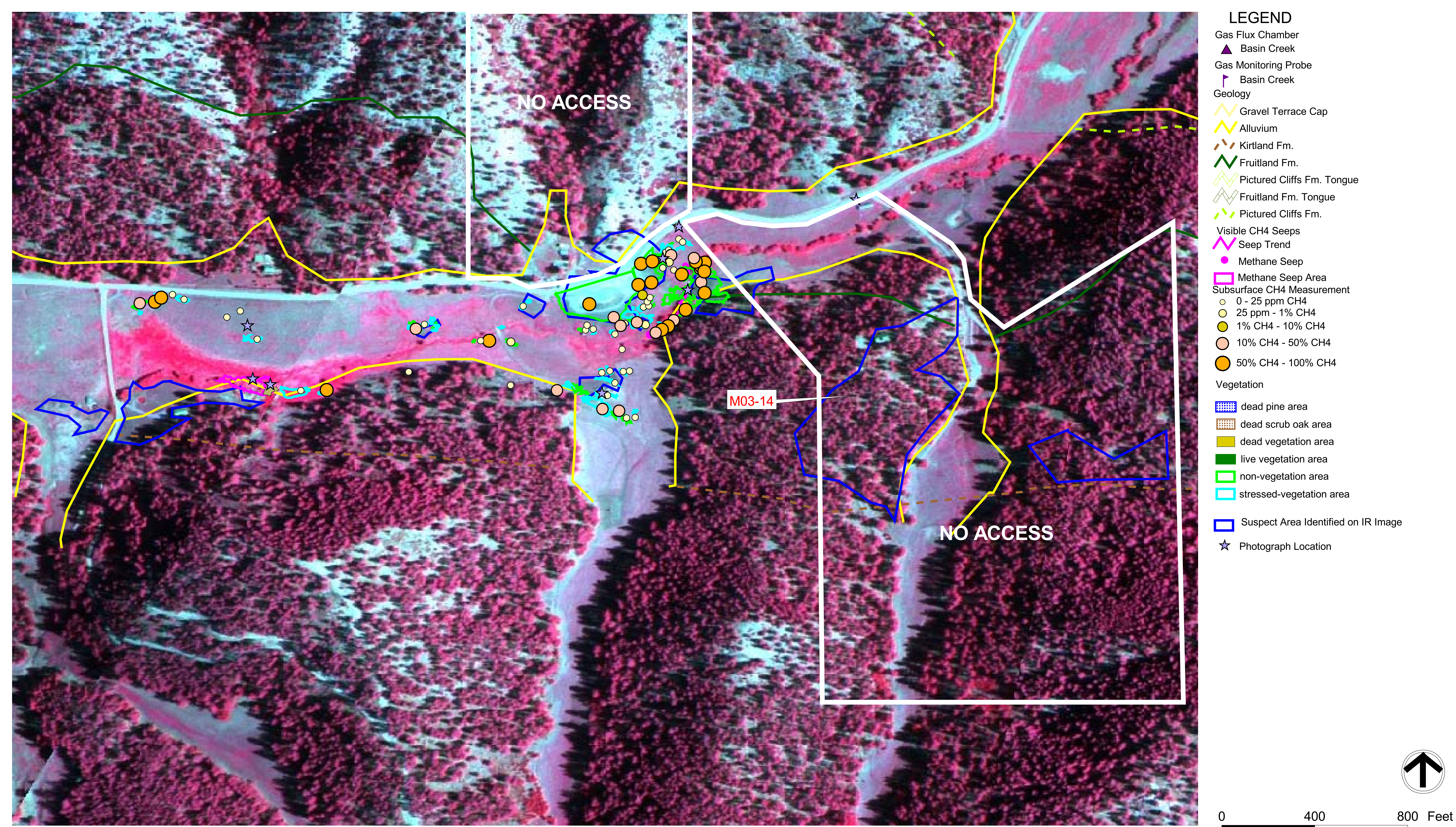
BC-1 Text Reference

IR imagery taken on August 14, 2002.
Mapping data collected on July 26, 2003.

FIGURE 20
TEXAS CREEK - WEST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr



BC-1 Text Reference

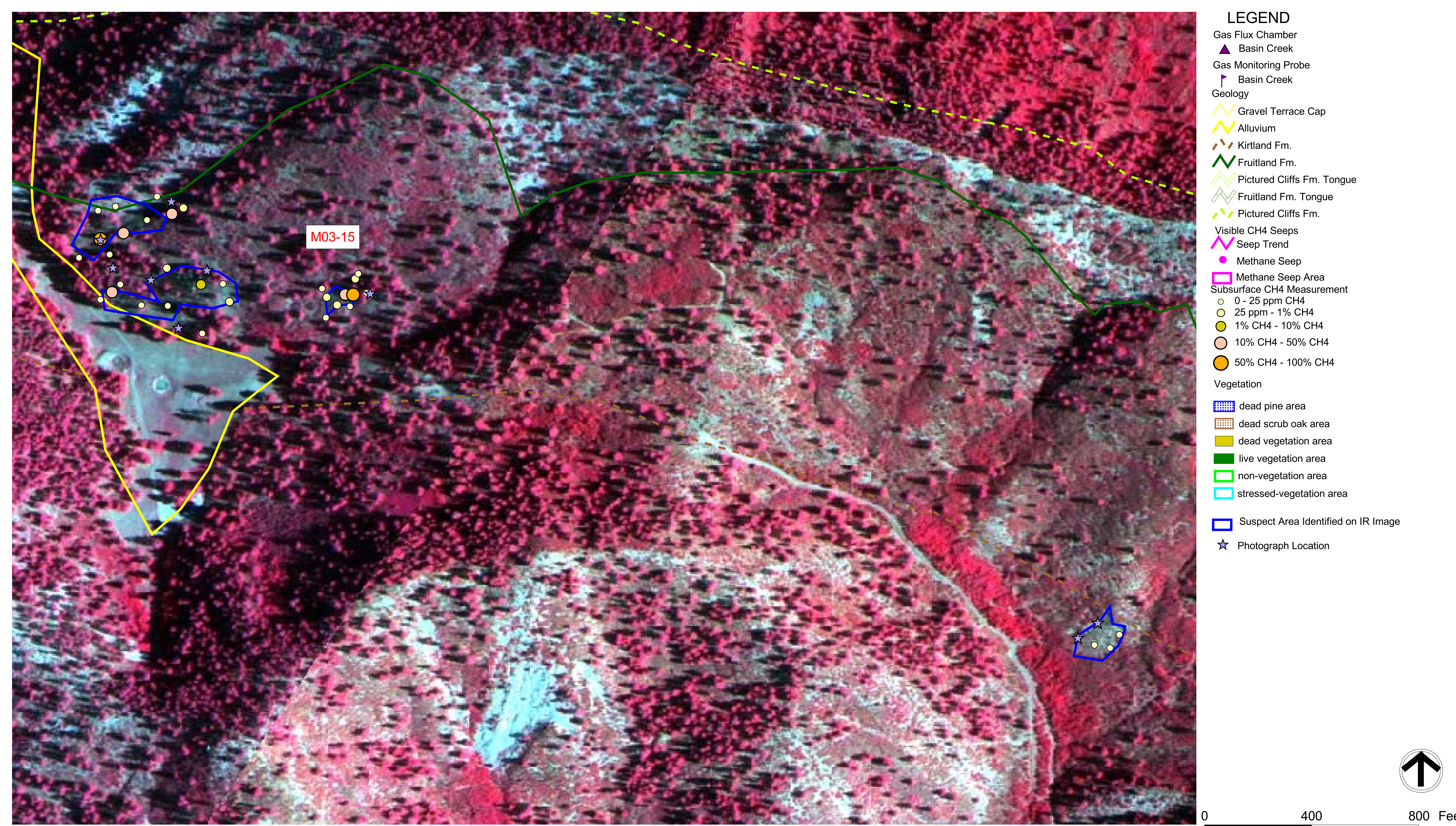
IR imagery taken on August 14, 2002.
Mapping data collected on May 25, 2003.

FIGURE 21
TEXAS CREEK - CENTRAL
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

LTE

dgomethane.apr



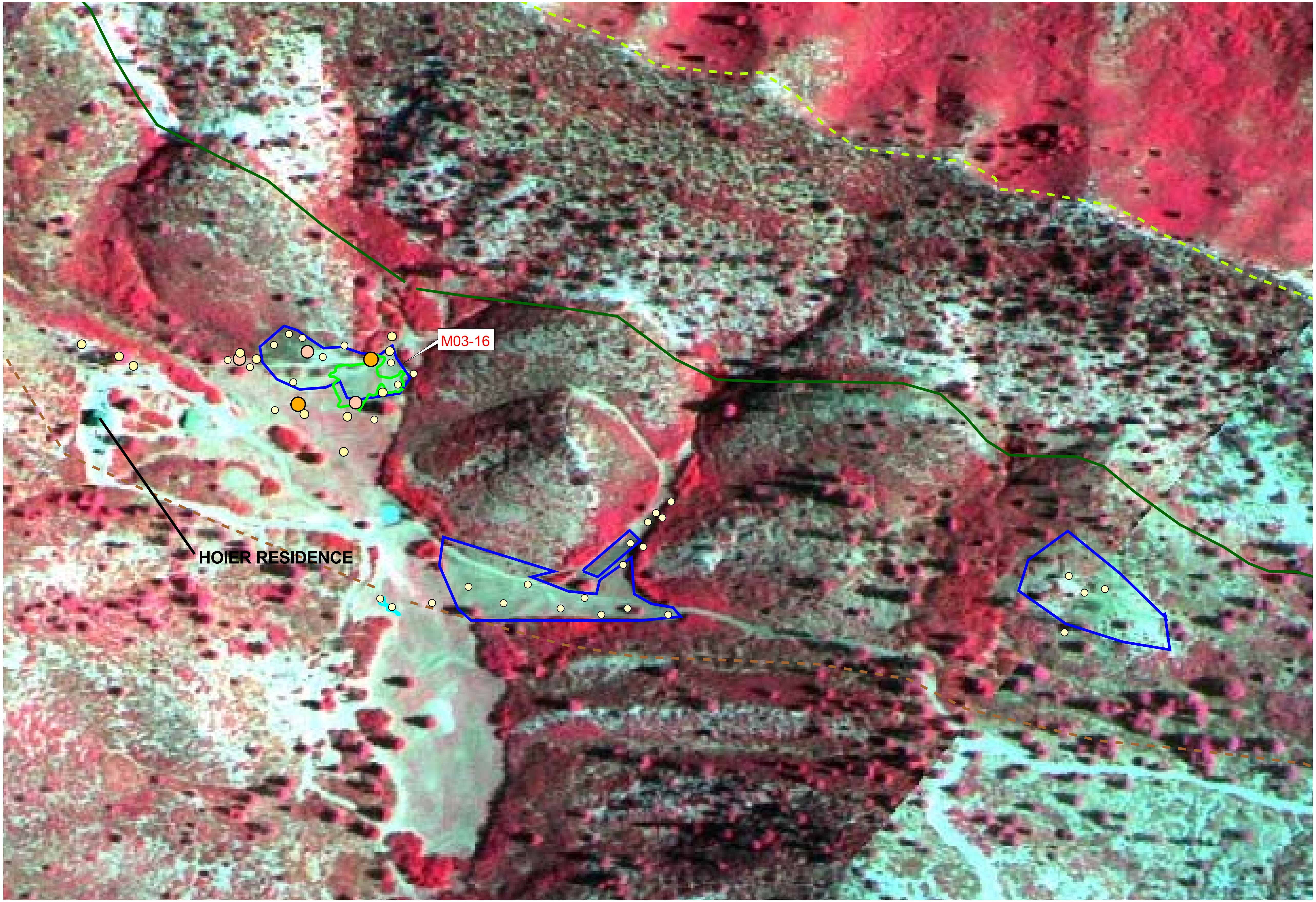
IR imagery taken on August 14, 2002.
Mapping data collected on July 30, 2003.

FIGURE 22
TEXAS CREEK - EAST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

LTE

dgomethane.apr



LEGEND

Gas Flux Chamber
- Basin Creek

Gas Monitoring Probe
- Basin Creek

Geology
- Gravel Terrace Cap
- Alluvium
- Kirtland Fm.
- Fruitland Fm.
- Pictured Cliffs Fm. Tongue
- Fruitland Fm. Tongue
- Pictured Cliffs Fm.

Visible CH4 Seeps
- Seep Trend
- Methane Seep
- Methane Seep Area

Subsurface CH4 Measurement
- 0 - 25 ppm CH4
- 25 ppm - 1% CH4
- 1% CH4 - 10% CH4
- 10% CH4 - 50% CH4
- 50% CH4 - 100% CH4

Vegetation
- dead pine area
- dead scrub oak area
- dead vegetation area
- live vegetation area
- non-vegetation area
- stressed-vegetation area

- Suspect Area Identified on IR Image
- Photograph Location

0 300 Feet

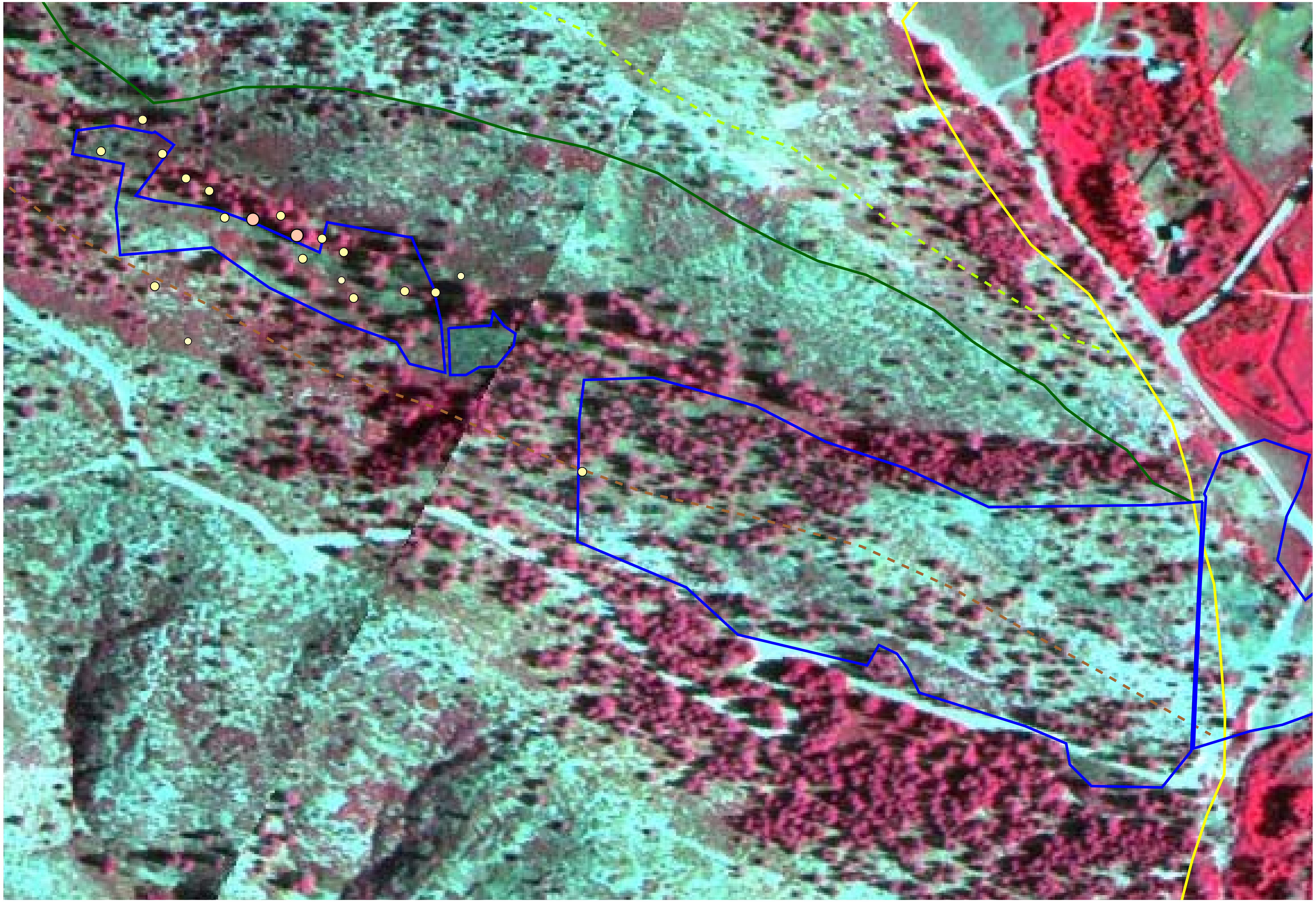
BC-1 Text Reference

IR imagery taken on August 14, 2002.
Mapping data collected on July 31 and August 17, 2003.

FIGURE 23
HOIER PROPERTY
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

dgomethane.apr



LEGEND

Gas Flux Chamber
- Basin Creek

Gas Monitoring Probe
- Basin Creek

Geology
- Gravel Terrace Cap
- Alluvium
- Kirtland Fm.
- Fruitland Fm.
- Pictured Cliffs Fm. Tongue
- Fruitland Fm. Tongue
- Pictured Cliffs Fm.

Visible CH4 Seeps
- Seep Trend
- Methane Seep
- Methane Seep Area

Subsurface CH4 Measurement
- 0 - 25 ppm CH4
- 25 ppm - 1% CH4
- 1% CH4 - 10% CH4
- 10% CH4 - 50% CH4
- 50% CH4 - 100% CH4

Vegetation
- dead pine area
- dead scrub oak area
- dead vegetation area
- live vegetation area
- non-vegetation area
- stressed-vegetation area

Suspect Area Identified on IR Image

Photograph Location

0 200 400 Feet

BC-1 Text Reference

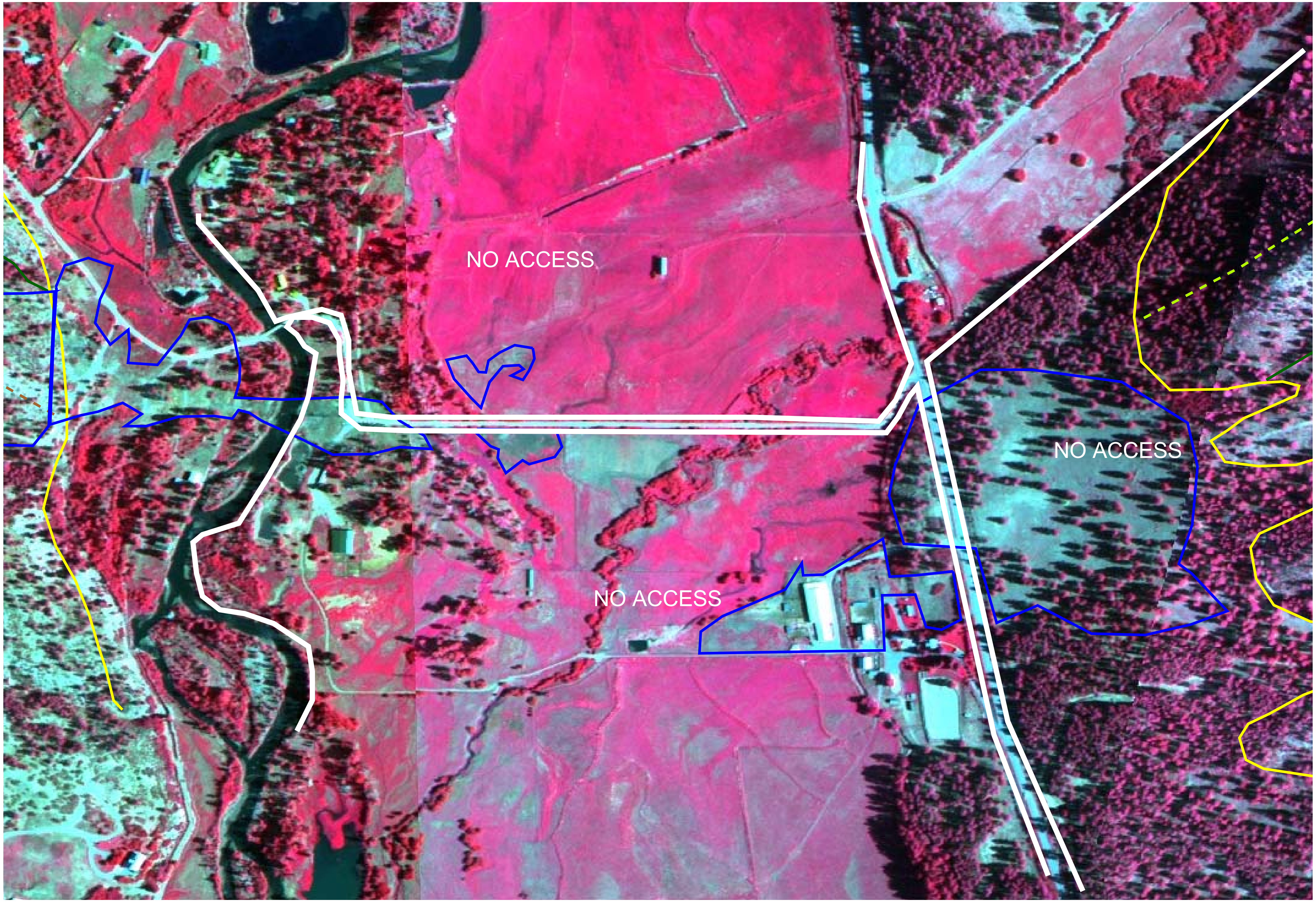
IR imagery taken on August 14, 2002.
Mapping data collected on August 18, 2003.

FIGURE 24
PINE RIVER - WEST
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

LTE

dgomethane.apr



LEGEND

Gas Flux Chamber
- Basin Creek

Gas Monitoring Probe
- Basin Creek

Geology
- Gravel Terrace Cap
- Alluvium
- Kirtland Fm.
- Fruitland Fm.
- Pictured Cliffs Fm. Tongue
- Fruitland Fm. Tongue
- Pictured Cliffs Fm.

Visible CH4 Seeps
- Seep Trend
- Methane Seep
- Methane Seep Area

Subsurface CH4 Measurement
- 0 - 25 ppm CH4
- 25 ppm - 1% CH4
- 1% CH4 - 10% CH4
- 10% CH4 - 50% CH4
- 50% CH4 - 100% CH4

Vegetation
- dead pine area
- dead scrub oak area
- dead vegetation area
- live vegetation area
- non-vegetation area
- stressed-vegetation area

Suspect Area Identified on IR Image

Photograph Location

0 200 400 Feet

BC-1 Text Reference

IR imagery taken on August 14, 2002.

FIGURE 25
PINE RIVER - CENTRAL
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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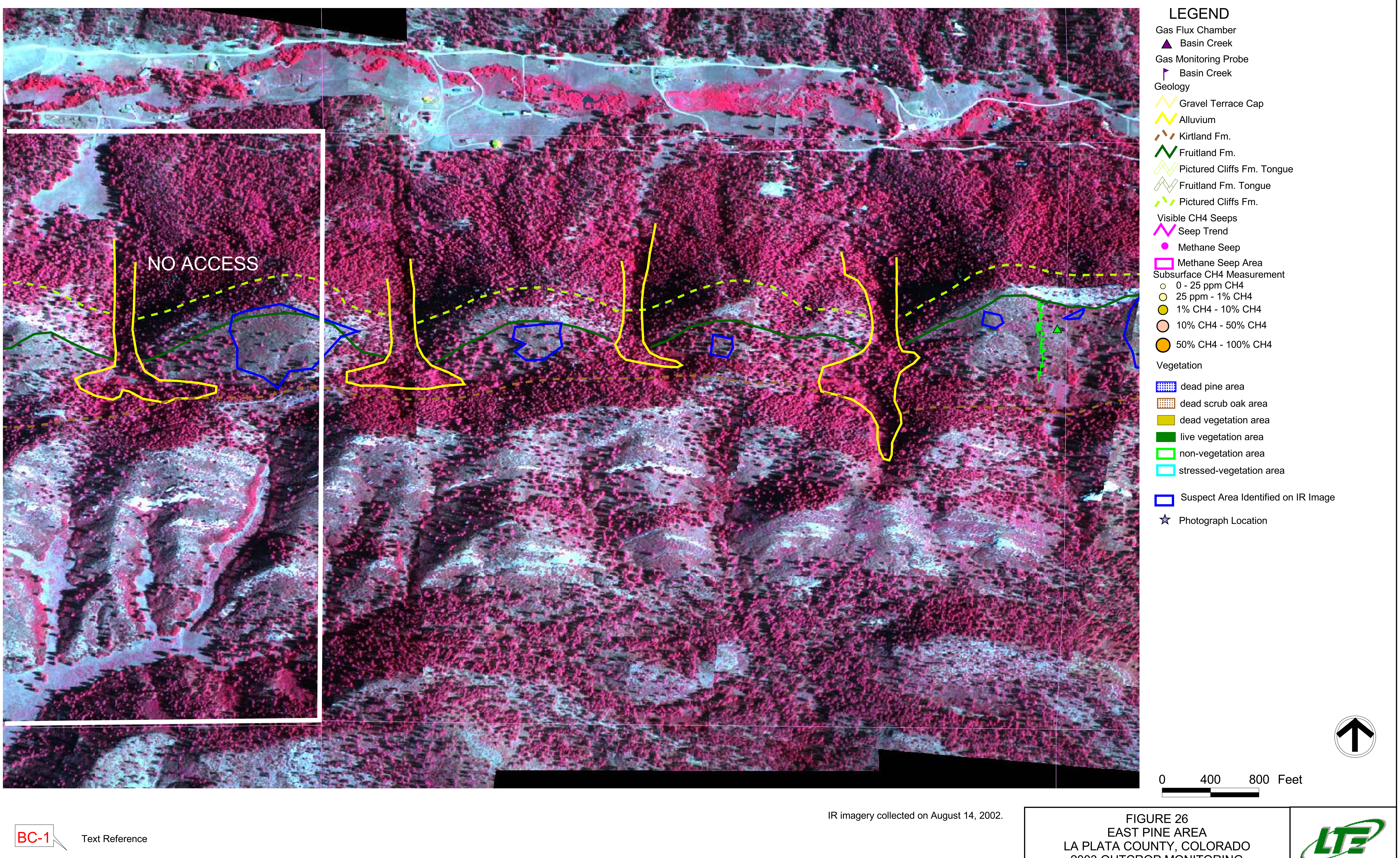

IR imagery collected on August 14, 2002.

FIGURE 26
EAST PINE AREA
LA PLATA COUNTY, COLORADO
2003 OUTCROP MONITORING

THE GROUP

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APPENDIX A

EQUIPMENT SPECIFICATIONS

MS3100

3-CCD Camera
1392(H) x 1040(V) Pixels

HIGH RESOLUTION 3-CCD DIGITAL MULTISPECTRAL CAMERA

High Resolution 3-Chip Digital Smart Camera Available in Multiple Spectral Configurations:

Color-Infrared
RGB
RGB/CIR
Multispectral

The MS3100 acquires three channels of crisp 1392 x 1040 images for your most demanding applications. A common aperture and acurate alignment provide true color fidelity and optimum image quality. Multispectral configuration options, smart camera features, and DirectView analog preview complete this unbeatable instrument.

FEATURES

- Color separating prism with three CCD imaging sensors
- 1392(H) x 1040(V) resolution (x3) for 4.3 Million pixels of data
- Image 3-5 spectral bands from 400-1100 nm
- Standard models for RGB, CIR, and RGB/CIR
- Custom multispectral configuration to meet your needs
- Frame rates up to 7.5 fps
- "Smart Camera" features for advanced control and processing
- Display composite, false color, or individual color plane images
- Digital Image Output - EIA-644 or RS-422
- Compact, rugged package
- Independent gain, offset, and exposure control for each channel
- External trigger input with three operating modes
- RS-232 input for configuration and control
- Optional *DirectView* video preview via NTSC/PAL or Progressive Scan
- Optional on-board image processing
- OEM Customization Available

APPLICATIONS

- Machine Vision
  - Food Processing
  - Textiles
  - Plastics
  - Lumber
  - Pharmaceuticals
- Remote Sensing
  - Precision Agriculture
  - Environmental Assessment
  - Archaeology
  - Geology
  - Oceanography
- Reconnaissance
- Advanced Surveillance
- Medical/Scientific Imaging
- Robotics

DuncanTech
A SPECTRUM OF SOLUTIONS

SPECIFICATIONS - MS3100

Image Device:	(3-ea) 1/2 inch Interline Transfer CCD
Picture Elements:	1392(H) x 1040(V)
Pixel Size:	4.65 x 4.65 micron
Pixel clock rate:	14.318 MHz Max
Sensing Area:	7.6 x 6.2 mm (1/2 inch format)
Frame Rate:	7.5 frames per second max
Digital Image Output:	8 bits x 4 taps or 10 bits x 3 taps (32 bits max). EIA644 or RS422
Signal/Noise:	60 dB
Lens Mount:	F-Mount or Canon ENG
Electronic Shutter:	Independent shutter time per channel. Range: 1/8,000 - 1/7.5 sec
Gain Selection:	Independent gain per channel. 0-36 dB
Offset Selection:	Independent offset per channel. 0-127 counts
External Trigger Input	Edge or level, Three modes
External Trigger Source:	Optically isolated BNC or Frame Grabber
Command/Control Input:	RS-232 port
Operating Temperature:	0-50 C
Operating Voltage:	12 VDC
Power Consumption:	10 Watts
Weight:	1.62 kg
Programmable Functions:	Offset, gain, exposure time, multiplexing, trigger modes, custom
Options:	processing.
Analog Video Output:	NTSC/PAL and Progressive Scan RGB (1280x1024 max display resolution)
Signal Processing	Thresholding, Ratios, Multipliers, Look up Tables, False Color Mapping,
	Custom Firmware Available

SPECTRAL CONFIGURATIONS

DuncanTech's multispectral cameras use a beam splitting prism and three CCD sensors to acquire images in 3-5 spectral bands within the 400-1100 nm sensitivity of the sensors. Standard configurations are available for RGB, CIR, and RGB/CIR. Custom spectral configurations are available to meet customer requirements. For more information on spectral configuration, ask for our *Spectral Configuration Guide*.

RGB CONFIGURATION

Acquires separate Red, Green, and Blue image planes for outstanding color fidelity.

CIR CONFIGURATION

Color Infrared imaging acquires Red, Green and Near Infrared bands approximating Landsat satellite bands. These images are mapped to the Blue, Green, and Red color planes to create false color images similar to color-infrared film for remote sensing applications.

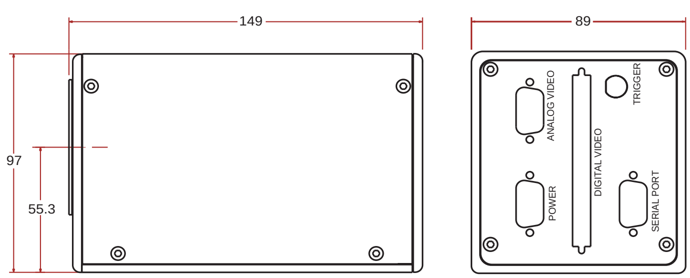
RGB/CIR CONFIGURATION

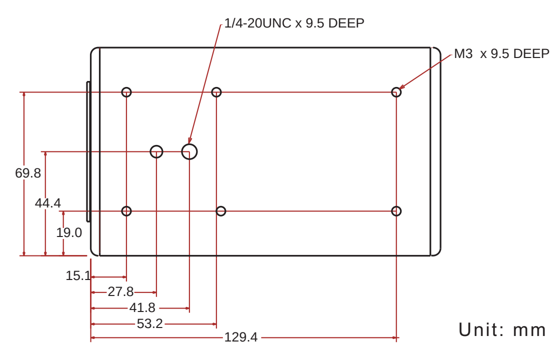
Acquires red, green, blue, and near infrared bands which can be displayed as standard color, color infrared, or single color images.

CUSTOM MULTISPECTRAL

Specify the wavelengths and bandwidths required for your application. This configuration is tailored to meet your needs.

DIMENSIONS





Unit: mm

DuncanTech
A SPECTRUM OF SOLUTIONS

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Auburn, CA 95603 USA
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Email: info@duncantech.com
Web: www.duncantech.com

GPS Pathfinder Systems

GPS systems for better data management and decision-making

Key features and benefits

- **Fast map display**
- **Easy to use graphical interface**
- **High-performance DGPS receivers**
- **Better accuracy with postprocessing**
- **Rugged and field proven**

Trimble's GPS Pathfinder® Systems are effective tools for data collection, update, and processing. This versatile family offers a variety of software, data collector, and GPS receiver options that are powerful, easy to use, and integrate seamlessly with industry-standard GIS databases. With a GPS Pathfinder System, you'll have the most accurate, current, and reliable data you need to make the best decisions.

Productive field software

Timesaving field software is essential for productive GIS data collection and data maintenance.

With Trimble's field software options, you can quickly and easily collect point, line, and area features, along with customized attribute information. Our field software makes it easy to take existing data from your GIS into the field for verification and update. In the field, your productivity will be enhanced by better graphics. A fast map display allows you to display background data and imagery, to ensure you're working in the right location, with the right data. And flexible map symbology enables you to tailor your data display to match your GIS.

Trimble offers two field software solutions for collecting and maintaining quality data:

TerraSync™ software operates on Trimble's rugged GIS TSCe™ field device, or any Windows field computer.

Asset Surveyor® software runs on Trimble's rugged, field-proven TSC1™ data collector.

Trimble GPS Pathfinder Systems are rugged and field-proven

Accurate and reliable data

Trimble's GPS Pathfinder System receivers offer real-time differential GPS (DGPS) and postprocessing options. Real-time DGPS provides you with immediate results in the field—great for navigation, and relocation of existing assets. Postprocessing enables you to improve the reliability and accuracy of your data when you're back in the office.

The GPS Pathfinder Power receiver integrates GPS, real-time satellite differential, and Wide Area Augmentation System (WAAS) capabilities into a single, lightweight unit.

The GPS Pathfinder Pro XR system integrates GPS, real-time beacon, and WAAS capabilities.

The GPS Pathfinder Pro XRS system integrates GPS, real-time beacon, satellite differential, and WAAS capabilities.

The best data for your GIS

The GPS Pathfinder Office software gives you the tools to manage your GPS projects from start to finish. With it, you can define your field data collection requirements and control the quality of your data. The result is more consistent, reliable, and accurate data for your GIS.

The GPS Pathfinder Systems family offers you a variety of software, data collector, and GPS receiver options. Choose the solution that meets your requirements, and realize the benefits of better decisions based on better data.

GPS Pathfinder Systems

Versatile GIS data collection and maintenance

FEATURES AND OPTIONS

GPS Pathfinder Systems Standard Features

- GPS Pathfinder Office software
- Choice of GPS receiver
- Choice of field software
- Ergonomic backpack carrying system
- Rechargeable system batteries (provide 8 hours of field use)
- Battery charger and AC power supply

Optional Receiver Accessories

- Vehicle kit: includes cigarette lighter power adapter, quick release, 2 quick-release adapters, and magnetic mount
- GPS Pathfinder Centimeter Processing option

Available Receivers and Standard Features

- GPS Pathfinder Pro XRS receiver
- GPS Pathfinder Pro XR receiver
- GPS Pathfinder Power receiver

- 12-channel GPS receiver
- EVEREST™ multipath rejection technology
- WAAS differential correction capabilities

Available Field Software

- Asset Surveyor software for Trimble TSC1 data collector
- TerraSync software for Trimble GIS TSCe field device, and Windows field computers

GPS PATHFINDER POWER RECEIVER / ANTENNA SPECIFICATIONS

- Integrated GPS/Satellite Differential receiver and antenna
- RTCM input

General:	12 channel, L1/CA code tracking with carrier phase filtered measurements.
Update rate:	1 Hz
Power:	3.1 Watts, 9 to 32 VDC
Accuracy (RMS) (Note A):	
MCORR400 differential correction:	Submeter + 1 ppm on a second-by-second basis (horizontal)
	Submeter + 2 ppm on a second-by-second basis (vertical)
Carrier phase processing:	30 cm + 5 ppm with 5 minutes tracking satellites
	20 cm + 5 ppm with 10 minutes tracking satellites
	10 cm + 5 ppm with 20 minutes tracking satellites
	1 cm + 5 ppm with 45 minutes tracking satellites (with Centimeter Processing option)
RTCM satellite differential correction:	Better than 1 meter (Note B)
Time to first fix:	30 seconds (typical)
Size:	15.2 cm diameter x 12.7 cm high (6" x 5")
Weight:	0.625 kg (1.38 lbs)
Temperature:	–30°C to +60°C (–22°F to +140°F) (operating)
	–40°C to +80°C (–40°F to +176°F) (storage)
Humidity:	100% fully sealed
Casing:	Fully sealed, dustproof, waterproof, shock resistant

GPS PATHFINDER PRO XR AND PRO XRS RECEIVER & ANTENNA SPECIFICATIONS

GPS Pathfinder Pro XR

- Integrated GPS/Beacon receiver
- Integrated GPS/Beacon antenna
- RTCM input/output
- 3 meter antenna cable
- Base datalogging mode

GPS Pathfinder Pro XRS

- Integrated GPS/Beacon/Satellite Differential receiver
- Integrated GPS/Beacon/Satellite Differential antenna
- RTCM input/output
- 3 meter antenna cable
- Base datalogging mode

GPS Pathfinder Pro XR receiver

General:	12 channel, L1/CA code tracking with carrier phase filtered measurements and multibit digitizer
Update rate:	1 Hz
Power:	6 Watts (maximum), 10 to 32 VDC
Accuracy (RMS) (Note A):	
MCORR400 differential correction:	50 cm + 1 ppm on a second-by-second basis (horizontal) Submeter + 2 ppm on a second-by-second basis (vertical)
Carrier phase processing:	30 cm + 5 ppm with 5 minutes tracking satellites 20 cm + 5 ppm with 10 minutes tracking satellites 10 cm + 5 ppm with 20 minutes tracking satellites 1 cm + 5 ppm with 45 minutes tracking satellites (with Centimeter Processing option)
RTCM beacon radio transmissions:	Better than 1 meter (Note B)
Time to first fix:	30 seconds (typical)
Size:	11.1 cm × 5.1 cm × 19.5 cm (4.4" × 2.0" × 7.7")
Weight:	0.76 kg (1.68 lbs)
Temperature:	–30°C to +65°C (–22°F to +149°F) (operating) –40°C to +85°C (–40°F to +185°F) (storage)
Humidity:	100% fully sealed
Casing:	Dustproof, splashproof, shock resistant; sealed to 5 psi

GPS Pathfinder Pro XRS receiver

Specifications for the Pro XRS receiver are the same as for the Pro XR receiver with the following exceptions:

Power:	7 Watts (maximum), 10 to 32 VDC
Accuracy (RMS) (Note A):	
RTCM satellite differential correction:	Better than 1 meter (Note B)

GPS Pathfinder Pro XR antenna

General:	Right-hand, circular polarized; omnidirectional; hemispherical coverage
Size:	15.5 cm diameter × 10.8 cm high (6.1" × 4.2")
Weight:	0.49 kg (1.08 lbs)
Temperature:	–30°C to +65°C (–22°F to +149°F) (operating) –40°C to +85°C (–40°F to +185°F) (storage)
Humidity:	100% fully sealed
Casing:	Dustproof, waterproof, shock resistant

GPS Pathfinder Pro XRS antenna

Specifications for the Pro XRS antenna are the same as for the Pro XR antenna with the following exceptions:

Size:	15.5 cm diameter × 14 cm high (6.1" × 5.5")
Weight:	0.55 kg (1.2 lbs)

TRIMBLE GIS TSCe FIELD DEVICE SPECIFICATIONS

Screen:	320 x 240 color touch screen: 1/4 VGA reflective color TFT
Size:	25.8 cm x 13 cm x 5.2 cm (10.2" x 5.1" x 2.1")
Weight:	0.99 kg including internal battery
Temperature:	–20°C to +60°C (+14°F to +140°F) (operating) (Note C) –30°C to +60°C (–22°F to +140°F) (storage)
Environmental:	Meets IEC 68, EN61000, MIL-STD-810E standards for temperature, moisture and immersion, dust and sand, drop test, shock, vibration and altitude. IP 67 sealed against temporary immersion.
COM ports:	9-Pin serial port: RS232 (COM 1) 26-Pin MultiPort: (COM 2, Ethernet, USB client, power in/out, and audio in/out) Infrared: IrDA Type 1 (COM 3)
Memory:	128 MB (storage) 64 MB (RAM)
Batteries:	NiMH rechargeable pack, 3800 mAh gives continuous operation for over 30 hours recharges to 90% of capacity in 1 hour (Note D)

TRIMBLE TSC1 DATA COLLECTOR SPECIFICATIONS

Screen:	240 x 200 extended temperature graphics STN LCD monochrome display
Size:	26.7 cm x 11.7 cm x 4.2 cm (10.5" x 4.6" x 1.65")
Weight:	0.85 kg including internal battery
Temperature:	–30°C to +65°C (–22°F to +149°F) (operating)
	–30°C to +80°C (–22°F to +176°F) (storage)
Environmental:	100% fully sealed against sand, dust and moisture, buoyant, waterproof against accidental immersion
COM ports:	Two RS232 7-pin lemo ports
Memory:	2 MB (storage), memory extension through user accessible Type II ATA PC card slot (Note E)
Batteries:	The internal Li-ion battery will last for at least 10 hours. In the field the TSC1 will draw power from the GPS receiver's power source when possible.

(footnotes)

Note A: At least 5 satellites, PDOP ≤6, signal to noise ratio ≥6, satellite elevation mask at 15 degrees.

Note B: RTCM SC-104 standard format broadcast from a Trimble reference station.

Note C: Frontlight has an operation temperature of >0°C.

Note D: 30 hours of operation is achievable without using the frontlight.

Note E: Memory extension through user-accessible Type II PC card slot. 16 MB PCMCIA Data Cards are available (33050-16).

Trimble follows a policy of continuous product improvement. Specifications are therefore subject to change without prior notice.

For further information, contact your nearest Trimble Authorized Distributor or Trimble Office. Please visit our web site at www.trimble.com

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011-44-1-256-760-148 Fax

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Singapore
011-65-348-2212
011-65-348-2232 Fax

TRIMBLE AUTHORIZED DEALER

Gasport® Gas Tester

The Gasport Gas Tester is designed for gas utility workers to detect methane and certain toxic gases. It is a reliable, simple, versatile tool to help your service technicians get the job done quickly! With multiple ranges and sensing capabilities built into one rugged housing, the Gasport Tester simplifies your work by reducing the number of meters you have to carry on the job.

Applications

The Gasport Tester's poison-tolerant methane sensor provides three measurement ranges for your daily service needs:

- Open air, safety sampling
- Small, in-home leak detection
- Street/outdoor service line leak detection

Features and Benefits

- **Proven in field use–rugged and reliable**
  Less costly to maintain, less time in repair
- **Multiple functions in one instrument**
  No need to buy, carry & maintain multiple instruments
- **New, poison-tolerant combustible gas sensor**
  Reduces meter ownership costs
- **User-selectable, "silent" operation mode**
  Reduces customer disturbances and worries
- **Fast warm up time**
  Fastest warm up time in industry saves time
- **Can monitor up to four gases at a time**
  Fewer instruments to carry
- **Show all gas concentrations simultaneously**
  Eliminates guesswork on what reading is displayed
- **Autoranging methane sensor**
  Automatically switches between 0-5% and 5-100% methane ranges
- **Gas readings recorded for later retrieval**
  Can double check readings after job is done
- **Simple manual or automated calibration options**
  Reduces training time and helps ensure accuracy
- **Intrinsically safe**
  Meets safety standards for work in hazardous areas
- **Lifetime warranty on case and electronics**
  Reduced maintenance and lifetime costs

Specifications

Gas	Range	Resolution
Methane	0–5000 ppm	50 ppm
Methane	0–100% LEL or 0–5% CH_4	1 % LEL or 0.1% CH_4
Methane	5–100% CH_4	1% CH_4
Oxygen	0–25%	0.1%
Carbon Monoxide	0–1000 ppm	1 ppm
Hydrogen Sulfide	0–100 ppm	1 ppm

Battery types:	NiCd and Alkaline
Case material:	Impact resistant, stainless-steel-fiber-filled polycarbonate
Operating temperature:	normal -10 to 40°C; extended -20 to 50°C
Operating humidity:	Continuous: 15-95% RH, non-condensing Intermittent duty: 5-95% RH, non condensing
Warm up time:	Less than 20 seconds to initial readings
Datalog capacity:	12 hours
Input:	3 clearly marked, metal domed keys
Warranty:	Case and Electronics: Lifetime Sensors and consumable parts: 1 year

The answer for gas utilities' gas detection needs

Ordering Information

Battery Chargers

Part No.	*Description*
494716	Omega 120 VAC 50/60Hz
495965	Omega 220 VAC 50/60Hz
801759	Omega 110/220 VAC, Five Unit, 50/60Hz
800525	Omega 8 - 24VDC for vehicle use

Battery Packs

Part No.	*Description*
496990	Standard NiCd Rechargeable
800526	Alkaline, Type C
711041	Alkaline, with Thumbscrews
800527	Heavy Duty NiCd Rechargeable

Sensors

Part No.	*Description*
813693	Combustible Gas
480566	O_2
812389	CO
812390	H_2S

Protective Boots

Part No.	*Description*
804955	Black, for NiCd Battery Packs
802806	Orange, for NiCd Battery Packs
806751	Black, for Alkaline Battery Packs
806750	Orange, for Alkaline Battery Packs
806749	Black, for HD NiCd Battery Packs
806748	Orange, for HD NiCd Battery Packs
812833	Yellow Soft Carrying Case with Harness
711022	Black padded Vinyl Carrying Case with Harness

Sampling Equipment

Part No.	*Description*
800332	Probe - 1 ft., plastic
800333	Probe - 3 ft., plastic
803561	Probe - 3 ft., plastic (holes 2" from end) (bar hole probe)
803962	Probe - 3 ft., plastic (holes 2" from handle) (solid probe)
803848	Probe - Hot Gas Sampler
710465	Sampling Line - 5 ft., coiled
497333	Sampling Line - 10 ft.
497334	Sampling Line - 15 ft.
497335	Sampling Line - 25 ft.

Sampling Accessories

Part No.	*Description*
801582	Replacement Filter, Probe, pkg. of 10
801291	External Filter Holder
014318	Charcoal Filter
711039	Line Scrubber Filter Holder
711059	Line Scrubber Replacement Cartridges, Box of 12
808935	Dust Filter, Pump Module
802897	Water Trap (Teflon) Filter, Pump Module

Calibration Check Equipment

Part No.	*Description*
477149	Calibration Kit Model RP with 0.25 lpm Regulator
491041	Calibration Gas - methane, 2.5%
473180	Calibration Gas - 300 ppm CO
813718	Calibration Gas - methane, 2.5% oxygen, 15%60 ppm CO
813720	Calibration Gas - methane, 2.5% oxygen, 15%300 ppm CO 10 ppm H_2S
710288	Gasmiser™ Demand Regulator 0 - 3.0 lpm

Accessories

Part No.	*Description*
804679	Data Docking Module Kit. Includes the Data Docking Module, MSA Link Software and Instruction Manual

Approvals

The Gasport Gas Tester has been designed to meet intrinsic safety testing requirements in certain hazardous atmospheres.

The Gasport Gas Tester is approved by MET (an OSHA Nationally Recognized Testing Laboratory [NRTL]) for use in Class I, Division I, Groups A, B, C, D; Class II, Division I, Groups E, F, G; and Class III Hazardous locations. Gaspor tGas Testers sold in Canada are approved by CSA for use in Class I, Division I, Groups A, B, C, and D locations.

Contact MSA at 1-800-MSA-2222 for more information or with questions regarding the status of approvals.

Gasport Gas Tester Kits

	LEL Display	O_2	CO	H_2S	Alarms Always	Alarms Optional	Leak Detect Page	Peak	Alkaline Battery	NiCd Battery	5ft Coiled Line	1ft Probe	Part No.
4-Gas, Selectable, NiCd	•	•	•	•		•	•	•		•	•	•	711489
4-Gas, Selectable, Alkaline	•	•	•	•		•	•	•	•		•	•	711490
3-Gas, Selectable, NiCd	•	•	•			•	•	•		•	•	•	711493
3-Gas, Selectable, Alkaline	•	•	•			•	•	•	•		•	•	711494
2-Gas, Selectable, NiCd	•		•			•	•	•		•	•	•	711495
2-Gas, Selectable, Alkaline	•		•			•	•	•	•		•	•	711496
4-Gas, Alarms On, NiCd	•	•	•	•	•		•	•		•	•	•	711491
4-Gas, Alarms On, Alkaline	•	•	•	•	•		•	•	•		•	•	711492

Assemble-to-Order (ATO) System: You Make the Choices

The ATO System makes it easy to "custom order" the Gasport Gas Tester, configured exactly the way you want it. You can choose from an extensive line of base instrument components and accessories. To obtain a copy of the "ATO System and Price Information for the Gasport Gas Tester," call toll-free 1-800-MSA-2222, and request Bulletin 0804-28. **To obtain a copy of the ATO via FAX, call MSA QuickLit Information Service at 1-800-672-9010. At the prompt, request QuickLit Document #2345 (ATO for Gasport Gas Tester).**

Note: This Data Sheet contains only a general description of the products shown. While uses and performance capabilties are described, under no circumstances shall the products be used by untrained or unqualified individuals and not until the product instructions including any warnings or cautions provided have been thoroughly read and understood. Only they contain the complete and detailed information concerning proper use and care of these products.

ID 08-04-27-MC / May 2000

Corporate Headquarters
P.O. Box 426
Pittsburgh, PA 15230 USA
Phone (412) 967-3000
www.MSAnet.com

U.S. Customer Service Center
1-800-MSA-2222

MSA International
Phone (412) 967-3354
FAX (412) 967-3451

Offices and representatives worldwide
For further information:

APPENDIX B

DCIR IMAGERY EXPERT QUALIFICATIONS

KEVIN LEE HAYES

1010 McHugh Street
Fort Collins, CO 80524
kevinlh@cnr.colostate.edu
970-472-9251 Home
970-391-4351 Cell

OBJECTIVE: Contribute to the creation, management and use of Geographic Information Systems at county and regional scales. Make it easier, faster, and more cost effective to do a good job of planning for the future, while remaining sensitive to human needs and the local ecosystem. Current interest is in Digital Infrared Photograpy for forest health assessment.

EDUCATION:

M.S. Geomatics (Geographic Information Systems and Remote Sensing), CSU
B.S. Computer Information Systems, Business Administration, CSU
A.S. Earth Science, CMC, Phi Theta Kappa, GPA 3.6
Minor: Spatial Information Management Systems, CSU
Graduate Certificate: GIS and Remote Sensing, CSU

CLASSES AND STUDIES

NR695 Team Leader for undergraduate **GIS** independent studies
NR621 Design of **Geographic Information Systems (GIS)**
ST511 Experimental Design and Data Analysis for Researchers
NR506 Applications in **GIS**
NR505 Concepts in **GIS**
NR504 Computer Processing of **Remotely Sensed Data** (2x)
NR503 **Remote Sensing and Image Interpretation**
NR440 **Land Use Planning**
NR424 **Forest Fire Management**
NR422 Applications of **GIS**
NR493/793 Seminar in **GIS** (3x)
NR322 Introduction to **GIS**
NR495 Application Project : **Global Positioning System (GPS)**
ER416 **Watershed** Management

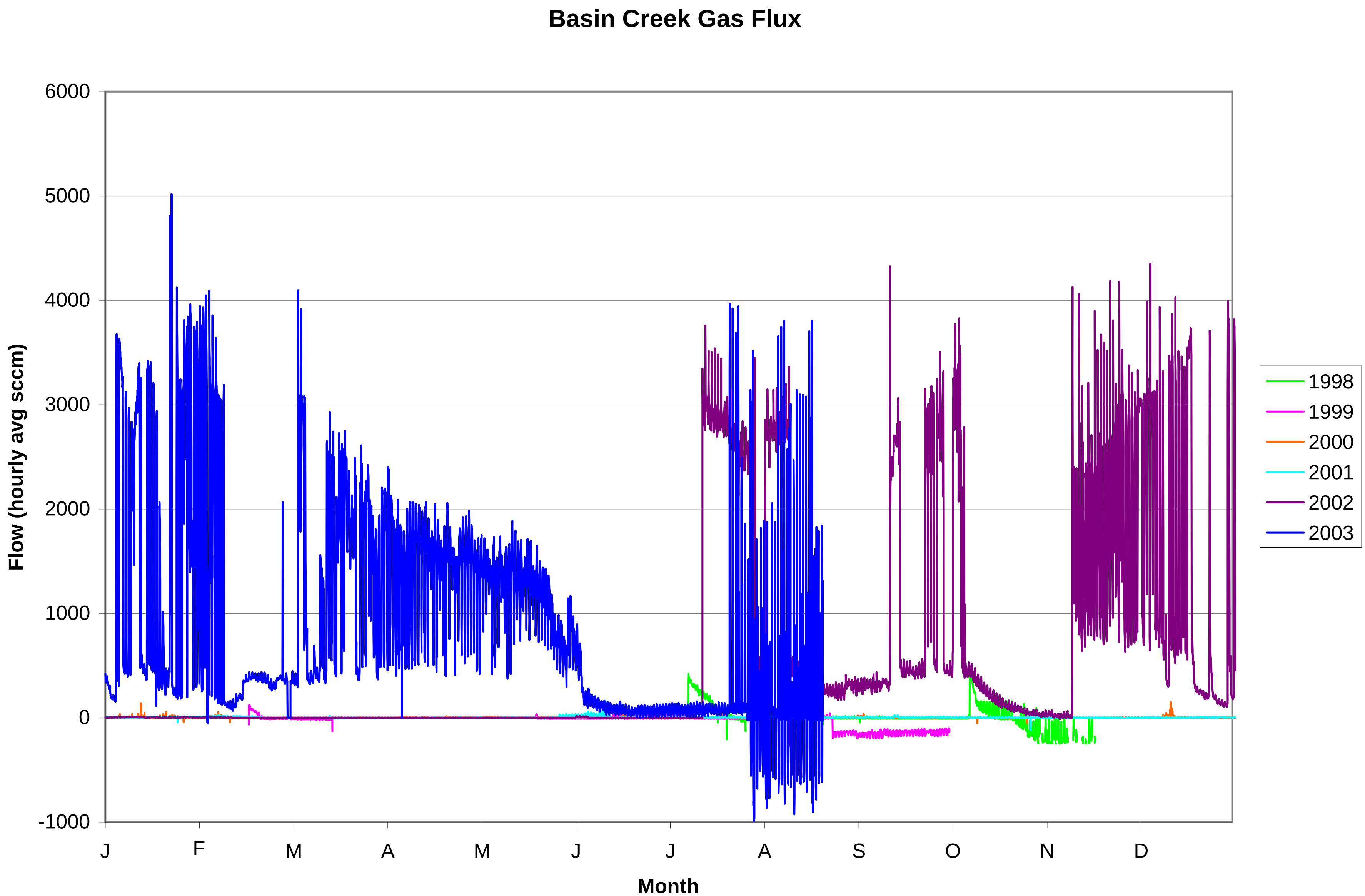
SC442 **Forest and Range Soils**
CS200 **Algorithms and Data Structures Using C++**
CS151 Introduction to **C++ programming**
BD355 **Database Systems**
IS261 **Surveying**

OTHER EMPLOYMENT, VOLUNTEER EXPERIENCE, CLASSES

- **ARC/INFO**, **ARCView,** SML, and Arc Macro Language **(AML) Programming**
- **HTML, and Web Page Design**
- **SAS Statistical Programming**
- **Erdas Imagine**
- **Colorado State Forest Project Manager ***
- **United States Forest Service Contractor** remote sensing and GIS *
- **Larimer County GIS Contractor *** same project
- **Instructor** for CSU Lifestyles Program for 3 years
- **Red Card:** completed wildland fire crew training (1997)
- **Database** Applications in dBASE, dBASE III+, MS Access, Info
- **GPS Technician:** USFS Volunteer
- Volunteer Wilderness Ranger and other
- "**Weather Watcher**": Mountain States Weather Service
- Land Use Hydrology, Hydrogeology, Meteorology, Chemistry, Geology
- **Wilderness First Responder** (WFR, 1998), and past holder of lifesaving certificates

APPENDIX C

FLUX CHAMBER DATA



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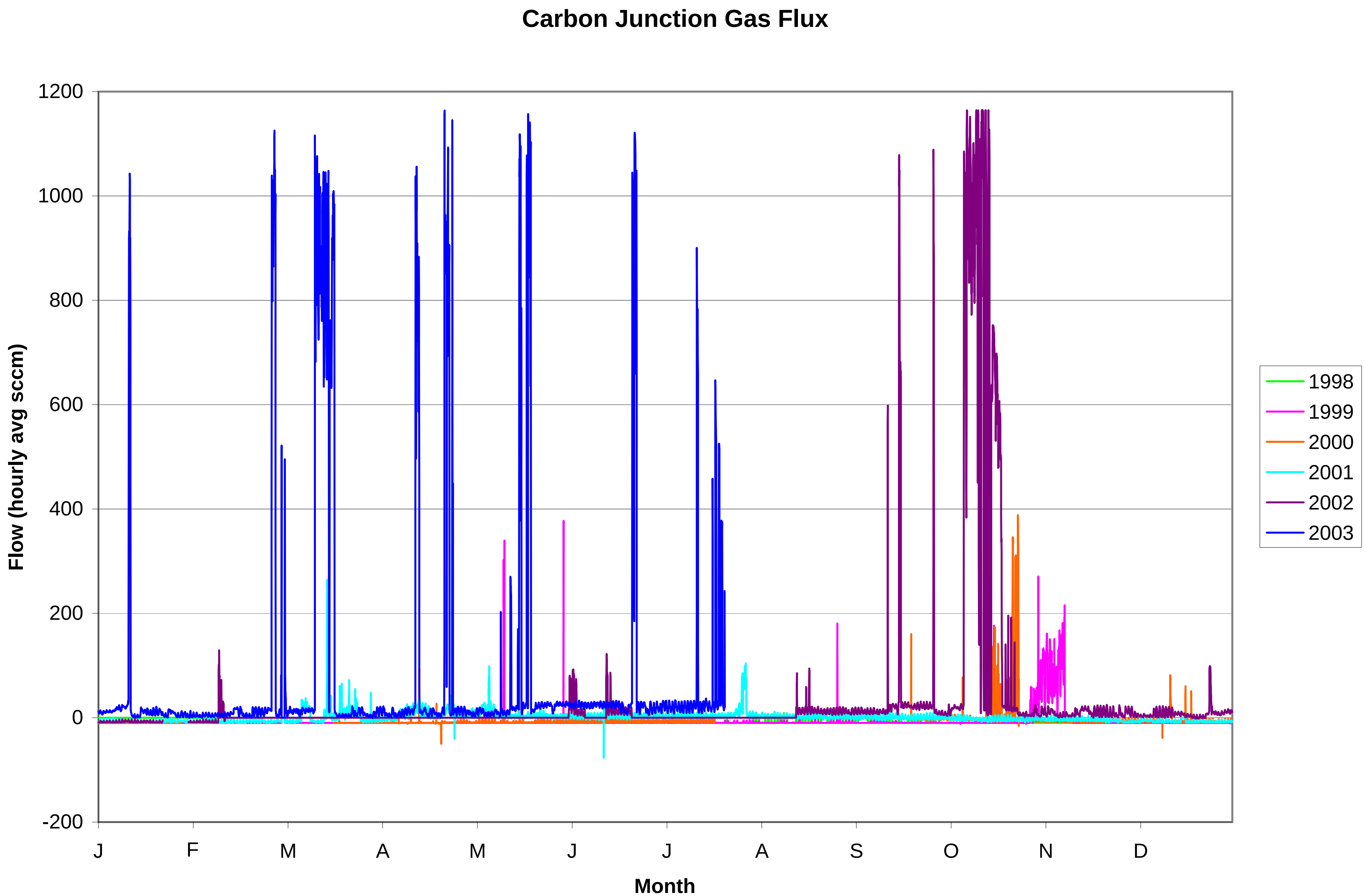

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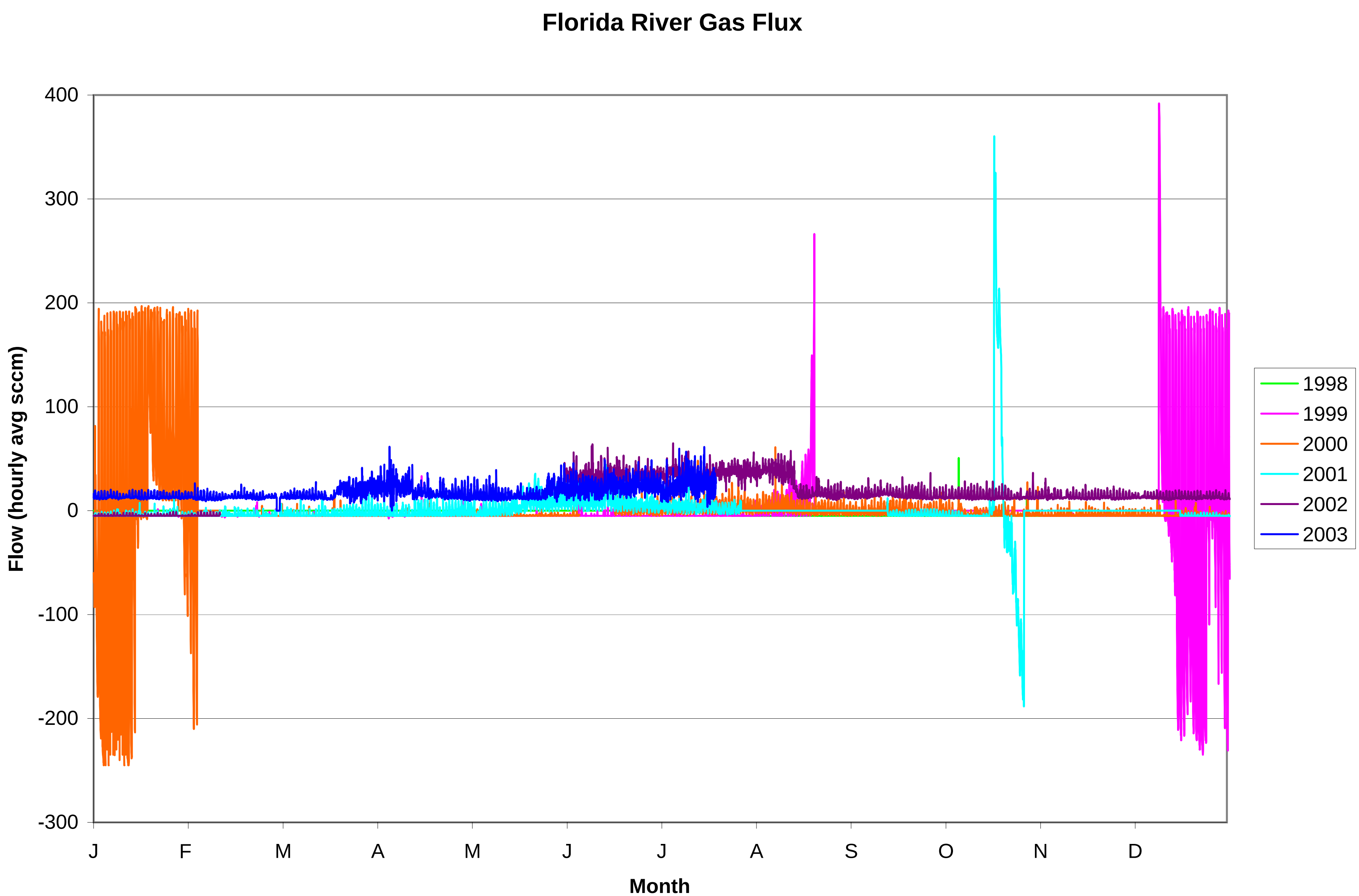

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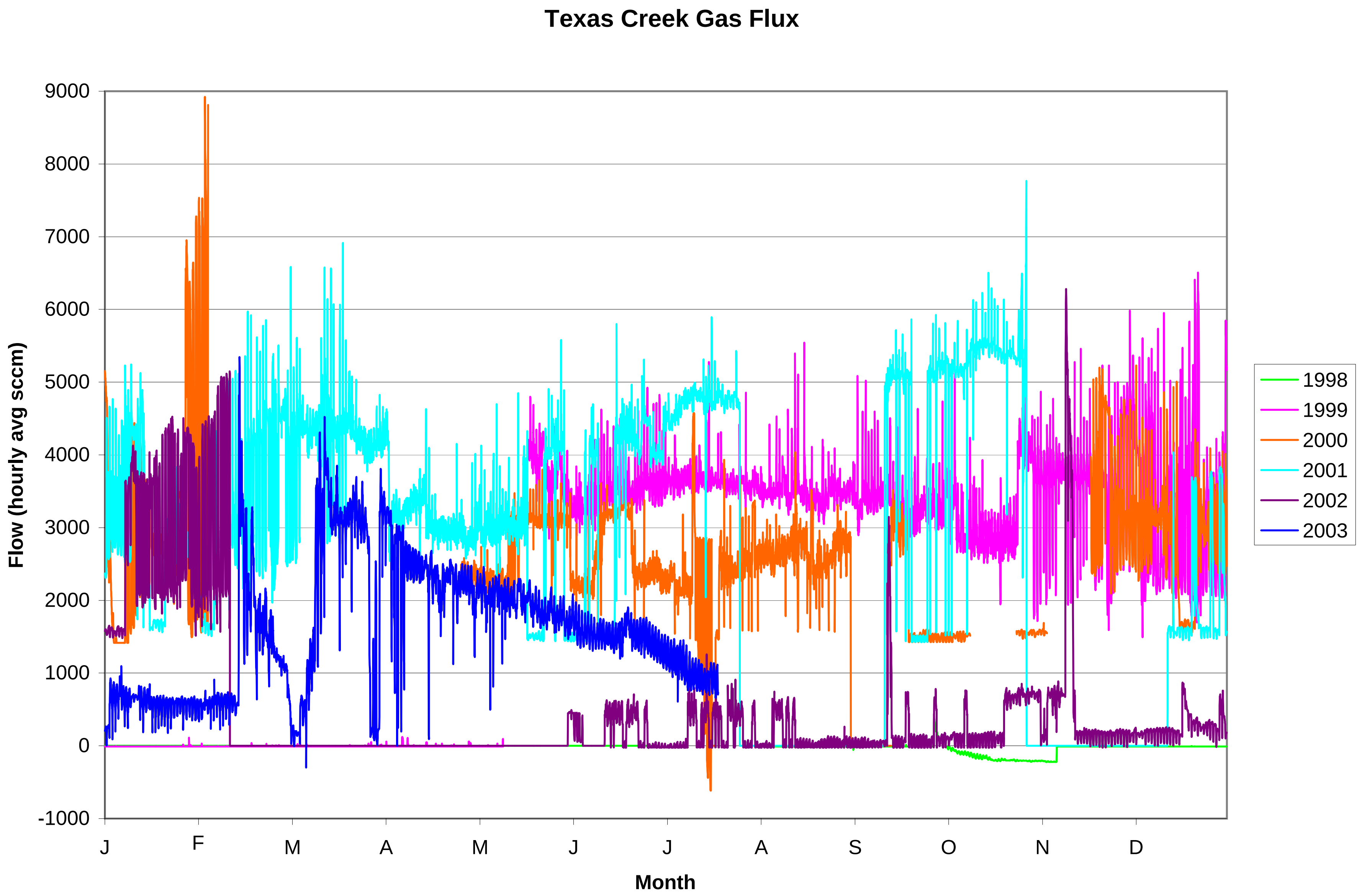
2/27/2004



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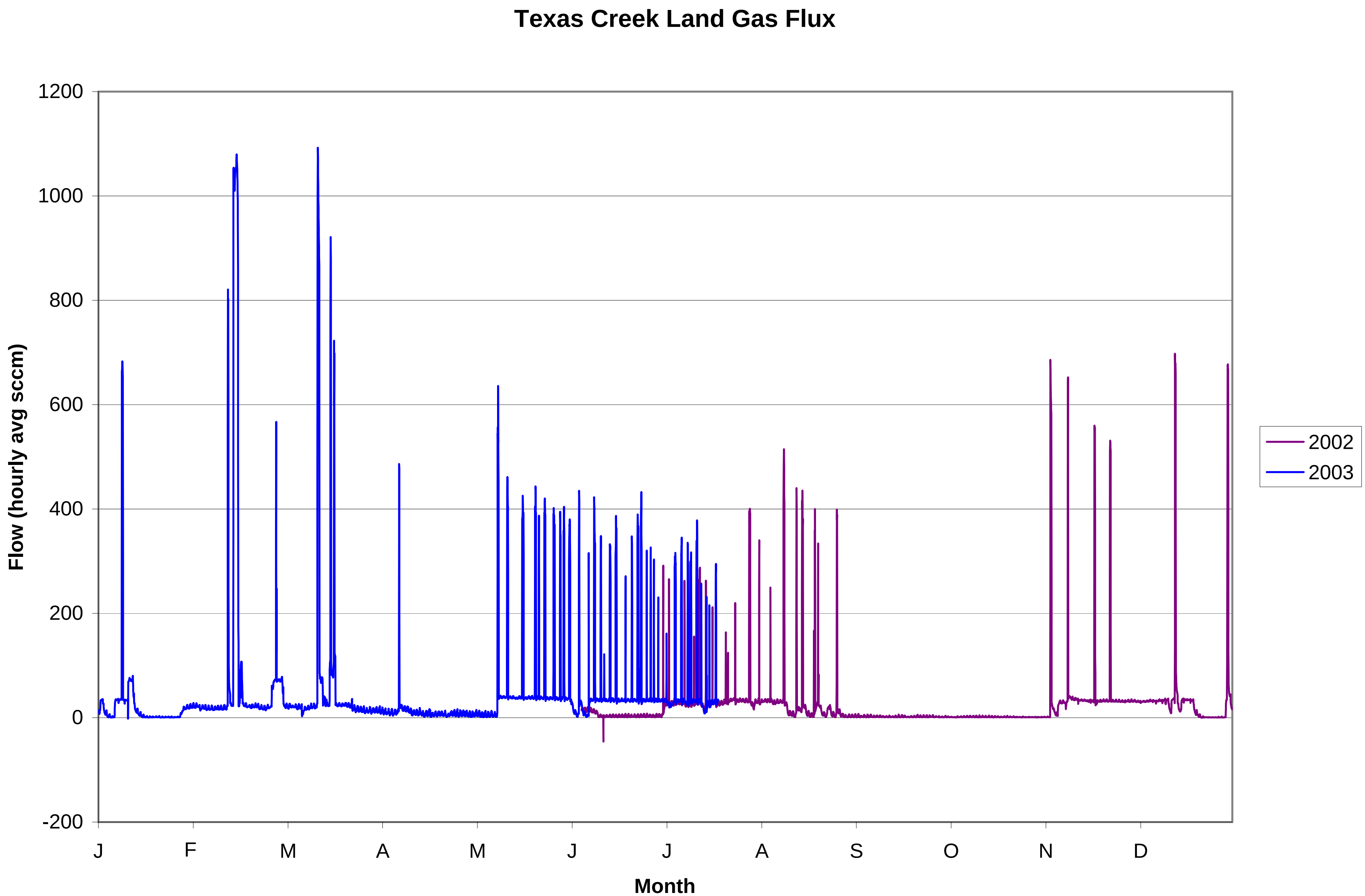

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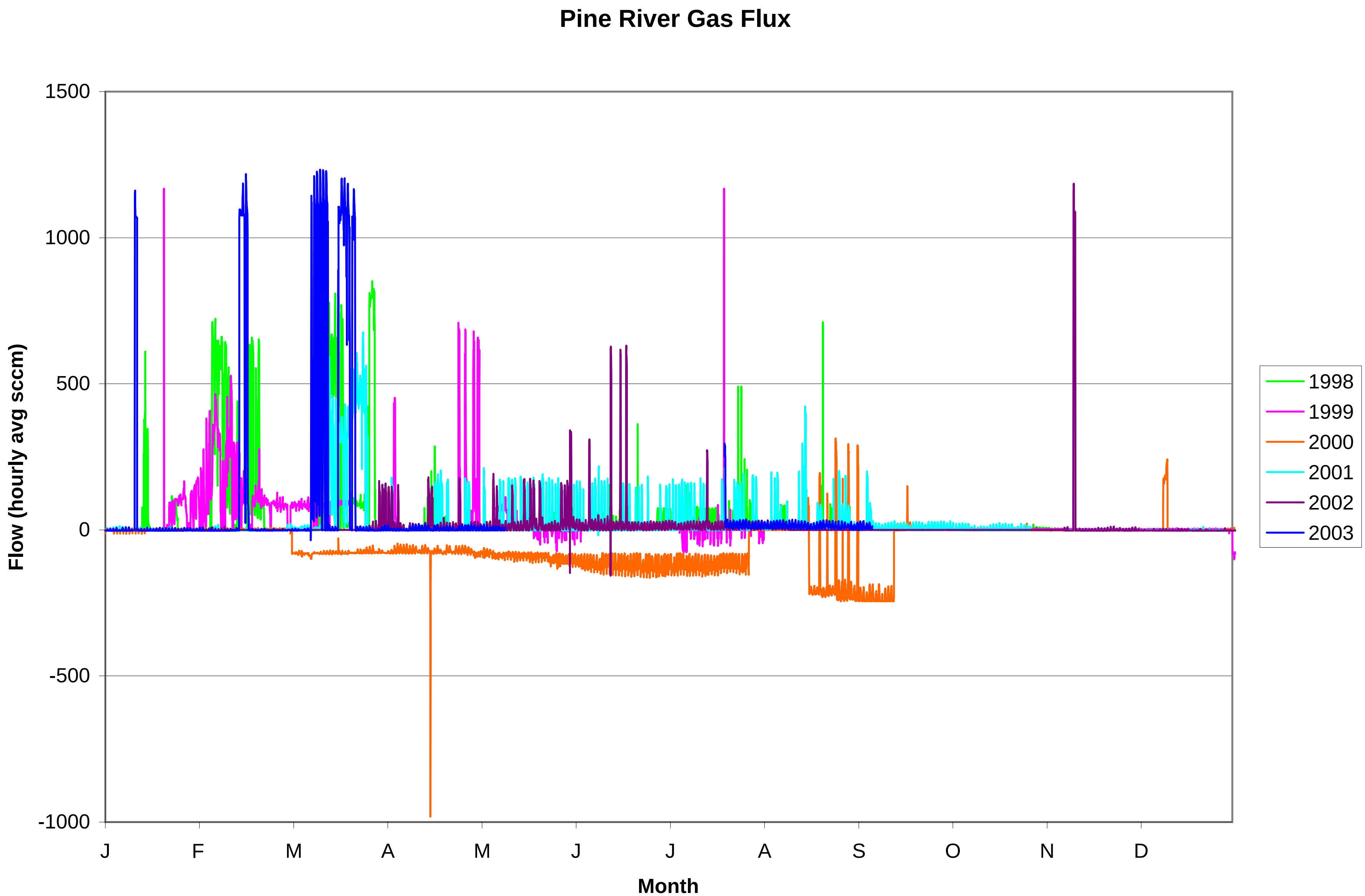

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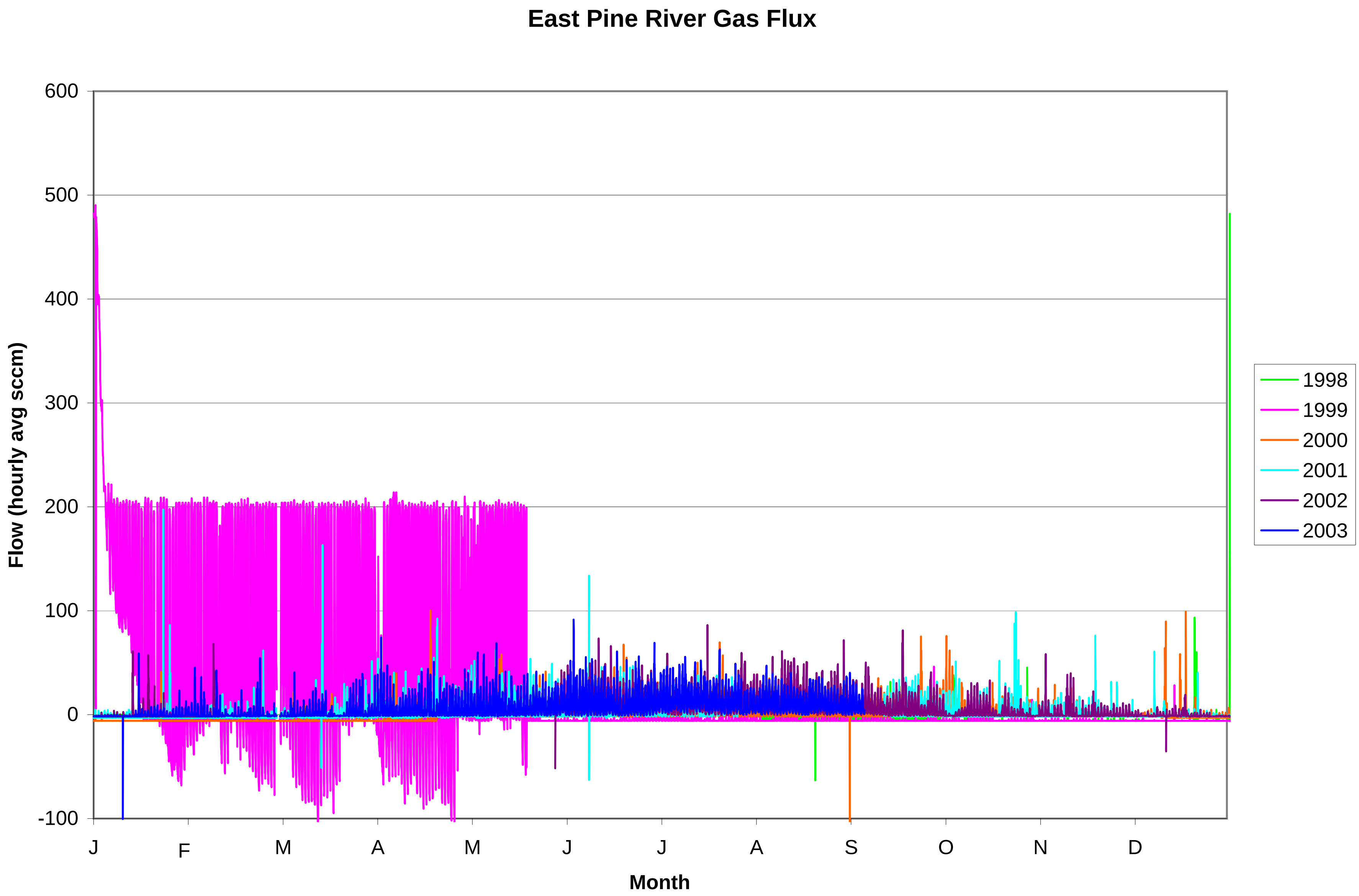

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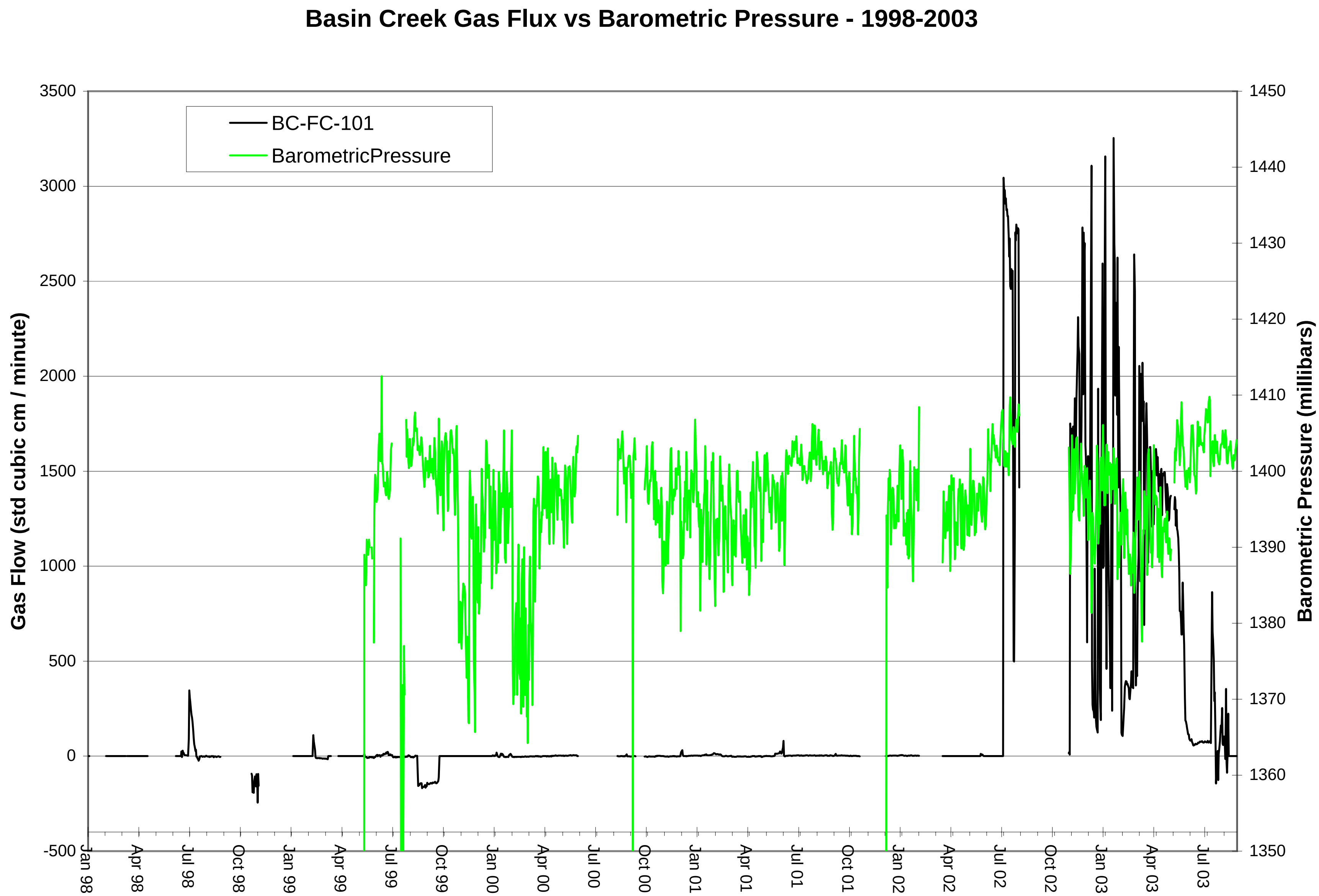

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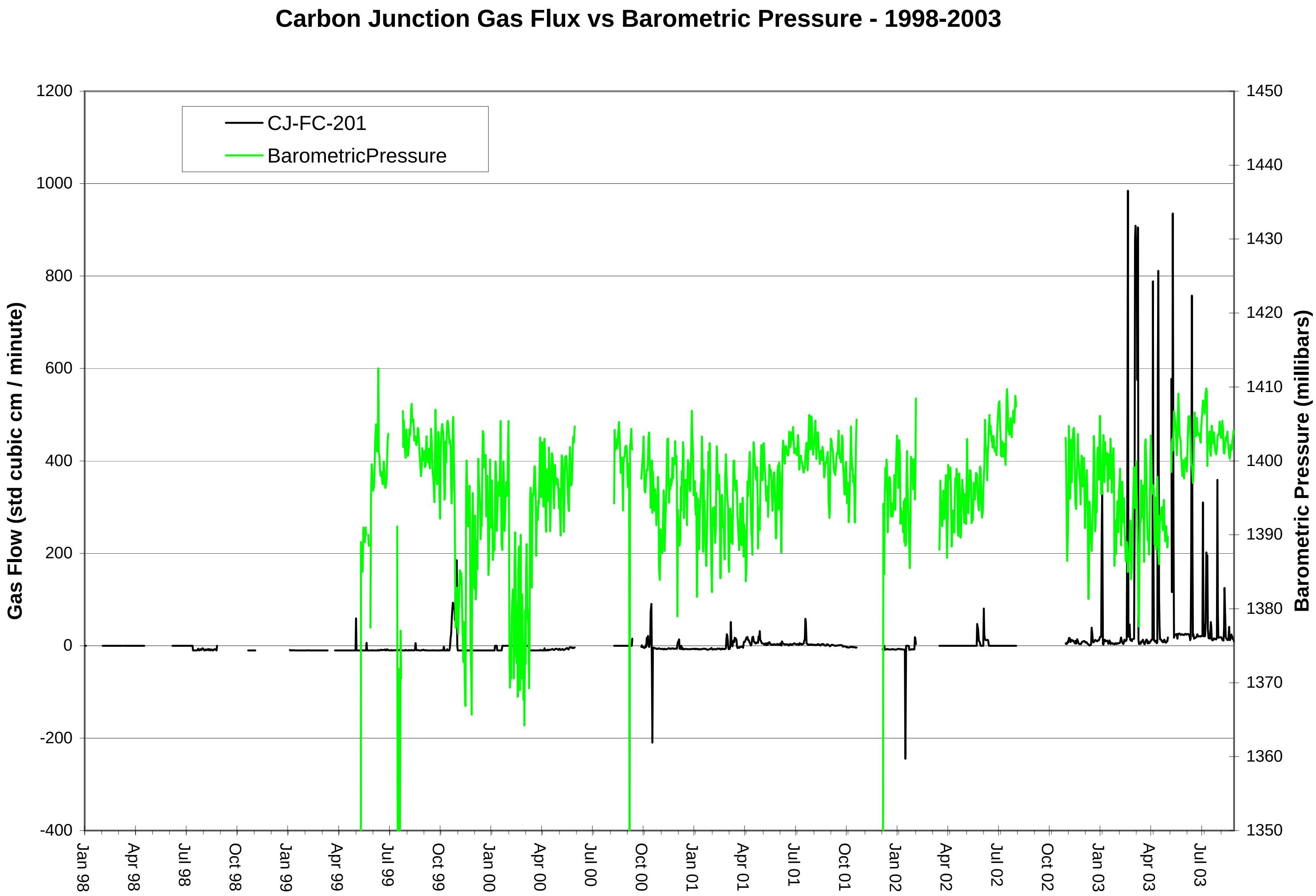

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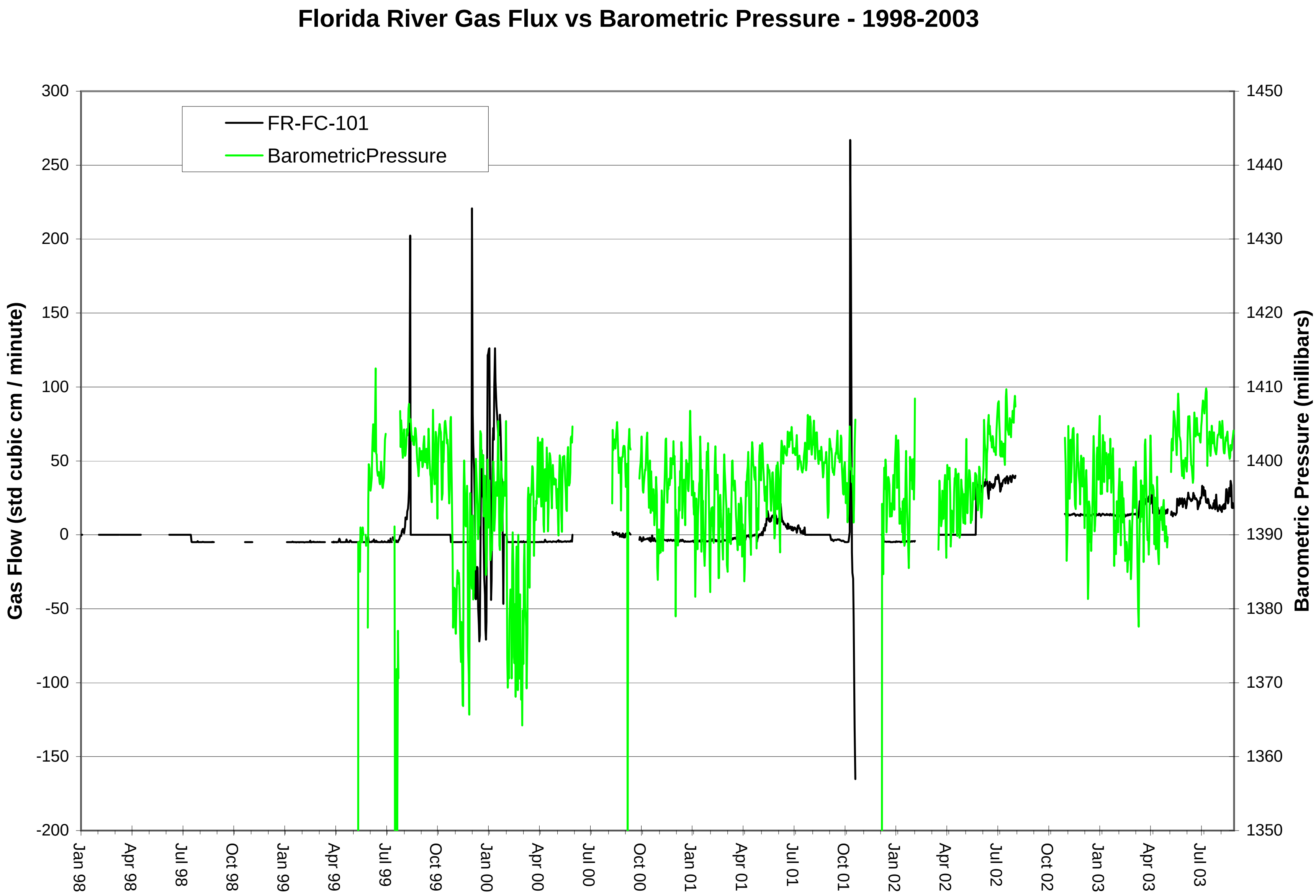

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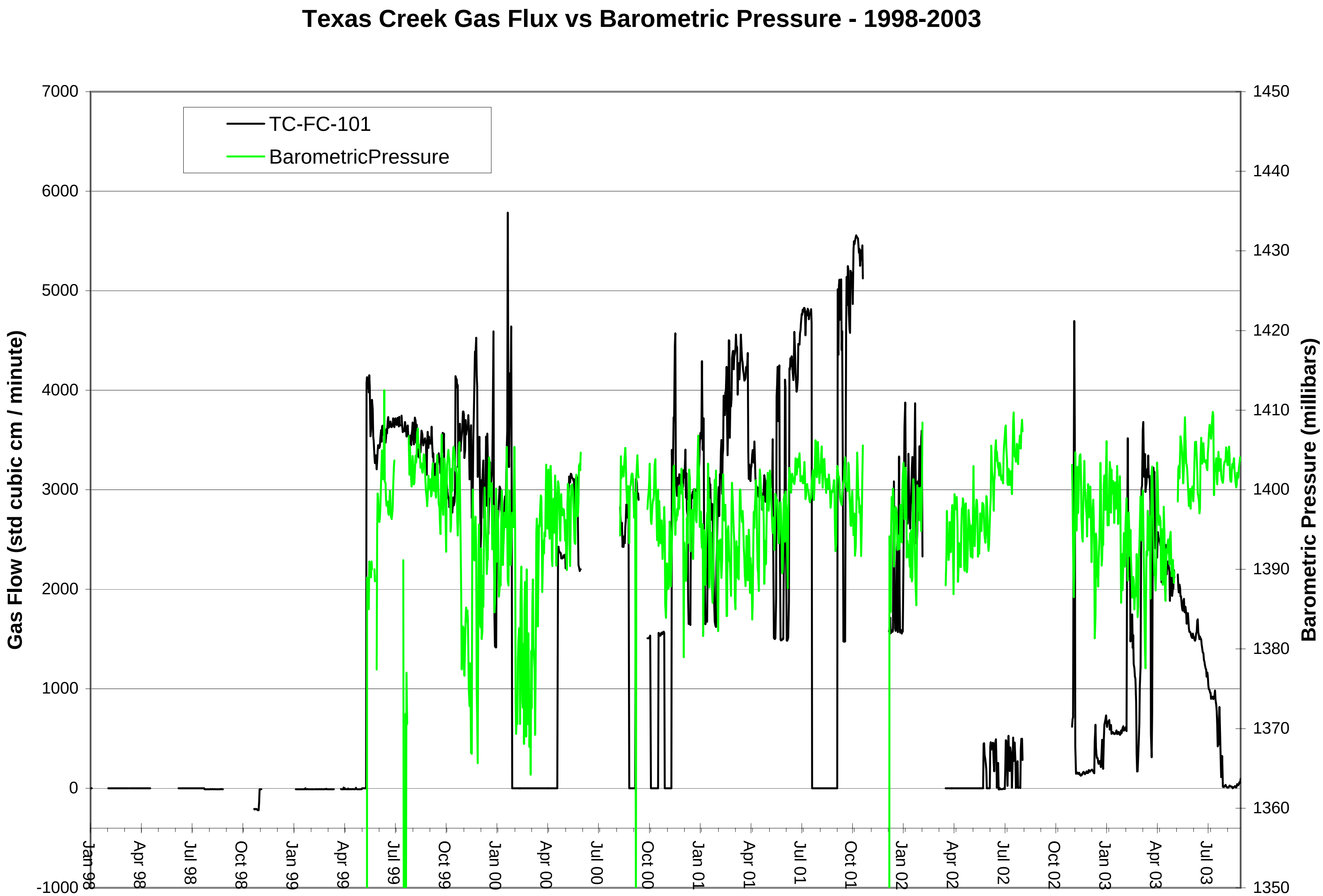

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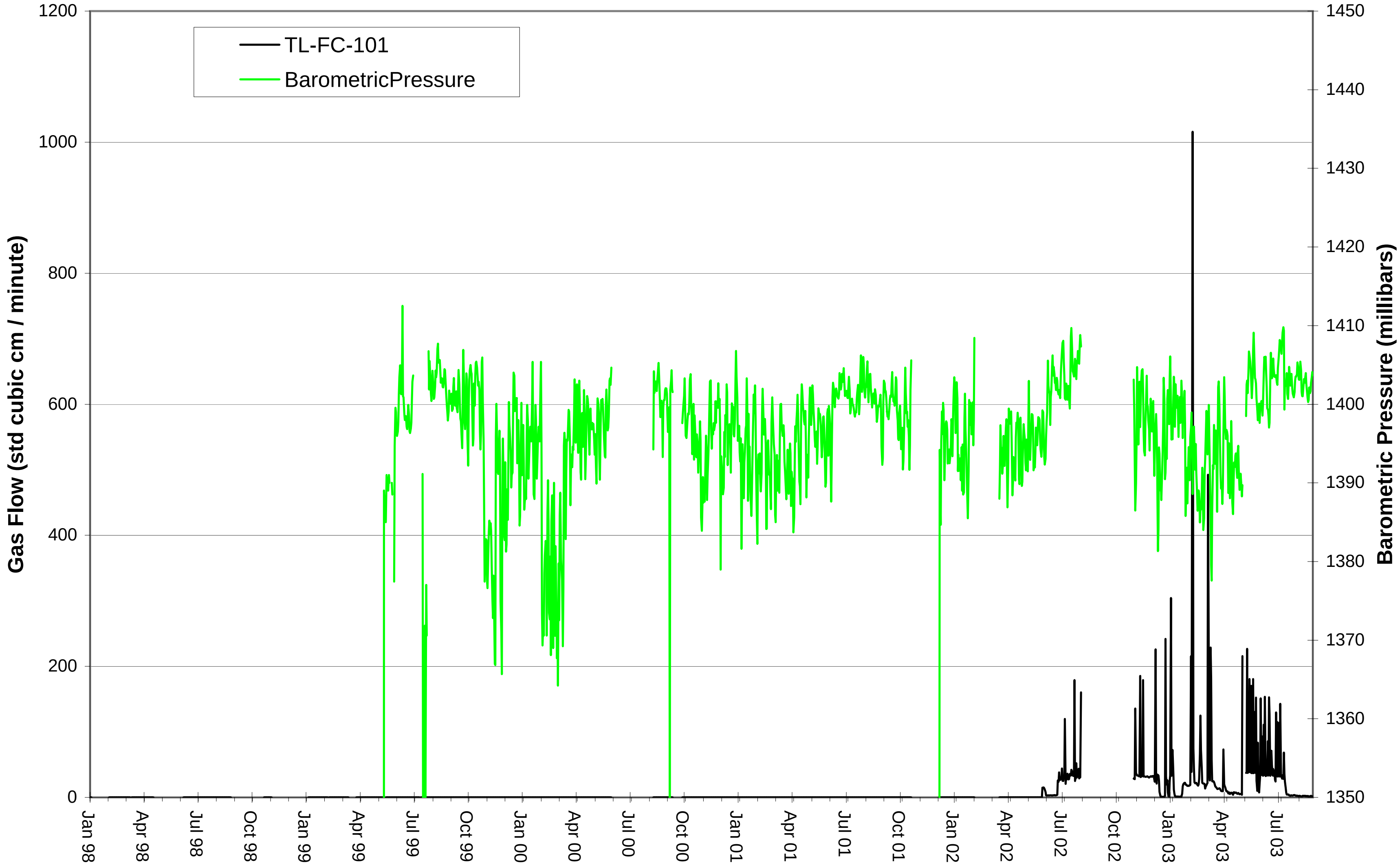
Texas Creek Land Gas Flux vs Barometric Pressure - 1998-2003



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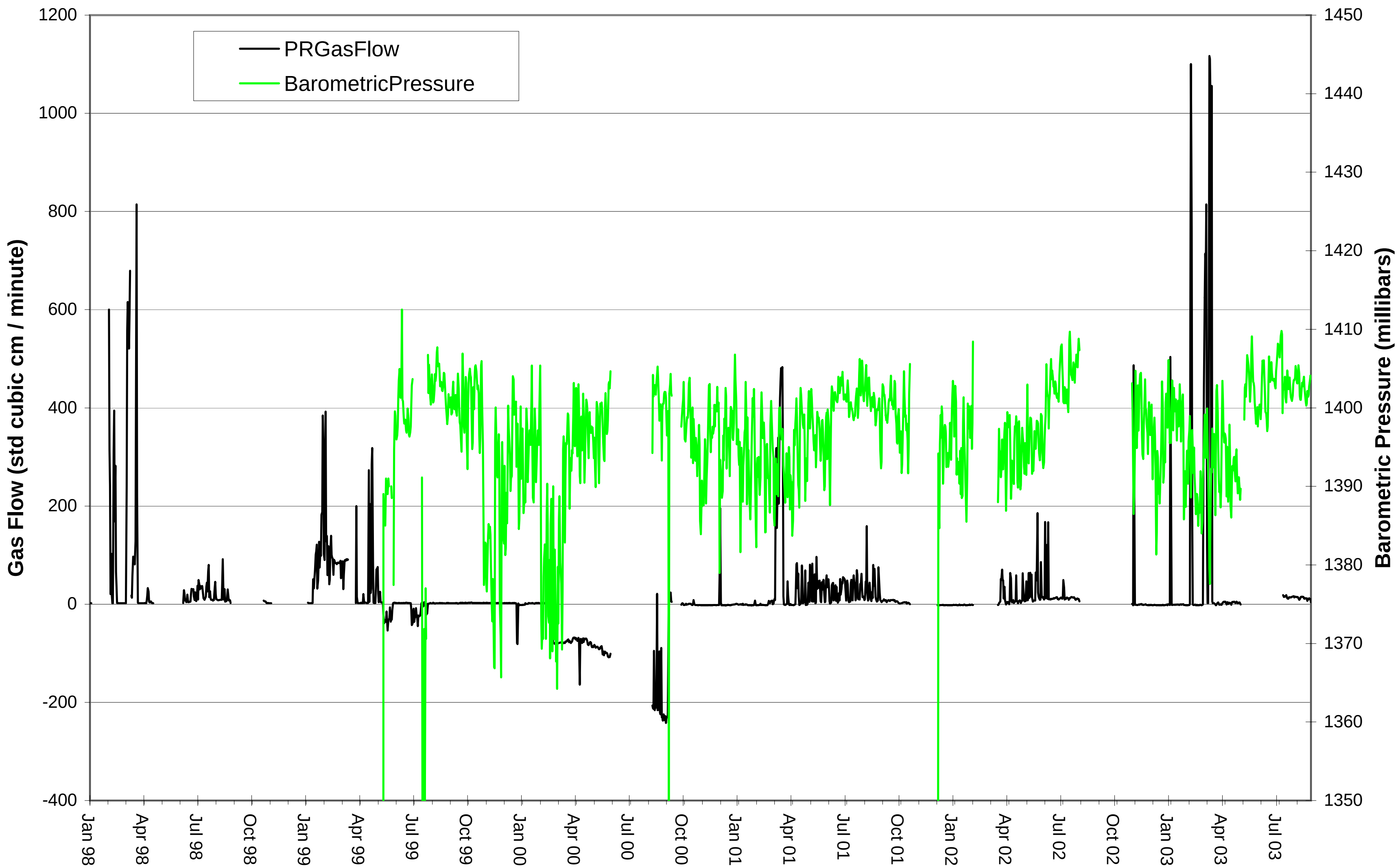
Pine River Gas Flux vs Barometric Pressure - 1998-2003



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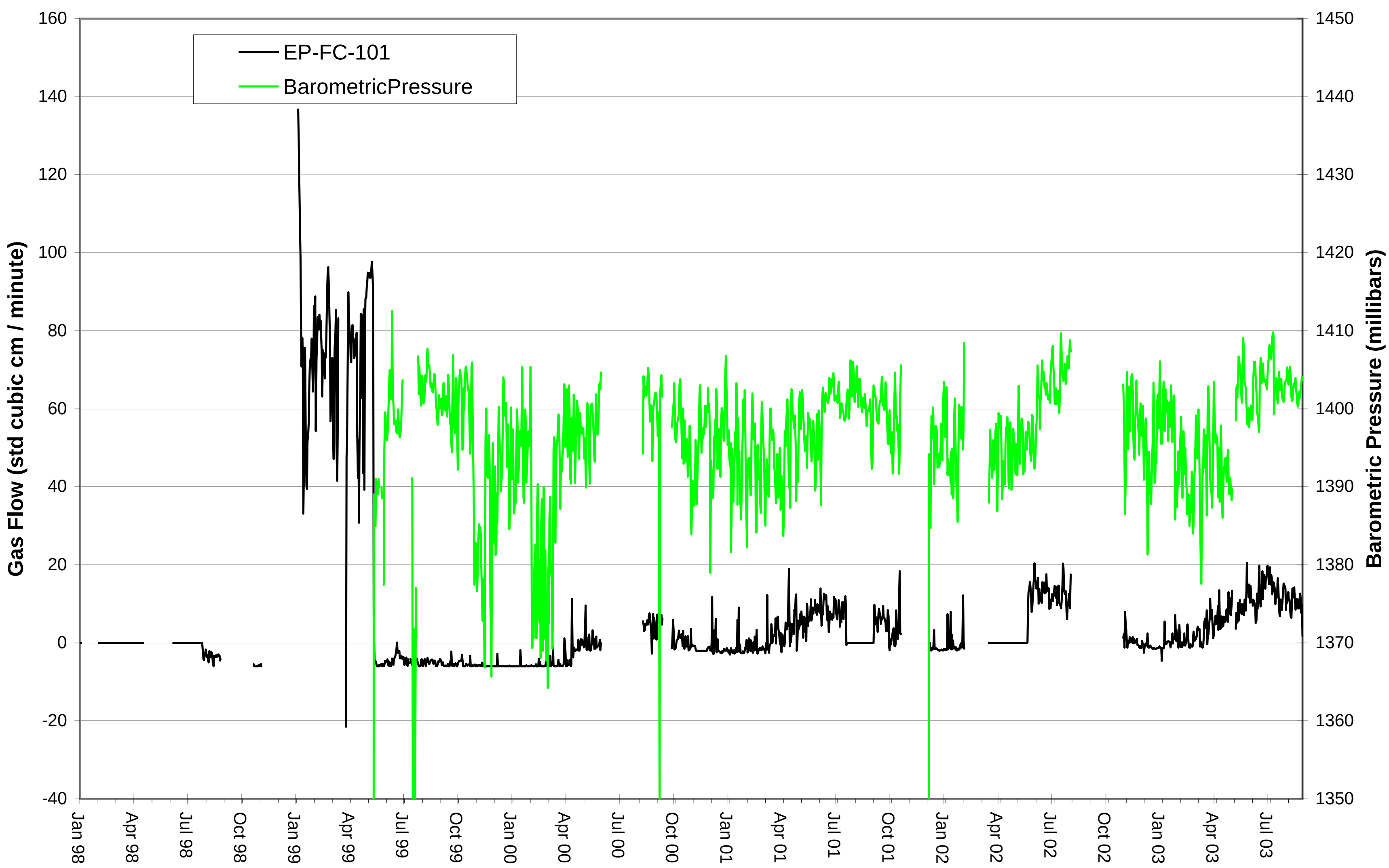
East Pine Gas Flux vs Barometric Pressure - 1998-2003



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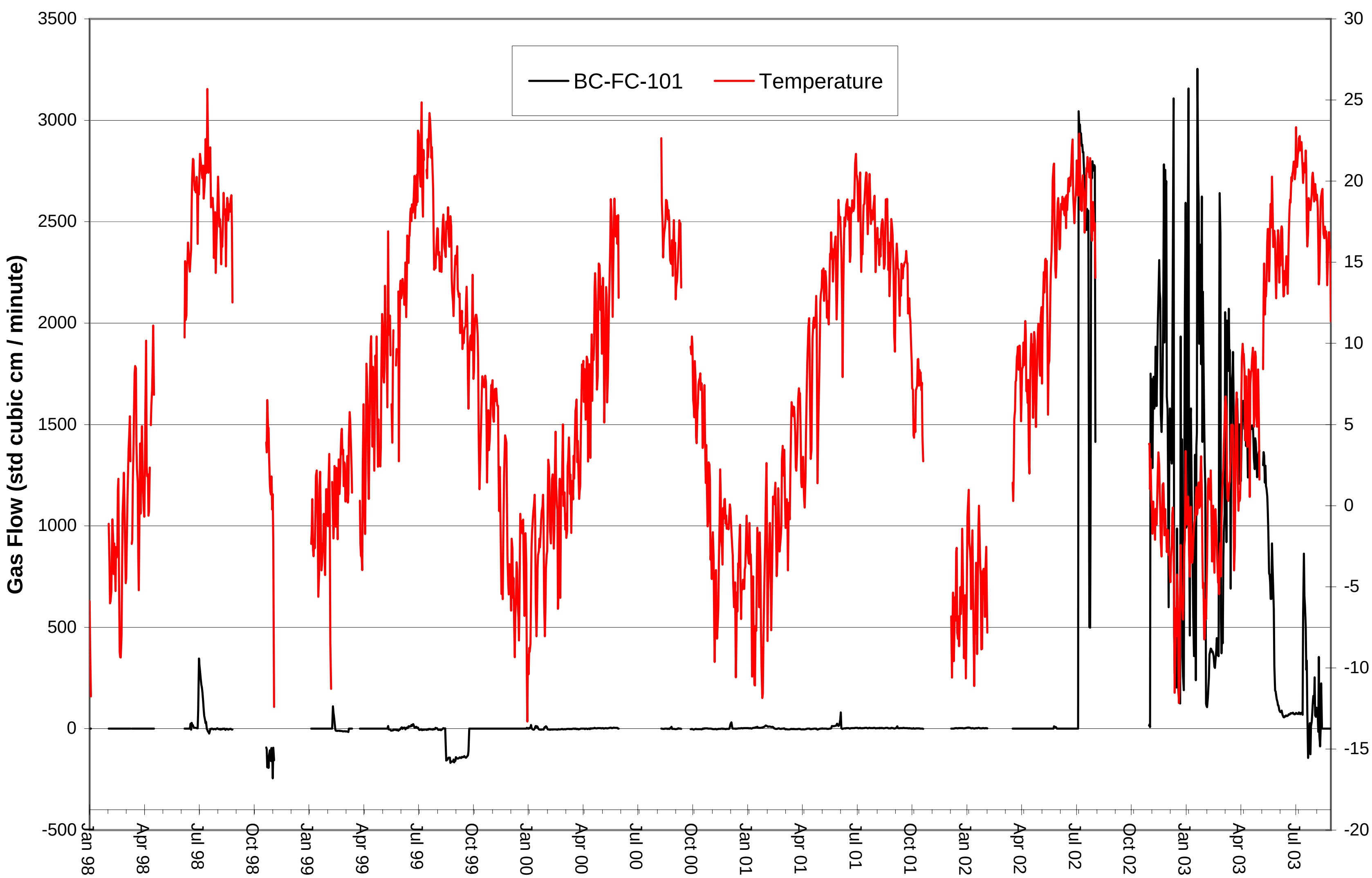
Basin Creek Gas Flux vs Temperature - 1998-2003



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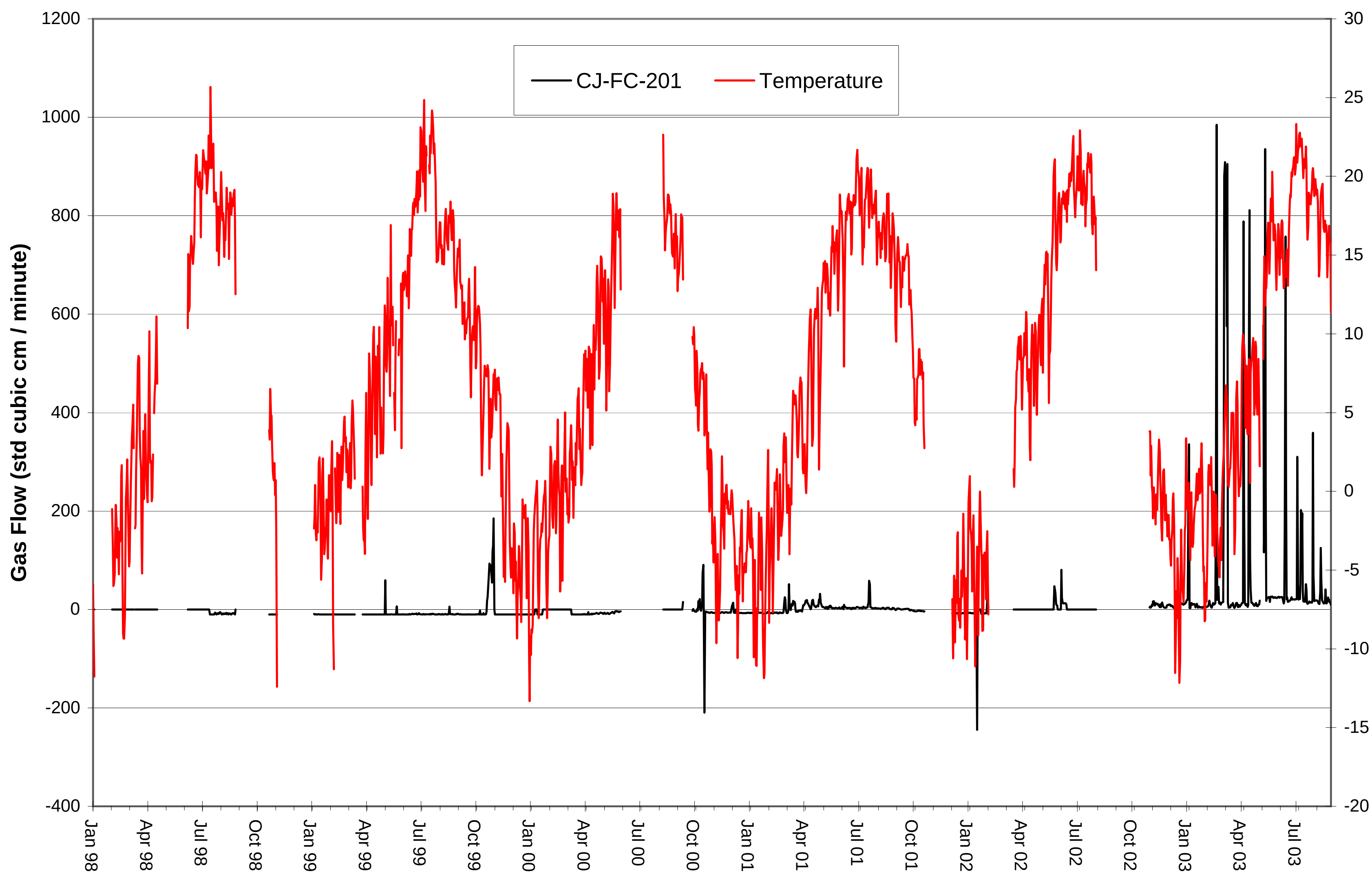
Carbon Junction Gas Flux vs Temperature - 1998-2003



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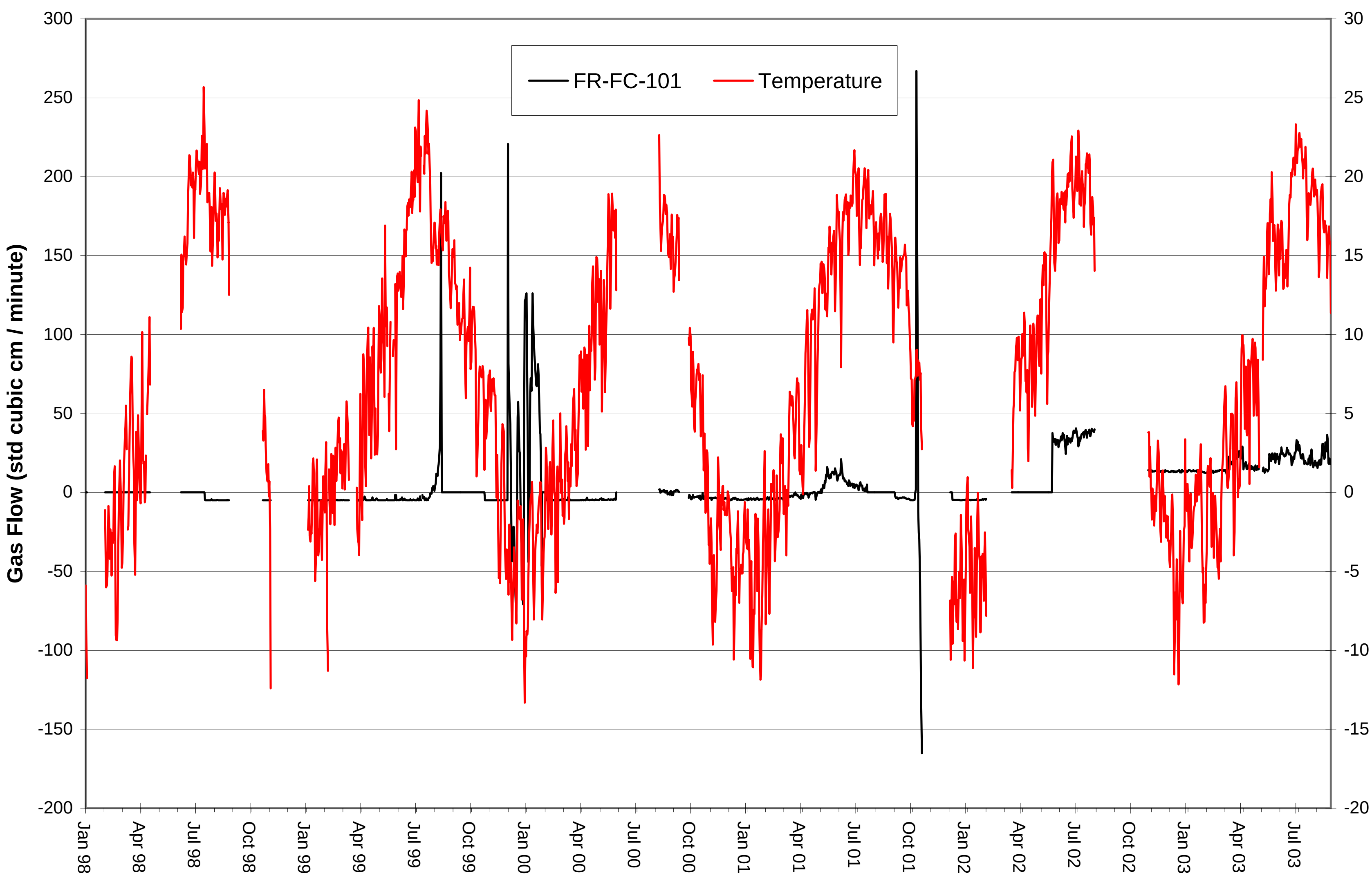
Florida River Gas Flux vs Temperature - 1998-2003



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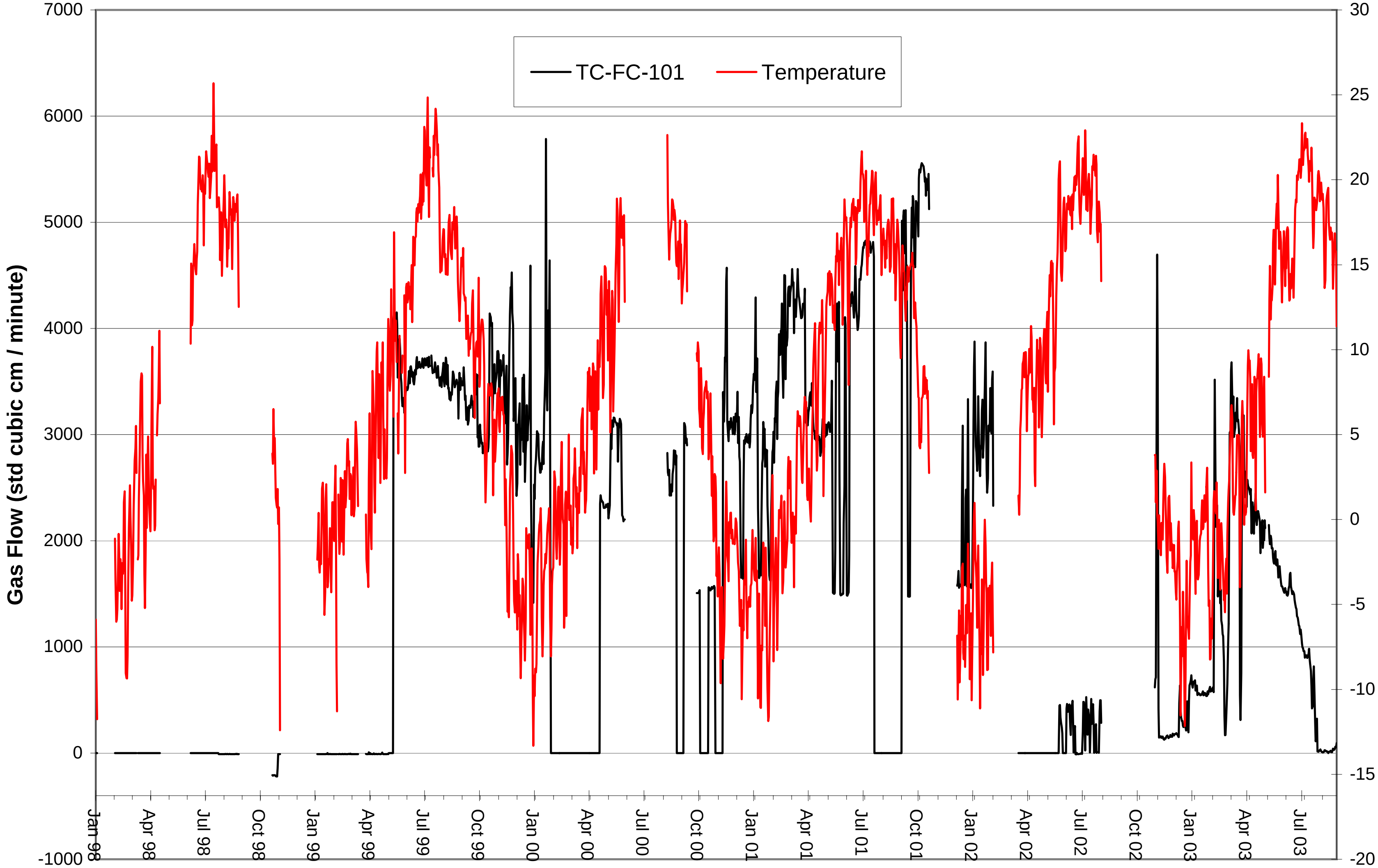
Texas Creek Gas Flux vs Temperature - 1998-2003



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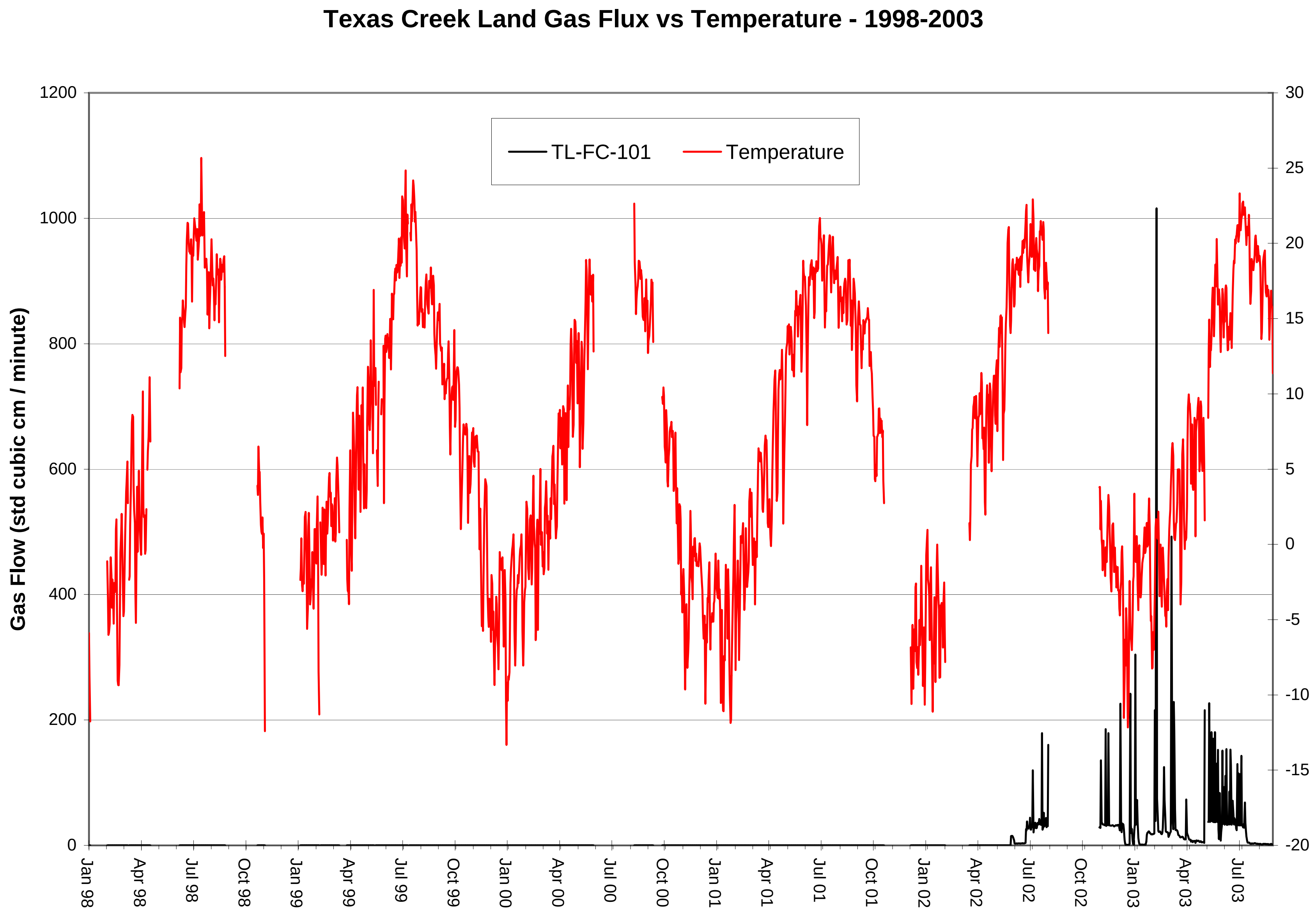

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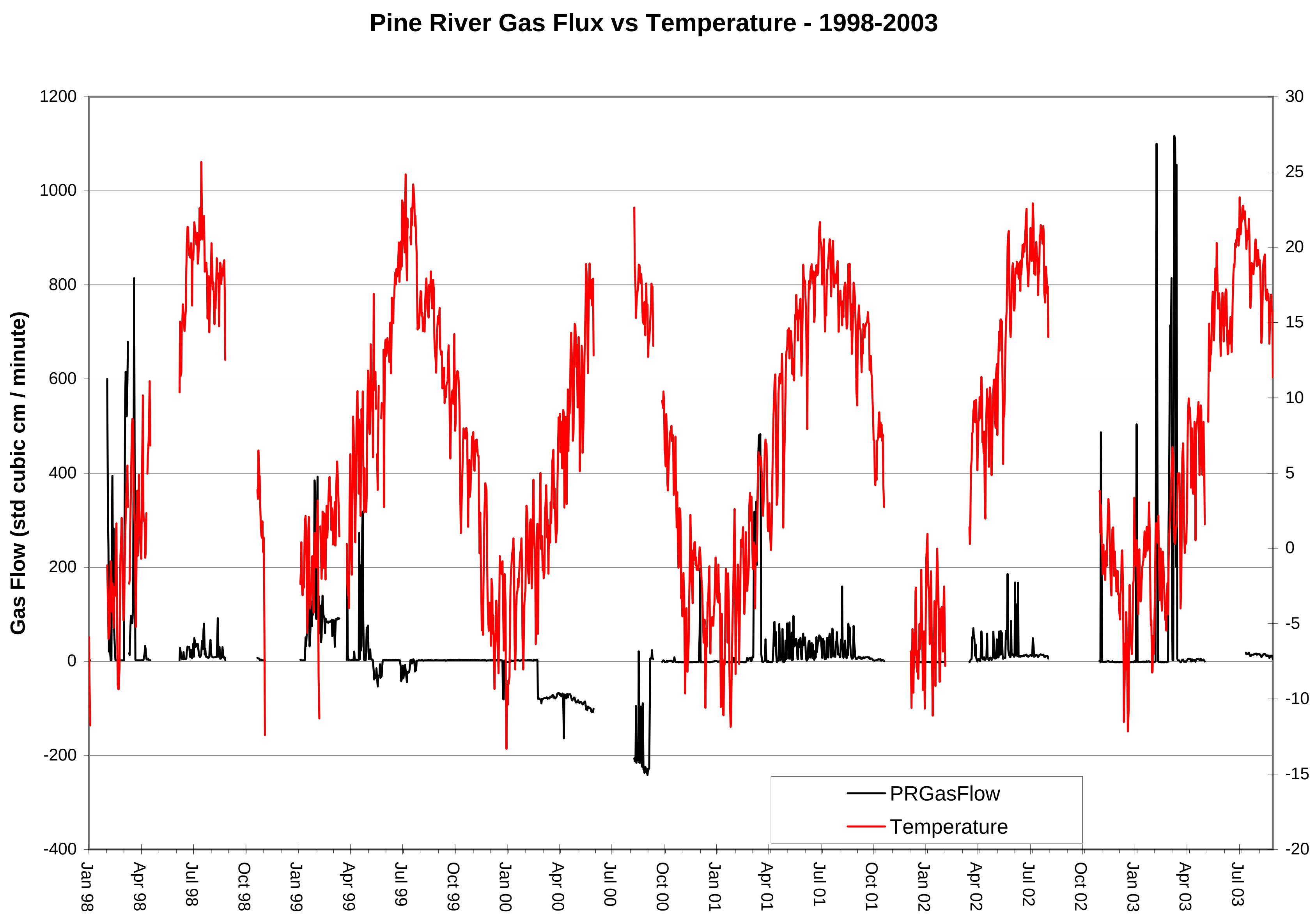

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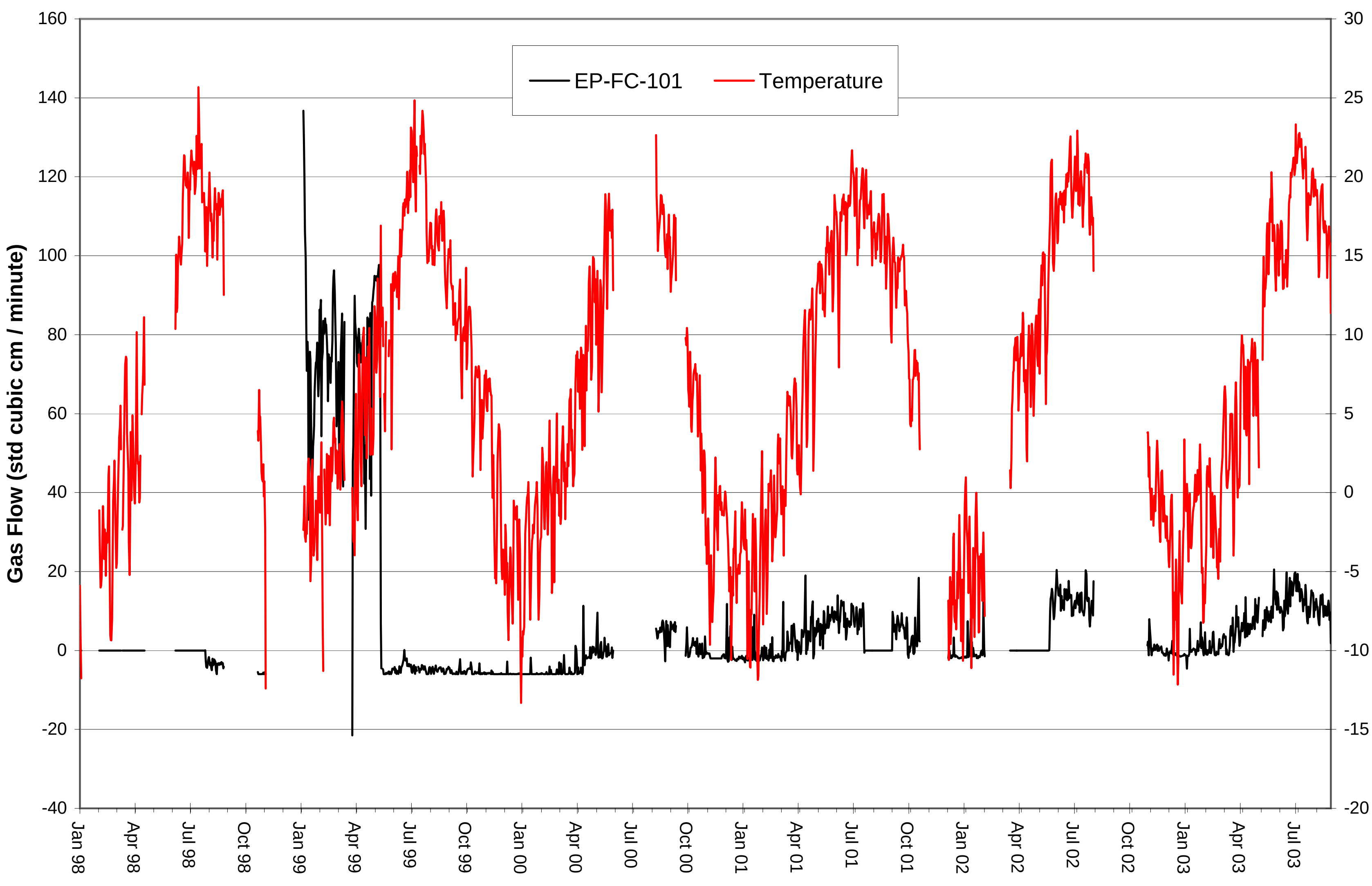
East Pine Gas Flux vs Temperature - 1998-2003



FlowCht2003 chtEPFlowVsTemp
2/27/2004

APPENDIX D

LABORATORY ANALYTICAL REPORT

ISOTECH®

www.isotechlabs.com mail@isotechlabs.com

Isotech Laboratories, Inc. 1308 Parkland Court Champaign, IL 61821-1826 Telephone 217/398-3490 FAX 217/398-3493

September 15, 2003

John Peterson
LT Environmental
4400 W. 46th Ave.
Denver, CO 80212

Dear Mr. Peterson:

Enclosed is the analysis report for the Headgate-1 gas sample recently submitted for compositional and isotopic analysis. This sample was assigned to Isotech job number 4308. These are the same data that were faxed to you earlier. I hope the data are helpful. If you have any questions concerning this data, or if there is anything else we can do for you, please do not hesitate to contact us.

We will hold the sample until 10/06/03 in case you should want any additional analyses carried out and will then dispose of the remaining sample material. If you should need us to hold them longer, please contact us. I have also enclosed an invoice for this work and would appreciate it if you would pass it on to the appropriate office for processing. Thank you for choosing Isotech for your analysis needs, we appreciate your business.

Sincerely,

Steven R. Pelphrey

Steven R. Pelphrey
Laboratory Manager

Enclosure

SRP:cw

ANALYSIS REPORT

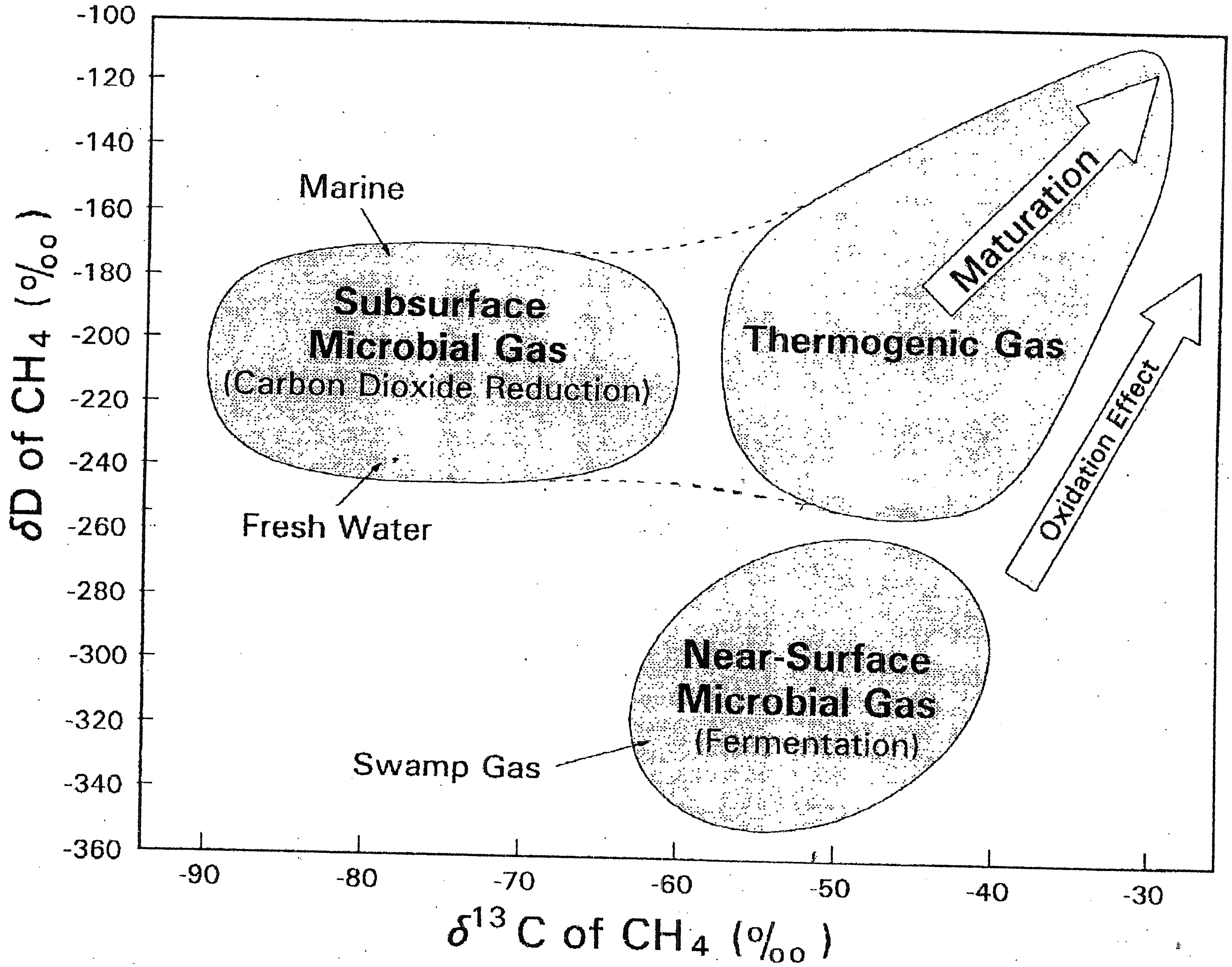
Lab #:	56396	Job #:	4308
Sample Name/Number:	Headgate 1		
Company:	LT Environmental		
Date Sampled:	7/31/2003		
Container:	Glass Bottle		
Field/Site Name:			
Location:			
Formation/Depth:			
Sampling Point:			
Date Received:	8/05/2003	Date Reported:	9/09/2003

Component	Chemical mol. %	Delta 13C per mil	Delta D per mil	Delta 15N per mil
Carbon Monoxide	nd			
Hydrogen Sulfide	nd			
Helium	nd			
Hydrogen	nd			
Argon	0.371			
Oxygen	0.251			
Nitrogen	17.29			
Carbon Dioxide	2.05	-20.71		
Methane	80.04	-61.72	-381.6	
Ethane	nd			
Ethylene	nd			
Propane	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Total BTU/cu.ft. dry @ 60deg F & 14.7psia, calculated: 811

Specific gravity, calculated: 0.650

nd = not detected. na = not analyzed. Isotopic composition of carbon is relative to VPDB. Isotopic composition of hydrogen is relative to VSMOW. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %. Chemical analysis based on standards accurate to within 2%


Subsurface
Microbial Gas
(Carbon Dioxide Reduction)
Marine
Fresh Water
Thermogenic Gas
Maturation
Oxidation Effect
Near-Surface
Microbial Gas
(Fermentation)
Swamp Gas
δD of CH4 (‰)
δ13 C of CH4 (‰)
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
-90
-80
-70
-60
-50
-40
-30

APPENDIX E

VEGETATION SUMMARY

PINYON PINES

(Pinus edulis)

- Major diseases include black stain root disease, dwarf mistletoe, Armillaria root disease, and pinyon decline.
- Common insect pests are pinyon pitch mass borer, Ips bark beetles, pinyon tip moth, pinyon pitch nodule moth, pinyon needle scale, and pinyon spindlegall midge.
- Drought-tolerant compared to many trees. Drought-susceptible when compared to junipers and sage brush vegetation in Durango area.
- Lots of Ips beetle caused mortality and some pinyon pitch mass borers observed in study area. Black stain mortality centers observed in study area at Carbon Junction. Time consuming to determine if tree is affected by black stain. This disease was looked for in other areas visited but was not found.

PONDEROSA PINES

(*Pinus ponderosa*)

- Live at higher elevations than pinyon where there is slightly more precipitation but pinyon and ponderosa pine often are found growing together where their ranges meet.
- Taller than Pinyon with longer needles. Bark smells like butterscotch.
- Affected by similar diseases and insects as pinyon pines. The major ones are dwarf mistletoe; Armillaria root disease, Ips and Mt pine bark beetles and certainly abiotic stresses like drought or flooding. Ponderosa do not like “wet feet”.

JUNIPERS

(*Juniperus osteosperma* and *Juniperus scopulorum*)

- Junipers are difficult to kill. They are about 1/3 less susceptible to drought than the pinyon pine.
- Insects: Bark beetle- occasionally Phloeosinus sp, a few insects try to defoliate but are rare. Did not actually observe any junipers affected by bark beetles.
- Fungus: Rust is the most distinctive type of fungus. There are various Gymnosporangium rusts on junipers and they mainly cause galls of round to fusiform shapes on branches and one distinctive witches broom. These rusts were not common in study areas. These rusts are slow killers and there has to be much of the tree infected before there is impact noted.
- Parasite: Phorodendron (leafy mistletoe) mistletoe causes strange colored witches brooms on the tree. Yellow and orange. This is a type of water parasite so a tree has to have many infections before there are serious impacts. Seeds are carried by birds so many infections are at the top of the crown. Observed throughout the study area.
- Typically, if juniper was dead methane was detected nearby.

COTTONWOODS – NARROW LEAF AND PLAINS (BIG LEAF)

(*Populus agustifolia* and *Populus deltoides*)

- Cottonwoods are more susceptible to drought than pinyons and junipers. They have a difficult time with fluctuating moisture. Their roots are normally close to water (potentially oxygen deficient areas).
- Typically die and resprout if seriously stressed. Roots don't generally die.
- Have alternate branching.
- Not commercial trees so less of a knowledge base of cottonwoods vs. pines, juniper, and aspens.
- Major diseases would be Cytospora canker, bacterial wetwood/slime flux and decay fungi that affect the strength of the wood.
- Foliar fungi and insects chew up leaves but are not normally serious to tree survival.
- Rarely have bark beetles, but borer beetles (Buprestid) can cause significant damage and dieback of sections of a tree.
- Sign of stress is bacterial wetwood/slime flux.

ELMS

(Ulmus sp)

- Relatively tough. Good indicator species. Often used as street trees because difficult to kill.
- Major diseases and insects include: Dutch elm disease, bark beetles, and stress related fungal cankers-Cytospora, Tubercularia, and foliar and twig insects such as European elm scale and elm leaf beetle.
- Most elms in Durango area would be some version of a Siberian elm. There are a few American elms in town

WILLOWS

(Salix sp)

- Survive flooding better than cottonwood trees. Their roots are typically in the water.
- Susceptible to borer beetles.
- Rarely affected by bark beetles but they are commonly attacked by aphids which are a nuisance and not usually lethal.
- In general more susceptible to drought stress than cottonwoods
- Cytospora canker is common on willows and when coupled with drought can be lethal.

GAMBEL'S OAK

(Quercus gambelii)

- Fairly tough plant.
- Has a few fungal cankers but it is rare to see mortality form them
- Gall making insects common on stems and leaves
- Witches broom common and is caused by the fungus *Articularia quercina* var. *minor*- does not usually kill trees but can trees can have dieback from this pathogen.
- Frost and insects often cause defoliation. Insects rarely cause mortality.
- Dieback commonly seen throughout study area. If tips of vegetation or dieback occurs in oak at relatively same elevation (example, valley floors) the mortality could be a result of frost.

ASPEN

(Populus tremuloides)

- Susceptible to everything so not a good indicator species. Numerous diseases and insect problems.
- However, since it is not resistant to many disease and insects it might be a good indicator of gas stress. However, it would be hard though to separate normal health issues from that which are induced by excess methane.
- Grows at higher elevations or at least at wetter sites than pinyon –juniper sites-
- Sign of stress is Cytospora canker and bacterial wetwood/slime flux.

CHEATGRASS

- Foreign species. Extremely aggressive. Out completes many species. Seeds attach to animals and humans and are carried to new areas. Cheat grass will quickly grow in burnt area before the native vegetation can recover.
- Green in May, dies in early summer. Extremely flammable in early summer.
- May have been mapped as dead grass during previous mapping excursions.

BOXELDERS/MAPLES

(Acer negundo)

- Opposite branching. – maple looking leaves

- Not commonly encountered in study area except along streams such as at the Carbon Jct area and Florida River areas.

- Disease and insects are not commonly seen killing the tree but it usually has a lot of foliar insects. There are some borers that can cause some major issues. Cytospora canker can be common if the tree is stressed.

TYPES OF MORTALITY

BEETLES

Ips beetles and borer beetles have random patterns of mortality and distribution. Trees affected by bark beetles have similar ages of mortality and can be found in groups of 1-6 trees under normal conditions. Currently with the epidemic conditions triggered by the 5 years of drought these Ips beetles are killing trees in larger groups of up to 50 or more trees on a hillside.

Ips Beetles – bark beetle, polygamist beetle, male mates with 3-4 females in mating chamber and females make trails away from chamber to lay eggs. Larvae mature, exit through bark, and fly to other trees. Blue stains are present radially in the trunk of the tree.

When you peel bark away from the tree small brown sawdust is present over trails from beetles eating. Holes in bark are really small and difficult to observe. Beetles are dormant from November to March and have 2-5 generations per year.

Ips beetle is always present in forests. If a tree is healthy it is able to defend itself from the invading beetles. Normally it is nearly impossible to determine the exact cause of death when Ips beetle is present because it could be a secondary killer. For example, drought weakens the trees and makes them more susceptible to the Ips beetle. A combination of the drought and Ips cause the mortality. However, now Ips populations are so large that Ips are killing many trees and can be considered the cause of death although the drought is the predisposing agent.

Ips beetle caused mortality was noted in numerous locations across the study area.

Borer Beetles – larger than bark beetle so produces larger exit holes. When you peel bark away from the tree long stringy brown and white saw dust is present vs. the fine non stringy sawdust (frass) of bark beetles

Borehole beetles were noted in across the study area.

BACTERIA WETWOOD/SLIME FLUX

Bacteria in tree ferments and produces gases that push liquids out of pores or wounds. The liquid smells bad and is toxic. The bacteria wetwood/slime flux can kill large sections of bark and form huge cankers when the tree is stressed- we call this cambial wetwood. Typically wet wood is noted in the middle of the tree. Observed in the study area.

WITCHES BROOM

Fungus and insects kill parts of gambel’s oak. Branches appear closer together without any leaves and resemble a broom. Noted on gambel’s oak throughout the study area.

BLACK STAIN ROOT DISEASE

Vascular disease on pinyon pine and causes black staining of the sapwood in the root and lower stem before killing the sapwood. The fungus runs vertically in the tubes of the wood. Spread occurs through root contacts and by insects that carry the spores. The disease moves from tree to tree by root contact in most areas so there is a radial pattern of expansion with the most recent mortality at the edges of the root disease area and there are a variety of ages of dead trees. When several root disease centers merge there is no distinct pattern of mortality since some trees survive and mortality becomes a mosaic.

The root of the tree must be cut into to determine whether black stain root disease is present to confirm the presence of the disease. Fading crowns have a particular yellow green color and can be picked out from fading Ips dying trees but one does not always find a declining/dying tree on all centers. This process of chopping into roots to look for stain is time consuming but all areas were assessed for the disease. It was detected in the Carbon Junction area.

ADDITIONAL ITEMS OF INTEREST

Holes in bark that are distinctively horizontal and/or vertical are a result of sap suckers.

Wood peckers often leave large holes in bark as they try to catch beetles living in the trees.

TERMINOLOGY

Abiotic: Nonliving: *The abiotic factors of the environment include light, temperature, and atmospheric gases*

Defoliate: Deprive of leaves. Strip of leaves.

Cankers: Dead area on surface of plant caused by organism.

Wounds: Caused by something not diseased. (ex. Axe, hammer)

Galls: swollen plant tissue caused by anything)

Dieback: Defense mechanism. Nutrients kept toward bottom of plant. Oaks tend to die from top to bottom.

APPENDIX F

SUBSURFACE METHANE CONCENTRATION DATA COMPARISON 1995-2003

Comparison of 1995 and 2003 Methane concentrations

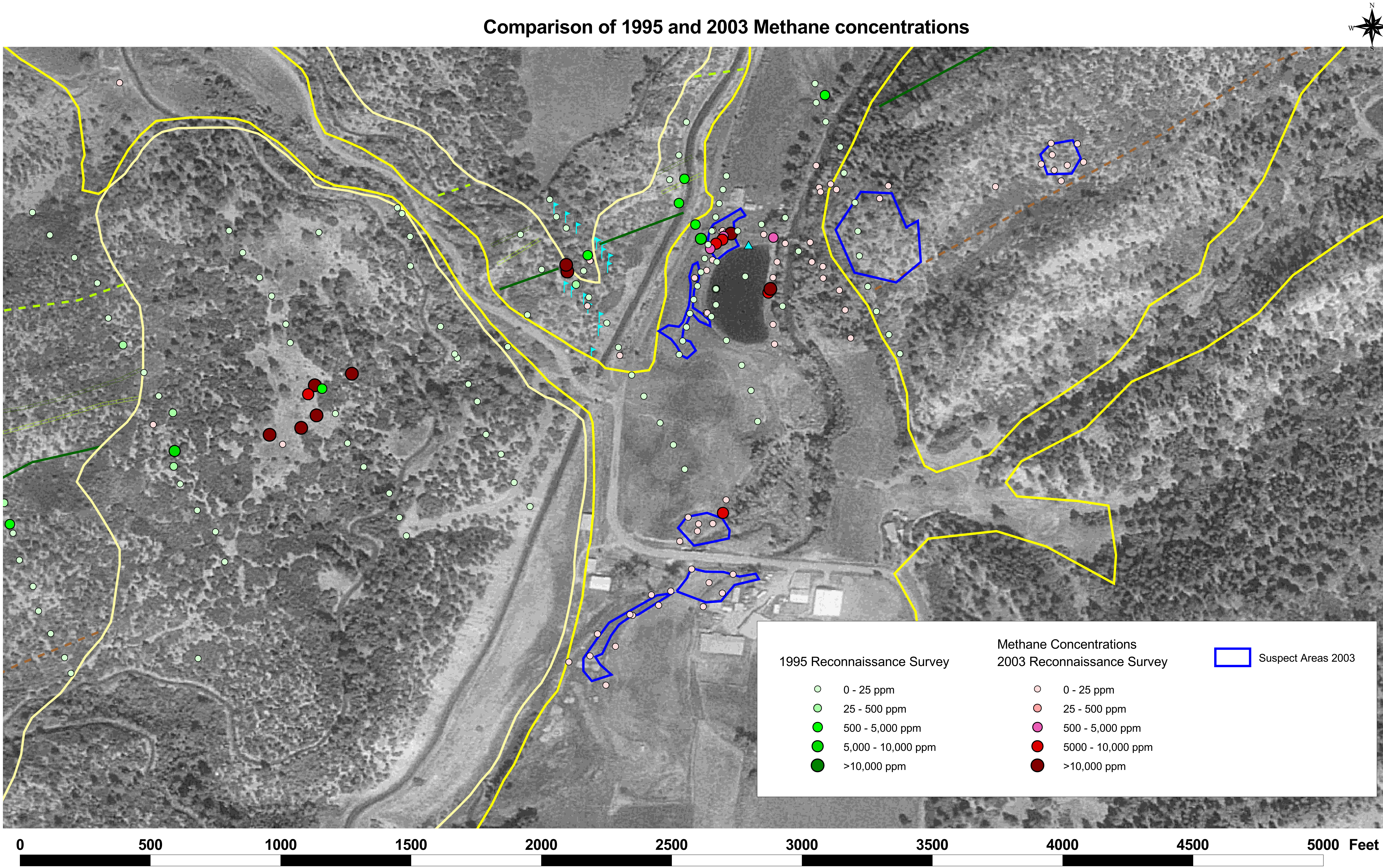


Figure A - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

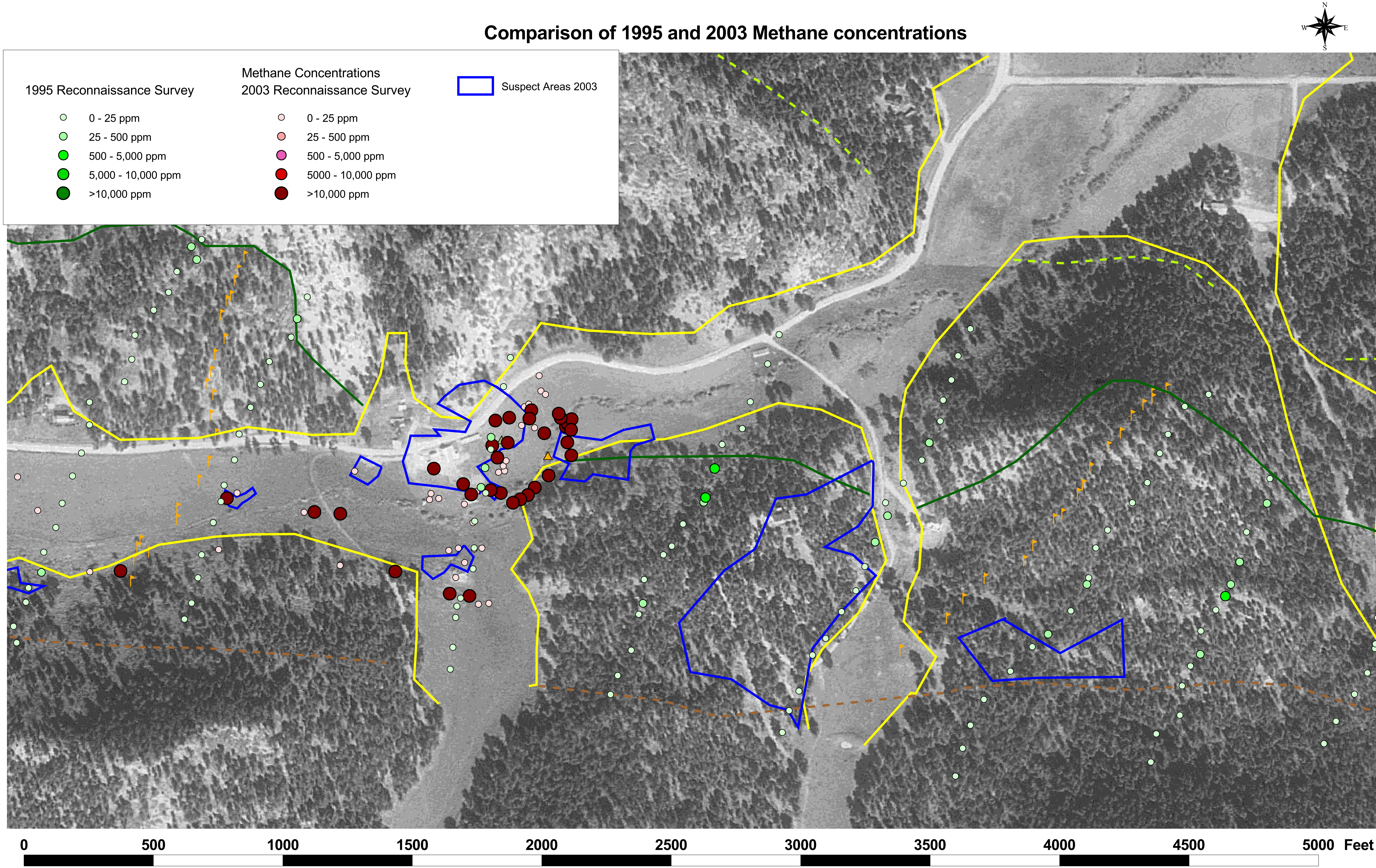


Figure B - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

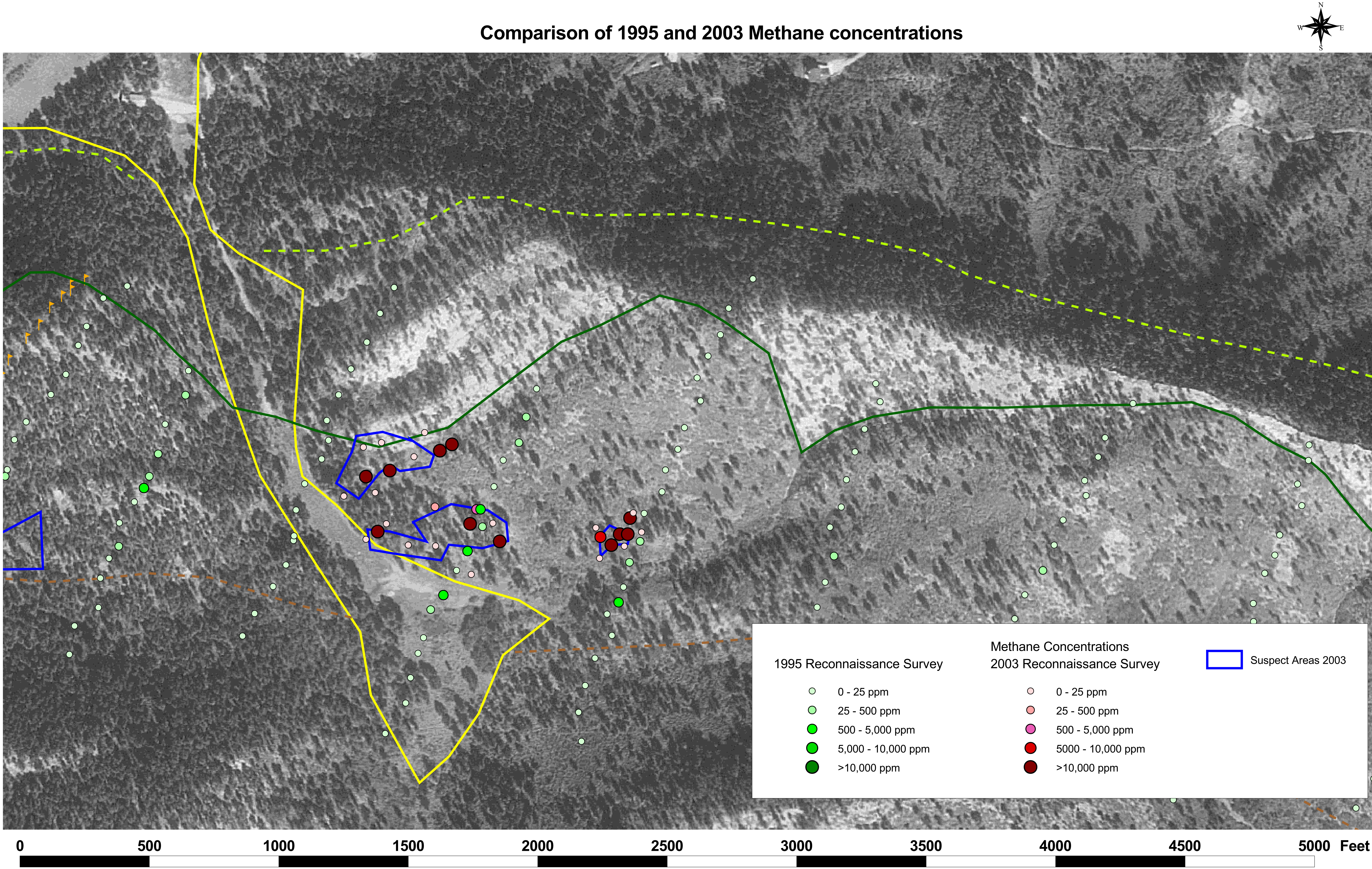


Figure C - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

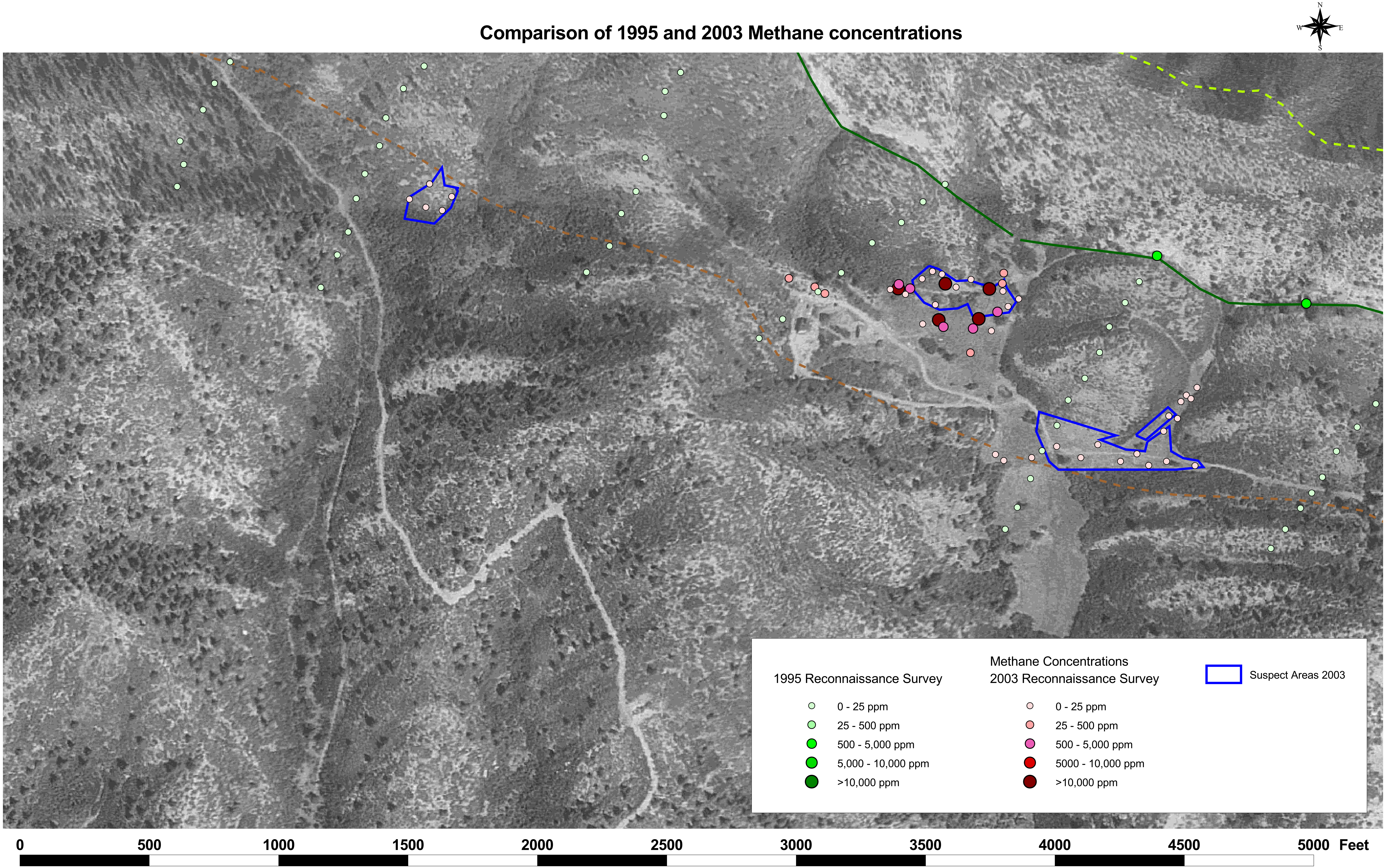


Figure D - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

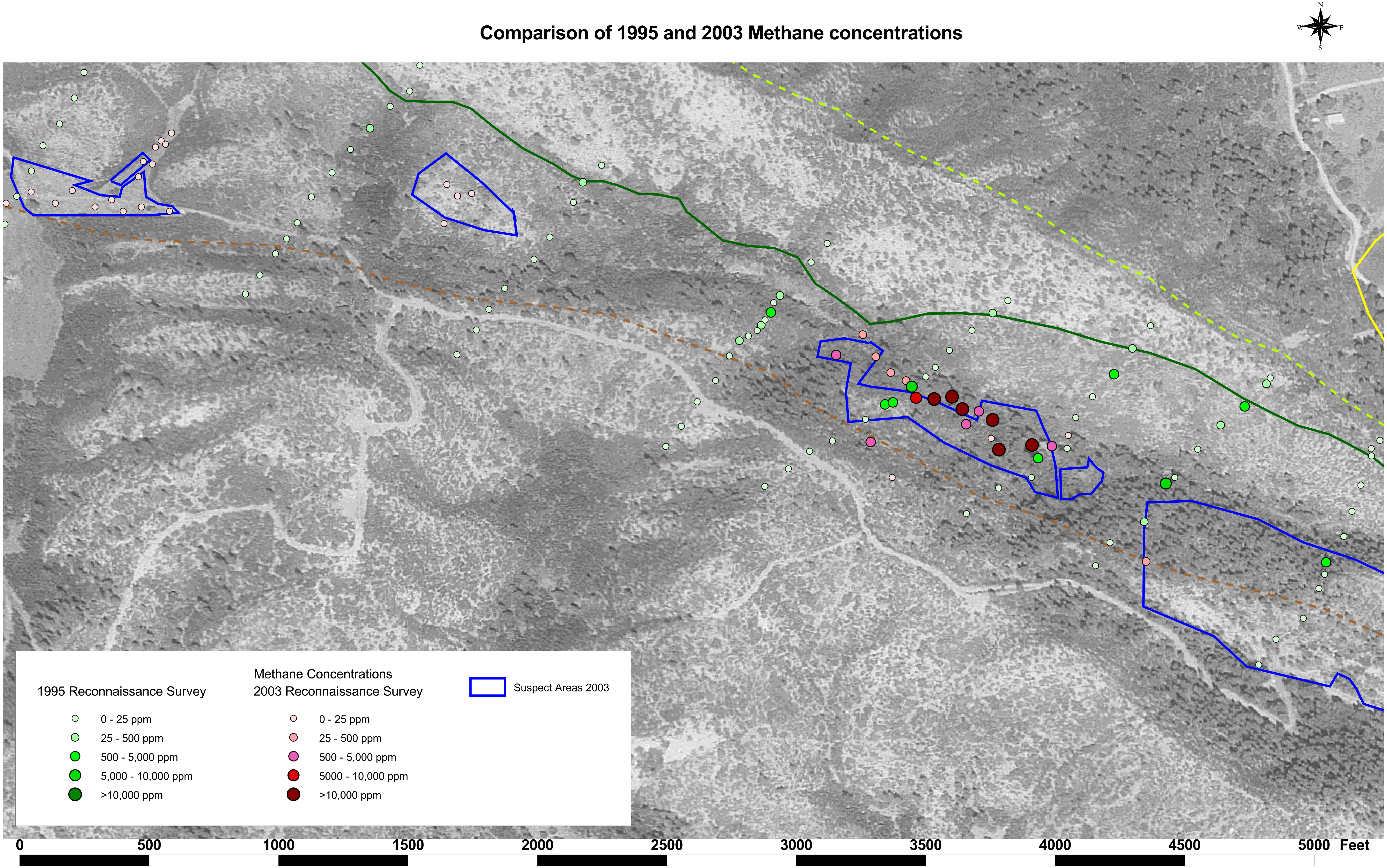


Figure E - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

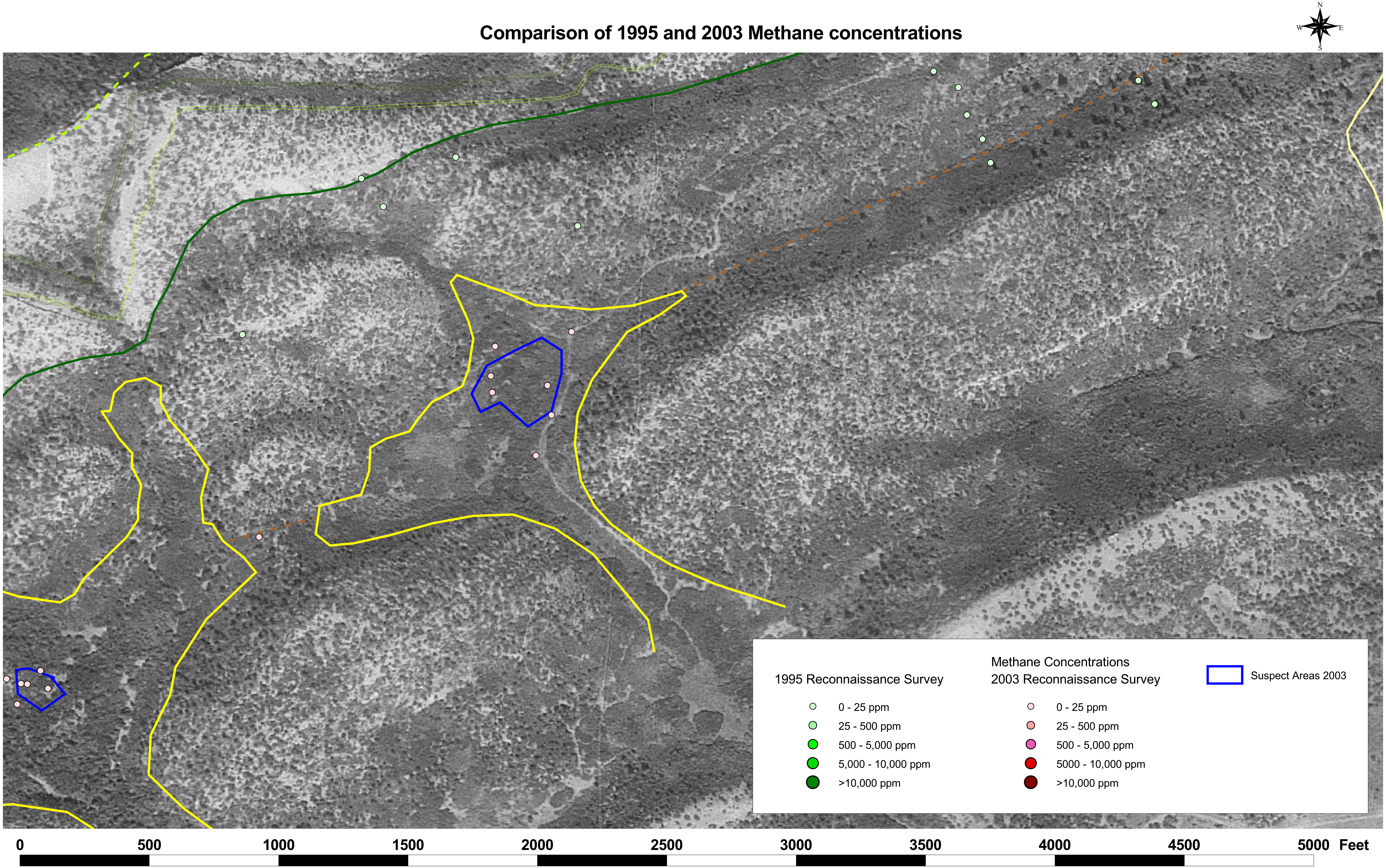


Figure F - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

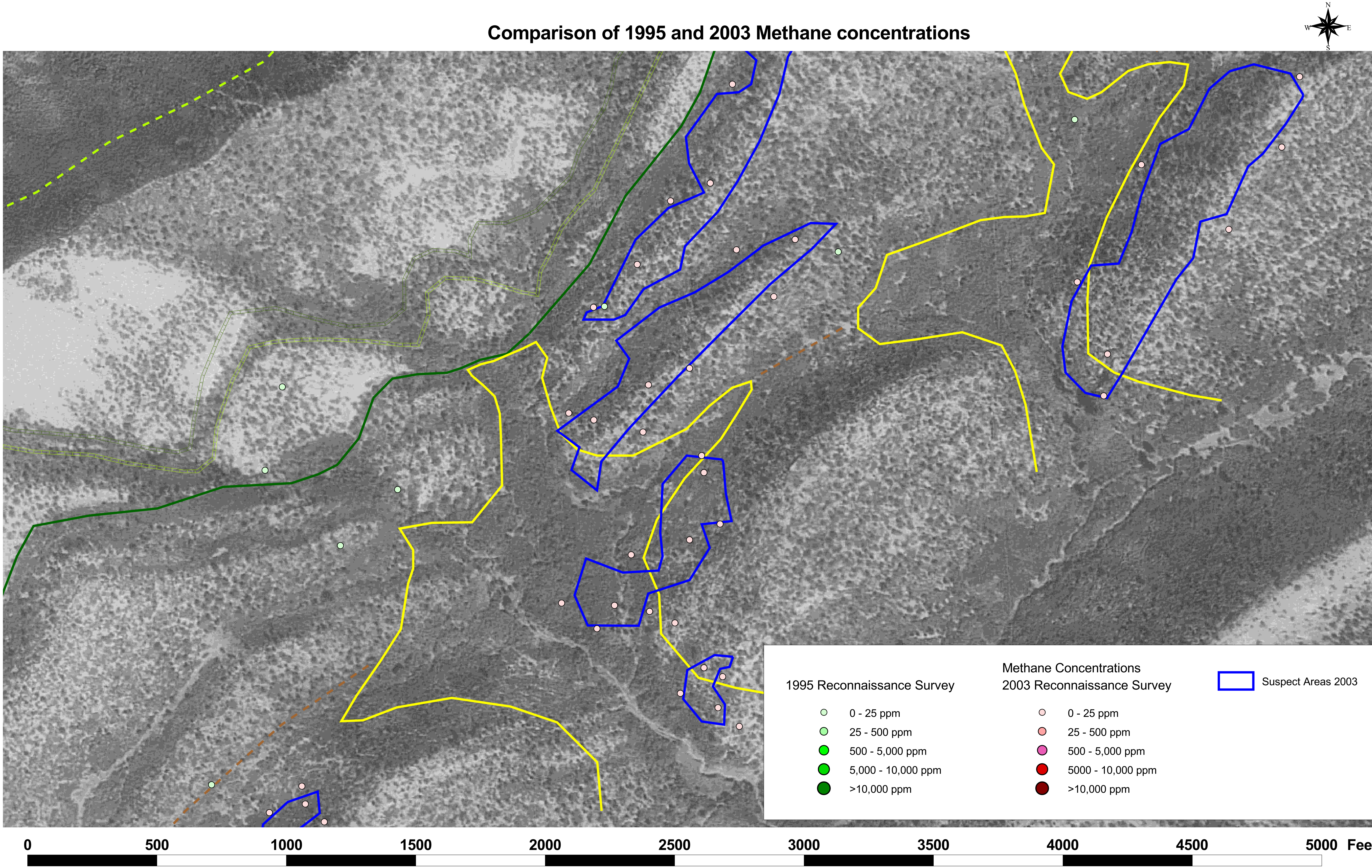


Figure G - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

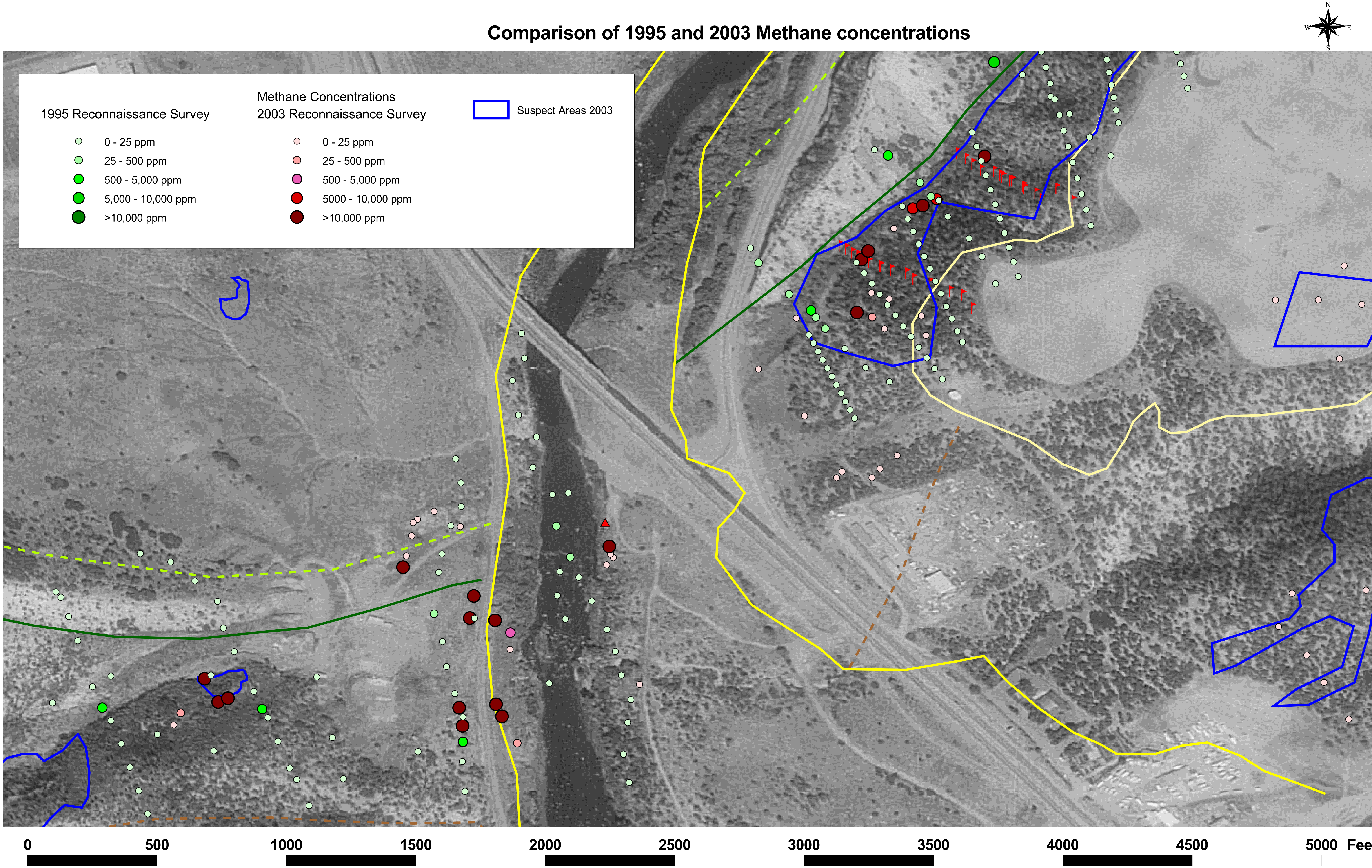


Figure H - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

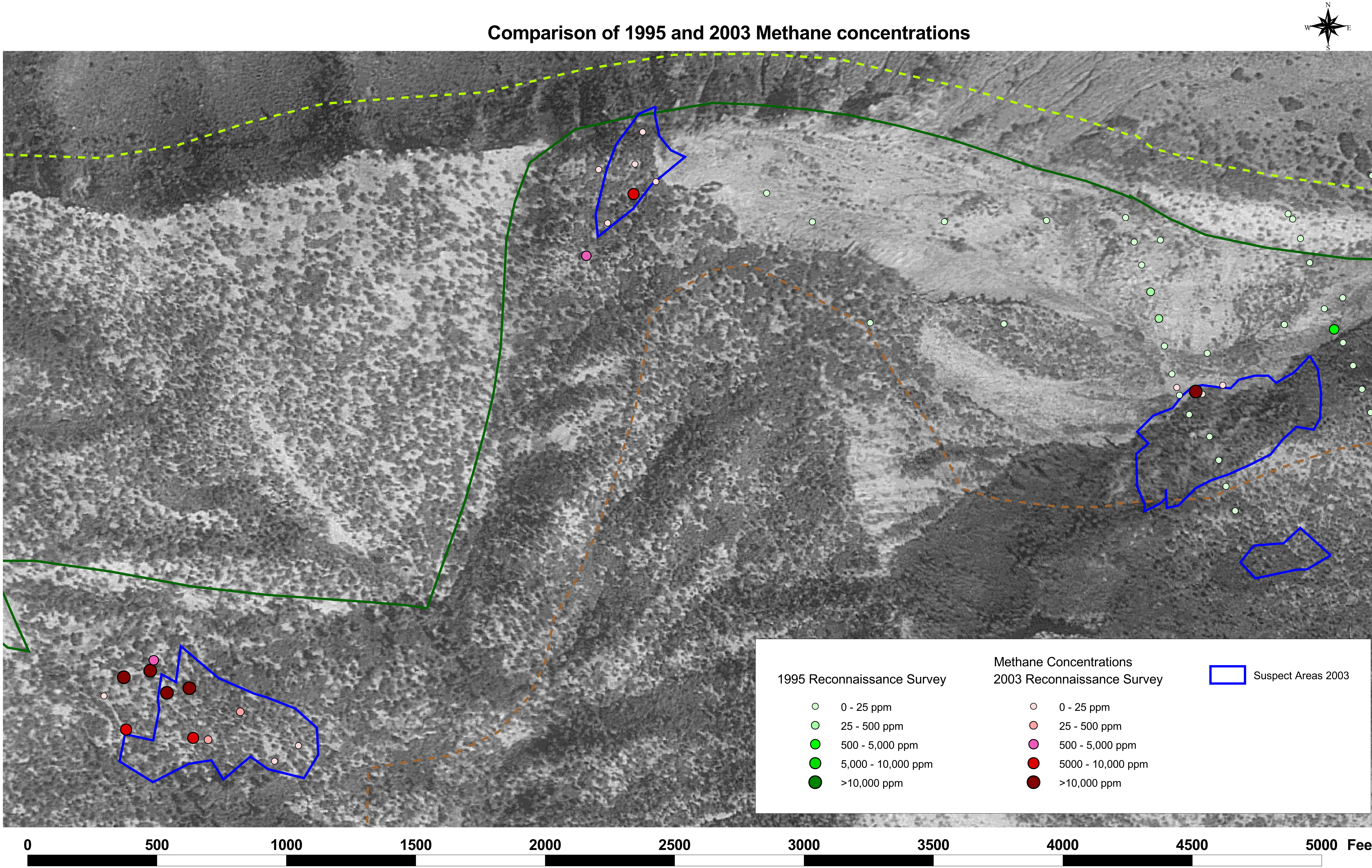


Figure I - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

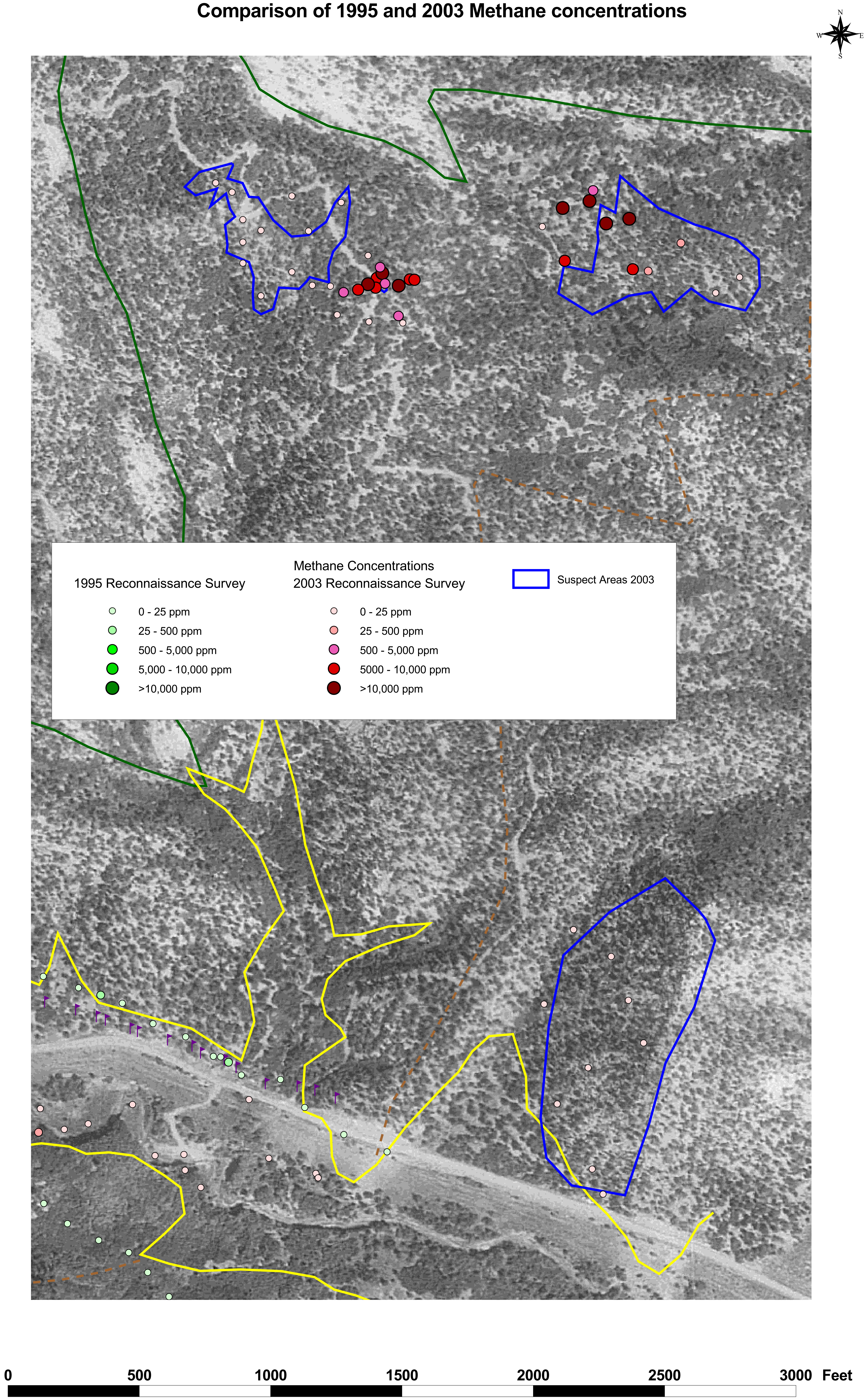


Figure J - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

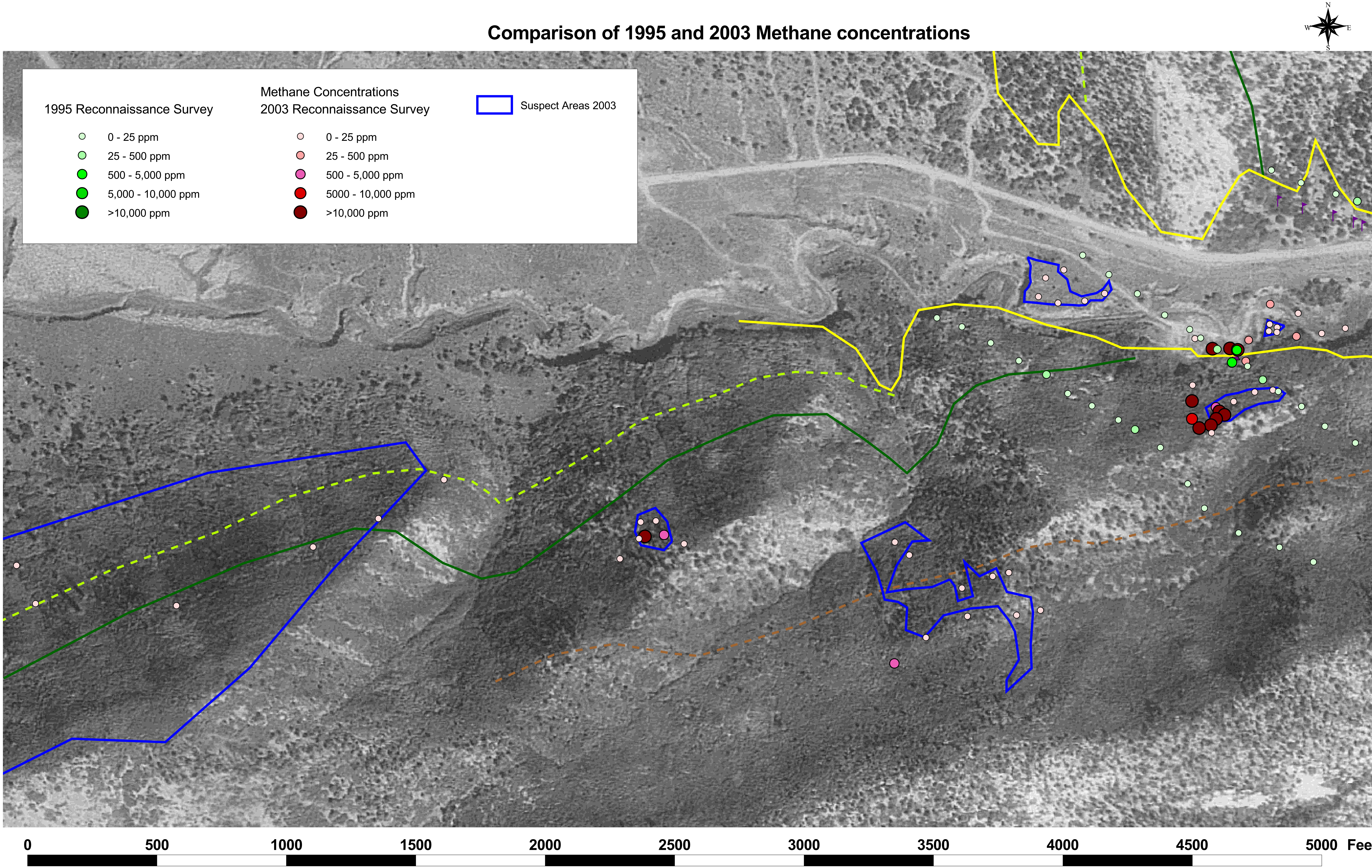


Figure K - Methane 1995-2003

Comparison of 1995 and 2003 Methane concentrations

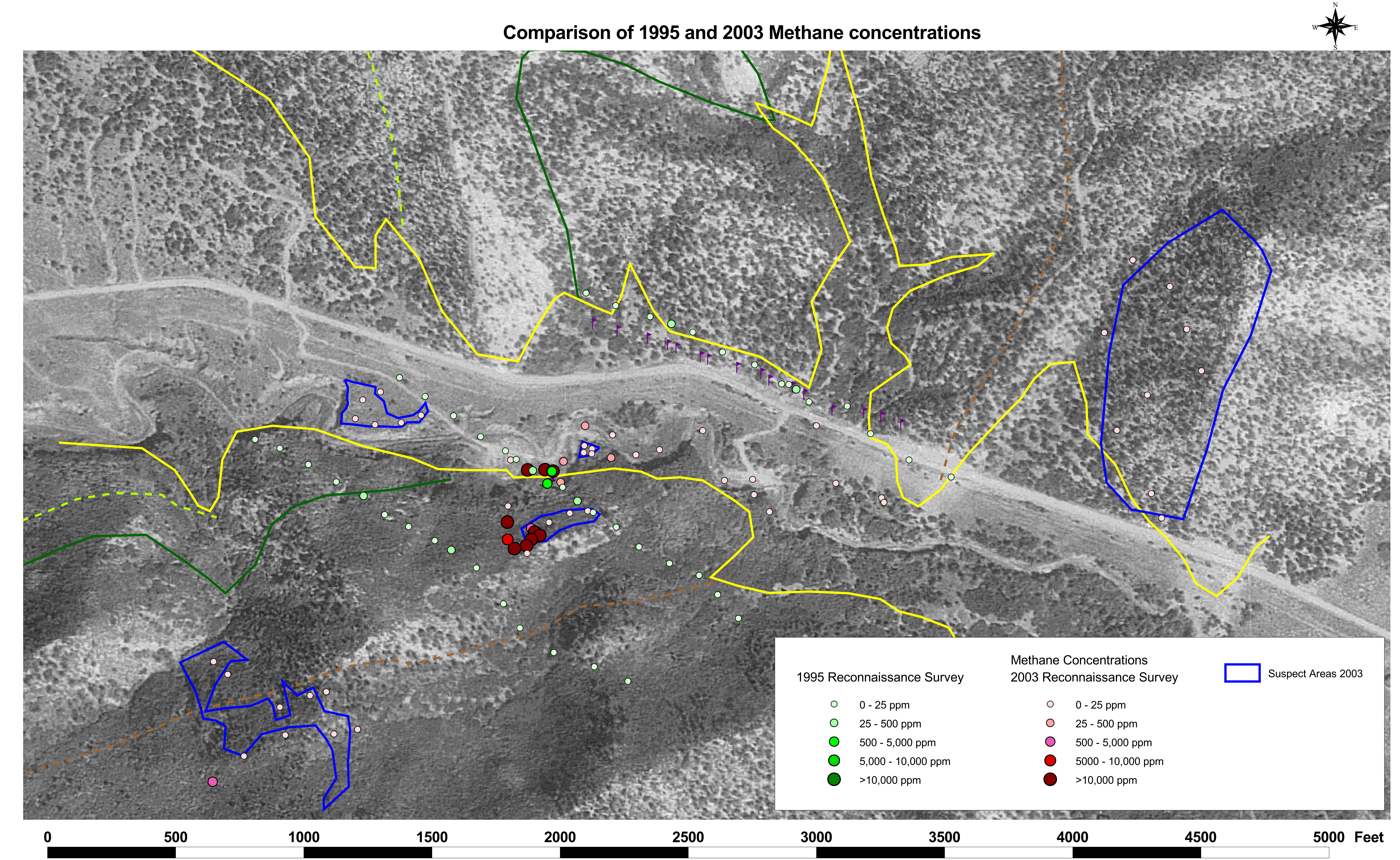


Figure L - Methane 1995-2003