A Survey of Tiger Beetles (Coleoptera: Cicindelidae) in the Black Hills of South Dakota

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Introduction

Most taxonomists place tiger beetles in the family Cicindelidae, closely related to the family Carabidae or ground beetles (Graves and Brzoska 1991). Cicindelidae is represented by 2 genera and 24 species within South Dakota. Both genera and 17 species have been recorded in the Black Hills of South Dakota. All Black Hills species are ground-dwelling predators. Most are diurnal, fast runners, and good fliers. Amblycheila is the single exception, being strictly nocturnal and flightless. Some other species, though primarily diurnal, can be attracted to artificial lights.

The Black Hills are one of 11 physiographic regions found in South Dakota (Van Bruggen 1985). The Black Hills are further divided into 6 geomorphic regions (Larson and Johnson 1999) and 73 Ecological Land Units (USDA Forest Service 1980). Annual precipitation varies from 71 cm in the higher northern hills to 33 cm in the southern foothills (Larson and Johnson 1999) and greatly influences vegetation dynamics from north to south.

The primary objectives of this survey are to identify and document the species of tiger beetles that occur in the Black Hills of South Dakota, discuss preferred habitats, and demonstrate temporal and spatial distributions. Information recorded for each specimen includes identification of species, the reference used for identification, collection number, date and site of collection, air temperature at the time of collection, and the elevation, habitat type, and description of each collection site. The data collected is combined with historical data and compared with recent literature to support our conclusions. A key to the tiger beetles of the Black Hills is also included.

Methods

The study area consists of the South Dakota portion of the Black Hills, including parts of Butte, Custer, Fall River, Lawrence, Meade, and Pennington Counties. The northern boundary of the study area follows the Belle Fourche River east from the Wyoming state line to Highway 79. The eastern boundary follows Highway 79 from the Belle Fourche River to Interstate 90 at Sturgis, Interstate 90 from Sturgis to Highway 79 in Rapid City, Highway 79 from Rapid City to Highway 385, and Highway 385 from Highway 79 to Angostura Reservoir. The southern boundary is the Cheyenne River from Angostura Reservoir to the Wyoming line. The state line is the western boundary.

This area is approximately 145 km from north to south and 58 km from east to west. Elevations range from 975 m at the edge of the prairie to 2207 m at Harney Peak.

Surveys of adult tiger beetles were conducted 3 times at each of 16 sites throughout the study area. The surveys began in April 2001 and ended early in October of the same year. These sites represent various elevations, vegetation types, and geomorphology, as well as both xeric and riparian areas. Specimens were collected with an insect net from open areas, trails, unvegetated streambanks, and lakeshores. At each site, a transect 225-1300 m in length was surveyed. A black light was used to attract beetles at night at 5 sites, mostly during July and August. All species collected were identified using "Key to the Cicindela of Nebraska" (Carter 1989), and representatives of each species from each study site were preserved and later pinned in our display cases. Duplicate species representatives were released.

Description of Survey Sites

Sites are described from north to south. Site descriptions are based on collection notes and characteristics of the Ecological Land Unit (ELU) where each site is located. Detailed site maps are in Appendix A.

The **McNenny Fish Hatchery** (Lawrence County, ELU #35) is the northernmost site, located in the "Red Valley" that encircles the Black Hills. The collection site is in the Opeche formation, which is characterized by red clay soils (Gries 1996). Two spring-fed lakes are found on the site. The transect runs from west to east on the north side of West Mirror Lake, then to the north along approximately 800 m of native-surface road closed to motorized vehicles. Vegetation on the gently rolling prairie consists of grasses, forbs, cacti, yucca *(Yucca glauca)*, and shrubs such as silver buffaloberry *(Shepherdia argentea)*, interspersed with exposed patches of dense red clay soil. Elevation ranges from 1100 to 1200 m.

The **Boundary Gulch** site (Lawrence County, ELU #32) is at the edge of an area burned by wildfire approximately 15 years ago. Habitat type is dry pine/oak. The transect follows a trail along a ridgetop, with the burned area to the west and fairly dense, mature ponderosa pine *(Pinus ponderosa)* to the east. The burned area is now vegetated with shrubby bur oak *(Quercus macrocarpa)* over a variety of grasses and forbs. Soil is generally a channery and sandy loam, with a sand inclusion at the end of the trail. Elevation is approximately 1490 m.

The **Sturgis Bureau of Land Management** (BLM) site (Meade County, no ELU #) is part of the forested hogback ridge that surrounds the Black Hills. The transect follows a closed-off jeep trail approximately 480 m through a large open meadow of grass and forbs, terminating in a mature, closed-canopy, dry pine/oak site. Soils are sandy loam to pure sand. Elevation is 1090 m.

Steamboat Rock (Lawrence County, ELU #25) is a dry ponderosa pine site at an elevation of 1370 m. The transect follows an old logging road about 480 m through a forested stand with about a 50% overstory canopy cover. About 80% of the road surface area is vegetated, primarily with grasses and forbs. Soils are channery and silty loam.

The **Keough Draw** site (Lawrence County, ELU #23) is a primitive road running about 800 m up the moist drainage. The north end of the transect is in a moist, open meadow with willows *(Salix spp.)* along the stream. The transect then enters a forested area with white spruce *(Picea glauca)* on the north-facing slope and ponderosa pine on the south-facing slope. Soils are loamy and densely vegetated, although the road bed is rocky with little vegetation. The elevation is 1795 m.

The **Black Fox** site (Lawrence County, ELU #23) follows an old logging road through about 600 m of open meadow at the bottom of a draw. The adjacent north-facing slope is densely forested with white spruce, while ponderosa pine dominates the south-facing slope. Substrate ranges from silty loam soil to rocky limestone. Elevation at this site is 1830 m.

The **Hayward** site (Pennington County, ELU #07) is primarily a riparian site. The transect crosses Iron Creek and follows a heavily used dirt road a short distance through ponderosa pine and mixed hardwoods, ending at the open banks of Battle Creek. Canopy cover in the forested area is up to 75%. There is very little vegetation on the road. The creek banks are heavily vegetated, but mud banks become exposed in mid- to late summer when the water level drops. Soils are sandy/silty with bits of mica. The elevation is 1150 m.

Deerfield Lake (Pennington County, ELU #08) is a high-elevation reservoir. The transect runs 400 m along a foot trail through upland meadow with scattered ponderosa pine, then follows the rocky beaches of the reservoir for another 400 m. Meadow vegetation is fairly dense, dominated by grasses such as little bluestem *(Schizascyrium scoparium)* and timothy *(Phleum pretense)* and forbs such as western yarrow *(Achillea millefolium)* and prairie smoke *(Geum triflorum)*. Water levels were high in 2001, with little exposed bank until late August. The elevation is 1830 m.

Moon Campground (Pennington County, ELU #22) is, at 1920 meters, the highest of the 16 sites. The transect follows an ATV trail approximately 600 m through a mature ponderosa pine stand. About 60% of the trail is vegetated with grasses and forbs. Forest overstory cover is 65%. Soil is a sandy loam. The trail is open to motorized vehicles, but is not heavily used.

Bismark Lake (Custer County, ELU #01) is near the exposed granite core area of the Black Hills. The transect follows a road about 900 m through ponderosa pine/common juniper *(Juniperis communis)* forest. The trail is rocky and has varying vegetation densities. Overstory forest canopy cover ranges from 20% to 60%. Collections could not be made along the lake, since water levels were high and unvegetated bank was not exposed. Elevation is 1580 m.

The **Schenk Canyon** site (Custer County, ELU #21) is a dry ponderosa pine site in the southern Black Hills. The transect follows a logging road approximately 1400 m through open pine forest. There is little vegetation on the trail, and overstory forest canopy cover averages 20%. Soils are channery and silty loam with some rocky areas. The 486-hectare Rogers Shack wildfire burned within 400 m of this site during the survey period. The elevation of this site is 1400 m.

few small, mostly intermittent streams nearby. The lack of appropriate habitat and the evidence of strong dispersal ability (Larochelle and Larivière 2001) lead us to believe that there is probably not a population of this species in the study area. Knisley and Schultz (1997) reported wind events as having an effect on dispersal of certain tiger beetle species. This may have been the cause of the 1964 record, as *C. hirticollis* has been reported from northern Nebraska and Martin, South Dakota.

C. terricola cinctipennis has been reported twice in the study area: once in the Custer area (Gilbertson 1929) and once in Cascade Valley (McIntosh 1928). Larochelle and Larivière (2001) report this species to inhabit grassland prairies, roads, dry creek beds, and edges of ponds, creeks and rivers. Carter (1989) indicates that soil salinity and alkalinity may affect distributions of this species. Nebraska records show that *C. t. cinctipennis* is found in less saline habitats than other types of *C. terricola*. Based on this information, it appears that Cascade Valley does have suitable habitat for this species, though the area around Custer probably does not. We surmise that since there is appropriate habitat, there was or possibly still is a population of this species somewhere in the far southern Black Hills. Dispersal from populations in the Nebraska panhandle would also be possible. Further surveys are needed to determine the status of this species.

For the purposes of this report, 2 genera and 17 species will be considered to inhabit the Black Hills area.

Table 1 shows species observed at each survey site.

Table 1. Species observed by survey site

	Site																
Species	*McNenny*	*Boundary Gulch*	*Sturgis BLM*	*Steamboat Rock*	*Black Fox*	*Keough Draw*	*Hayward*	*Deerfield*	*Moon CG*	*Bismark Lake*	*Schenk Canyon*	*Rifle Pit Road*	*Cold Brook*	*Whitney TNC*	*Cheyenne River*	*Angostura*
C. cuprascens															X**	
C. denverensis	X												X	X		
C. duodecimguttata	X	X											X			X
C. formosa															X	
C. fulgida	X															
C. lengi		X													X	
C. limbalis	X	X		X	X	X	X	X		X						
C. longilabris	X	X	X	X	X	X		X	X			X		X		
C. nebraskana	X	X	X													
C. punctulata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C. purpurea	X	X	X	X	X				X	X	X	X	X	X		X
C. repanda															X**	X
C. scutellaris		X	X													
C. sexguttata			X				X*									
C. splendida	X															
C. tranquebarica	X	X		X**							X		X		X	
County	*Lawrence*	*Lawrence*	*Meade*	*Lawrence*	*Lawrence*	*Lawrence*	*Pennington*	*Pennington*	*Pennington*	*Custer*	*Custer*	*Custer*	*Fall River*	*Fall River*	*Fall River*	*Fall River*

*Observed but not collected.

**Not collected by the authors.

Note: *Amblycheila cylindriformis* was not captured at any of the study plots, but has been captured in and around the southern portion of the study area and will be considered in this report.

Spatial Distribution of Black Hills Tiger Beetles

Table 2 shows distribution of tiger beetle species in the survey area by county. Data reflects records from this survey and historical records.

Table 2. Species distribution by county – all records

	County				
Species	*Lawrence*	*Meade**	*Pennington*	*Custer*	*Fall River*
A. cylindriformis					X
C. cuprascens					X
C. denverensis	X				X
C. duodecimguttata	X		X	X	X
C. formosa	X			X	X
C. fulgida	X				
C. lengi	X				X
C. limbalis	X		X	X	X
C. longilabris	X	X	X	X	X
C. nebraskana	X	X	X	X	X
C. punctulata	X	X	X	X	X
C. purpurea	X	X	X	X	X
C. repanda	X		X	X	X
C. scutellaris	X	X			
C. sexguttata	X	X	X	X	X
C. splendida	X				
C. tranquebarica	X			X	X

*Most of Meade County is not within the study area.
Note: There is no data for the small portion of Butte County that is within the study area.

Our 1999-2001 collections yielded 6 new county records. New to Meade County were *C. longilabris, C. punctulata, C. scutellaris,* and *C. sexguttata. C. lengi* had not previously been reported in Lawrence County, and *C. duodecimguttata* was a new record in Pennington County.

Survey data was compared to range maps for known distributions of North American tiger beetles (Pearson, Barraclough, and Vogler 1997). These maps do not show *C. splendida* or *C. sexguttata* occurring in the Black Hills. Backlund (2000) and Marrone (2000) have previously reported both of these species in the Black Hills area.

- *C. splendida* has been collected at several locations in western South Dakota. Backlund (2000) has reported it well to the north and east of the Black Hills. Range maps should be updated to reflect this change.
- *C. sexguttata* is a boreal species that has been now been reported from all of the counties within the study area. This species has also been reported in eastern South Dakota, and maps show range ending at the Missouri River. *C. sexguttata* has not recently been reported in the 290-km gap between the sites of the eastern South Dakota records and the Black Hills, although Gilbertson (1929) reported this species in the northwestern and southwestern parts of the state. While most of this area is open prairie, there are small tracts of forest where Gilbertson

reported this species. We are not aware of any published research on the minimum area of forest needed to support a population of this species. Dispersal may also explain Gilbertson's occurrence of this species. It is reported to be a strong flier (Larochelle and Larivière 2001) and has a tendency toward seasonal dispersals (Pearson and Vogler 2001), but we have not seen data indicating how far it might travel. Further collecting should be done in western South Dakota to determine the status of this species.

- The Black Hills are at the edge of the range of *C. longilabris.* Like *C. sexguttata, C. longilabris* is a forest-associated species, and a finger of its range extends to the Black Hills from the mountainous areas of central and western Wyoming. There is little suitable habitat for this species between the Black Hills and the Big Horn Mountains, so it also may be disjunct in the Hills.

Table 1 suggests that *C. limbalis*, *C. longilabris*, *C. punctulata*, and *C. purpurea* are the most widespread of the species found in the survey area. This finding is consistent with literature suggesting *C. longilabris, C. punctulata*, and *C. purpurea* are habitat generalists (Larochelle and Larivière 2001). *C. limbalis*, however, is generally thought to be a habitat specialist, preferring moist areas, streambanks, clay soils, roads, roadcuts, and openings in forests and meadows (Larochelle and Larivière 2001). The northern and central Black Hills provide for abundant habitats of this type.

Numerous factors play a role in tiger beetle distribution and habitat selection. We looked at the roles of geomorphology and elevation and the resulting vegetation and habitat characteristics in determining tiger beetle distributions. The remainder of this discussion will focus on these factors.

Geomorphology. The survey area includes 6 **geomorphic regions** (Larson and Johnson 1999). Owing to the formation of the Black Hills through deposition, uplift, and erosion, these regions lie roughly in the shape of a bull's-eye as concentric circles around the highest parts of the hills. The oldest geological formations are found at the higher elevations, where the younger formations that once covered them have eroded away. Regions are characterized by unique geology and topography, and are discussed below from lower to higher elevations and thus younger to older formations.

At the lowest elevations, the **Gray Shale Foothills** are characterized by gray shales and bentonite clay, often exposed. Vegetation is generally shortgrass prairie in the north with scattered ponderosa pine and bur oak, while in the south sagebrush steppe is dominant. These foothills are relatively dry, but the Belle Fourche River in the north and the Cheyenne River in the south cross this formation and provide a significant variation in habitat. Seven tiger beetle species are found in this region, including *A. cylindriformis, C. cuprascens, C. formosa, C. lengi, C. punctulata, C. purpurea,* and *C. tranquebarica.* This region includes the only locations in the study area where *A. cylindriformis* and *C. cuprascens* are known to occur. The Cheyenne River collection site is in this region.

Inside the foothills, a sandstone ridge known as the **Hogback** forms the next ring around the Black Hills. This ridge is generally dry, but east- and north-facing slopes are often forested with ponderosa pine and bur oak. Exposed soils are present but not abundant. Ten species are known to occur in this region: *C. denverensis, C.*

Location data associated with many of the historical records is too vague to determine elevation. Further research could show that some species occupy a larger range of elevations than this survey suggests. This is especially likely for *C. duodecimguttata* and *C. sexguttata,* which have been reported in 5 of the 6 geomorphic regions.

Tables 1 and 2 show that species diversity is greatest in the northern Black Hills (Lawrence County) and the far southern Hills (Fall River County). Species diversity otherwise gradually decreases from north to south, and also generally decreases as elevation increases.

The lowest level of species diversity is in the Limestone Plateau and the Central Core, while species diversity is the greatest in the other geomorphic regions. Several factors could account for this. First, the lower elevations provide a greater range of habitats, ranging from prairie to open forest and riverine sandbars. Habitat in the Limestone Plateau and Central Core is overwhelmingly dominated by conifer forest. Second, due to soil morphology and precipitation, there are generally more exposed soils at the lower elevations. Tiger beetles prefer habitat with interspersed areas of bare ground and vegetation (Knisley and Schultz 1997). At the higher elevations, increased moisture causes greater density and coverage of vegetation.

Though at a lower elevation, the Angostura site did not yield any beetles on the first collecting trip. It was not until later in the summer, when water levels had dropped, that beetles appeared in any abundance. We theorize that since thick, often weedy vegetation has encroached most of the bare ground above the lake's high-water line, very little suitable habitat is available. We have also noted tiger beetle absence in thick aspen stands with heavy canopy cover and dense ground cover.

Another possible factor is that the Central Core has many areas of exposed rock. This may inhibit burrow digging, which is important for tiger beetle adults and larvae. Research has shown that in the northern latitudes, larvae must dig their burrows below the freeze line in order to survive the harsh winter conditions (Pearson and Vogler 2001). A shallow bedrock layer or rocky substrates such as found in the central core would not be conducive to overwintering larvae. The data collected indicated fewer species in these two regions, and our observations indicated smaller overall numbers of beetles here as well.

A detailed comparison of the habitats with which we found tiger beetles to be associated in the Black Hills and habitat preferences from other published research is considered under the Species Accounts section, below.

Temporal Distributions

Tiger beetles exhibit two different types of life cycles (Huber 1988). Some species exhibit a spring-fall strategy, in which sexually immature adults emerge from the pupa in the fall, overwinter underground, emerge in the spring, mate, and then die. Other species exhibit a summer pattern, where the sexually mature adults emerge in early summer and breed. Larvae then overwinter. The adults may or may not overwinter, depending on species. This seasonal control of the life cycle is important for reproduction as well as surviving long-term environmental stress (Pearson and Vogler 2001).

These two life cycles are strongly influenced by diapause. Diapause is a physiological condition in which development ceases and metabolic rates are lowered. This dormancy period is critical to surviving adverse conditions, and has an influence on temporal distributions as well as habitat selection (Pearson and Vogler 2001). Pearson and Vogler indicate that diapause is usually triggered by photoperiod. Once diapause has begun, only an increase in daylight hours and possibly increased temperatures will bring the beetles back out of it.

Pearson and Vogler (2001) state that the northern latitudes have more spring-fall species than summer species. Our data indicates this is the case in the Black Hills.

Kippenhan (1994) reports that emergence is sometimes delayed in high-elevation species, including *C. longilabris*. This may explain why *C. longilabris* has been found during the spring, summer and fall seasons in the Black Hills.

As we theorized earlier, larvae may not be able to burrow deep enough to diapause below the frost line and survive winter at the higher elevations in the Black Hills. This would influence habitat selections as well as numbers of beetles.

Chart 2 represents temporal distributions of Black Hills tiger beetles.

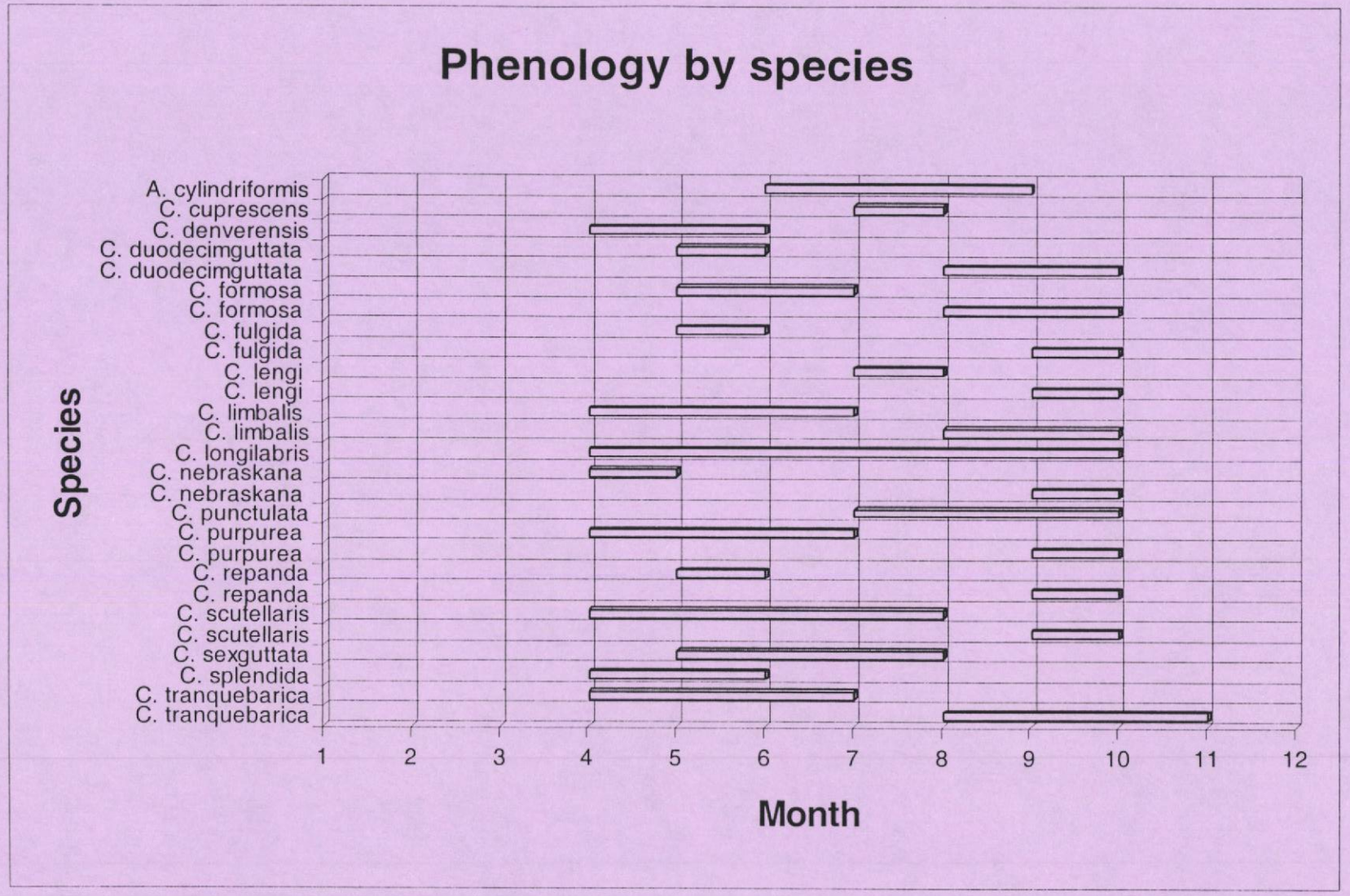

Chart represents January 1 through November 30.

Dates from our collection as well as other tiger beetle collections from the Black Hills were compiled to show seasonality of the Black Hills tiger beetles. Most of our collecting took place during May through September. It is likely that surveys focusing on early spring and late fall (mainly April and October) would demonstrate the presence of additional species, especially during favorable weather.

Summer species include *A. cylindriformis, C. cuprascens,* and *C. punctulata. C. sexguttata*, a spring-fall species, exhibits a fall diapause due to its cellular biochemistry (Pearson and Vogler 2001). The remaining species can be considered spring-fall species. *C. longilabris* is the only species found throughout the spring, summer, and fall months. Teneral adults of this species have been reported to emerge during the summer months at higher elevations, which would explain the long seasonal presence (Larochelle and Larivière 2001). *C. denverensis* and *C. splendida* have not been collected in the fall, despite numerous attempts in locations where the species is known to occur in spring.

We found few *C. lengi,* and insufficient sample size may explain the odd results for this species' distribution (July and September). Carter (1989) and Larochelle and Larivière report this as a spring-fall species. Reports by McIntosh (1928) indicate this species as being common in May and August, which would also indicate that it is a spring-fall species.

Our findings are otherwise consistent with published reports on the tiger beetle seasonality.

Species Accounts

One factor influencing tiger beetle distributions is habitat selection. Some species of tiger beetles are considered habitat generalists and will occupy a wide range of environmental conditions, while other species are habitat specialists and will occupy a much smaller environmental niche. For North American cicindelids, 17 habitat types have been identified (Pearson et al. 1997). Physical and chemical characteristics as well as climatic traits influence these habitats. Species-specific physiological, morphological and behavioral traits allow tiger beetles to survive the extremes of their physical environment (Pearson and Vogler 2001).

The following species accounts include a discussion of habitats in which we found each species. This was compared to the habitat preferences reported by Larochelle and Larivière (2001), and discrepancies are noted and discussed.

Amblycheila cylindriformis Say, a summer species, is the largest of the Black Hills tiger beetles. It has been reported from the prairie fringes of the Black Hills in Fall River County. Most collection records of this species are from areas around Angostura Reservoir and just south of the Cheyenne River. *A. cylindriformis* is associated with sandy soils and sagebrush steppe habitats that are not found anywhere else within the study area. Larochelle and Larivière indicate that this species prefers clay-type soils, rarely sand. The only records of this species in South Dakota, however, have been from sandy soils, often with sand sagebrush *(Artemisia filifolia)* vegetation cover. Habitat loss

and fragmentation have had negative impacts on this species (Johnson 1996) and consequently it has been assigned a global ranking of G4 and a South Dakota state ranking of S1 (South Dakota Natural Heritage Program).

Cicindela cuprascens LeConte, a summer species, is reported from the sandy banks of the Cheyenne River in Fall River County. This species prefers sandy inland beach habitats (Larochelle and Larivière 2000), and while it has been reported in numerous areas across the state, the banks of the Cheyenne River are probably the only suitable habitat within the study area. At least one of the recorded specimens was captured after being attracted to a black light.

Cicindela denverensis Casey, a spring-fall species, has been reported from Lawrence and Fall River Counties. This species seems to be associated with eroded banks, gullies, and road cuts in the Red Valley and hogback ridge surrounding the Black Hills. They have not been reported above 1400 m. Larochelle and Larivière report this to be a prairie species. The only collections of *C. denverensis* have been in the spring; no fall records have been reported anywhere in the state.

Cicindela duodecimguttata Dejean is a spring-fall species and has been recorded in Lawrence, Pennington, Custer and Fall River Counties at elevations up to 1460 m. Habitat preferences for this species are varied; wet beach areas or open streamside bars seem to be the preferred habitats, but we have also collected them in dry, open, sandy areas and roadside ditches. Soil type does not seem to be a major factor, as individuals were collected on sandy, clay, and rocky substrates.

Cicindela formosa formosa Say is a spring-fall species with records from Lawrence and Fall River Counties. Preferred habitat is sandy areas with sparse vegetation. There is little suitable habitat for this species within the study area.

Cicindela fulgida fulgida Say is a spring-fall species that has only been reported from Lawrence County. This species prefers both alkaline and saline habitats (Larochelle and Larivière 2001), which are probably found only within the Red Valley encircling the Black Hills. This species is associated with prairie grassland habitats.

Cicindela lengi versuta Casey is a spring-fall species known from Lawrence and Fall River Counties. Though primarily a grassland species, it is reported to inhabit sandy substrates and open forested areas (Larochelle and Larivière 2001). It has been reported as common along the floodplains of the Cheyenne River south of Hot Springs (McIntosh 1928), but we collected only one in the same area in the past three years.

Cicindela limbalis Klug is a spring-fall species reported from all but one of the Black Hills counties. It does appear to be more common in the northern Black Hills, possibly due to the extra moisture found in that region. Clay soils seem to be the preferred substrate. This species is extremely common in the eroded soils and cut banks of the Red Valley, but are found in open areas and road cuts throughout the Hills. Most of the specimens from the McNenny site show reduced maculation, while the specimens from

all other locations are fully maculated. This gradation of maculation was also mentioned by Cutler (1968), who observed and described four different maculation and color variants of this species from one location.

Cicindela longilabris Say is a spring-fall species reported from all Black Hills counties. This is a forest species (Larochelle and Larivière 2001) found on trails, roads, and grassy areas. *C. longilabris* seems to tolerate more heavily vegetated areas than most of the other tiger beetle species in the study area. It is also the only species collected during every month of this survey. This species may be disjunct in the Black Hills.

Cicindela nebraskana Casey is a spring-fall species from the foothills and prairie transition areas. Habitats of this species are very similar to *C. longilabris,* and where the two species overlap they are often difficult to tell apart. *C. nebraskana* is present early in the spring and seems to disappear by early June.

Cicindela punctulata punctulata Olivier, a summer species, is the most ubiquitous of the Black Hills species. It has been found in all Black Hills counties and is the only species caught at all 16 survey sites. Habitats for this species vary from city sidewalks to open, generally dry areas at all elevations surveyed. This species has been observed when temperatures were 90° to 100° F and no other species were present. The green and blue Chihuahua morphologies (McIntosh 1928) have been collected at Angostura, Schenk Canyon and near Custer Crossing (Forest Service Road 256) in the northern hills. *C. punctulata* also comes readily to artificial lights.

Cicindela purpurea Olivier is a spring-fall species reported from all counties within the study area. A habitat generalist, it is found on packed roads, eroded soils, and cutbanks, and like *C. longilabris* and *C. nebraskana* seems to tolerate areas with relatively thick vegetation cover.

Cicindela repanda Dejean is a spring-fall species found in open areas along lakes and streams. While this species is very common throughout the state, there are few records from the Black Hills area despite the presence of numerous small lakes and streams. Additional collecting should be done along Black Hills riparian areas to determine the status of this species. There may be too much vegetation cover along Black Hills waterways for too much of the year to provide suitable habitat.

Cicindela scutellaris Say is a spring-fall species reported only from the northern Black Hills. This prairie species has been found in mixed forests at lower elevations of Meade and Lawrence Counties, usually in small, sparsely vegetated sand inclusions.

Cicindela sexguttata Fabricius is reported by Larochelle and Larivière as being a spring-fall species. Reports from Nebraska (Carter 1989) indicate that it is a summer species. It has been reported from all counties in the study area and is considered to be a forest species. It seems to prefer openings, roads, and cleared log landings within mixed coniferous and hardwood stands. This species may be disjunct in the Black Hills.

Cicindela splendida Hentz is a spring-fall species only known from the red clay banks at the McNenny site. This species has been reported from a variety of habitats across its range. It has not been found elsewhere in the Black Hills, even in habitat similar to that at McNenny.

Cicindela tranquebarica tranquebarica Herbst is a spring-fall species found on sandy, clay, or rocky substrates, generally on the prairie and at the lower elevations of the Black Hills. This species may be found in dry forested areas or in close proximity to water.

Future Research Needs

The larval forms of tiger beetles are generally the longest stage in the life cycle. Larvae may spend one to several years in underground burrows. During this time, individuals are vulnerable to disturbance and adverse climatic conditions. Research showing larval microhabitat preferences and effects of land management practices would be valuable for determining conservation measures for this group of beetles.

Local data suggests that *C. longilabris* and *C. sexguttata* could be disjunct in the Black Hills, but additional surveys should be carried out in the gap between the Black Hills and the nearest known populations. The outlying regions where *C. sexguttata* has been reported do have some small forested tracts, but whether these are large enough to support a population is not known. More collecting in northeast Wyoming will be needed to determine the status of *C. longilabris*.

Several very large wildfires burned more than 100,000 acres in the southern Black Hills between August 2000 and September 2001. Studies of tiger beetle re-colonization of the burned areas and distributional changes due to vegetational succession would be of interest.

Amblycheila cylindriformis has been in decline through much of its range due to habitat loss. It is associated with the sandy sagebrush steppe in Fall River County. What is not known is how much of this habitat is present. Mapping the preferred habitat of *A. cylindriformis* would help in developing appropriate conservation measures for this species.

Other Species of Interest

While conducting this study, we observed several vertebrate species that are monitored by the South Dakota Natural Heritage Program.

An eastern short-horned lizard *(Phrynosoma hernandesi)* was observed at the Boundary Gulch site on July 28, 2001 and on September 2, 2001. UTM coordinates for the area where the specimen was found on July 28 are 575,359.67 x 4,922,353.06.

A green grass snake *(Liochlorophis vernalis)* was observed at the Bismark Lake site on September 11, 2001. UTM coordinates are 619,764.46 x 4,847,938.10.

A northern sagebrush lizard *(Sceloporus graciosus)* was seen at the Schenk Canyon site on September 29, 2001. UTM coordinates are 588,136.24 x 4,835,407.07.

Acknowledgements

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Conclusions

While species diversity seems quite high in the Black Hills, a comparison of our data from the Cascade Springs and Cheyenne River areas with McIntosh's 1928 records from the same general locality yields some differences in species presence as well as abundance of certain species. McIntosh reported 11 tiger beetle species along the Cheyenne River and Cascade Creek. We collected this area numerous times and have not found *C. fulgida* as reported by McIntosh, though this species has been reported elsewhere in the study area. McIntosh also reported *C. cuprascens* and *C. lengi* as being common along the Cheyenne River, but we have only one record of each species from this area in the past three years of collecting. Conversely, McIntosh did not report *C. denverensis, C. longilabris* or *A. cylindriformis*, though these species have been reported at or very near the areas that McIntosh collected. We speculate that habitat change may play a role in these changes of distribution and abundance.

Published research indicates that habitat degradation and habitat loss have strong influences on tiger beetle populations. Urban sprawl, heavy recreational use, cattle grazing, and pollution have all been shown to have an adverse affect on certain tiger beetle species (Pearson and Vogler 2001). Habitat change resulting from both natural and human-caused succession of vegetation communities may have a positive or negative effect on tiger beetle populations. Brush clearing and clearing of roads and trails have been shown to improve habitat, while natural encroachment of vegetation, often a result of fire suppression, adversely affects beetle habitat (Knisley and Schultz 1997). Maintenance of natural or human-made openings is important for thermoregulation behaviors in tiger beetles. Openings allow tiger beetles to bask in direct sunlight and maintain a high body temperature. If openings become thickly vegetated, they no longer serve as suitable habitat (Knisley and Hill 1992).

Several studies have shown the relationship between tiger beetle distributions and plant succession (Knisley and Hill 1992, Kritsky et al. 1999). As vegetational characteristics change, distribution and abundance of beetle species will also change.

The Black Hills area is intensely managed by four different federal government agencies, the state of South Dakota, and the Nature Conservancy, as well as having many private landholdings. Management of the Black Hills includes logging, grazing, fire management, wildlife habitat improvement, and increasing recreational use. There has also been a large increase in human inhabitance in the last 10 years. While we have attempted to document all tiger beetle species present, identify habitat preferences, and demonstrate temporal and spatial distributions, this report does not investigate the ways in which present management of this unique area could affect future tiger beetle populations. We hope that this research will be of use for providing baseline data on Cicindelidae populations and for management decisions and development of conservation measures.

Appendix A
Site Coordinates

Site	Begin	End
Angostura	625,191.36 X 4,794,418.63	624,279.37 X 4,794,021.48
Cheyenne River	616,654.15 X 4,795,519.83	616,561.39 X 4,795,549.64
Whitney Preserve	612,475.92 X 4,803,115.84	612,003.28 X 4,803,838.71
Cold Brook	622,282.37 X 4,812,744.03	622,132.68 X 4,813,683.16
Cold Brook	Archery Range	
Riflepit Road	620,098.37 X 4,827,313.86	619,583.18 X 4,826,705.64
Schenk Canyon	587,599.61 X 4,835,495.83	588,248.71 X 4,835,501.95
Bismark Lake	619,764.46 X 4,847,938.10	620,147.36 X 4,848,098.59
Moon Campground	579,582.58 X 4,866,204.17	579,213.28 X 4,866,473.76
Hayward	633,030.27 X 4,859.049.72	633,281.24 X 4,859,101.87
Steamboat Rock PG	622,501.63 X 4,890,175.61	622,108.75 X 4,889,998.06
Deerfield Lake	594,921.89 X 4,874,549.00	595,629.14 X 4,874,316.02
Black Fox	591,791.87 X 4,887,919.69	591,344.84 X 4,888,399.32
Keough Draw	593,292.66 X 4,900,626.60	593,119.18 X 4,899,849.14
Boundary Gulch	575,183.70 X 4,922,233.21	575,586.03 X 4,922,074.10
McNenny	104° 01'15" X 44° 33'30"	104° 01'00" X 44° 33'45"
Sturgis BLM	622,200.00 X 4,916,500.00	621,800.00 X 4,916,400.00

Note: The McNenny site coordinates are in Lat/Long. All others are in Universal Transverse Mercator (UTM).

Bibliography

Backlund, D.C., N. Backlund, G.L. Marrone, and S.A. Weins. 2000. New Distribution Records of Tiger Beetles (Coleoptera: Cicindelidae) from South Dakota, USA. CICINDELA 32:(1-2) 9-12.

Carter, M.R. 1989. The Biology and Ecology of the Tiger Beetles (Coleoptera: Cicindelidae) of Nebraska. Trans. of the Nebraska Academy of Sciences. XVII: 1-18.

Coffin, B., and L. Pfannmuller. Editors. 1988. Minnesota's Endangered Flora and Fauna. University of Minnesota Press. pp. 409-419.

Cutler, B. 1969. An Unusual Series of Cicindela limbalis from South Dakota. CICINDELA. pp. 5-7.

Freitag, R. 1999. Catalogue of the Tiger Beetles of Canada and the United States. NRC Research Press, Ottawa, Ontario, Canada K1A 0R6. 195p.

Gilbertson, G.I. 1929. The Cicindelidae (Tiger Beetles) of South Dakota. Proc. South Dakota Academy of Science. 29:22-26.

Glassel, R., R.L. Huber, and H.E. Huber. 1964. Log of a Black Hills Trip. South Dakota Bird Notes. 16(3): 67-68.

Graves, R.C., and D.W. Brzoska. 1991. The Tiger Beetles of Ohio (Coleoptera: Cicindelidae). Ohio Biol. Surv. Bull. New Series Vol 8 No. 4 vi + 42p.

Gries, J.P. 1998. Roadside Geology of South Dakota. Mountain Press Publishing Company, Missoula, Montana 59806.

Johnson, P.J. 1996. South Dakota's High Plains Tiger. South Dakota Conservation Digest. March/April. pp. 18-20.

Kippenhan, M.G. 1994. The Tiger Beetles (Coleoptera: Cicindelidae) of Colorado. Trans. Am. Entomol. Soc. 120: 1-86.

Kirk, V.M., and E.U. Balsbaugh, Jr. 1975. A List of the Beetles of South Dakota. Technical Bulletin 42. Agricultural Experiment Station, South Dakota State University, Brookings, South Dakota 57006.

Knisley, C.B., and T.D. Schultz. 1997. The Biology of Tiger Beetles and a Guide to the Species of the South Atlantic States. Special Publication No. 5. Virginia Museum of Natural History, Martinsville, VA.

Knisley, C.B., and J.M. Hill. Effects of Habitat Change from Ecological Succession and Human Impact on Tiger Beetles. 1992. Virginia Journal of Science. Vol. 43, Number 1B. 133-142.

Kritsky, G., A. Watkins, J. Smith, and N. Gallagher. 1999. Mixed Assemblages of Tiger Beetles on Sand Piles of Various Ages (Coleoptera: Cicindelidae). CICINDELA 31: (3-4) 73-80.

Larochelle, A. and M.-C. Larivière. 2001. Natural History of the Tiger Beetles of North America North of Mexico. CICINDELA 33: 41-162.

Larson, G.E., and J.R. Johnson. 1999. Plants of the Black Hills and Bear Lodge Mountains. South Dakota State University, Brookings, South Dakota 57007.

McIntosh, A.C. 1928. Biological Features of Cascade Valley and Vicinity. The Black Hills Engineer. Vol. 16, pp. 68-83.

Pearson, D.L., and A.P. Vogler. 2001. Tiger Beetles: The Evolution, Ecology, and Diversity of the Cicindelids. Comstock Publishing Associates, a Division of Cornell University Press.

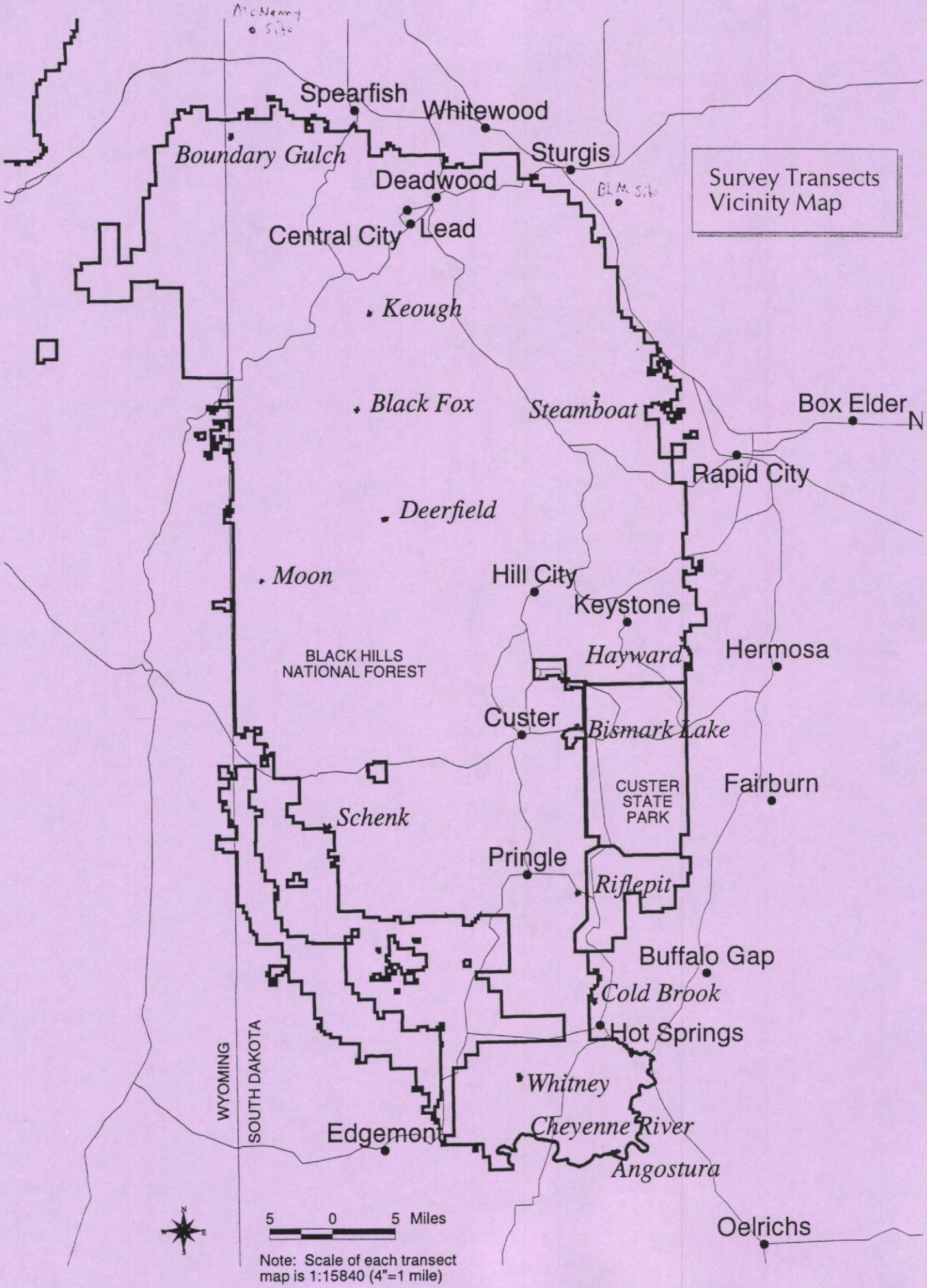
Pearson, D.L., T.G. Barraclough, and A.P. Vogler. 1997. Distributional Maps for North American Species of Tiger Beetles (Coleoptera: Cicindelidae). CICINDELA 29:33-84.

Schincariol, L.A. 1988. Mating Behaviour, Spermatophore Structure, Ecology and Systematics of the Cicindela Splendida Group (Coleoptera: Cicindelidae). M.Sc. Thesis, Lakehead University, Thunder Bay, Ontario. 236 pp.

Schincariol, L.A., and R. Freitag. 1991. Biological Character Analysis, Classification, and History of the North American Cicindela Splendida Hentz Group Taxa (Coleoptera: Cicindelidae). Can. Ent. 123: 1327-1353.

USDA Forest Service. 1980. Black Hills National Forest Ecological Land Units Study. Custer, South Dakota.

Van Bruggen, T. 1985. The Vascular Plants of South Dakota. Iowa State University Press. Ames, Iowa 50010.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Whitewood
Boundary Gulch
Sturgis
Deadwood
BLM Site
Central City
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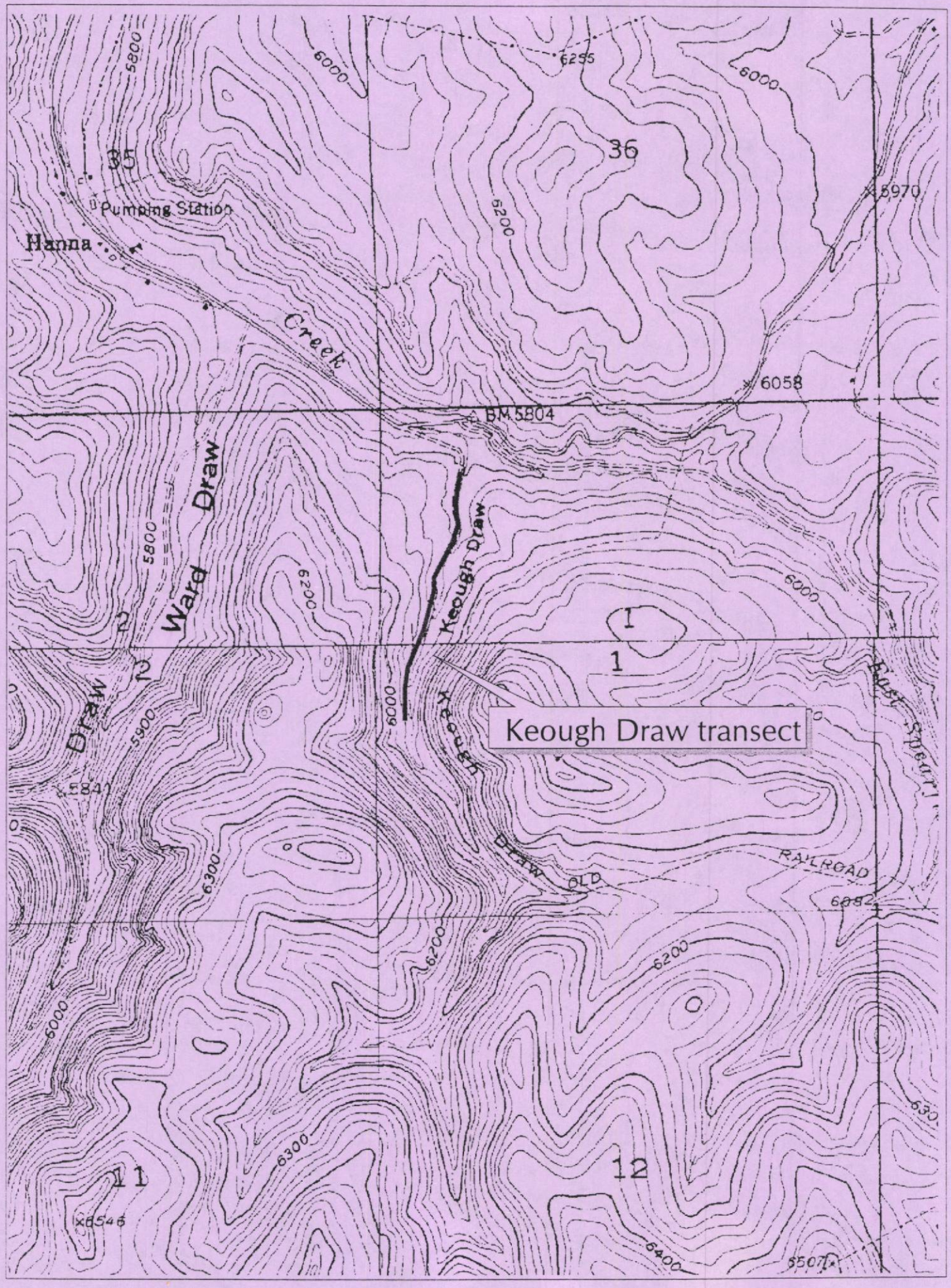
Keough
Black Fox
Steamboat
Box Elder
N
Rapid City
Deerfield
Moon
Hill City
Keystone
BLACK HILLS
NATIONAL FOREST
Hayward
Hermosa
Custer
Bismark Lake
CUSTER
STATE
PARK
Fairburn
Schenk
Pringle
Riflepit
Buffalo Gap
Cold Brook
Hot Springs
WYOMING
SOUTH DAKOTA
Whitney
Edgemont
Cheyenne River
Angostura
Oelrichs
5 0 5 Miles
Note: Scale of each transect
map is 1:15840 (4"=1 mile)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Keough
Draw
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Railroad
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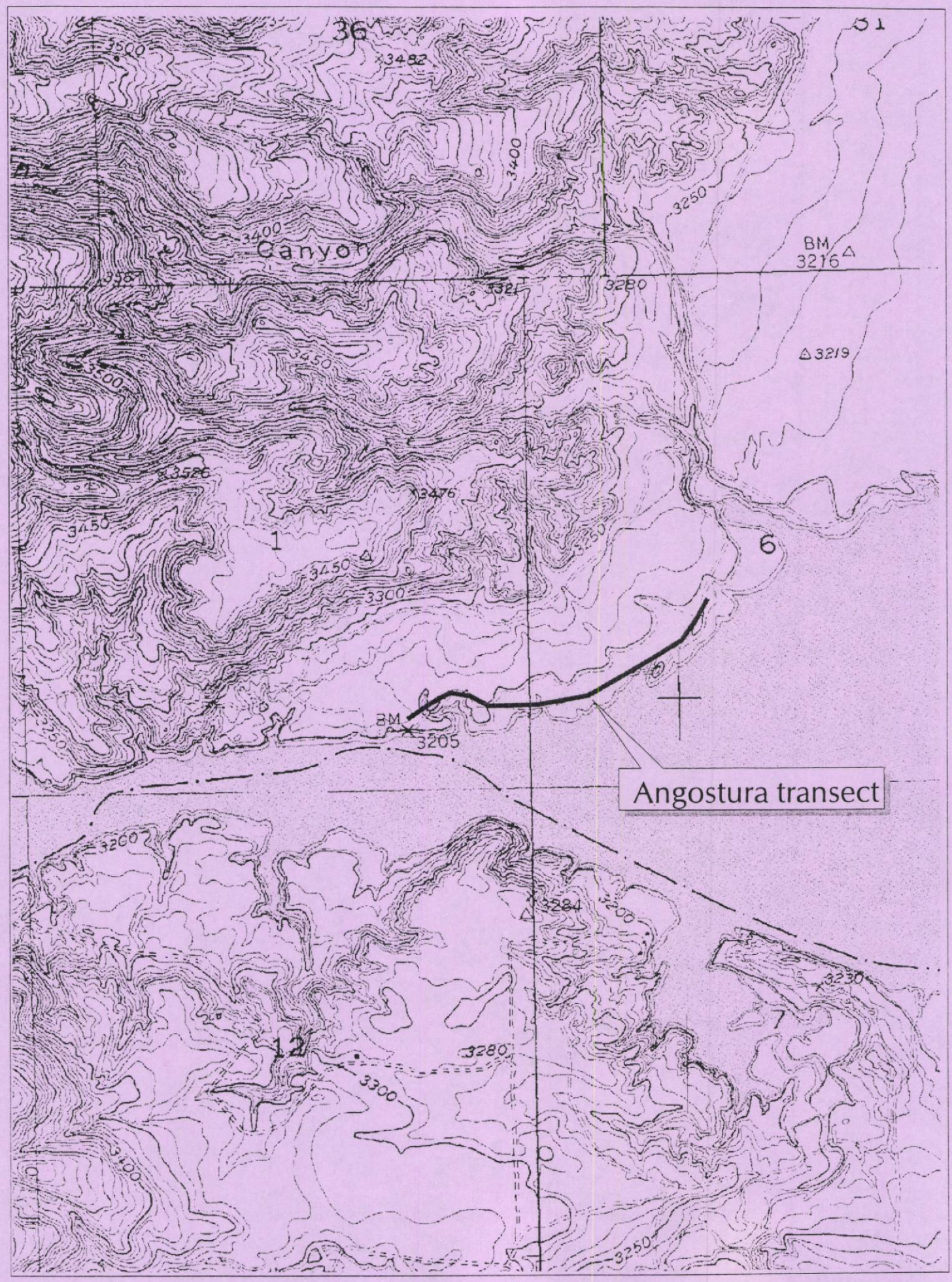
2
11
12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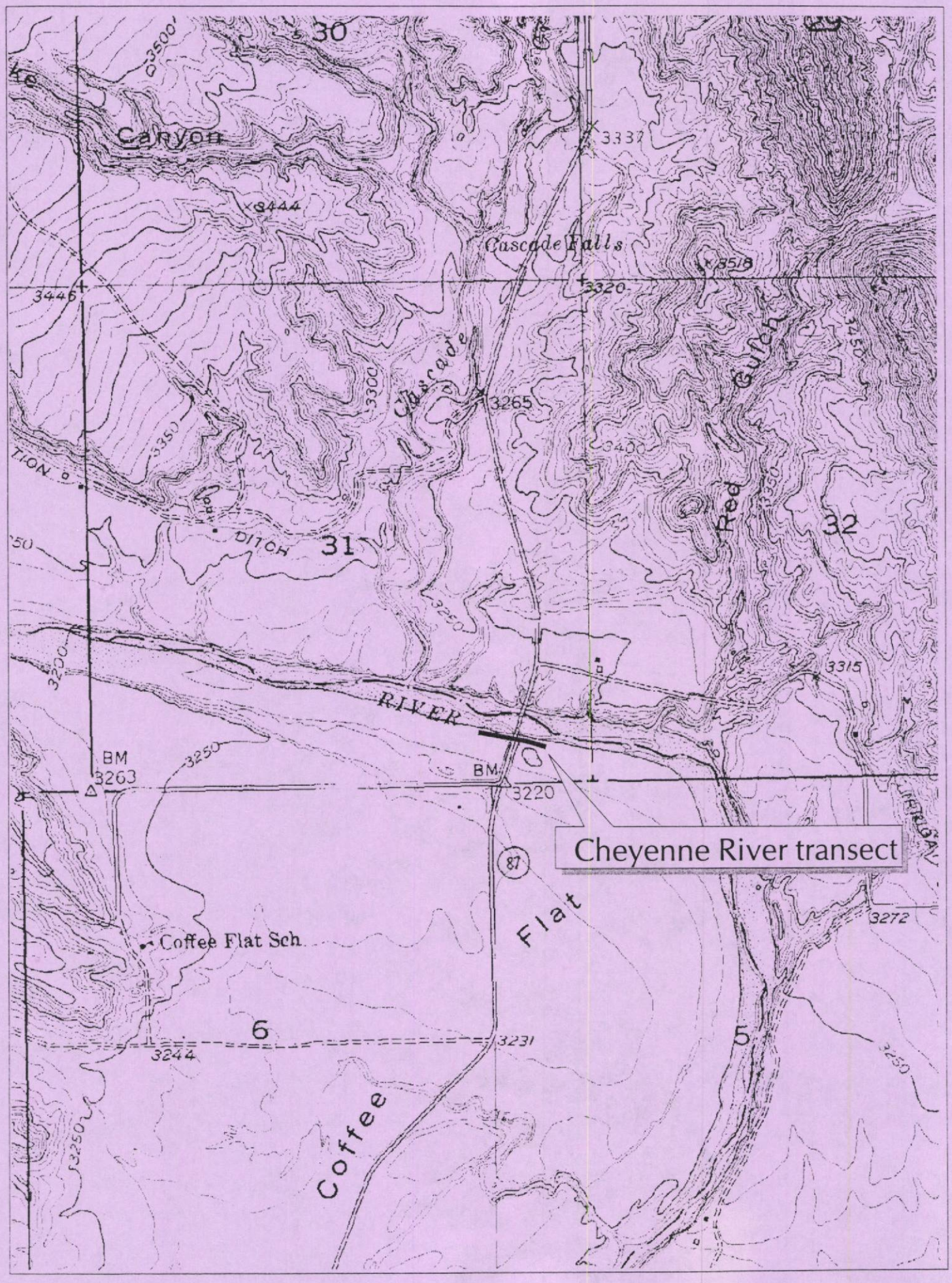
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Cascade Falls
Cascade
Red Gulch
RIVER
Coffee Flat Sch
Coffee Flat
DITCH
TION
BM 3263
BM 3220
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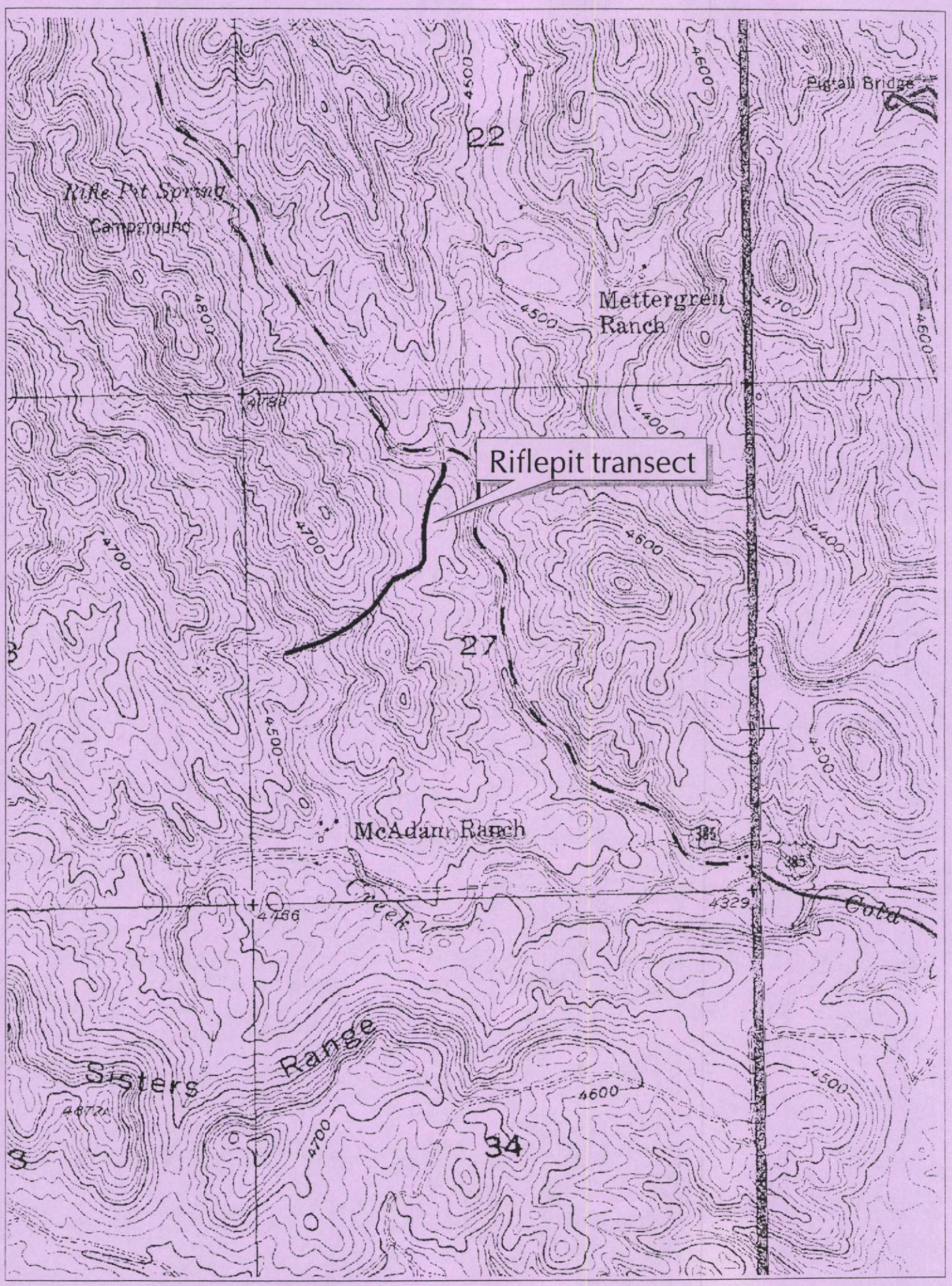
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Pigtail Bridge
Sisters
Range
Creek
Gold
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4600
4700
4800
4400
4329
4186
385


Whitney Preserve transect
Roundtop Hill
Falls Canyon
Miller Cabin
4435
4350
4366
4300
4179
4100
4162
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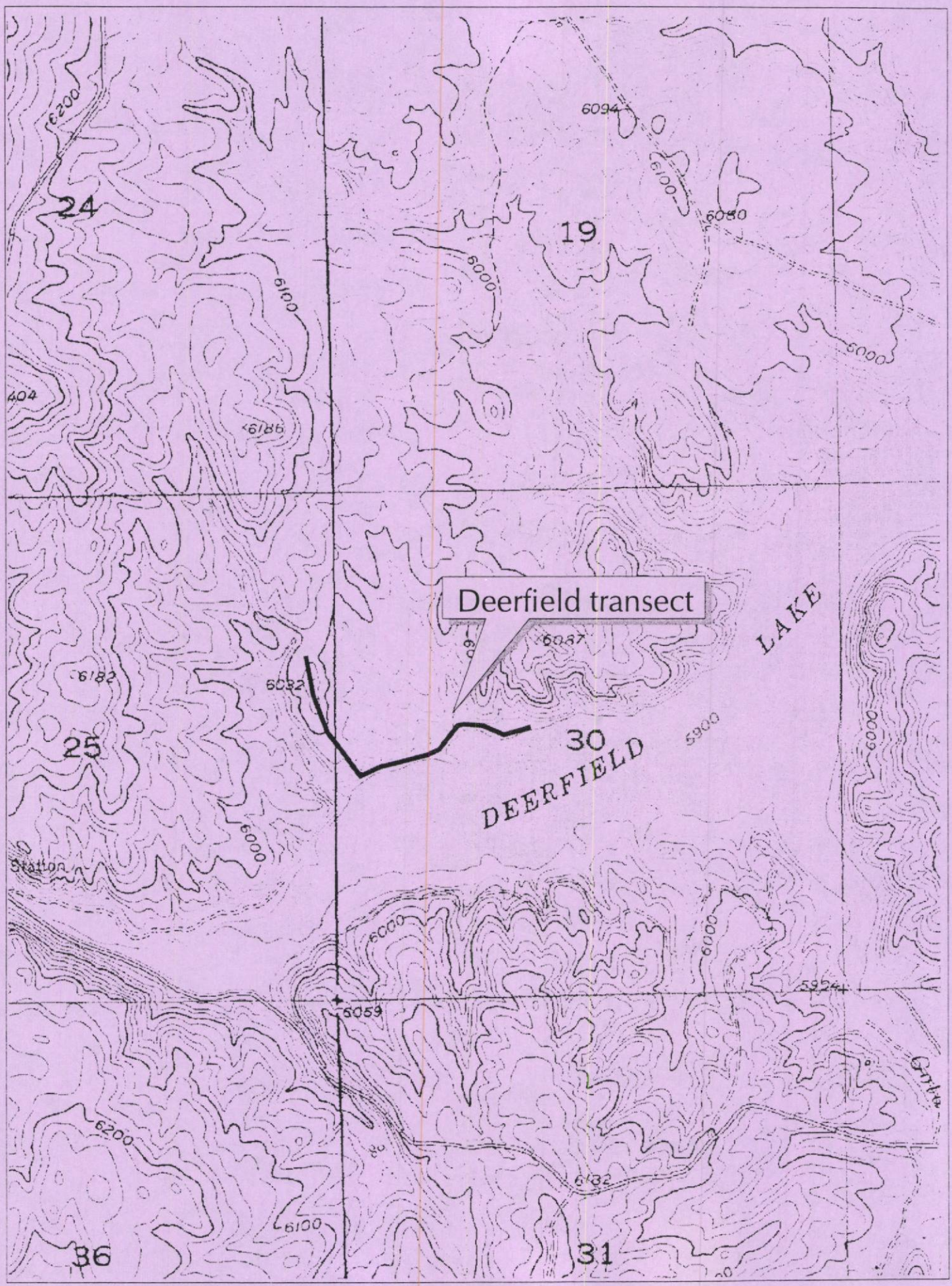
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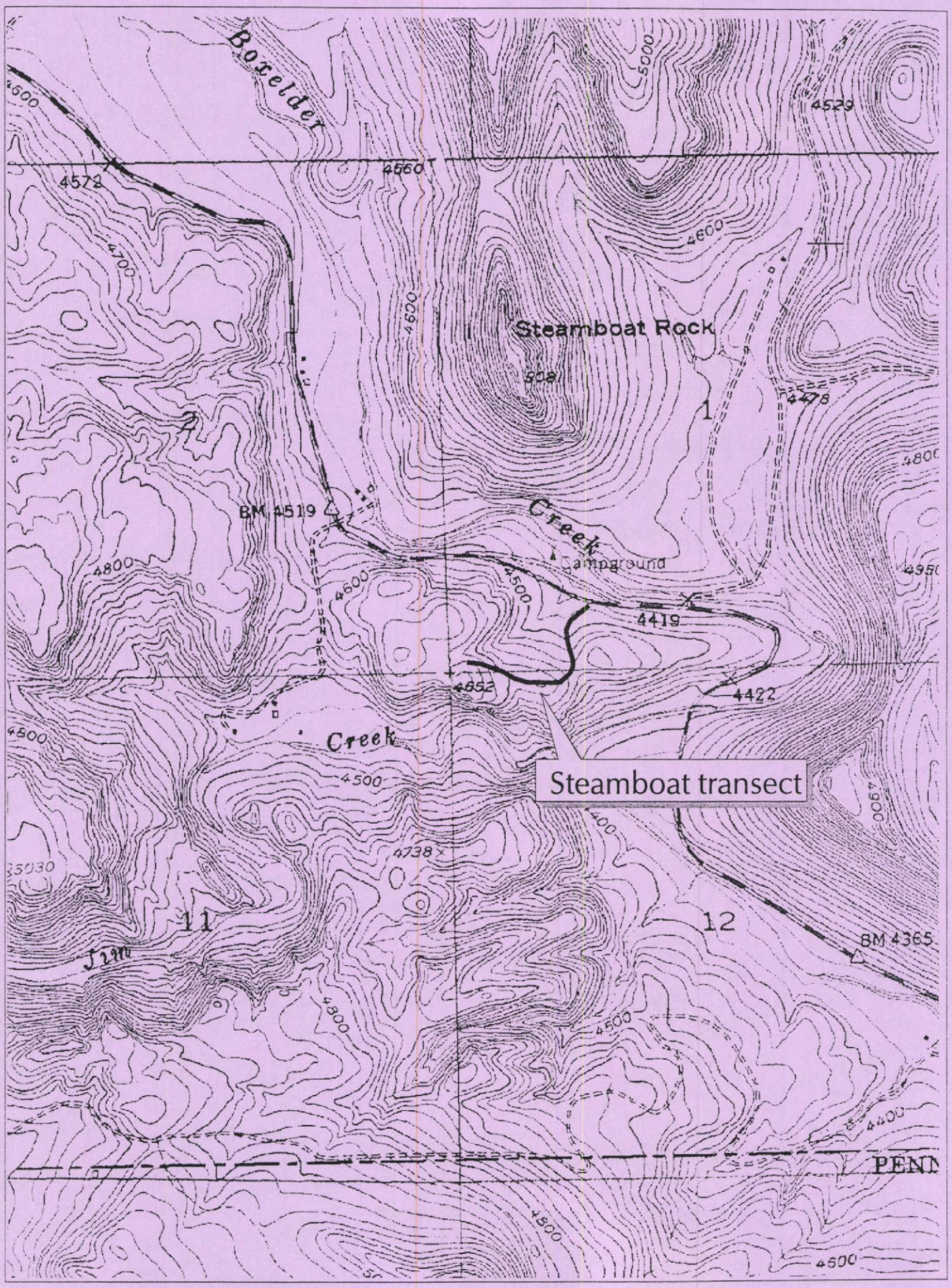
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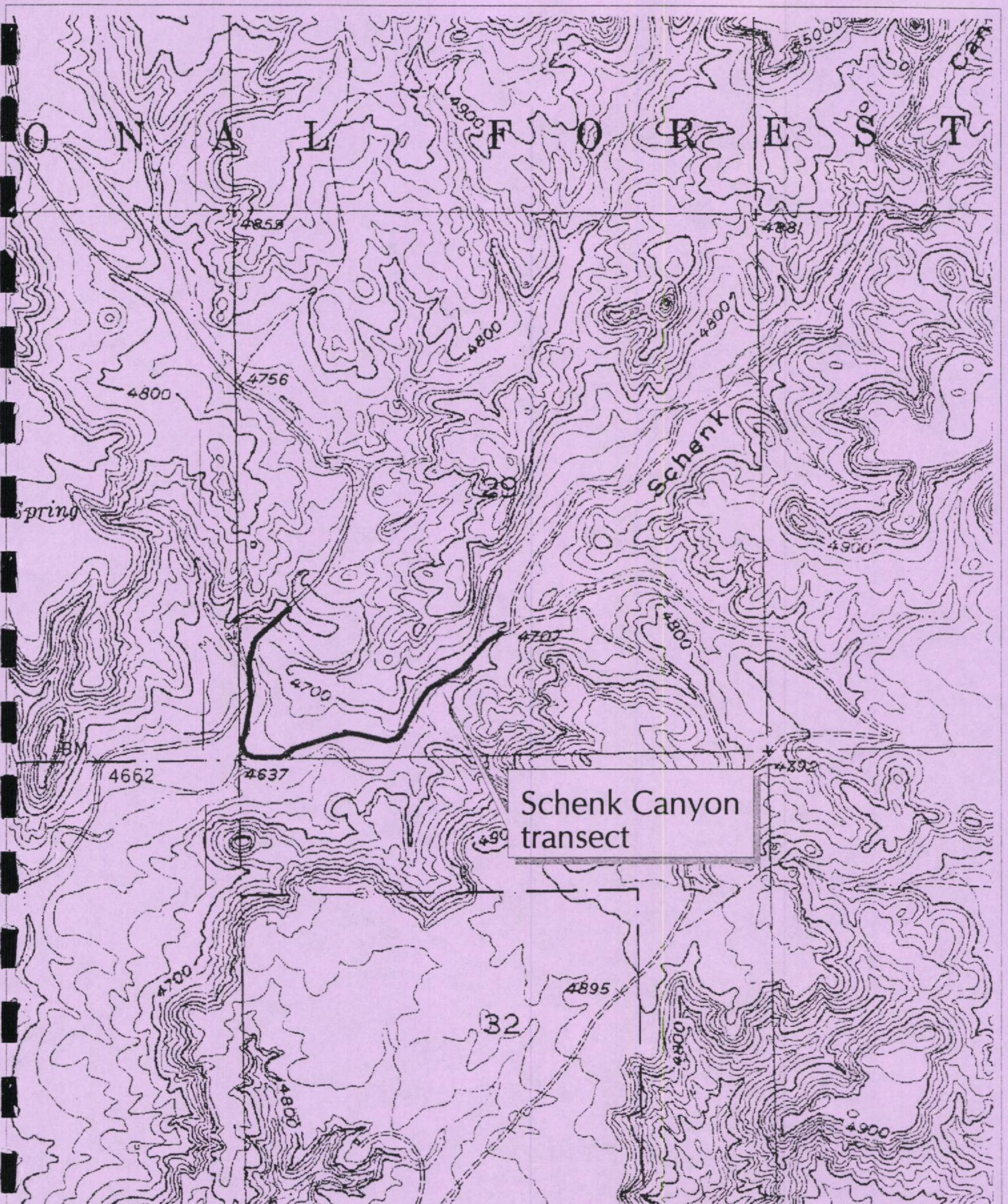
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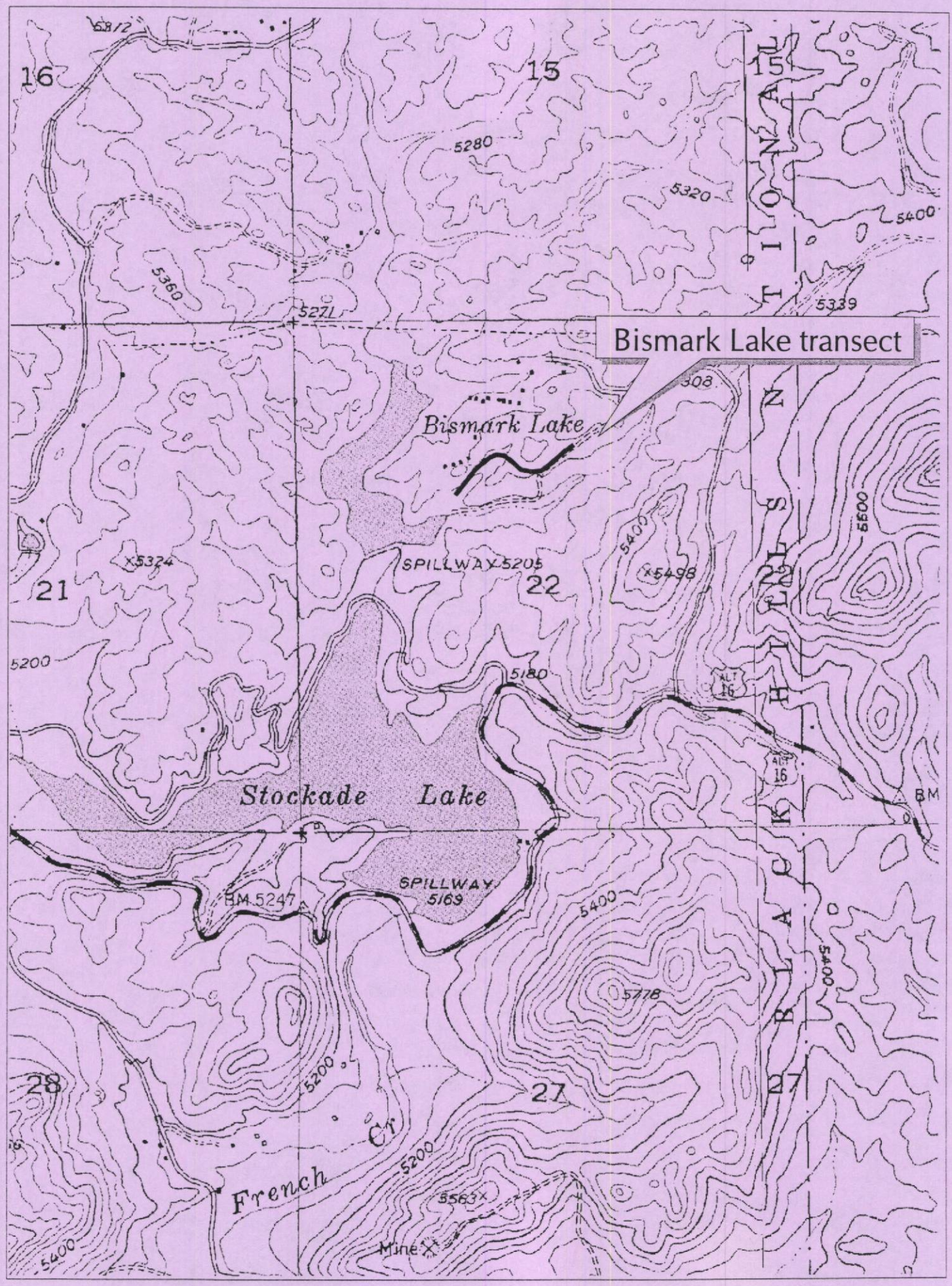
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Stockade Lake
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Mine
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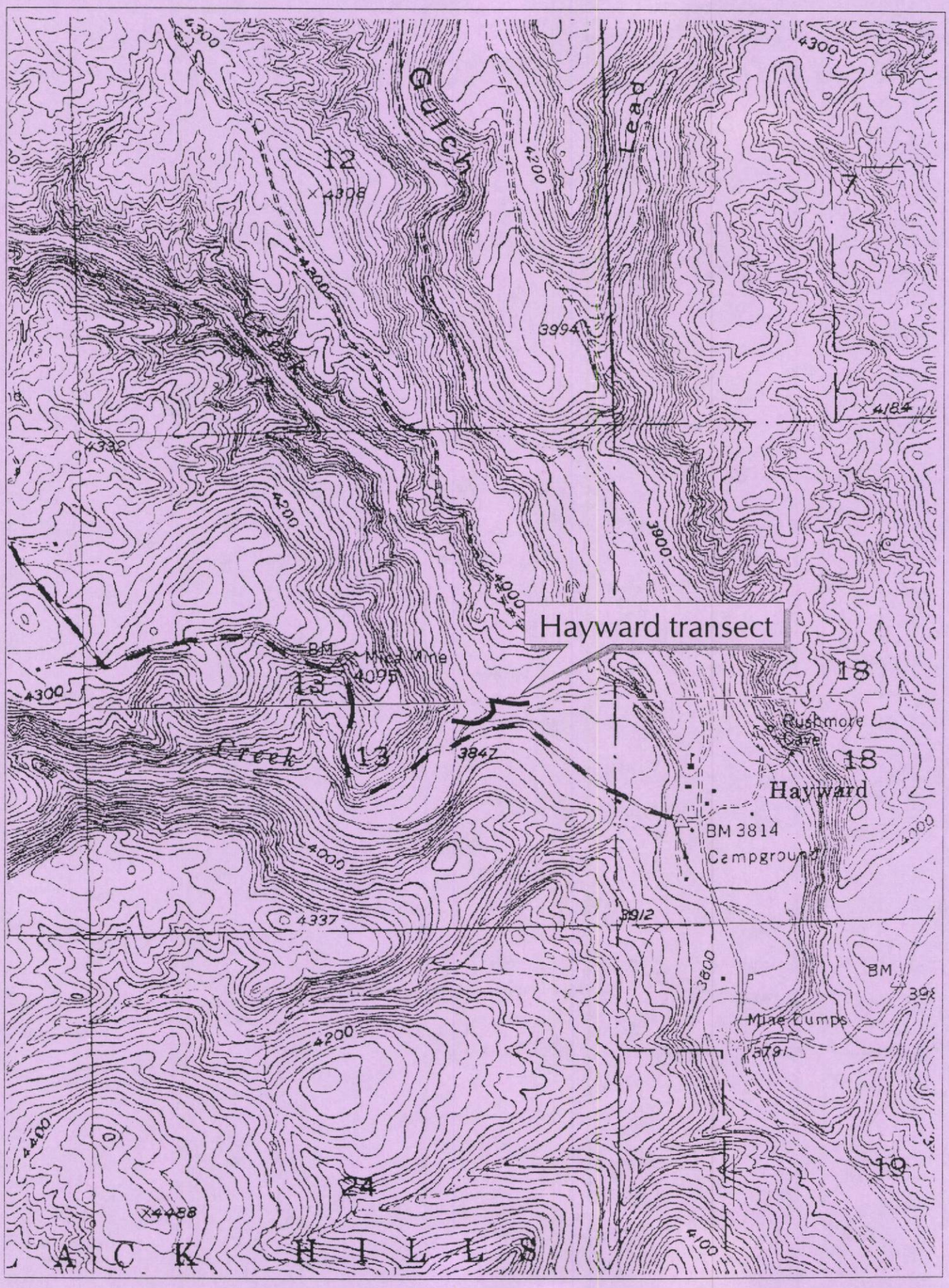
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Hayward
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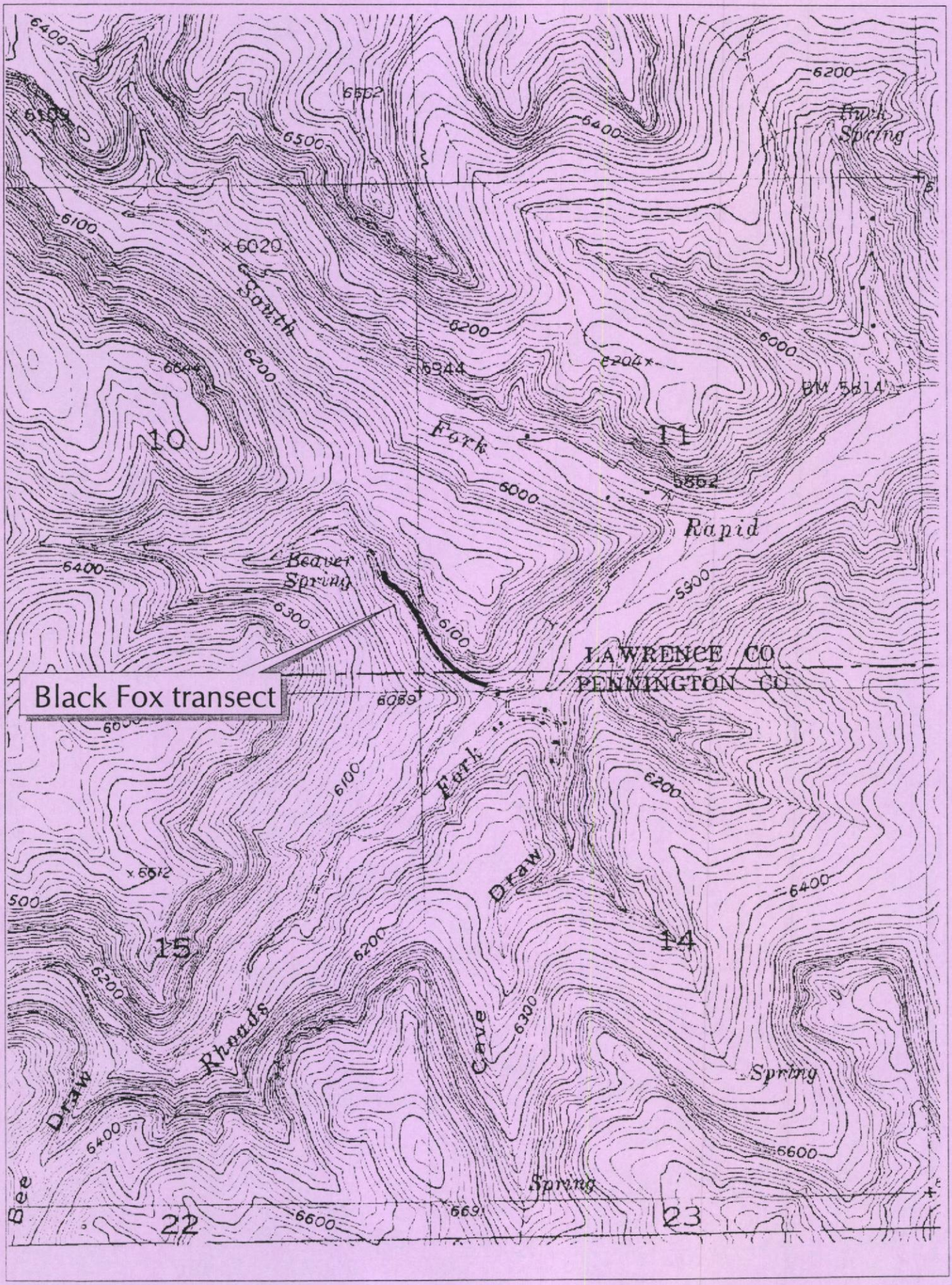
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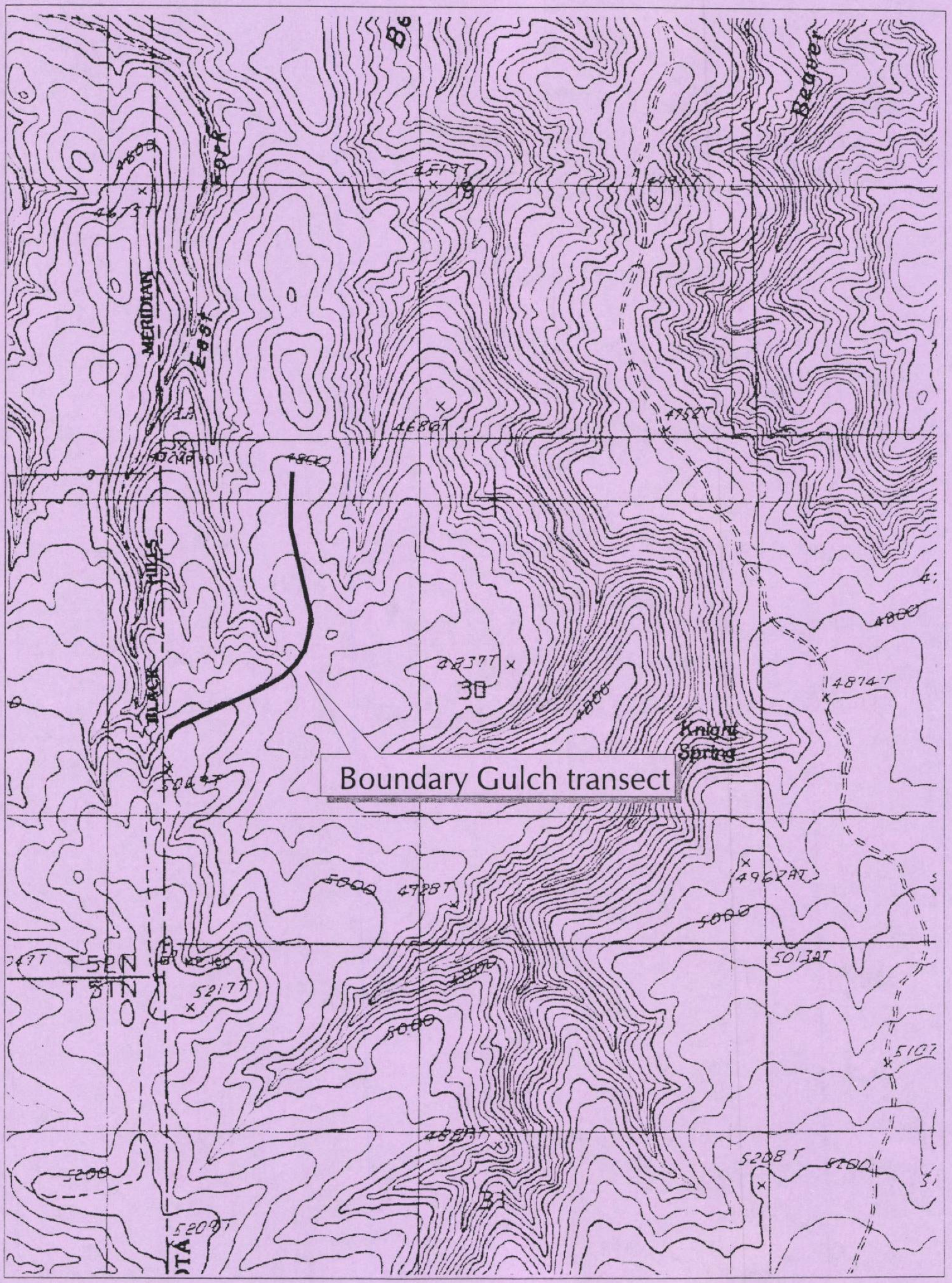

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T51N
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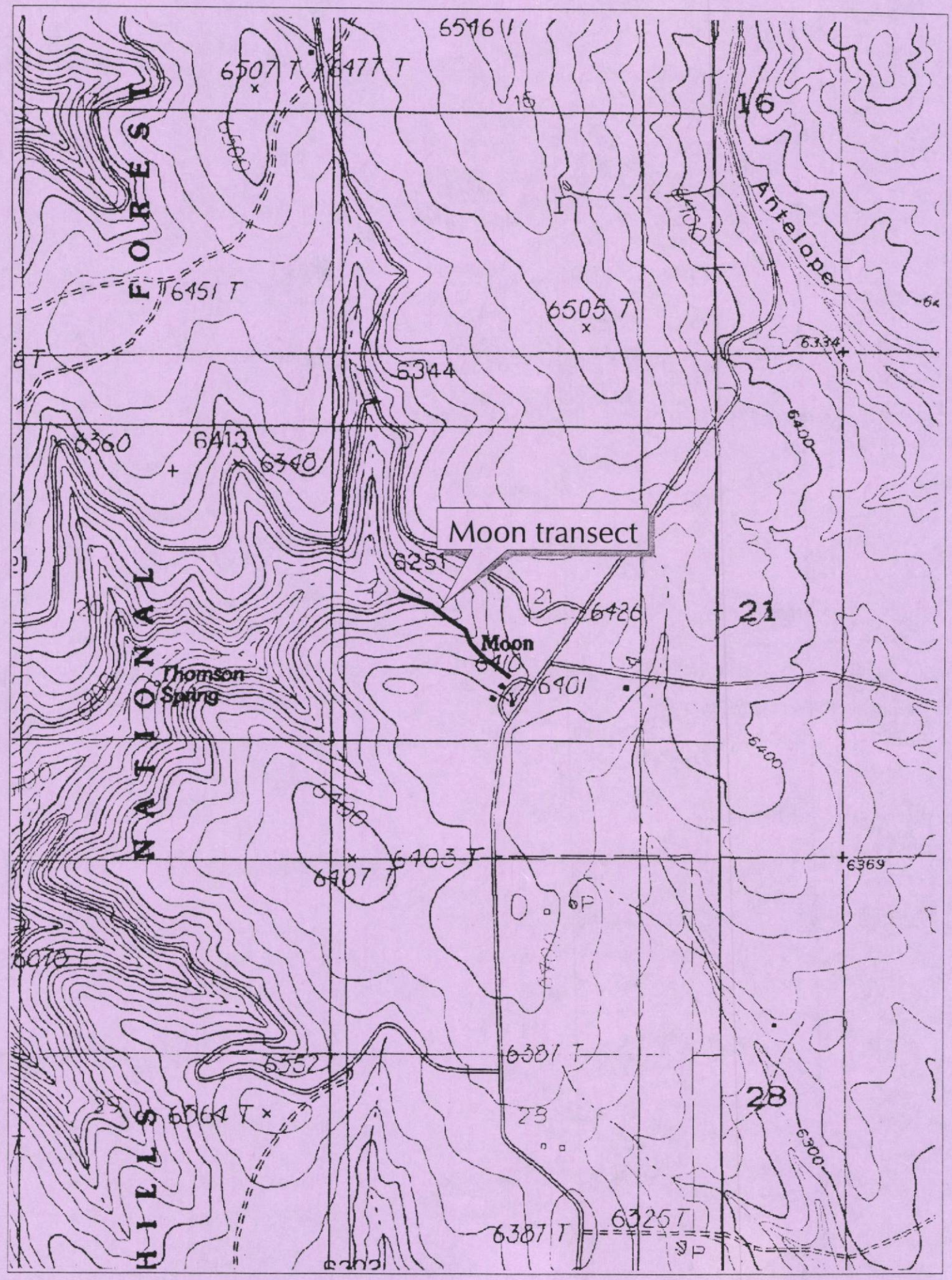
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6426
6401
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6381 T
6352
6364 T
6387 T
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