IDENTIFICATION OF ALLUVIAL VALLEY FLOORS IN STRIPPABLE COAL AREAS OF NEW MEXICO

Report to Emery Arnold, Director
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Introduction

In 1977, the U.S. Congress protected agriculturally-important alluvial valley floors in the western states from disruption by surface mining (U.S. Congress, 1977; U.S. House of Representatives, 1977a, b). Guidelines released by the Region V Office of Surface Mining (OSM) on June 11, 1980, suggested identification and study of alluvial valley floors (AVF) in areas of surface-mineable coal proceed in three phases. Phase I consists of preliminary investigations which can be used quickly to distinguish between "possible alluvial valley floors" and "lands clearly not alluvial valley floors". The other two phases consider detailed analyses of geology, hydrology, biology and land use of areas containing possible alluvial valley floors. To expedite planning and review processes in the State of New Mexico, initial (Phase I) identification of "clearly not alluvial valley floors", "possibly not alluvial valley floors" and "potential alluvial valley floors" was carried out by the New Mexico Bureau of Mines and and Mineral Resources and the Energy and Minerals Department. Such preliminary classification allows the staff of the Energy and Minerals Department, mine operators and other involved parties time to concentrate on the bottomland areas in and adjacent to mine sites whose hydrologic and agricultral functions must be protected during and after mining operations.

Procedures

Phase I studies were designed to evaluate the surficial geologic characteristics, hydrologic characteristics, biologic characteristics and land use characteristics that qualify or disqualify valley floors as potential alluvial valley floors (Table 1). This evaluation included office review of available hydrologic and geomorphic information on parts of the San Juan and Raton Basins with strippable coal resources, as well as field reconnaissance of most major stream valleys in these areas. Hydrologic data were collected and analyzed by T.C. Hobbs. Field work involved traverses (vehicular and foot) across critical valley-floor and stream-channel areas, and visits to wells and gauging stations where hydrologic data have been collected. Figures shown below are prints from photographs of representative drainages which were selected from a large set of color slides taken to illustrate the geomorphic setting at each traverse site. Once field investigations indicated the presence of possible alluvial valley floors, aerial photographs of the areas were studied to map the possible extent of irrigation and subirrigation adjacent to the modern streams. References given at the end of the report are divided into published references available in major libraries, and unpublished reports and communications on file at the Mining and Minerals Division in Santa Fe, New Mexico.

Results

Drainages within the strippable coal areas of New Mexico include the San Juan River System, La Plata River System, Chaco River System, Rio Puerco System, Puerco River System, and the Vermejo River System (Map 1). Table 2 lists the stream segments and valley-floor areas visited, as well as the 1:24,000 and 1:62,500 scale quadrangle maps used in the study. Figure 1 shows monthly discharge for monitored streams in the region.

Phase I studies indicate that alluvial valley floors are not present in most areas with existing or planned coal mine operations. There are only two areas in the San Juan and Raton Basins where hydrologic conditions are favorable for presence of alluvial valley floors. These are the valleys of larger perennial streams that head in alpine areas of the Sangre de Cristo, San Juan and La Plata Mountains. River valley segments with potential alluvial valley floors identified in this study are shown by solid lines on Map 1. They are the valleys of the La Plata River above La Plata to the state line, the San Juan River above the Hogback to Farmington, and the Vermejo River above Dawson to Vermejo Park. Water is fed to these streams by precipitation, snow melt, springs and seeps and is sustained throughout the growing season. The quality of water is acceptable for plant growth, and the regional practice of flood irrigation and subirrigation is clearly visible. It should be stressed that these river-valley segments contain reaches that probably are not alluvial valley floors, but detailed studies will be needed to establish the presence or absence of alluvial valley floors. As suggested in the Office of Surface Mining draft guidelines (7-11-80), applicants for mining permits in or adjacent to these potential AVF areas should consider starting Phase II AVF studies as soon as possible.

Two valley segments on Map 1 are marked with a dashed-line symbol. These include the lower reaches of Caliente and York Canyons (tributaries to the Vermejo River). The valley-floor areas contain channels of small perennial streams, but have not been flood-irrigated and do not appear to have potential for flood irrigation. York Canyon discharge partly reflects Vermejo River diversion for coal processing at the Kaiser Mine. Due to the high water table, there may be short valley-floor segments where limited subirrigation of crops is possible. Therefore, these areas were not placed in the "clearly not alluvial valley floors" category and they are informally designated "possibly not alluvial valley floors". Each area must be evaluated further.

"Lands clearly not alluvial valley floors" are shown by dotted symbols on Map 1. Streams in these valleys are primarily ephemeral with local intermittent reaches. Nearly all of the drainages in this classification can be characterized as incised steep-walled stream channels with sparse vegetation, flowing in response to runoff from precipitation. Flows are short-lived, and total suspended concentrations reach as much as 400,000 mg/l (U.S. Geological Survey data from numerous years; see references). There is no evidence (hydrologic or historic land use) that the valley floors can be successfully utilized for agricultural production involving flood irrigation or subirrigation practices. This conclusion is supported by unpublished independent studies by the Bureau of Land Management and Soil Conservation Service that relate directly to agricultural land use in the San Juan Basin (i.e. identification of prime farmlands and soils suitable for irrigation, as well as alluvial valley floors).

Investigations in Specific Drainages

San Juan River

The San Juan River System includes the San Juan River itself and the Shumway and Westwater Arroyos in the Fruitland (Kf) Coal Field (Map 1). The San Juan River (Map 2) has been classified as a "potential alluvial valley floor", as discussed earlier. Farming activities and extensive irrigation systems (e.g. Farmer's Mutual Irrigation Ditch and Jewett Valley Ditch) are clearly visible (Figure 2; Map 2).

Shumway and Westwater Arroyos are ephemeral (except for waste water discharge from the San Juan Power Plant; Figure 3). The arroyo channels are deeply incised and generally free of vegetation. Due to the waste water discharge from the San Juan Power Plant, the water quality can not be evaluated effectively. Water quality records indicate total dissolved solids as high as 9,600 mg/l and pH as low as 2.7 (U.S. Geological Survey, 1979). Water supplied to farming activities at the lower end of the Shumway drainage comes from irrigation facilities along the San Juan River and not from the Shumway watershed. These field areas are included in the potential alluvial valley floor area of the San Juan River (Map 2).

La Plata River

Streams within the upper Fruitland (Kf) coal field along the La Plata River drainage include the La Plata River, Murphy and McDermott Arroyos and Cinder Gulch. The La Plata River is a potential alluvial valley floor (Map 3). Discharge records for the La Plata River at Farmington and the Colorado-New Mexico State line show perennial flow at both stations. Agricultural activities are present throughout the La Plata valley (Figure 4) and a well-established irrigation network exists (e.g. Pioneer Ditch, Highland Park Ditch, Greenhorn Ditch and Cunningham Ditch).

McDermott, Cinder Gulch (Figure 5) and Murphy Arroyos are ephemeral tributaries to the La Plata system. The streams are incised, steep-walled channels with sparse vegetation, flowing only in response to runoff from precipitation. No irrigation practices exist along any of the three drainages. Water within the alluvial aquifer is at a depth of about six feet. Water quality is poor, with total disolved solids reaching as high as 12,000 mg/l (Western Coal Company, 1980).

Chaco River

The Chaco River System includes drainages within the Navajo (Kf), Bisti (Kf), Toadlena (Kmv), Hogback (Kmv), Newcomb (Kmv), Standing Rock (Kmv), Chaco Canyon (Kmfu), and Star Lake (Kf) coal fields (Map 1; Table 2). All streams are ephemeral, flowing in response to runoff from precipitation (Figures 6-13), except for the main stem of the Chaco River below the Four Corners Power Plant, which has a waste water base flow of about 30 cfs (U.S. Geological Survey data) and a short intermittent reach at the west edge of Chaco Canyon. Most streams are incised 10 feet or more. Total suspended sediment is normally above 30,000 mg/l, and has been reported at ten times this amount. Total dissolved solids average about 300 mg/l. Water-control structures in this area include spreader dikes and check dams. There is no evidence that flood irrigation is now being used or has been used on a regional scale in the recent historic past.

Small plots of "dry land" farming have been observed (commonly less than one acre), but these generally depend upon precipitation and hand-carried water from wells rather than irrigation as a water source. There are a few areas where farming is being conducted along Escavada Wash and Chaco River where shallow alluvial or deeper ground water wells are used to obtain water for irrigation.

For the most part, watersheds within the Chaco River system are not able to deliver enough water to sustain significant agricultural activity during the growing season. For example, De-Na-Zin Wash, located south of Bisti Trading Post, has a drainage area of 184 square miles. Water records for this drainage indicate that flows vary in frequency and intensity, with long periods when no flow of water is recorded. From October 1978, to September 1979, the De-Na-Zin gaging station recorded a total discharge for the watershed of 8992 acre-feet. Between April and September, 3165 acre-feet was discharged. Of 3165 acre-feet, 2650 acre-feet occurred during the middle of August and 474 acre-feet occurred in July. From April 15 through July 2 (79 days), 21 acre-feet of discharge was recorded, occurring entirely during the last week in May. No flows were recorded in June and September. From this data, it is evident that agricultural activities would require storage facilities for water to sustain crops through the high stress periods such as no flow periods which occurred during June and September. The expense of storage facilities would probably outweigh the viability of farming in these areas.

Puerco River

Streams in the Gallup (Kmv) coal field include the Puerco River, Defiance Draw, Burned Death Wash, Tse Bonita Wash, tributaries to Tse Bonita Wash, Coal Mine Wash, tributaries to Coal Mine Wash, Coal Mine Drainage, and the east and west forks of Catalpa Canyon (Figures 14-16). Except for Puerco River and part of Coal Mine Drainage, streams in the area are ephemeral, with deeply incised channels. Total suspended sediment in the northwestern ephemeral drainages is reported between 10,000 and 90,000 mg/l, and total dissolved solids are about 250 mg/l (Carbon Coal Company, 1979, 1980, 1981; Pittsburg and Midway Coal Company, 1981). No flood irrigation practices were found along the ephemeral drainages, and with stream channels so deeply incised, it is doubtful that any flood or subirrigation could exist.

Coal Mine Drainage flows intermittently from springs and seeps along the channel. The channel is incised discontinuously as an arroyo, but locally the channel is capable of overbank flooding and diversion to small (less than 10 acre) fields. No discharge records are available. Water analysis reports indicate the quality is poor, having total dissolved solids in the neighborhood of 4000 mg/l. Sulfate (SO_4) and Sodium (Na) concentrations are extremely high (Amcoal, Inc., 1978, 1979, 1980).

The Puerco River was a major ephemeral drainage prior to opening the Church Rock uranium mines. The Puerco River became perennial with base flow dependent upon mine dewatering at the Church Rock mines and sewage treatment at Gallup. Presently, the Puerco River has a base flow of about 3.0 cfs and peak flows occur between December and March (U.S. Geological Survey data). Water quality records are scarce, but episodic monitoring by the New Mexico Environmental Improvement Division shows a large variation in water quality, particularly after the tailings spill from the Church Rock area (Gallaher and Goad, 1981). No evidence of irrigation or subirrigation was found along the Puerco River near Mentmore.

Rio Puerco

The La Ventana (Kmv) coal field is within the Rio Puerco system. The Rio Puerco is intermittent in this area, as are some tributaries from the east. Diversions have been used for irrigation in the past, but none is used now. The Rio Puerco is incised up to 35 feet, and most tributaries are incised as well. An alluvial water table exists just below the stream bottom, with total dissolved solids of 1800 mg/l (Mining and Minerals Division, 1980, 1981; Ideal Basic Industries, 1980, 1981), but the vertical distance from the valley surface to the stream bottom precludes any type of subirrigation.

The Arroyo Hondo, San Pablo and San Miguel drainages can be considered intermittent, deriving their flow from precipitation, snow melt and seepage. All three drainages have deeply incised channels (at least 20 feet). Natural flood irrigation does not occur in these drainages. One land owner pumps water from the San Miguel drainage to the valley surface for crop use, but this is not considered a natural or gravity-fed irrigation system. No discharge or water quality data are available for these drainages.

Arroyo Balcon is an ephemeral drainage. No discharge or water quality reports were found. However, total suspended sediment is thought to be high during flows in response to runoff from precipitation events. A few stock tanks exist in the watershed, but normally they are dry.

Vermejo River

Drainages in the Raton coal field are part of the Canadian River system and include the headwaters of the Canadian River, Vermejo River, York Canyon, Salyers Canyon, Chimney Canyon, Caliente Canyon, Sawmill Canyon, Gachupin Canyon, Saltpeter Canyon, Spring Canyon, Dawson Canyon, Dillon Canyon, Raton Creek, and Potato Canyon. Vermejo River is considered a potential alluvial valley floor (Maps 1, 4, 5, Figures 17-22).

According to flow records, Vermejo River is perennial. Water quality is good, having total dissolved solids of about 200 mg/l. Suspended sediment in the base flow is generally about 30 mg/l while storm events produce much higher concentrations. Approximately 85 percent of all discharge occurs between May and September from precipitation and snow melt (U.S. Geological Survey data). Irrigation practices were employed in the past, but none was operating in 1980 (Figures 17 and 18).

Discharge in York Canyon and Caliente Canyon apparently is intermittent with perennial reaches (Figures 19-21). Water quality is good; total dissolved solids average about 280 ml/l (Kaiser Steel Corporation and Mining and Minerals Division, 1980). Discharge records are poor for the York Canyon drainage and virtually nonexistent for Caliente Canyon. Actual stream discharge computations were not part of the present study, so no conclusive interpretations can be made concerning the streams' potential to support significant agricultural activity. Stream channels are incised as much as 10 feet below the canyon floors (Figures 18-20). Appreciable amounts of vegetation line the channels. Because flow occurs at least intermittently and water quality is high, there is a potential for subirrigation at least. Further investigation needs to be conducted to verify irrigation potential.

All other drainages in the Raton Coal Field (KTvr) have been classified as "areas clearly not alluvial valley floors". These include Salyers Canyon, Chimney Canyon, Sawmill Canyon, Gachupin Canyon, Saltpeter Canyon, Spring Canyon, Dawson Canyon, Dillon Canyon (Figure 22), Raton Creek, Canadian River Canyon and Potato Canyon drainages. With the exception of Potato and Canadian Canyon drainages, all of these streams are ephemeral. Alluvium is extremely thin in places along the stream channels and stream channels are cut into bedrock in some areas. Flood plains locally are less than 50 feet wide. Water quality records for these streams are not available, but probably the quality is fair.

Discussion of Special Problems

Application of the suggested criteria for identifying alluvial valley floors encounters special problems in New Mexico. These include (1) the actual amount of water needed for crops compared with the two-acre-foot suggested criterion, (2) obtaining water rights for development of presently unirrigated land, (3) changes in stream regime due to other development in the area (i.e. uranium mine dewatering), and (4) minimizing disturbances to the hydrologic balance on and off mine sites, whether or not an alluvial valley floor is involved.

The two acre-feet of water per acre criterion discussed in the AVF guidelines may be adequate if the irrigation system employed is operating at near 100 percent efficiency. However, few systems operate at 100 percent efficiency. Sprinkler irrigation systems normally operate at about 65 percent efficiency, and flood irrigation ditches operate at about 30 percent efficiency (S.P. Neville, 1981, written communication). Unimproved flood irrigation ditches can be expected to operate at a lesser efficiency, depending upon the evaporation and infiltration characteristics of the structures. Thus, for alfalfa, 8.3 acre-feet of water would have to be diverted. Corn and other crops would require approximately 6 acre-feet of water.

Construction of structures to store water could enhance the amount available for irrigation in marginal areas. However, storage of water for irrigation requires a permit from the State Engineer for constructing structures and appropriating water (New Mexico Statutes, 1978). The persons involved would have to acquire existing water rights elsewhere in the hydrologic basins (San Juan and Raton). For the most part, these rights exist along the major perennial streams which would have more potential for productive agriculture than marginal lands along ephemeral channels.

As the present discharge along the Puerco River indicates, further mine dewatering and community development in the region could change many streams from being ephemeral to intermittent or perennial. This change in flow regime could affect the classification of the streams and make irrigation or subirrigation possible. However, the quality of mine water is not particularly good (Gallaher and Goad, 1981) and use permits would still have to be obtained because the water has already been appropriated.

Protecting essential hydrologic functions and maintaining the hydrologic balance in drainages disturbed by surface mining pose several difficult problems. The hydrologic balance and function of specific ephemeral streams are poorly understood. Maintenance of an alluvial aquifer upstream and downstream from a mined area may be impossible during the period of mining, but the system may return to near base-line conditions after mining ceases. Transport of water and sediments through areas disturbed by mines must be maintained in order to balance base-line conditions downstream. This implies that runoff and sediment production from mined areas may not need to be minimized and that water quality may not need to be upgraded beyond that produced by the natural system.

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Table 1. Guideline Criteria Indicative of Alluvial Valley Floors.

Surficial Geologic Criteria

1. Alluvial valley floors are underlain by nearly horizontal deposits of gravel, sand, silt and clay which are deposited by streams.
2. An alluvial valley floor is coursed by a bankfull channel at least 3.0 feet wide and 0.5 feet deep.
3. Valley width is greater than 50 feet.
4. Low terraces and distal portions of alluvial fans integrated with modern streams in lowland areas adjacent to modern streams may be included as parts of alluvial valley floors.

Hydrologic Criteria

1. The watershed must be capable of producing flood irrigation or have a potential for subirrigation which could sustain agricultural activities (generally more than 2 acre-ft of water per acre for irrigation; shallow water table for subirrigation).
2. The nature of waters used for irrigation are of a quality which poses no detrimental effect to soils or plants.
3. To the point to which it is economically feasible, the water to be used for irrigation can be taken readily from the watershed, in a manner which does not violate state or federal laws, and will not adversely affect any downstream users.
4. There is evidence that either flood irrigation or subirrigation is a regional practice.

Vegetative Criteria

1. Abundant vegetation in lowlands compared with adjacent areas.
2. Agriculturally-useful vegetation indicative of a shallow water table.
3. Evidence of recent hay production.

Land-use Criteria (other than those mentioned above)

1. Regional pattern of flood irrigation or subirrigation.
2. Standards for water application must be consistent with regional practice.
3. Area of alluvial valley floor generally must be more than 10 acres.

Exclusions

1. Colluvial and other surficial deposits along the valley margins which are higher than the modern flood plain and "are not irrigated by diversion of natural flow or ephemeral flood flow and are not subirrigated by underflow" (U.S. House of Representatives, 1977a).
2. Upland areas which are underlain by thin colluvial deposits.

Table 1 (cont'd)

3. Valleys without stream channels.
4. Areas where water quality data or solids data indicate that long-term degradation of the soil resource would result in reduction of the agricultural utility of the area.
5. Undeveloped range lands not significant to farming.
6. Small acreages within otherwise "clearly not alluvial valley floors".

Table 2.

Drainages checked under phase I of alluvial valley floor determination.

	Name of Coal Field Area	7½ Minute Quadrangle Map Name and Number
	Fruitland Field (Kf)	
**	La Plata River	La Plata (4-2)
	McDermott Arroyo	La Plata (4-2)
	Cinder Gulch	La Plata (4-2)
	Murphy Arroyo	La Plata (4-2)
	Westwater Arroyo	Waterflow (3-3)
	Shumway Arroyo	Waterflow (3-3
**	San Juan River	Waterflow (3-3), Fruitland (27-2), The Hogback North (26-1)
	Navajo Field (Kf)	
	Chaco River	The Hogback North (26-1), The Hogback South (26-4), Newcomb NE (50-1), Newcomb SE (50-4)
	Pinabete Wash	Newcomb NE (50-1), The Pillar NW (51-2)
	Cottonwood Wash	The Hogback South (26-4), Kirtland SW (27-3)
	Brimhall Wash	Newcomb SE (50-4), Burnham Trading Post(51-3)
	Chinde Wash	The Hogback North (26-1), Fruitland (27-2)
	northern No Name (Tpotla)	The Hogback South (26-4)
	southern No Name	Newcomb NE (50-1)
	Bisti Field (Kf)	
	Chaco River	Newcomb SE (50-4), Great Bend (74-1), The Pillar 3 NW (75-2), The Pillar 3 NE (75-1)
	Hunters Wash	Newcomb SE (50-4), Burnham Trading Post (51-3), Bisti Trading Post (51-4)
	Alamo Wash (tributary to De-na-zin)	Alamo Mesa West (52-3), Tanner Lake (76-2)
	De-na-zin Wash (Coal Creek)	The Pillar 3 NE (75-1), Tanner Lake (76-2)
	Ah-shi-sle-pah Wash	Pueblo Bonito NW (77-2), Pretty Rock (76-1), Kin Klizhin Ruins (76-4)
	Kimbeto Wash	Kimbeto (77-1), Pueblo Bonito (77-3)
	Escavada Wash	Pueblo Bonito (77-3), Sargent Ranch (77-4), Fire Rock Well (77-3)
	Toadlena Field (Kmv)	
	Chaco River	Newcomb SE (50-4)
NC	Captain Tom Wash	Newcomb SE (50-4), Newcomb (50-3)
	(others not checked)	

Table 2 (cont'd)

<u>Hogback Field (Kmv)</u>

	Chaco River (lower) (others not checked)	The Hogback North (26-1), Chimney Rock (2)

<u>Chaco Canyon Field (Kmfu)</u>

	Chaco River	Tanner Lake (76-2), La Vida Mission (76-3), Kin Klizhin Ruins (76-4), Pueblo Bonito (77-3)
	Tsaya drainage	Tanner Lake (76-2), Pretty Rock (76-1)
NC	Kim-ne-ni-oli Wash	La Vida Mission (76-3)
	No Name tributaries	La Vida Mission (76-3)

<u>Eastern Standing Rock Field (Kmfl)</u>

	Orphan Annie Tank	Orphan Annie Rock (125-1)
	tributaries	Orphan Annie Rock (125-1)

<u>Star Lake Field (Kf)</u>

	Chaco Wash	Pueblo Pintado (102-2), Pueblo Alto Trading Post (102-1), Star Lake (103-2)
	Gallo Wash	Pueblo Bonito (77-3), Sargent Ranch (77-4), Fire Rock Well (78-3)
	Escavada Wash	Pueblo Bonito (77-3), Sargent Ranch (77-4), Fire Rock Well (78-3)
	Canada Alemita	Fire Rock Well (78-3), Lybrook SE (78-4)
	Arroyo Pueblo Alto	Pueblo Alto Trading Post (102-1), Star Lake (103-2)
	Papers Wash	Star Lake (103-2)

<u>La Ventana Field (Kmv)</u>

	Rio Puerco	San Pablo (105-2), La Ventana (105-3)
	Arroyo Hondo	San Pablo (105-2)
	San Pablo	San Pablo (105-2)

<u>Gallup Field (Kmv)</u>

	Puerco River	Gallup West (121-4), Gallup East (122-3), Manuelito (145-2)
	Defiance Draw	Tse Bonita School (121-2), Samson Lake (121-3), Gallup West (121-4)
	Burned Death Wash	Twin Lakes (121-1), Gallup West (121-4)
	Tse Bonita Wash	Tse Bonita School (121-2), Zith-Tusayan Butte 4 NE (A129-1)
	Tributary to Tse Bonita Wash	Zith-Tusayan Butte 4 NE (A129-1)
	Coal Mine Wash (P&M)	Tse Bonita School (121-2), Zith-Tusayan Butte 4 NE (A129-1)

Table 2 (cont'd)

	Tributary to Coal Mine Wash (P&M)	Tse Bonita School (121-2), Zith-Tusayan Butte 4 NE (A129-1)
	Coal Mine drainage (Sundance)	Bread Springs (146-2)
	Catalpa Canyon	Bread Springs (146-2)
	Catalpa Canyon east tributary	Bread Springs (146-2)
	<u>Raton Field (KTvr)</u>	
**	Vermejo River	Casa Grande (17), Cimarron (41), Colfax (42-3)
*	York Canyon	Casa Grande (17)
	Salyers Canyon	Casa Grande (17)
	Chimney Canyon	Casa Grande (17)
*	Caliente Canyon	Casa Grande (17)
	Sawmill Canyon	Casa Grande (17)
	Gachupin Canyon	Casa Grande (17)
	Saltpeter Canyon	Saltpeter Mountain (42-2), Colfax (42-3)
	Spring Canyon	Cimarron (41)
	Dawson Canyon	Cimarron (41), Saltpeter Mountain (42-2)
	Dillon Canyon	Tin Pan Canyon (18-1), Raton (19-2)
	Raton Creek	Raton (19-2)
	Canadian River Canyon	Casa Grande (17), McWilliams Canyon (18-2)
	Potato Canyon	McWilliams Canyon (18-2)

** Potential AVF, needs intermediate level investigations (Part II OSM Guidelines).

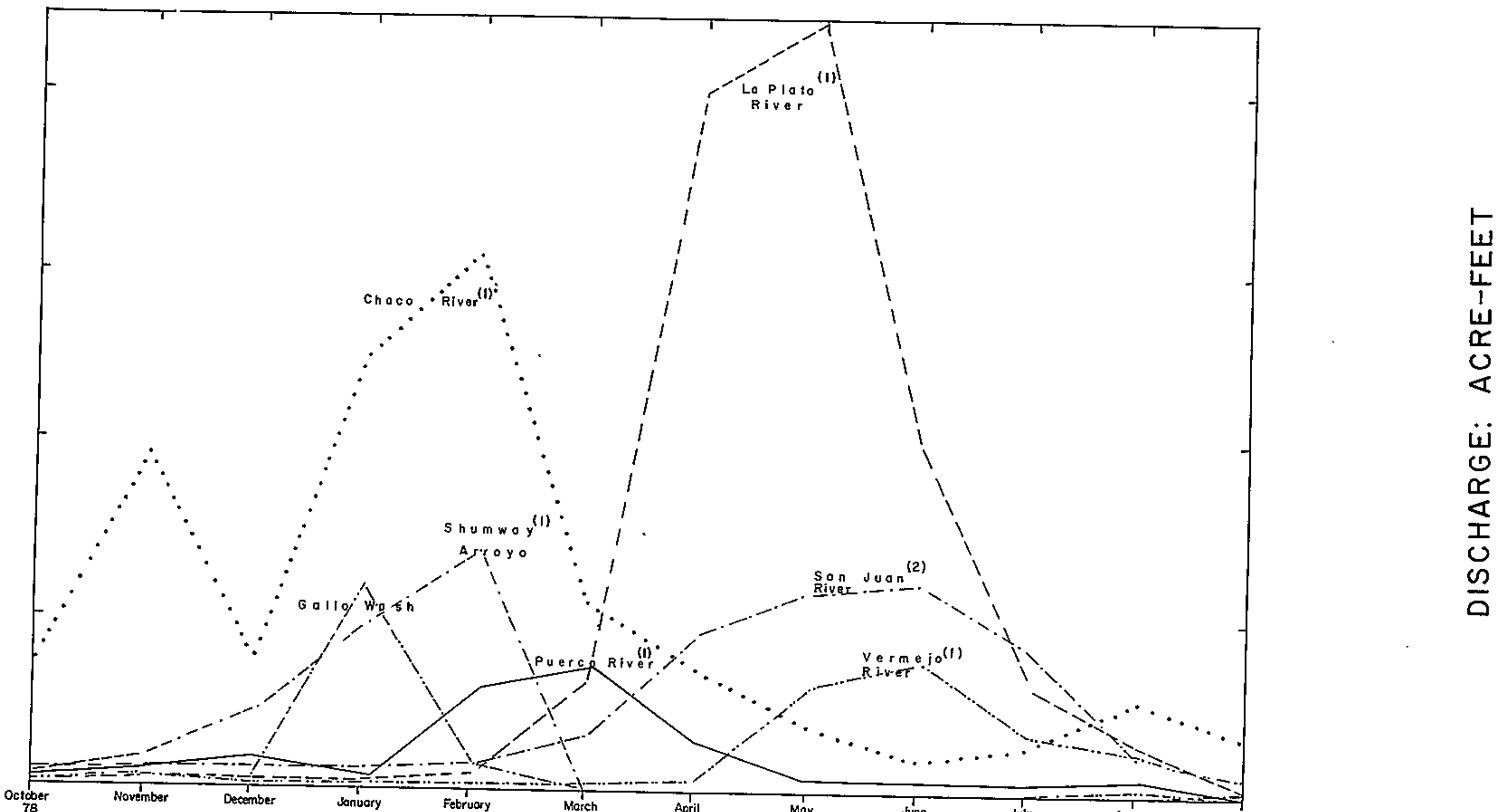
* Possibly not AVF, may need intermediate level investigations.

NC Not completely checked in this study

Drainages not marked with asterisks or NC are "clearly not alluvial valley floors".

List of Figures

List of Figures (cont'd)



(1) Exageration 1/10 to scale
(2) Exageration 1/1000 to scale

MONTH

SOURCE: USGS,WRD 1979

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OFR 188

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EXPLANATION FOR MAP 1 (IN POCKET)

Potential alluvial valley floors

Possibly not alluvial valley floors

Drainages clearly not alluvial valley floors

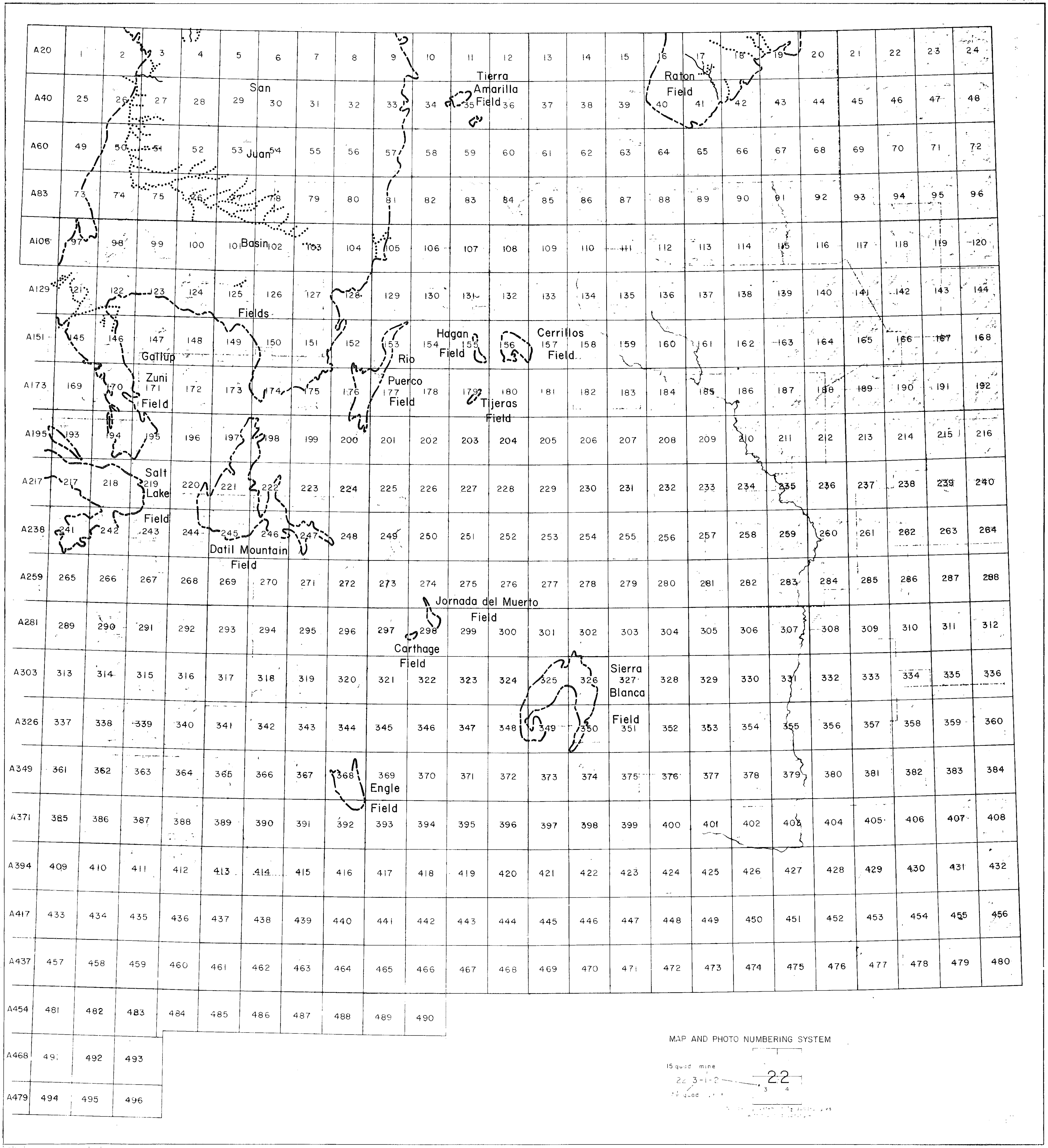
EXPLANATION FOR MAPS 2,3,4, AND 5 (IN POCKET)

Potential alluvial valley floors

Possibly not alluvial valley floors

Peripheral low-lying areas capable of irrigation

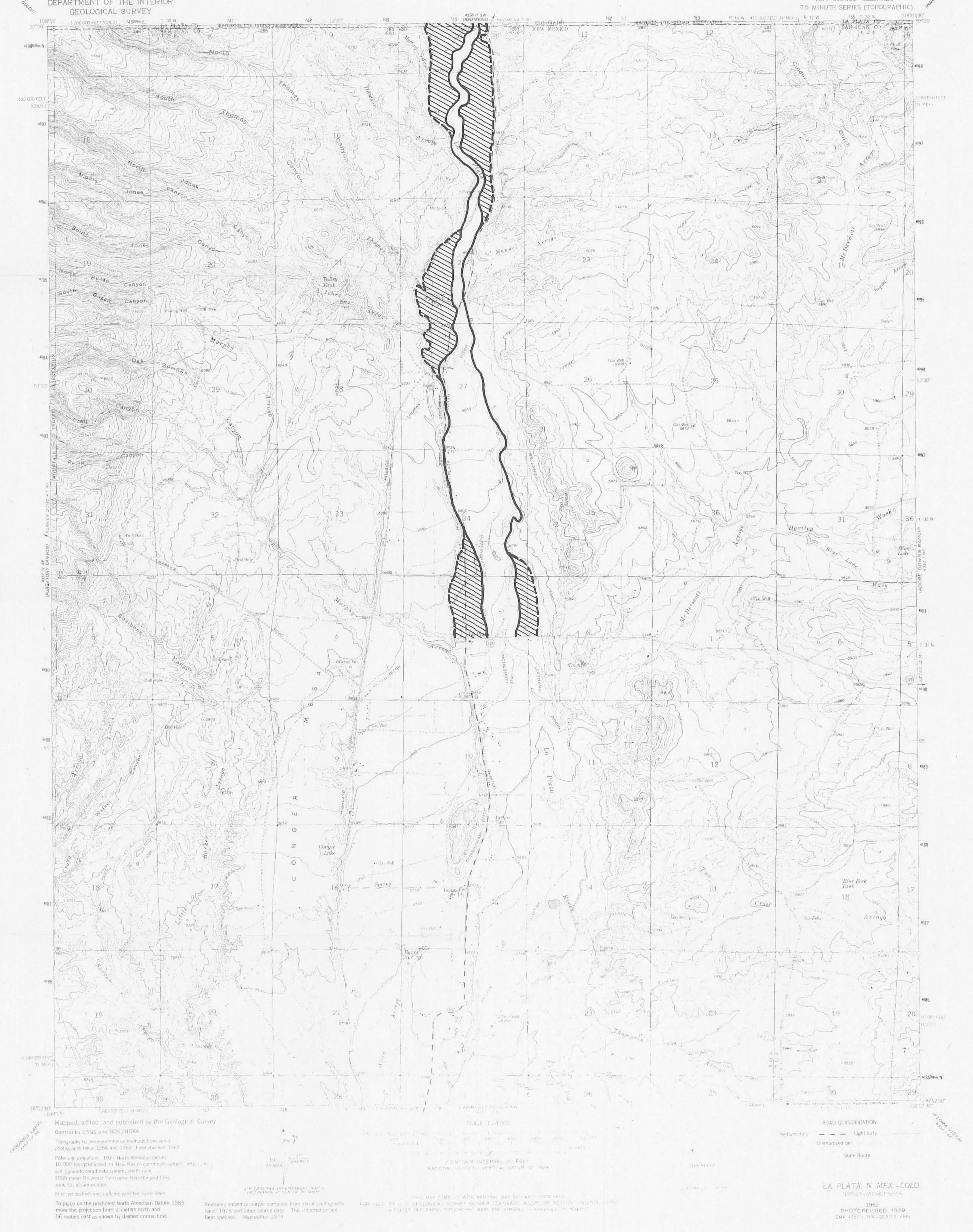
Map I


Tierra Amarilla Field
Raton Field
San Juan Basin Fields
Gallup
Zuni Field
Hagan Field
Cerrillos Field
Rio Puerco Field
Tijeras Field
Salt Lake Field
Datil Mountain Field
Jornada del Muerto Field
Carthage Field
Sierra Blanca Field
Engle Field
MAP AND PHOTO NUMBERING SYSTEM

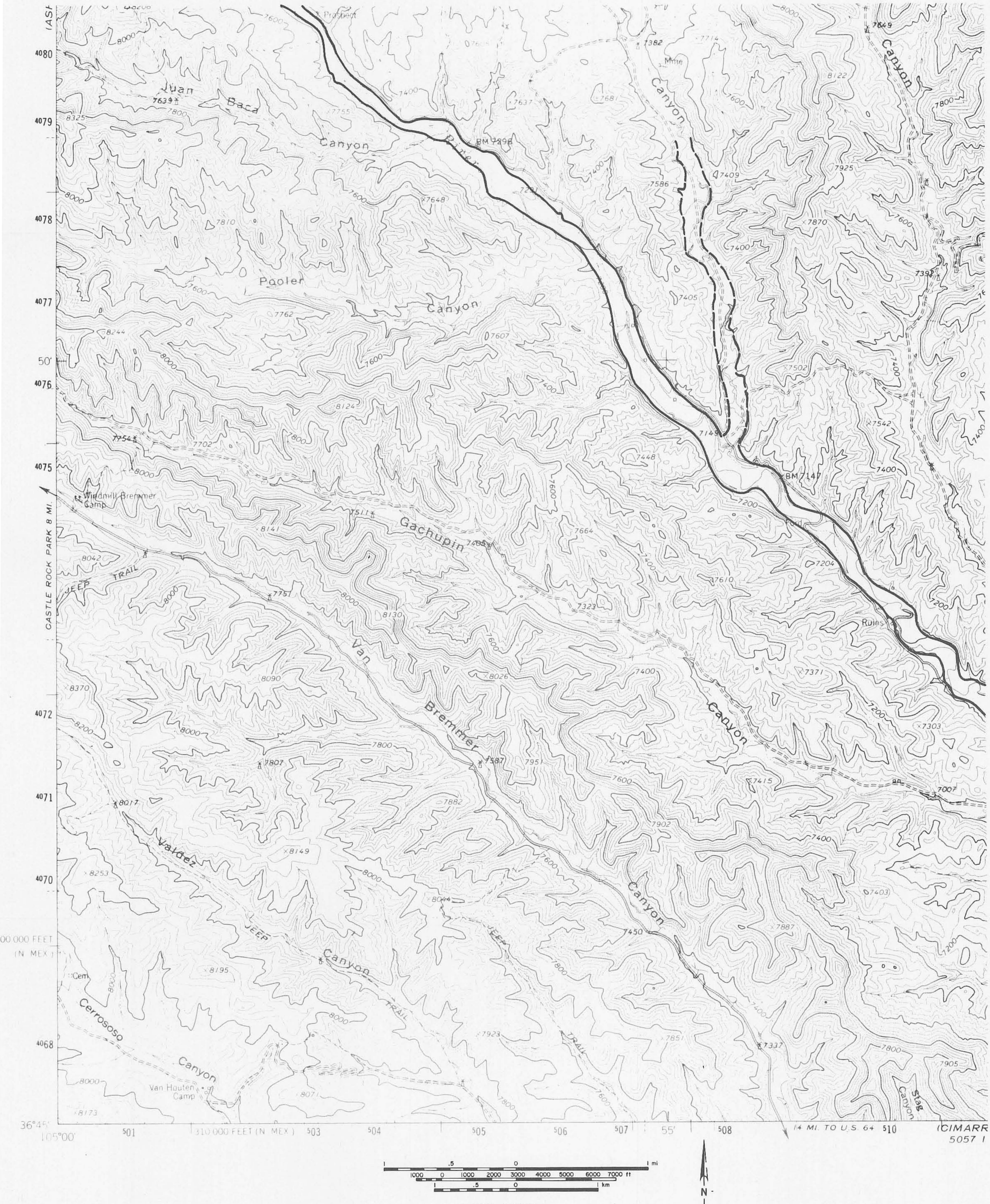
Map 2

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
7.5 MINUTE SERIES (TOPOGRAPHIC)
THE MEADOWS
Hutch
Canyon
Shumway
Jewett Valley
Waterflow
Trailer Park
FARMERS MUTUAL DITCH
SAN JUAN RIVER
NAVAJO INDIAN RESERVATION
IRRIGATION CANAL
FRUITLAND
Fruitland
Trading Post
Kirtland Cem
Pumping Sta
Sewage Disposal Pond
PIPELINE
MORGAN LAKE
NAVAJO
SPILLWAY ELEV 5328
Four Corners Powerplant
Stacks
Fatlings Pond
T. 30 N.
T. 29 N.
R. 16 W.
R. 15 W.
Mapped, edited, and published by the Geological Survey
Control by USGS, NOS/NOAA, and U. S. Bureau of Reclamation
Topography by photogrammetric methods from aerial photographs taken 1962. Field checked 1963
Polyconic projection. 1927 North American datum
10,000-foot grid based on New Mexico coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue
Fine red dashed lines indicate selected fence lines
Where omitted, land lines have not been established
To place on the predicted North American Datum 1983 move the projection lines 2 meters north and 57 meters east as shown by dashed corner ticks
UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
Revisions shown in purple compiled from aerial photographs taken 1978 and other source data. This information not field checked. Map edited 1979
SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U.S. Route
NEW MEXICO
QUADRANGLE LOCATION
FRUITLAND, N. MEX.
N3637.5—W10822.5/7.5
1966
PHOTOREVISED 1979
DMA 4357 III NW—SERIES V881
WATERFLOW, N. MEX.
N3645—W10822.5/7.5
1963
PHOTOREVISED 1979
DMA 4357 IV SW—SERIES V881

Map 3

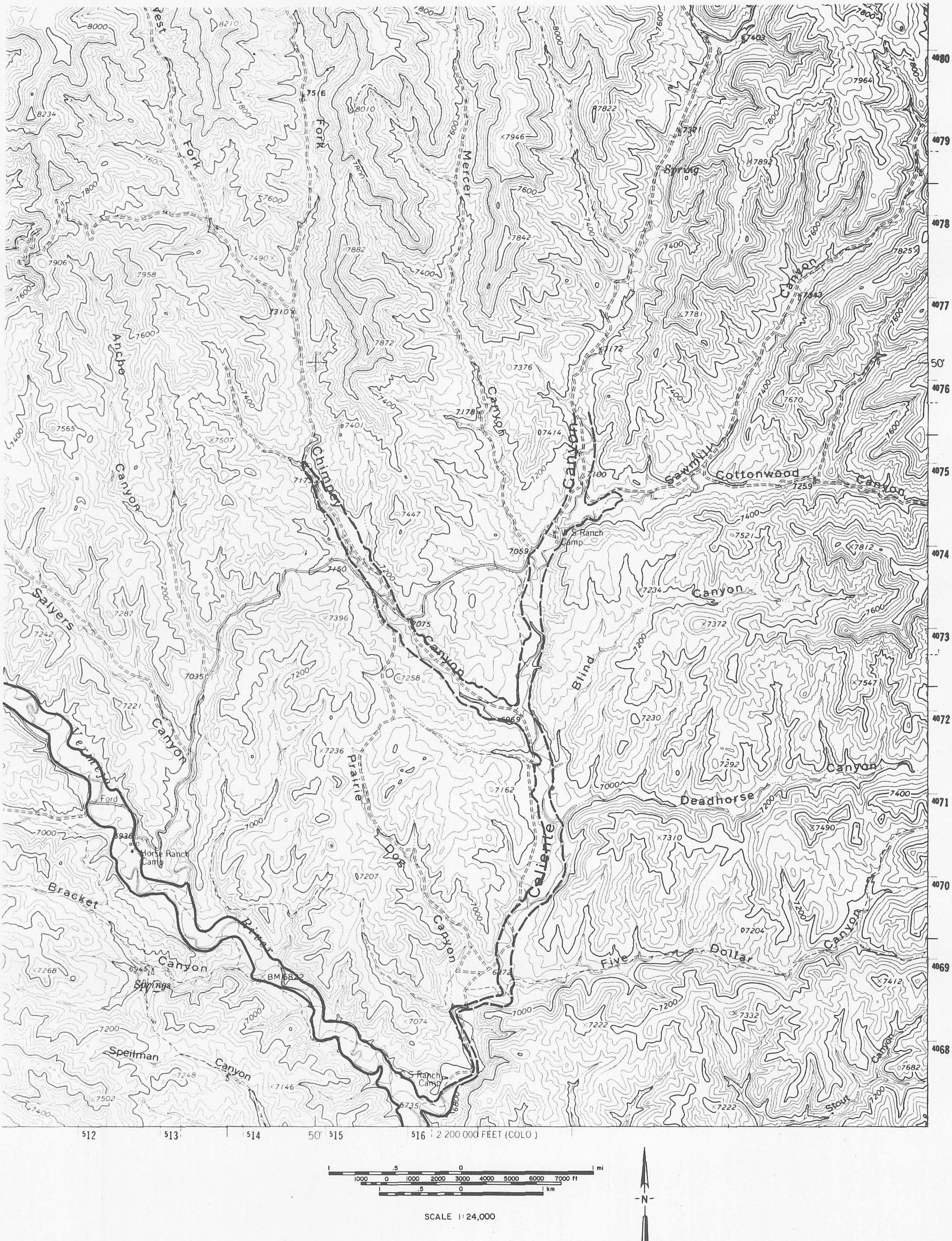

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
LA PLATA QUADRANGLE
NEW MEXICO-COLORADO
7.5 MINUTE SERIES (TOPOGRAPHIC)
COLORADO
NEW MEXICO
CONGER MESA
La Plata River
Mapped, edited, and published by the Geological Survey
Control by USGS and NOS/NOAA
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ROAD CLASSIFICATION
LA PLATA, N. MEX.-COLO.
1963
PHOTOREVISED 1979
To place on the predicted North American Datum 1983 move the projection lines 2 meters north and 56 meters east as shown by dashed corner ticks

Map 4



Juan Baca Canyon
Pooler Canyon
Gachupin Canyon
Van Bremmer Canyon
Valdez Canyon
Cerrososo Canyon
Canyon
Stag Canyon
Prospect
Mine
Ruins
BM 7298
BM 7147
Windmill Bremmer Camp
Van Houten Camp
Cem
JEEP TRAIL
CASTLE ROCK PARK 8 MI.
14 MI. TO U.S. 64
310 000 FEET (N. MEX.)
(N. MEX.)
36°45'
105°00'
55'
50'
(CIMARR
5057 I
SCALE 1:24,000
N

Map 5



Fork
Fork
Mercer
Canyon
Spring
Anche
Canyon
Chimney
Canyon
Canyon
Sawmill
Cottonwood
Canyon
S Ranch
Camp
Canyon
Salyers
Canyon
Blind
Deadhorse
Canyon
Prairie
Dog
Canyon
Caliente
Ford
Horse Ranch
Camp
Bracket
Canyon
River
Springs
BM 6822
Five
Dollar
Canyon
Speilman
Canyon
S Ranch
Camp
Stout
Canyon
50'
512
513
514
50'
515
516
2 200 000 FEET (COLO.)
1 .5 0 1 mi
1000 0 1000 2000 3000 4000 5000 6000 7000 ft
1 .5 0 1 km
N
SCALE 1:24,000