United States
Environmental Protection
Agency

Region VIII
1860 Lincoln Street
Denver, Colorado 80295

Solid Waste

EPA

A TECHNICAL ASSISTANCE PROGRAM REPORT

PAGOSA SPRINGS LANDFILL EVALUATION

#9491251

A TECHNICAL ASSISTANCE PANELS PROGRAM REPORT:

PAGOSA SPRINGS

LANDFILL EVALUATION

Prepared For:

U.S. Environmental Protection Agency
Region VIII

1860 Lincoln Street
Denver, Colorado 80295

Prepared by:

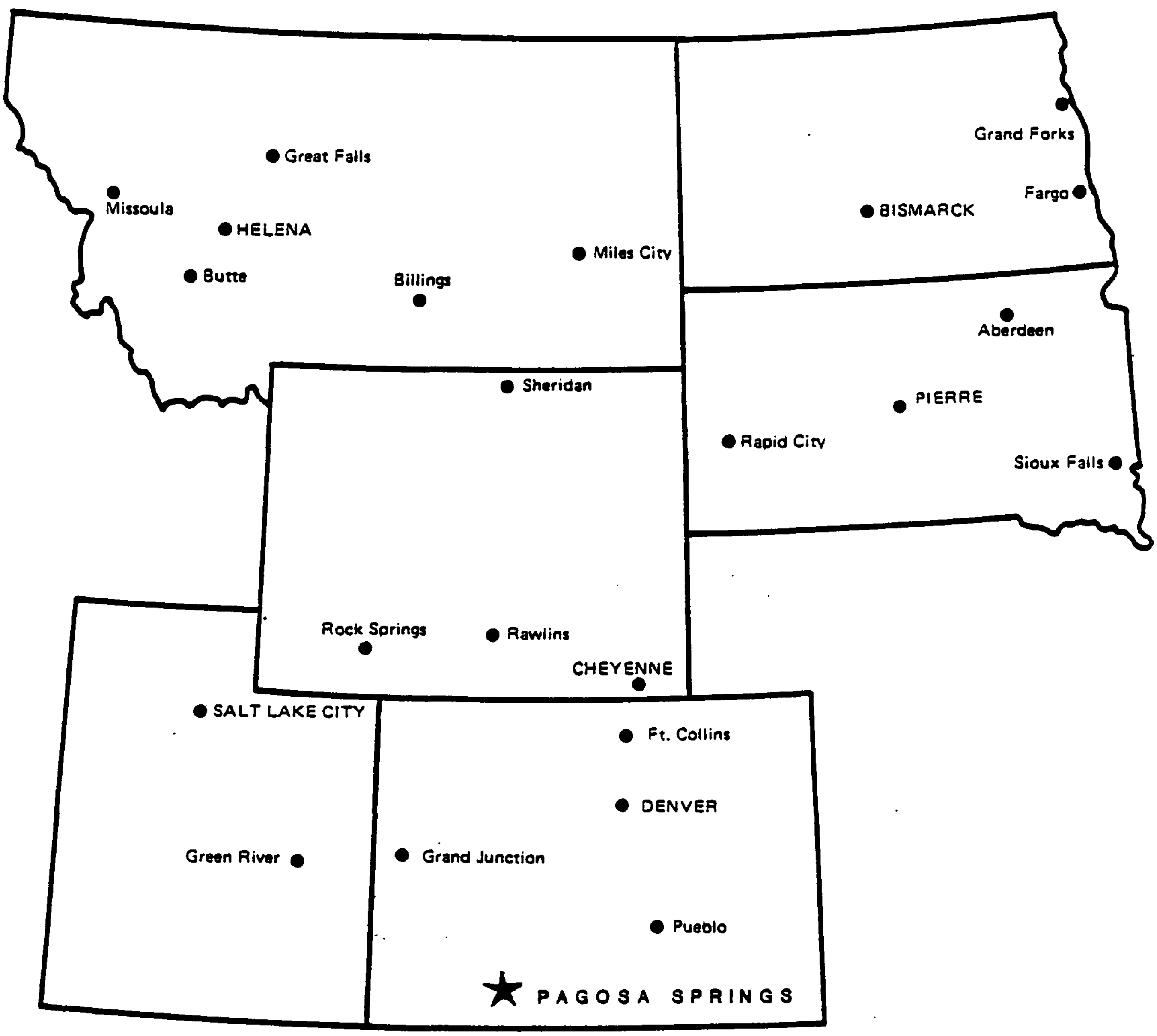
Fred C. Hart Associates, Inc.

Market Center
1320 17th Street
Denver, Colorado 80202

January, 1982

PAGOSA SPRINGS LANDFILL EVALUATION

ENVIRONMENTAL PROTECTION AGENCY REGION VIII



Public Law 94-580 - October 21, 1976

Technical assistance by personnel teams. 42 USC 6913

RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003. The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide States and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

Project Officer: William Rothenmeyer

TABLE OF CONTENTS

Page

LIST OF TABLES v

LIST OF FIGURES vi

I. EXECUTIVE SUMMARY 1

II. DESCRIPTION OF STUDY AREA

A. Introduction 3
B. Location 3
C. Population 4
D. Economy 8
E. Climate 9
F. Geology/Soils 11

III. PAGOSA SPRINGS LANDFILL EVALUATION

A. Introduction 17
B. Identification of Deficiencies 18
C. Upgrading Strategy 26
D. Estimated Life of Landfill 34
E. Landfill Operational Plan 39
F. Methodology For Implementing Proposed Plan 42
G. Review and Comment on User Charge System 44

IV. MILL CREEK SITE EVALUATION

A. Introduction 48
B. Surface Water 50
C. Hydrogeology 51
D. Other Environmental Constraints 51
E. Availability and Suitability of Cover Material .. 52

TABLE OF CONTENTS (Continued)

F. Land Area 53
G. Estimated Costs...................................... 57
H. Accessibility 61

REFERENCES 62

APPENDIX A

Soil Maps.. A-1

LIST OF TABLES

Table	Title	Page
1	Historical & Projected Population Data	7
2	Archuleta County Housing Data, 1978	8
3	Assessed Valuation of Archuleta County, 1979	9
4	Mean Monthly Precipitation and Evapotranspiration Data	11
5	Soil Survey Interpretations	14
6	Monthly Water Balance Analysis	21
7	Well Inventory, Pagosa Springs Area	24
8	Pagosa Springs Landfill Upgrading Costs	33
9	Estimated Available Landfill Capacity (Refuse)	37
10	Estimated Volume of Cover Material	38
11	Pagosa Springs Annual Landfill Operations Cost	41
12	Frequency of Customer Use at Pagosa Springs Landfill	45
13	Site Development Costs (Mill Creek Site)	58
14	Mill Creek Landfill Costs	60

LIST OF FIGURES

Figure	Title	Page
1	Topographic Map, Pagosa Springs Area	5
2	Geologic Map, Pagosa Springs Area	6
3	Cross Section through the Pagosa Springs Area, Colorado	13
4	Suitability of Soils for Landfill Operation	19
5	Elevation of the Potentiometric Surface, Dakota Sandstone	23
6	Potential Borrow Site Locations	28
7	Schematic of Landfill Cells	36
8	Mill Creek Site Location	49
9	Trench and Area Methods of Sanitary Landfilling	56

I. EXECUTIVE SUMMARY

The County's present population is served by a seven acre landfill situated near Pagosa Springs. Based on projected population figures (5,618 County residents by 1985) and a waste generation rate of 4.0 pounds per capita per day, it is calculated that eleven tons of waste per day (or 10,250 cubic yards of compacted waste per year) will be generated by the community. The estimated remaining life of the landfill is five years.

The primary concern to be addressed in order to ensure the environmental and esthetic integrity of the disposal site is the locating of sufficient quantity of soil that is suitable for cover material. Six potential borrow sites are designated that are: 1) in areas developed on Yawdim clay loam or Work loam, and; 2) within three or four miles of the landfill.

Hydrologic concerns at the landfill center on the recommended construction of diversion ditches to control run-on, leachate formation, contaminated run-off, and erosion. The report recommends that detailed groundwater monitoring not be initiated at this time, as minimal precipitation and rapid run-off limit leachate formation and the associated possibility of ground water contamination.

The upgrading strategy proposed for the landfill requires the following actions: 1) acquisition of sufficient suitable cover material; 2) upgrading of the present access road; 3) construction of a diversion ditch to control surface water flow; 4) construction of a gatehouse, and; 5) construction of a peripheral fence to control access and windblown debris. The total estimated cost of upgrading the Pagosa Springs landfill is $43,600.

A reconnaissance study of the Mill Creek area (2 1/2 miles east of Pagosa Springs) is also presented in this report. Preliminary investigations indicate that Mill Creek may prove suitable for landfill operations when the facility at Pagosa Springs reaches capacity (i.e., 1985). Favorable characteristics at Mill Creek include: 1) proximity to user population; 2) suitable topography and geology; 3) ready access via existing roads; 4) State ownership, and; 5) current non-intensive land use.

It is calculated that, if developed and operated properly, a landfill at Mill Creek will meet the requirements of the community for twenty-five years. The Mill Creek site development costs (exclusive of land purchase) are estimated to be $45,300.

II. DESCRIPTION OF STUDY AREA

A. Introduction

In the Resource Conservation and Recovery Act (RCRA) Congress gave the Environmental Protection Agency (EPA) authority to provide local governments with technical assistance on solid waste management. Using this authority, EPA Region VIII provided consultant assistance to evaluate the landfill at the Town of Pagosa Springs, Archuleta County, Colorado. This service is referred to as "Resource Conservation and Recovery Panels" assistance.

The scope of work for this evaluation includes an analysis of the deficiencies of the current landfill, the feasibility of upgrading the site to comply with RCRA regulations, provision of an operations plan, and initial study of the Mill Creek site as a location for another landfill, given the cover material and land constraints of the current site.

B. Location

The Town of Pagosa Springs is situated on the San Juan River in southwestern Colorado. It is about 30 miles north of the New Mexico boundary via U.S. Highway 84 and lies 25 miles west of the Continental Divide on U.S. Highway 160 (see Figure 1). The Town's landfill is two miles south of Highway 160 on the Trujillo Road in Section 26, R2W, T35N. Figure 2 is a portion of a geologic map of the Pagosa Springs area[1]. The list below explains the geologic symbols used in Figure 2.

Geologic Symbol Explanation

Qal - Alluvium
Qt - Terrace Deposits
Qtr - Travertine Deposits (calcium carbonate deposited by hot springs)

---

[1] Source: Reference 12.

Ti - Dikes

Kmu - Mancos Shale (upper member)

Kml - Mancos Shale (lower member)

Kd - Dakota Sandstone

C. Population

The Town of Pagosa Springs is the county seat of Archuleta County. The current population of the County is estimated by the County Planning Office to be approximately 4,235. This includes the Town's population of about 1,500. Historical and projected population data are shown in Table 1. (The Chief of the Planning Office, Mr. Ebeling, estimates that 85 percent of the County's residents live within 10 miles of Pagosa Springs). The "Plan for Progress", a master planning document for the Town[2], also indicates that about 80 percent (973 of 1222 units) of the County's year-round housing is located in the vicinity of the Town, i.e. the northeastern part of the County, as indicated in Table 2.

Therefore, the growth in this area warrants particular attention to the long-term solid waste needs of the community.

---

[2] Source: Reference 1.

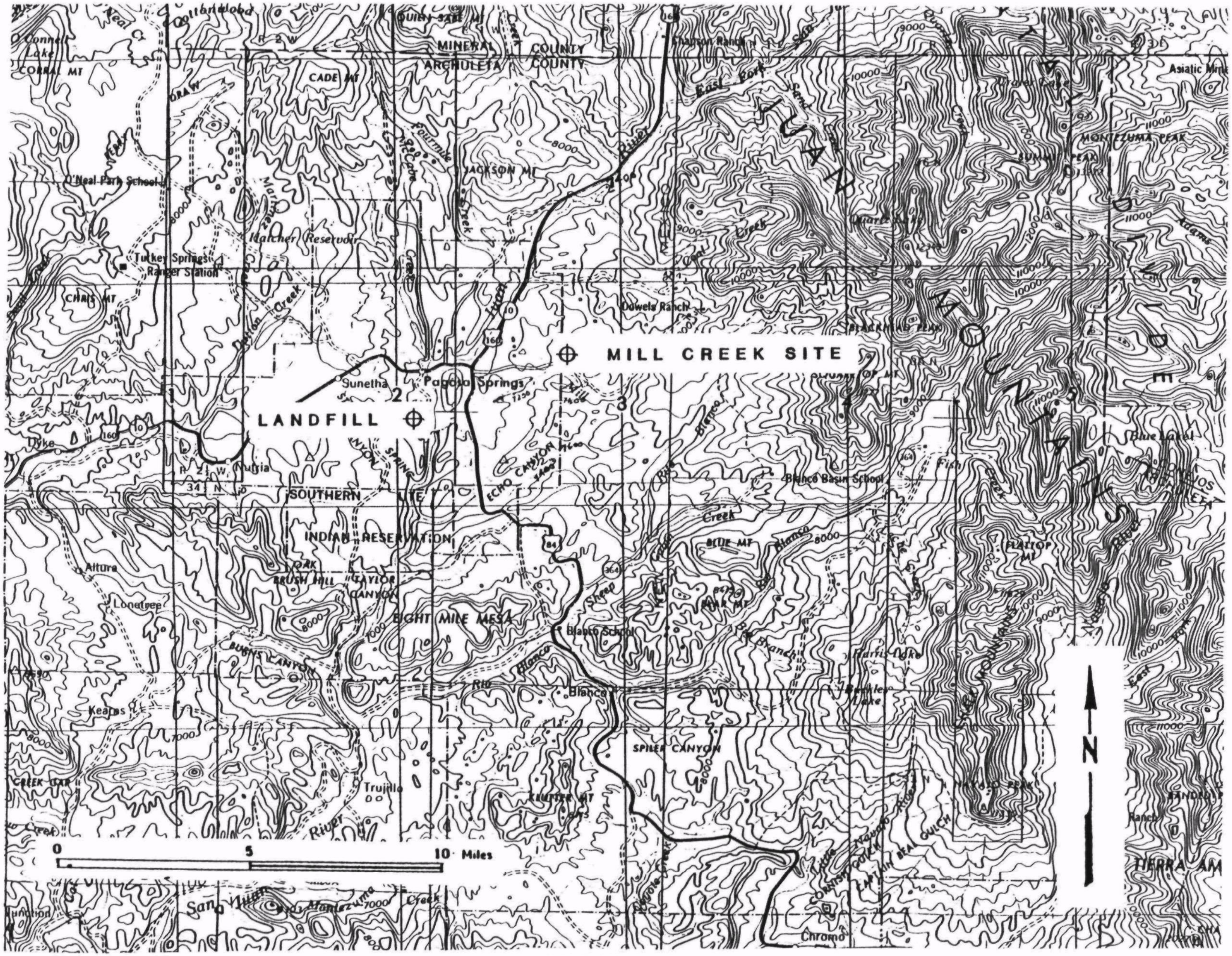


FIGURE 1.

TOPOGRAPHIC MAP, PAGOSA SPRINGS AREA

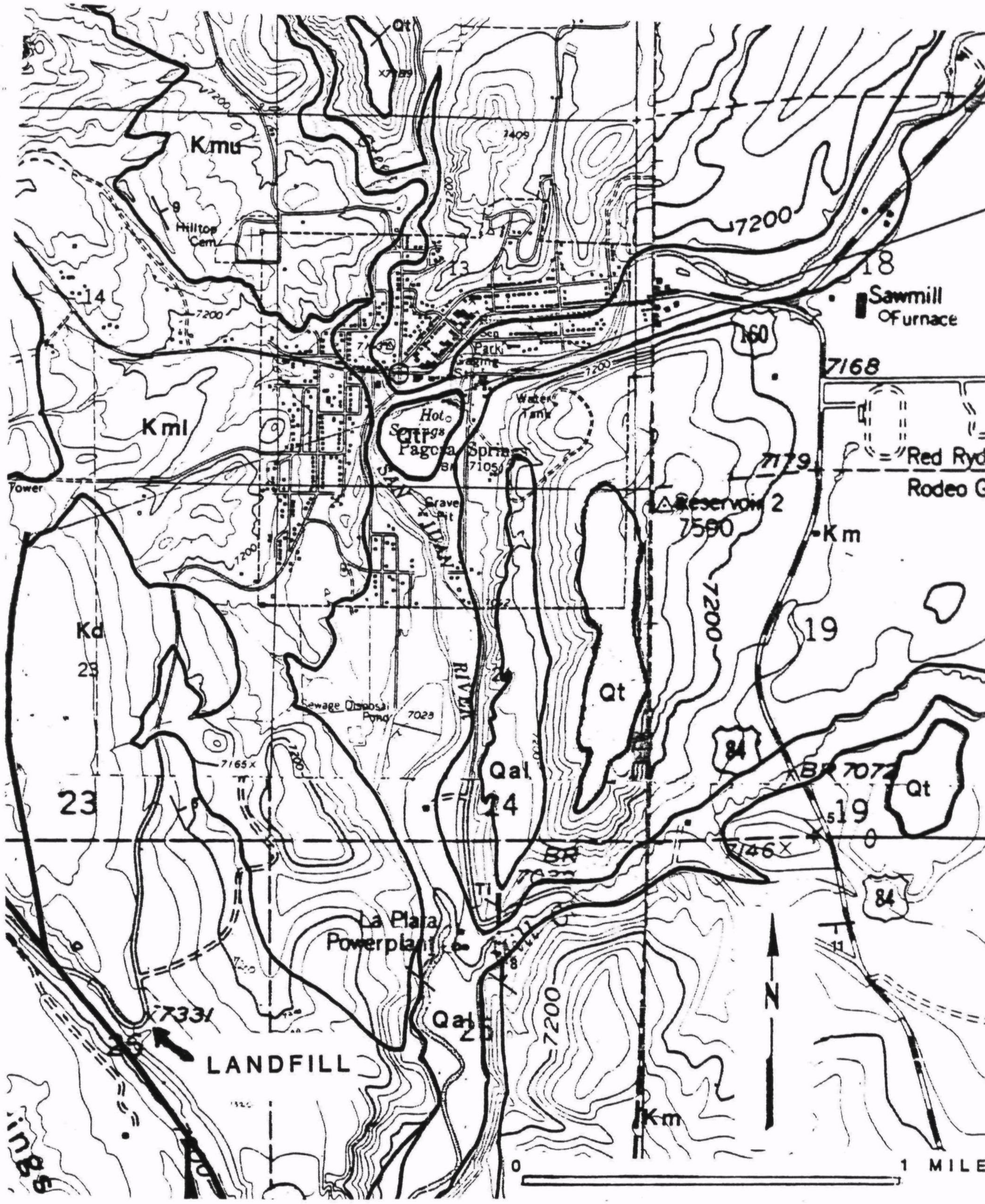


FIGURE 2.

GEOLOGIC MAP, PAGOSA SPRINGS AREA

TABLE 1
POPULATION DATA
HISTORICAL AND PROJECTED[a]

Year	Archuleta County	Town of Pagosa Springs
1890	826	
1900	2,117	
1910	3,302	669
1920	3,590	1,032
1930	3,204	804
1940	3,806	1,591
1950	3,030	1,379
1960	2,629	1,374
1970	2,733	1,360
1975	3,000[b]	1,400[c]
1977	3,594[d]	1,382[d]
1980	4,014[b] (4,325)	1,600[c]
1985	5,325[b] (5,618)	1,625[c]
1990	6,642[b] (7,007)	1,750[c]
1995	7,813[b] (8,243)	1,875[c]
2000	9,000[b] (9,500)	2,500[c]

---

a Source: Archuleta County Planning Office.

b Estimated by county planning office. The lower figures are based on 1975 estimates. The higher figures in parentheses are adjusted based upon 1977 census data.

c From "Land Use Inventory and Preliminary Land Use Plan for Pagosa Springs" by Carl S. Becker Company, 1975. Subsequent data indicates these projections to be too high for the Town itself.

d Special Census taken by the U.S. Bureau of the Census, June, 1977.

TABLE 2

ARCHULETA COUNTY HOUSING DATA - 1978

	Pagosa Springs	Northeast County[a]	Remaining County[b]	Total County
Total Living Units	511	1,267	528	1,795
Year-Round	467	973	249	1,222
Seasonal or Part-Time	21	216	265	481
Unknown	23	78	14	93

a Includes Town of Pagosa Springs.

b Includes Blanco, Chromo, Trujillo, Pagosa Junction, Arboles and Chimney Rock Districts.

D. Economy

Personal incomes in the county are low compared with the State as a whole. The U.S. Bureau of the Census, County and City Data Book, 1977 reports the 1974 per capita personal income in the County at $3,390 compared to $4,884 in the State of Colorado.

The Town master planning report concludes that the unemployment rate has consistently been higher than that of the State as a whole. The report summarizes the unemployment statistics since 1970, and portrays a 21.2 percent unemployment for the Town (versus 5.5 percent for the State) in 1978.

Table 3 was provided by the County Planning Office and shows the tax base for the County in 1979. About two-thirds of the County's assessed valuation comes from residential properties. This high proportion of residential property valuation contrasts with a relatively low commercial and industrial tax base.

TABLE 3[a]

ASSESSED VALUATION OF ARCHULETA COUNTY - 1979

Residential	$20.0 million
Commercial	3.0 million
Industrial	0.7 million
Agricultural	3.2 million
Natural Resources	0.9 million

---

[a] Source: Archuleta County Planning Office.

E. Climate

The average annual precipitation is 18.74 inches at Pagosa Springs. Minimum monthly precipitation generally occurs in June, and maximum monthly precipitation in August. (The period of record is 400 months.) Precipitation averages in the mountains are considerably higher with a few locations in the

County estimated to average 50 inches per year. Most of the increase in precipitation from the valley to the mountains occurs in mid-winter, when the mountains receive more snowfall. Average snowfall measurements are 104 inches per year at Pagosa Springs. The mean maximum temperature varies from 38.2° F in January to 83.5° F in July while the mean minimum varies from 1.3°F in January to 45.3°F in July.

Table 4 is a comparison of average monthly Pagosa Springs precipitation and evapotranspiation at Vallecito Reservoir (30 miles west of Pagosa Springs). Evapotranspiration, the combined evaporation from the plant and soil surfaces and transpiration from plants, represents the transport of water from the earth back to the atmosphere. Evapotranspiration approximately equals lake evaporation.[3] The evaporation is insignificant during winter months and is reported at 0 inches. At Vallecito Reservoir evapotranspiration equals 25.57 inches per year. (Evapotranspiration was calculated according to the method given in Thornthwaite and Mather).[4] (The elevation of the Pagosa Springs landfill is 7,331 feet; the reservoir elevation is 7,665 feet).

The climate, therefore, is relatively arid with wide seasonal precipitation and temperature fluctuations. In the winter, precipitation is greatest and evaporation is insignificant. Potential percolation, runoff, and run-on must be evaluated with this in mind. All climate data are from the Colorado Climatologist, Department of Atmospheric Science, Colorado State University and were provided for this report by William A. Ray, Jr., Pagosa Springs Town Manager.

---

[3]Source: Reference 8.

[4]Source: Reference 13.

TABLE 4

MEAN MONTHLY PRECIPITATION AND EVAPOTRANSPIRATION DATA

	Pagosa Springs Precipitation (inches)	Vallecito Reservoir Evapotranspiration (inches)
January	1.76	0.00
February	1.14	0.00
March	1.34	0.00
April	1.32	2.81
May	1.04	3.89
June	.93	4.68
July	1.59	4.71
August	2.34	4.09
September	1.77	3.21
October	2.29	2.18
November	1.25	0.00
December	1.96	0.00
TOTAL	18.74	25.57

F. Geology/Soils

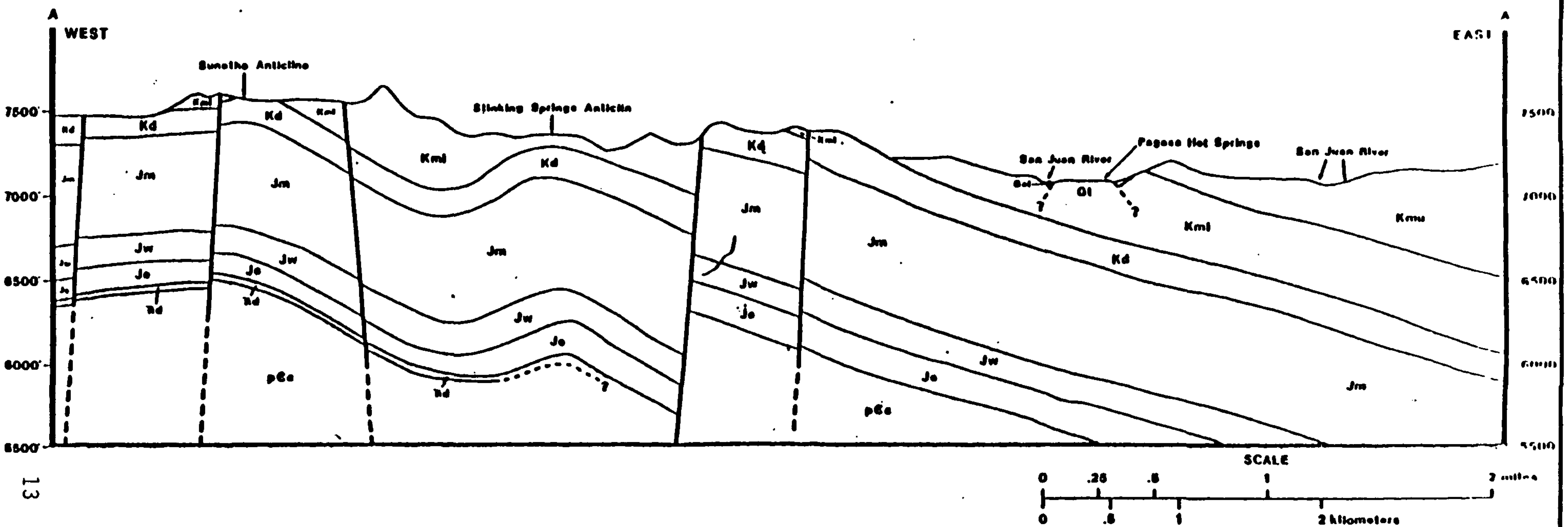
The Pagosa Springs landfill is situated on Dakota Sandstone (geologic map symbol Kd), a quartz sandstone with some dark carbonaceous shale. Figure 3 shows a geologic cross-section through the Pagosa Springs area[5]. The soil formed on the Dakota Sandstone in this area is the Valto stony loam, a shallow, highly permeable (2.0 - 6.0 inches per hour) soil. The Soil Conservation Service (SCS) symbol for the Valto stony loam is M1-CE. Table 5 represents the SCS intepretation sheet for the M1-CE soil.

---

[5] Source: Reference 7.

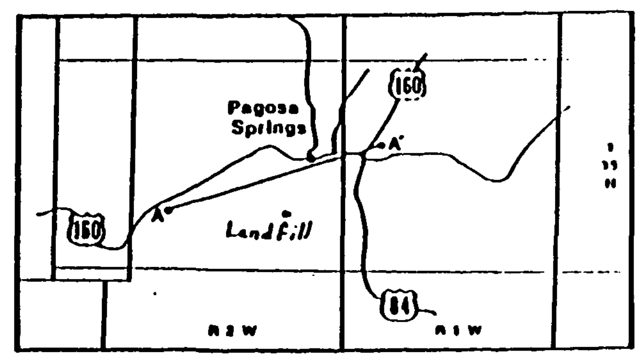
In the vicinity of the Town of Pagosa Springs, the Mancos Shale (geologic symbol Km) also predominates the surficial geology. To a large extent, the soil formed on the Mancos is the Yawdim clay loam and clay (SCS symbol CO-CE), a shallow soil exhibiting low permeability (.02-.6 inches per hour). The Work loam and clay loam soil (SCS symbol C2-CD) that formed from shale outwash in the area also occurs in the vicinity of Mancos shale soils. This is a slowly to moderately permeable soil (.2 - 2.0 inches/hour in the first 8 inches and .2-.6 inches per hour below 8 inches). (See Table 5 for soil data). The C2-CD soil is moderately deep and well drained. Soils at the Mill Creek site (discussed in Chapter IV) consist mainly of those derived from shale and shale outwash, i.e. the CO-CE and C2-CD soils.

A formal soil survey for Archuleta County has not been developed by the Soil Conservation Service. Soil maps have been prepared for some areas within the County including the Pagosa Springs landfill area and the Mill Creek site. The quality of these maps precludes adequate reproduction; therefore, these maps are included in Appendix A. The information regarding the Valto stony loam soil on the Pagosa Springs landfill site and the Yawdim and Work loam at the Mill Creek site was derived from these maps and conversations with the local SCS office.



EXPLANATION

Qa — Alluvium, Quaternary	Jm — Morrison Formation, Upper Jurassic
Qt — Travertine, Quaternary	Jw — Wanaka Formation, Upper Jurassic
Kmu — Mancos Shale (upper), Upper Cretaceous	Je — Entrada Formation, Upper Jurassic
Kml — Mancos Shale (lower), Upper Cretaceous	ꞧd — Dolores Formation, Upper Triassic
Kd — Dakota Sandstone, Upper Cretaceous	pЄc — Crystalline Rocks, Precambrian



Index Map

Figure 3. Cross Section through the Pagosa Springs Area, Colorado

Table 5

SOIL SURVEY INTERPRETATIONS

M1-CE Valto stony loam, 3 to 25 percent slopes. This unit consists of shallow, well drained soils 6 to 20 inches deep over sandstone. The soil is predominantly a stony sandy loam. There is about ten percent rock outcrop in the unit. [illegible]% of soil surface covered by sandstone fragments

MLRA: TPP 9/72

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES

MAJOR SOIL HORIZONS (INCHES)	CLASSIFICATION			COARSE FRACT. > 3 IN. %	PERCENTAGE LESS THAN 3 INCHES PASSING SIEVE NO. ---											
	USDA TEXTURE	UNIFIED	AASHO		4	10	40	200	LL	PI	PERMEABILITY (in/hr)	AVAILABLE WATER CAPACITY (in/in)	SOIL REACTION (pH)	SALINITY (EC x 10³ @25°C)	SHRINK-SWELL POTENTIAL	POTENTIAL FROST ACTION
0-12	Stony sandy loam	SM	A-4	20-40	85-95	80-90	45-60	35-50	20-30	0-5	2.0-6.0	.08-.10	6.6-7.8	—	Low	Low
12+	Sandstone	bedrock														

DEPTH TO BEDROCK OR HARDPAN: Six to 20 inches

FLOOD HAZARD: None

DEPTH TO SEASONAL HIGH WATER TABLE: None

HYDROLOGIC GROUP: D

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS RESOURCE MATERIAL

TOPSOIL: Poor - stony, shallow to bedrock	GRAVEL: Unsuited - no gravel
SAND: Poor - SM, stony, shallow	ROADFILL: Poor - shallow to bedrock

DEGREE OF LIMITATION AND MAJOR SOIL FEATURES AFFECTING SELECTED USE

LOCAL ROADS AND STREETS: Severe - shallow to bedrock	SEPTIC TANK FILTER FIELDS: Severe - shallow to bedrock
SHALLOW EXCAVATIONS: Severe - shallow to bedrock	SEWAGE LAGOONS: Severe - shallow to bedrock
DWELLINGS: Severe - shallow to bedrock	CORROSIVITY - UNCOATED STEEL: Low
RESERVOIR AREA: Shallow to bedrock; high seepage	CORROSIVITY - CONCRETE: Low
RESERVOIR EMBANKMENT: Shallow to bedrock; stony	

TABLE 5 (Cont.)

SOIL SURVEY INTERPRETATIONS

CO-CE YAWDIM **clay loam and clay, 3 to 25 percent slopes.** This unit consists of dark colored, shallow, well drained soil overlying Mancos and Lewis shale at depths of 8 to 20 inches. The surface and subsoil are clay loam or clay. Because of the hilly topography, there are inclusions of about 15 percent outcrops of shale, usually on ridge tops. There are also inclusions (15%) of soils deeper to shale, usually in narrow swale and footslope positions. MLRA: JPP 8/72

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES

MAJOR SOIL HORIZONS (INCHES)	CLASSIFICATION			COARSE FRACT. > 3 IN. %	PERCENTAGE LESS THAN 3 INCHES PASSING SIEVE NO ---				LL	PI	PERMEABILITY (in/hr)	AVAILABLE WATER CAPACITY (In/in)	SOIL REACTION (pH)	SALINITY (EC x 10³ @25°C)	SHRINK-SWELL POTENTIAL	POTENTIAL FROST ACTION
	USDA TEXTURE	UNIFIED	AASHO		4	10	40	200								
0-12	Clay or heavy cl	CL or CH	A-7	0-10	100	100	90-100	70-80	30-40	15-30	.02-.6	.17-.19	7.4-8.4	--	High	low
12-60	Shale	Bedrock														

DEPTH TO BEDROCK OR HARDPAN: Less than 20" to shale

FLOOD HAZARD: None

DEPTH TO SEASONAL HIGH WATERTABLE: None

HYDROLOGIC GROUP: D

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS RESOURCE MATERIAL

TOPSOIL: Poor - clay texture	GRAVEL: Unsuited - no gravel
SAND: Unsuited - no sand	ROADFILL: Poor - CL with PI over 15 or CH

DEGREE OF LIMITATION AND MAJOR SOIL FEATURES AFFECTING SELECTED USE

LOCAL ROADS AND STREETS: Severe - shallow to shale; CH or CL with PI over 15	SEPTIC TANK FILTER FIELDS: Severe - shallow to shale
SHALLOW EXCAVATIONS: Severe - shallow to shale; steep slopes	SEWAGE LAGOONS: Severe - shallow to shale
DWELLINGS: Severe - shallow to shale; steep slopes	CORROSIVITY - UNCOATED STEEL: High
RESERVOIR AREA: Shale at less than 20 inches	CORROSIVITY - CONCRETE: Low
RESERVOIR EMBANKMENT: High shrink-swell soil	

TABLE 5 (Cont.)

FILE CODE SOILS-13 — C2-CD WORK loam and clay loam, 3 to [illegible] slopes

JPW
8/72

SOIL SURVEY INTERPRETATIONS

MLRA:

This unit consists of a deep, well drained soil in areas of shale soils. The soil is derived from shale outwash. The surface is a dark colored loam 6 to 16" thick. The subsoil and substrata are a clay loam. Small inclusions of soil with shale above 40" are common.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES

MAJOR SOIL HORIZONS (INCHES)	CLASSIFICATION			COARSE FRACT. > 3 IN. %	PERCENTAGE LESS THAN 3 INCHES PASSING SIEVE NO.				LL	PI	PERMEABILITY (in./hr)	AVAILABLE WATER CAPACITY (In./In.)	SOIL REACTION (pH)	SALINITY (EC x 10³ @25°C)	SHRINK-SWELL POTENTIAL	POTENTIAL FROST ACTION
	USDA TEXTURE	UNIFIED	AASHO		4	10	40	200								
0-8	loam or cl	ML or CL	A-4 or A-6	0-5	100	100	85-100	60-80	30-40	5-20	.2-2.0	.16-.20	7.4-8.4	-	Mod.	Low
8-60	clay loam	CL	A-6	0-5	100	100	90-100	70-80	30-40	15-25	.2-.6	.18-.20	7.4-8.4	-	High	low

DEPTH TO BEDROCK OR HARDPAN: 60 +	FLOOD HAZARD: None
DEPTH TO SEASONAL HIGH WATERTABLE: None	HYDROLOGIC GROUP: C

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS RESOURCE MATERIAL

TOPSOIL: Fair to good - loam to clay loam	GRAVEL: Unsuited - No gravel
SAND: Unsuited - No sand	ROADFILL: Poor - CL with PI over 15

DEGREE OF LIMITATION AND MAJOR SOIL FEATURES AFFECTING SELECTED USE

LOCAL ROADS AND STREETS: Severe -CL with PI over 15	SEPTIC TANK FILTER FIELDS: Moderate - Moderately slow permeability
SHALLOW EXCAVATIONS: Moderate - Clay loam	SEWAGE LAGOONS: Moderate on slopes to 7%
DWELLINGS: Severe - High shrink - swell potential	CORROSIVITY - UNCOATED STEEL: Moderate
RESERVOIR AREA: Moderately slow permeability	CORROSIVITY - CONCRETE: Low
RESERVOIR EMBANKMENT: Moderate compressibility	

III. PAGOSA SPRINGS LANDFILL EVALUATION

A. Introduction

State and Federal regulations governing solid waste disposal are written in order to protect health and the environment. Solid waste disposal sites must be designed and operated to preserve the integrity of surface and groundwater supplies and to limit potential health problems associated with disease-transmitting vectors. Open burning at disposal sites may result in uncontrolled fires, air pollution, and aesthetic problems. Poorly-operated landfills that may be characterized by blowing debris and unpleasant odors impinge upon the aesthetic values of the community. These problems can be prevented through proper sanitary landfill design and operation.

The Radiation and Hazardous Waste Control Division of the Colorado Department of Health has conducted an inspection of the Pagosa Springs landfill and has classified it as an open dump in non-compliance with the Resource Conservation and Recovery Act (RCRA) criteria. The RCRA "Criteria for Classification of Solid Waste Disposal Facilities and Practices" Title 40 Code of Federal Regulations, Part 257 (40 CFR 257) includes criteria to evaluate the impacts of solid waste disposal on air quality, surface water quality and groundwater quality, disease, endangered species and safety. An open dump is a facility which does not comply with 40 CFR 257. In citing the reasons the site was classified as an open dump, the Department of Health specifically singled out the deficiencies of cover material and open burning and their relationship to safety hazards. The Department's inspection form also references the "Colorado Solid Waste Disposal Sites and Facilities Law" Minimum Standards, CRS 30-20-110. The Division has requested that the Archuleta County Commissioners inform them of the plans to bring the site into compliance or close it.

The purpose of this part of the report is to evaluate the Pagosa Springs disposal site and to investigate the feasibility of upgrading the site to comply with RCRA regulations. The scope of work is to: (1) identify the deficiencies of the current operation of the disposal site with respect to the State and Federal regulations; (2) develop an overall upgrading strategy (including upgrading costs); (3) develop an operational plan (defining staffing needs, equipment needs, etc.); (4) develop an implementation strategy for the proposed plan; and (5) review and comment on the user charge system for the disposal site.

B. Identification of Deficiencies

Cover. The major deficiency of the Pagosa Springs landfill site is its lack of suitable cover material. Suitable soil for covering the refuse each day is of utmost importance for the safe and sanitary operation of a landfill. Cover material is needed to prevent rodents from burrowing into the fill, keep flies from emerging, minimize the entrance of moisture in the fill, provide a pleasing appearance, control blowing litter, and control erosion. Figure 4 depicts in general terms the suitability of various soil types for cover material.

Table 5 shows the soil survey interpretation by the U.S. Department of Agriculture, Soil Conservation Service, for the predominant soil type located at the Pagosa Springs landfill area, namely the M1-CE soil. The table shows that the topsoil at the site is unsuitable for cover material. It is shallow soil to bedrock (approximately 12 inches) and consists of a predominantly stony sandy loam which has a high permeability, 2.0-6.0 inches/hour.

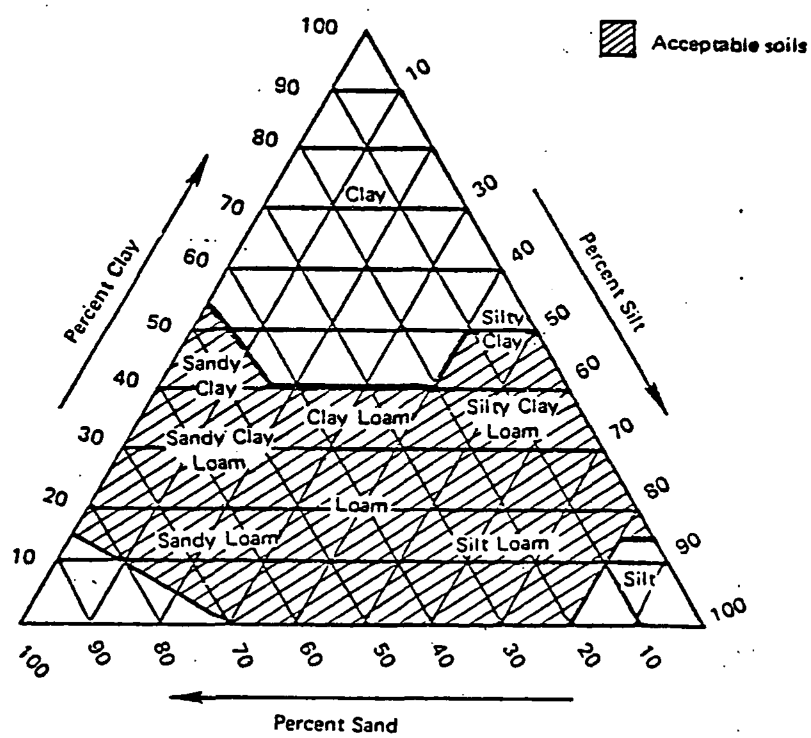
Also shown in Table 5 are the estimated physical and chemical properties affecting the soil as a cover material, and the degree of limitation and major soil features affecting selected use.

In the past, both Pagosa Springs and Archuleta County have hauled fill material to the site from road construction and excavations activities. This material, however, was dumped at the site and used to provide a working surface for vehicles dumping at the site. For proper operation of a landfill at the Pagosa Springs site additional fill will have to be hauled to the site. This will result in additional cost to the Town for operating the landfill. Potential sources of cover material are identified in Section C and the costs of procuring and hauling the cover material are presented in Section E of this Chapter.

A less permeable soil will have to be located and utilized to prevent leachate production and ensure the safe and efficient operation of the landfill.

FIGURE 4

SUITABILITY OF SOILS FOR LANDFILL OPERATION



Suitability of General Soil Types as Cover Material.[a]

Function	Clean gravel	Clayey-silty gravel	Clean sand	Clayey-silty sand	Silt	Clay
Prevent rodents from burrowing or tunneling	G	F-G	G	P	P	P
Keep flies from emerging	P	F	P	G	G	E[b]
Minimize moisture entering fill	P	F-G	P	G-E	G-E	E[b]
Minimize landfill gas venting through cover	P	F-G	P	G-E	G-E	E[b]
Provide pleasing appearance and control blowing paper	E	E	E	E	E	E
Grow vegetation	P	G	P-F	E	G-E	F-G
Be permeable for venting decomposition gas[c]	E	P	G	P	P	P

[a]E-excellent; G-good; F-fair; P-poor.
[b]Except when cracks extend through the entire cover.
[c]Only if well drained.

[d]Source: Reference 2.

Surface and Ground Water Pollution. Leachate production in a landfill might result in the pollution of surface water bodies and ground water. As mentioned in the previous section, the topsoil in the area is very shallow (approximately 12 inches) and, therefore, provides very little cover material for the site. It is also quite permeable. The bedrock at the landfill is the Dakota Sandstone. If fractures are present in this rock unit, and if leachate is generated, percolation could take place down to the ground water without benefit of much filtration by the soil or bedrock, thus contaminating the ground water. Fractures can be observed at points where the bedrock outcrops or soil can be stripped from the surface to expose the bedrock. Pagosa Springs can coordinate the bedrock fracture analysis with the State Health Department if the necessity of a groundwater monitoring program is in question.

To investigate the potential for leachate production, a water balance analysis is presented in Table 6. This water balance analysis is based on the generally accepted methodology outlined in EPA Report SW-168[6]. As pointed out by the EPA, the water balance method will serve as a useful engineering tool in conducting environmental assessments of proposed or existing landfill sites. However, it should be remembered that the method is intended only as a basic tool for the engineer, and certain site specific assumptions will be necessary to tailor the method for a particular location.

The clay loam C2-CD is used as the expected cover material for analysis. This soil has an available water holding capacity of as much as 0.2 inch per inch of cover or 4.8 inches for 24 inches of cover (2 foot final cover). Monthly precipitation and evapotranspiration are as stated in the introduction sections of this report. A relatively high runoff coefficient of 0.35 is assumed. This means that 35 percent of the precipitation will be runoff and 65 percent will infiltrate the ground surface. EPA Report SW-168 estimates that grass covered heavy soil on a 7 percent slope will have a coefficient between 0.25 and 0.35 while the Pagosa Springs landfill has a 10 percent slope and intermittent shrub growth. The conclusion of this analysis, as presented in

---

6 Source: Reference 6.

TABLE 6. MONTHLY WATER BALANCE ANALYSIS
IN MILLIMETERS FOR PAGOSA SPRINGS, COLORADO

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Average Precipitation	45	29	25								25	50	174
(P) +			9	34	26	24	40	59	45	58	7		302
Runoff (RO)*	0	0	3	12	9	8	14	21	16	20	2	0	105
Moisture available for Infiltration (I)	0.00≠	0.00≠	6	22	17	16	26	38	29	38	5	0≠	197
Potential evapotranspiration (PET)	0	0	0	71	99	119	120	104	82	55	0	0	650
Potential Water Loss (I - PET)	0	0	6	-49	-82	-103	-94	-66	-53	-17	5	0	
Accumulated Potential Water Loss (Σ neg (I - PET))			(-294)	-343	-426	-528	-623	-689	-742	-759			
Soil moisture storage (ST)	6	6	12§	8	4	2	1	1	1	1	6	6	
Change in Storage (ΔST)	0	0	6	-4	-4	-2	-1	0	0	0	5	0	
Actual evapotranspiration (AET)	0	0	0	26	21	18	27	38	29	38	0	0	
Percolation (PRC)	0	0	0	0	0	0	0	0	0	0	0	0	0

\+ Precipitation is in form of snow (upper line) and rainfall (lower line).
* Runoff coefficient estimated at 0.35.
≠ Ground freeze limits infiltration in winter months.
§ Water-holding capacity is assumed to be at maximum in March when snow melts.

Table 6, is that no percolation will occur which could contribute to leachate production at the landfill.

It should be pointed out that only the 24 inches of final cover material was used to calculate leachate percolation. Like its cover material, the underlying solid waste cells (including the relatively thin layers of daily cover material) will exhibit a certain capacity to hold water. The field capacity of solid waste has been determined by many investigators to vary from 20 percent to as high as 35 percent by volume[7]. The ability of waste to hold water, a factor not included in the water balance analysis, will further retard leachate generation and movement.

The aquifer underlying the landfill site is the Dakota Sandstone which is used in some areas of the County as a domestic water supply. The direction of ground water flow is predominantly to the east towards its discharge point at the San Juan River. A potentiometric surface map for the Dakota Sandstone prepared by Galloway[8] indicates that, at the Pagosa Springs landfill, depth to ground water may be well over 100 feet below the ground surface (see Figure 5). According to the map, the elevation of ground water in this aquifer varies between 7,150 and 7,200 feet at the site while the elevation of the landfill land surface varies between 7,270 and 7,330 feet (it averages 7,300 feet). Two domestic water wells exist in the vicinity of and upgradient from the landfill, wells 23 DD and 26 BD, presented in Table 7. The depth to water in these wells is somewhat shallow at 5 feet in 23 DD and 39 feet in 26 BD. The shallow water depth at these two well sites, however, cannot be extrapolated to represent conditions at the landfill site. This is because the land surface elevation of these wells is lower than the elevation at the landfill site. The land surface elevation at the two well locations is therefore closer to the ground water level.

---

7 Source: Reference 2.

8 Source: Reference 7.

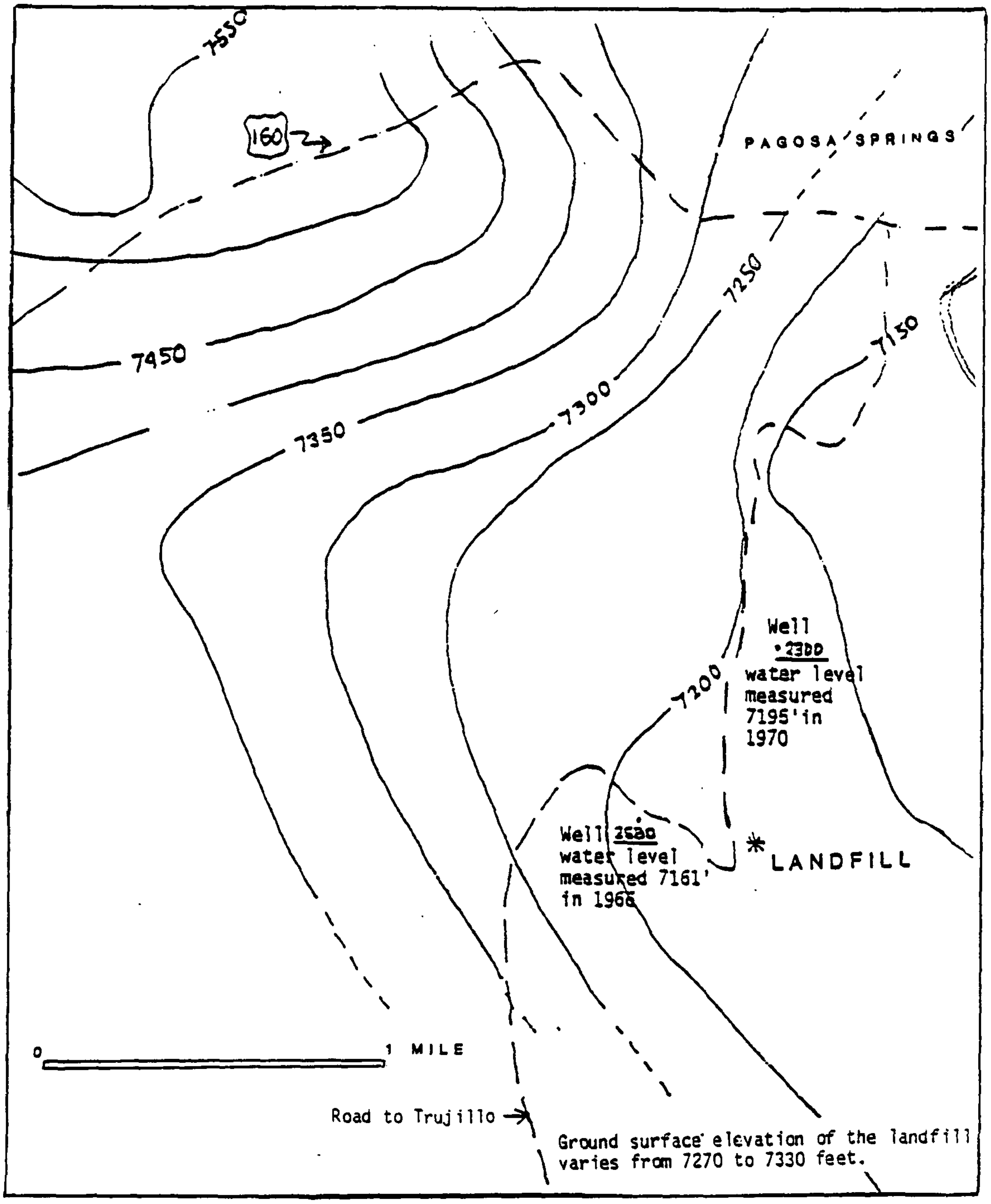


FIGURE 5.

ELEVATION OF THE POTENTIOMETRIC SURFACE, DAKOTA SANDSTONE

TABLE 7[a]

WELL INVENTORY, PAGOSA SPRINGS AREA, COLORADO

WELL LOCATION	ELEVATION (ft above MSL)	WELL DEPTH (ft)	CASING DIA. (in)	WATER LEVEL DEPTH (ft)	WATER LEVEL DATE MEAS.	WATER LEVEL ELEVATION (ft above MSL)	USE	Yield (GPM)	Pumping Data Drawdown (ft)	Pumping Data Specific Capacity (gpm/ft)	Aquifer	Owner
02W15DAA	7580	66	8	58	2/1/66	7522	D	3	56	.05	D	Robert Snow
02W15DD	7480	67	8	56	2/12/66	7424	D	30	101	.3	D	Milton D. Remey
02W15CB2	7602	107	8	54	3/1/66	7548	D	1	100	1.01	D	Gerard Cripe
02W15AC1	7620	81	8	40	7/31/66		D	4	76	.05	M	Henry Trujillo
02W15ACA2	7620	170	8	90	9/28/66	7530	D	2	160	.01	D	Santana Lujon
02W15CA	7580	78	8	48	10/24/66	7532	D	4	75	.05	D	Forrest E. Bozani
02W15AC3	7600	75	8	20	10/10/66	7580	D	5	65	.08	M	C. E. Gay
02W15CC	7510	94	8	40	11/12/70	7470	D	1	80	.01	D	Fred Harmon
02W15DA	7500	80	4 1/2	10	12/6/72	7490	D	15	11	1.36	D	Robert Snow
02W15BD2	7600	90	4	20	9/20/75	7510	D	5	70	.07	D	1st Assembly of God Ch.
02W16BAAA	7560	70	7	22	6/14/72	7538	D	3			D	Stanley Belmear
02W16ADC	7610	300	6 5/8	270	6/19/71	7340	C	1	0	10	D	Over Niter Inc.
02W16DA1	7595	320	8	250	9/28/65	7345	I	30	220	.14	D	R. J. Sullivan
02W16DA2	7595	104	6	15	9/9/71	7580	D	6	90	.07	D	Fred Ebeling
02W20DB1	7540	200	6 5/8	32	3/28/66	7508	C	5	150	.03	D	Navajo Trail Truck-O-Tel
02W20DB2	7540	110	6 5/8	30	3/25/66	7510	D	4	60	.07	D	Jim Garven
02W20DB3	7540	78	6 5/8	30	3/25/66	7510	D	4	36	.11	D	Bernie Harris
02W20DB4	7540	72	8	26	4/19/66	7514	D	10	50	.2	D	Harol Harris
02W20DC	7540	93	6 5/8	60	3/16/67	7447	D	3	20	.2	D	M. W. Mendal
02W20DBA	7529	70	10				C					Wt. Williams
02W20DBB	7524	200	6	72	1974	7452					D	Eaton Industries
02W20CD	7515	82	6	30	5/13/67	7485	D	5	70	.07	D	F. A. Thompson
02W320DB5	7540	66	8	16	8/15/67	7524	D	6	55	.11	D	Milo Smith
02W20DB6	7540	70	10	36	11/27/67	7505	D	6	64	.09	D	M. T. Williams
02W20DB7	7540	125	8	60	11/15/69	7480	D	10	75	.13	D	M. T. Williams
02W20BD	7520	73	8	13	10/2/69	7507	D	2	65	.03	D	Vern L. Smith
02W20AB	7495	136	5	60	9/21/72	7435	D	12	85	.14	D	M. W. Mendell
02W21BCD		35	8	5	5/23/62		D	4			A?	J. F. Whitefield
02W21BDB		35	8	8	5/23/62		D	4			A	J. F. Whitefield
02W21AB	7517	200	8	175	10/12/65	7342	D	2	190	.01	M	Herbert Tishner
02W21BB	7500	42	8	20	6/15/70	7480	D	10	30	.33	M	Navajo Trail Corp.
02W22CC	7360	46	6	Flowing	9/25/71	7360 +	D	15	15	1.0	D	W. W. Scoggins
02W23AD	7140	130	7	50	6/8/58	7090	D	10	70	.14	D	W. F. Wall
02W23AD2	7140	50	6	23	11/3/68	7117	D	6	43	.14	D	Donald Martinez
02W23AC	7260	52	6	32	11/16/78	7228	D	5	45	.11	D	Roger Sanchez
02W23AB1 *	7260	25	6 5/8	10	3/5/70	7250	D				D	Reymundo Maez
02W23DD *	7200	53	8 5/8	5	5/13/70	7195	D				D	David Maez
02W23DA	7180	21	6	10	8/17/71	7170	D	6	16	.38	D	Reymundo Maez
02W23DB	7210	30	6	6	6/29/74	7204	D	6	24	.25	D	Felipe Maez
02W23AB2	7260	100	6	47	9/6/73	7213	D	8	65	.12	D	Reymundo Maez
02W24DB		20	6	12	5/11/66		D	5	12	.42	A	A. M. Gomez
02W24BC *	7100	50	8	22	5/1/70	7078	D	5	40	.13	M	Harland Pierce
02W26BD	7200	45	8	39	4/26/66	7161	D	10	35	.29	D	John Snow
02W26DC	7085	140	4	85	6/56	7000	D				M?	Jeanette Smith
02W27ADA	7160	130	6 1/4	20	7/21/74	7140	D	4	97	.04	M	Wm. V. Flowers
02W29CB	7435	65	6	45	8/30/71	7390	D	10	60	.17	D	Harley Merrick

*Wells upgradient of landfill.

[a] Source: Reference 7.

Although some potential for ground water contamination exists by virtue of the soil and hydrogeological conditions, it can be concluded that leachate production should be virtually nonexistent at the site because of the low level of precipitation and high degree of vegetation in the region. Field inspection of the site confirmed that steady leachate seepage from the fill toe could not be observed.

The steepness of the slope, estimated at approximately 10 percent, and the low-permeability clay loam soil will also contribute to runoff and will increase the speed of the runoff. Surface runoff from the site is not expected to affect surface water quality. It may, however, affect erosion. Surface water diversion structures must therefore be considered to mitigate this problem.

Burning. Open burning commonly occurs at the site. Frequent, if not daily outbreaks of smoke and flame occur. Town officials indicated that attempts to put out the fires have never been successful. Open burning is not consistent with the safe operation of a landfill. In addition to creating a safety hazard, open burning will result in air pollution and aesthetic problems in the area. The Colorado Solid Waste Disposal Sites and Facilities Law - Minimum Standards prohibits the open burning of solid waste deposited at any site and facility except by incineration or in extreme emergencies under controlled conditions and as authorized by the Department of Health.

Fencing/Access. The area is enclosed by a barbed wire fence that prohibits the entry of cattle and other large animals. Smaller animals, however, can gain entry to the site. The fence will not prevent blowing debris from being scattered outside the site area. Currently there is no barrier prohibiting unauthorized access to the site. Access to the site is through a steep paved all-weather road off Route 145. The on-site access is a dirt road leading down into previously filled areas.

Blowing Litter and Dust. At the time of the site inspection the soil was moist and there was little problem with blowing litter or dust. However, wastes are tossed from the top of the dump down onto the steeply sloping open face (east face). There is no evidence of soil covering the exposed face of the refuse pile which is approximately 20-feet high. Therefore, there is no control being exercised to prevent blowing litter.

Waste Types Accepted. Currently, the operation consists of a dumping area where wastes are deposited on the edge of a steep embankment built up by previously deposited waste. There are no controls over the kinds of wastes accepted at the site. About 20-25 abandoned car bodies are located in one area of the site, and the drum of a truck-mounted rotary concrete mixer is also on the site.

C. Upgrading Strategy

Sources of Cover Material. As mentioned in Section B of this chapter, the topography and geology of this area are such that there is very little topsoil available for use as cover material.Therefore, suitable soil, which is vital to the sanitary operation of the landfill, will have to be hauled to the site. The costs involved with providing proper cover material will be presented in the upgrading costs section of this chapter.

To locate suitable sites for obtaining cover material, the areas containing Mancos Shale were investigated. Mancos Shale locations were chosen as potential borrow areas for cover material due to the soils associated with the Mancos. Soils on the Mancos include the previously discussed Yawdim clay loam (SCS symbol CO-CE) and the Work loam (SCS symbol C2-CD). The Yawdim clay loam is not the ideal final cover material because of the high percentage of ground-up shale and sandstone it will contain as a result of the excavation operation. The ground-up shale is very inert and it would be difficult to establish plant cover on this material. It is, however, quite suitable for daily cover material. The Work loam (SCS symbol C2-CD) is rated quite good for daily and final cover material. Soil from the top three feet is the best soil for plant growth.

The locations of the potential borrow sites were determined from a geological map of the Pagosa Springs area[9]. Areas consisting of Mancos Shale (a clay-like material) within a 3 to 4 mile road distance from the landfill and

[9] Source: Reference 12.

haul distance, and hence the cost of the cover material. Figure 6 is a portion of the geological map of the Pagosa Springs area. Highlighted are areas designated "Km" (Mancos Shale) and described as C2-CD and CO-CE soils. These are possible sites where cover material may be obtained. (Note: the numbers in Figure 6 depicting the potential borrow locations are quarter-quarter section numbers of Standard Township Range 2 West, Township 34 North (23 NWNW refers to the NW quarter of the NW quarter of Section 23 of Township R2W,T34N.

Ground Water Monitoring. Within a 1/2 mile of the landfill, there are two private wells tapping the aquifer in the Dakota Sandstone formation on which the landfill is sited (see Figure 5). The wells, identified as 23 DD and 26 BD in Figure 5 are, however, upgradient from the site. By interpolation, lines of equal elevation of the potentiometric surface show the ground water level in the vicinity of the landfill at 7,175 feet compared to 7,180 feet for well 23 DD and 7,190 feet for well 26 BD. (These same wells are listed in Table 7 with the identifying prefix 02 W). As mentioned previously, these two wells are used for domestic water supply and yield relatively small amounts of water. The pumping rates and the resulting cones of depression for the wells are of such magnitude that it is unlikely that ground water would flow towards the wells from the landfill. Because of the location of these two wells, they cannot be used to detect ground water contamination down-gradient from the landfill; they can, however, be used to obtain background water quality data and to measure ground water elevations. There are no wells in the Dakota Sandstone aquifer down-gradient and in the vicinity of the landfill site.

There are two alternatives for monitoring the ground water quality in the area: 1) either well 23 DD or 26 BD can be utilized as an up-gradient well and one to three wells can be drilled down-gradient in the aquifer and the water tested for possible pollution from leachate production; or 2) no action, or in other words, no attempt at monitoring will be made. This report recommends that no monitoring wells need be drilled because initial calculations indicate essentially that no leachate generation will occur in this arid region. The added expense of establishing an independent new ground water monitoring system appears unnecessary for this site. However, the Colorado Department of Health has the final authority to determine the need for ground water monitoring.

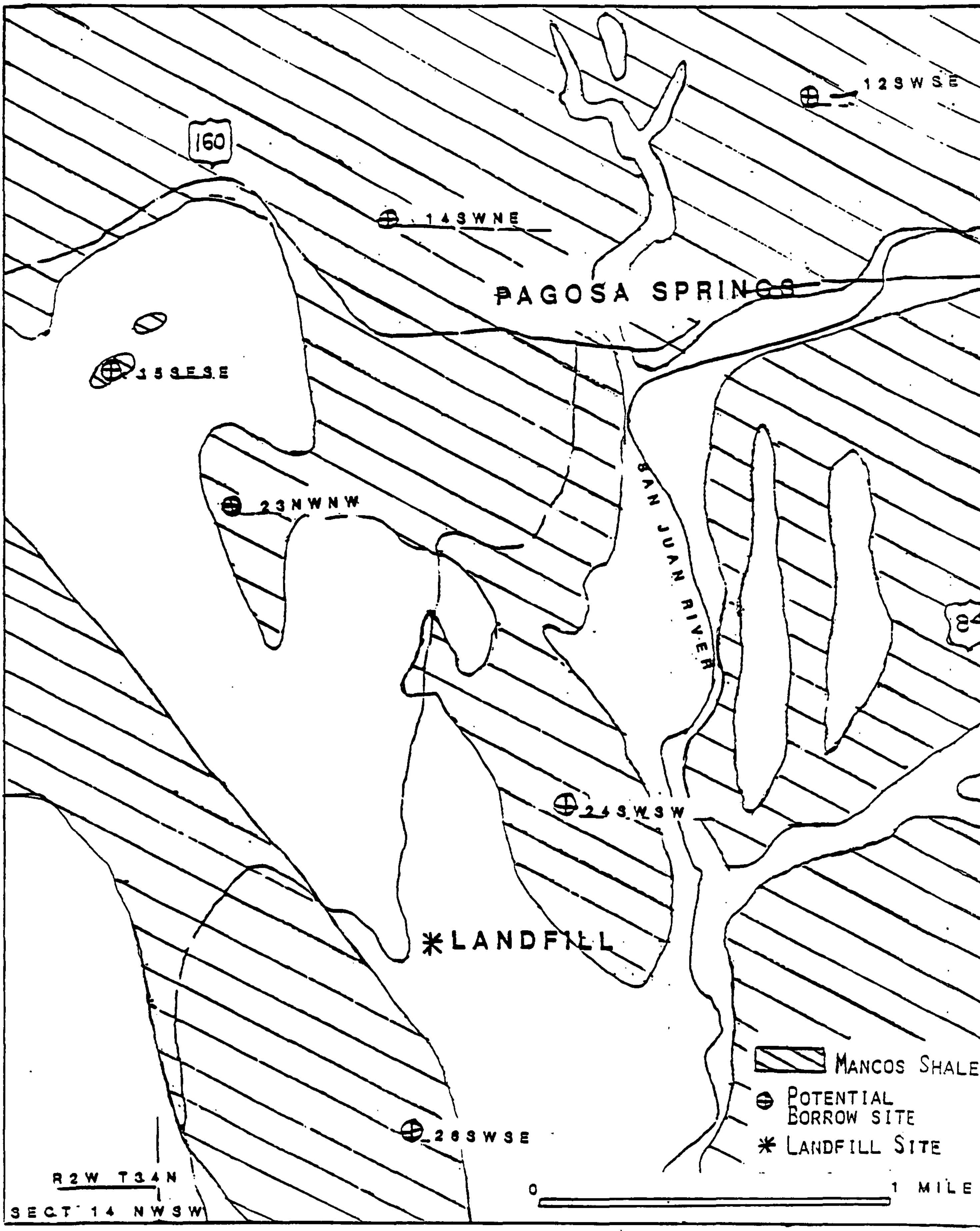


FIGURE 6. POTENTIAL BORROW SITE LOCATIONS

If nearby landowners seek reassurance that the ground water is indeed not being polluted, the monitoring program in alternative 1 could be used. Instead of drilling a well upgradient from the site, the two existing wells upgradient from the landfill could be sampled periodically (two to three times a year) and their water analyzed for leachate contamination. The Environmental Protection Agency (Fenn, D. G. et al., Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities, U.S. Environmental Protection Agency, Report SW-611, Washington, D.C., 1980.) recommends using the following key indicators for determing potential solid waste landfill contamination: specific conductance, pH, chloride, iron, color, turbidity, and COD.

Surface Drainage Improvement. Since rainfall will most likely result in rapid runoff because of steep slopes and shallow depth to bedrock, diversion ditches should be provided around the top slope between the road and the landfill to divert water from adjacent areas from flowing onto the landfill. This will direct the run-on around the site and futher prevent potential contaminated run-off and percolation of the water through the fill, and minimize erosion as well. Although leachate production does not seem likely, such preventive measures minimize any risk or potential impacts.

Site Cleaning and Preparation. The first step in cleaning the site is to properly dispose of the junked automobiles and the concrete mixer drum. A U.S. EPA study[10] has shown that small communities can successfully handle their junked automobile problems. One of the important requirements is that the community should have access to a vehicle processor or dismantler who can recycle the junked automobiles. San Juan Resource Recovery in Durango has hauled junked cars from the Southern Ute Indian Reservation. This company should be contacted to determine if it is interested in taking the junked automobiles from the Pagosa Springs Landfill.

---

[10] Source: Reference 4.

If recycling is uneconomical, the junked automobiles should be flattened and buried on site and the mixer drum should be cut in several pieces using a welding torch and similarly buried. The junked automobiles, once flattened, can be laid side by side along the active face of the dump and covered along with the waste; placing the flattened automobiles in a methodical fashion along the toe of the active face would assist in providing a degree of slope stability.

The inactive portion of the site should be covered with two feet of compacted low permeability soil as a final cover. The active portion is on a face that may be too steep to permit efficient operation of a bulldozer. Enough cover will have to be hauled to the site to cover the exposed refuse with a 6-in. cover at the end of each day and to reduce the slope of the active face to provide a better working surface for the bulldozer. Cost figures are presented in the upgrading costs section of this chapter.

Subsidence and Slope Stability. Two potential operational hazards, which were not in evidence during the field investigation, were postulated by the Colorado Department of Health---subsidence and slope instability. These two interrelated problems might occur as a consequence of open burning at the landfill and as a result of an active fill which is steeply sloping, particularly at the working face. Although a rigorous analysis consisting of the collection and interpretation of laboratory and field data is beyond the scope of this study, the initial conclusion, based on historical record and the proposed strategy for closing the inactive portion and for future landfill operations at the site, is that neither subsidence or slope stability will present significant problems.

At the Pagosa Springs landfill, subsidence might result from biological decomposition and/or past burning practices. Biological decomposition of organic matter in the solid waste occurs gradually over a number of years. The amount of organic matter in the existing fill has been reduced substantially due to the past practice of burning nearly all combustible materials. This practice reduces the potential for subsidence resulting from biological decomposition but increases the potential for the creation of voids due to pockets of smoldering refuse. However, the relatively shallow depth of the landfill (approximately 20 feet or less), the cover material which has been placed over most of the inactive fill (albeit intermittently), the inactive fill's ability to support vehicular traffic, and the lack of subsidence to date point to the relatively low possibility of significant subsidence occuring in the future, especially if the inactive fill is closed and future operations are implemented as proposed in this report. Vehicular traffic should not be allowed on the inactive site to further reduce the possibility of subsidence.

Related stability problems could potentially occur in two ways. The working face, which is currently very steep, could slump or, additionally, all or a portion of a cell could slide along the underlying sandstone bedrock. Also, it is conceivable that the two potential stability problems could act in tandem. A slumping failure in the inactive fill would initially be retarded by the proposed new cell construction (new cell construction is described in the next section). However, the additional pressure created by such a potential failure might contribute to sliding failure in the new cell configuration.

Preliminary stability calculations based on conservative assumptions regarding the refuse and the underlying sandstone indicate a static safety factor ranging between 1.4 and 2.0. This safety factor range and the lack of evidence of past slumping or sliding support the premise that slope stability will not represent a significant problem at the Pagosa Springs Landfill.

If signs of subsidence or slope instability become evident, Pagosa Springs should engage a local engineering firm to conduct a rigorous analysis based on comprehensive laboratory and field data.

Preliminary Landfill Operation and Site Layout. If the site is to continue operation while the upgrading strategy is being carried out, the following steps should be followed:

(1) direct landfill users to the active portion of the fill by providing a well defined access road. Identify the dumping area with a sign;

(2) begin covering operation by spreading final cover from the top portion of the used fill toward the active portion;

(3) construct a diversion ditch along the top slope of the finished and covered landfill site;

(4) construct a diversion ditch culvert under the access roadway where it intersects the ditch;

(5) plant vegetation as soon as possible after the cover is completed.

Upgrading Costs. The major cost involved in upgrading the disposal site is the purchase and transport of soil to be used as cover. In addition, a diversion ditch should be provided for redirecting surface drainage. Revegetation of the closed and covered portion of the site should also be accomplished to prevent erosion. Final grading of the closed landfill to a gradual slope will minimize erosion. Table 8 is an itemized listing of the capital costs for upgrading the disposal site. The table lists the items necessary for bringing the landfill into compliance with State law. (The table does not indicate the items or cost necessary for continued operation of the fill. Such data are presented in Table 11, Pagosa Springs Annual Landfill Operations Cost).

The quantity of fencing is based on enclosing the entire perimeter of the site. The dimensions of the site are rough estimates. Ditching is for diversion of surface run-on. It is estimated that ditching will only be required for the west side of the fill adjacent to Trujillo Road. The length of the ditch is approximately 600 feet. Based on the local climate and geology the final cover selected need not be completely impermeable, as such material is costly and difficult to obtain. There are possible sources for obtaining cover materials within a three and one half mile radius of the landfill as shown in Figure 7. The unit cost for the cover material is based on availability of cover material within three and one half miles of the landfill. In Table 8, the calculation for final cover assumes a three acre landfill area covered to a depth of two feet.

To ensure that the final cover placed over closed portions of the landfill is protected from erosion and kept intact, the revegetation of the final cover must be performed in a careful and methodical manner. Revegetation with seeds and plants which will grow well in the relatively dry Pagosa Springs climate and resist erosion is best for the landfill. Western Wheat and Crested Wheat grass would be good choices for seeding; examples of woody shrubs which are climatically suitable and would have adequate space for their root zones in the two feet of final cover are Sumac, Hansen Rose, and Nanking Cherry.

TABLE 8

PAGOSA SPRINGS LANDFILL UPGRADING COSTS[a]

Item	Unit Cost	Quantity	Total
Fencing (stock, 4' high)	$3.30/linear ft.	2,200 ft.	$7,300
Diversion Ditching	$2.70/linear ft.	600 ft.	1,600
Final Cover (permeable, off-site source transport @ $ .84/ yd.^{3}, material @ $ .30/yd.^{3}, placement @ $ .56/yd.^{3}, 3 mile average transport distance)	$1.70./yd.	10,000[b] yd.^{3}	17,000
Cover for Working Face (same assumptions as final cover)	$1.70/yd.^{3}	1,000 yd.^{3}	1,700
Revegetation[c]	$1,170/acre	3 acres	3,500
Dismantle Concrete Mixer (skilled welder)	$14.90/hour	16 hr.	240
Flattening and Burial of cars (labor only)	$12.60/hr.	16 hr.	200
Dozer Rental (270 HP)	$2,457/week	4 weeks	9,800
		TOTAL	$41,300
OPTION:			
Ground Water Monitoring Well (does not include sampling)	$1,170/well	2	$2,300
		TOTAL	$43,600

a Source: Unit costs were derived from the 1979 Dodge Guide (Reference 5) and the 1976 Building Construction Cost Data Handbook (Reference 3). These figures were converted to 1980 dollars by using the 1980 Product Price Index (Reference 9).

b $\frac{3 \text{ acres} \times 43{,}560 \text{ ft.}^2/\text{acre} \times 2 \text{ ft.}}{27 \text{ ft.}^3/\text{yd.}^3}$

c Cost for revegetation developed by Fred C. Hart Associates, Inc.

The Work Loam soil recommended as the soil to be used for final cover is sufficient if the following revegetation program is executed: the revegetated area must be properly prepared (discing, harrowing, etc.), fertilized, seeded, woody shrubs transplanted, and mulched. Simple seed broadcasting over the area to be revegetated will not be sufficient.

The revegetation cost of $1,170 per acre in Table 8 includes seed bed preparation, fertilizing, seeding, transplanting, and mulching. Following revegetation and closure of the landfill, periodic visual inspection of the site (on the order of 2 to 3 times per year) should be performed to ensure that erosion is under control and that the final cover is intact.

A rented Caterpillar Model D8 bulldozer and a dozer operator will be needed to flatten the cars and cover them at the working face. If operation of the site is to be discontinued, it will be necessary to use a dozer to grade the site and apply the final cover. Although a machine with the horsepower output of a D8 dozer will be needed to flatten the junked automobiles, such a large machine would not be required to close out the site nor for daily landfill operations---a Caterpillar Model D6 crawler dozer is a more properly sized piece of equipment for the Pagosa Springs landfill. The County, therefore, could reduce the overall rental cost significantly through the expeditious purchase of the D6 crawler dozer (see Section E of this chapter). The abandoned concrete mixer drum cannot, however, be flattened by a bulldozer and a skilled welder will therefore be needed to dismantle it.

The ground water well drilling costs are shown in the event that the Town decides to monitor water quality in the Dakota aquifer down-gradient from the landfill. Well sampling costs are recurring costs and are not included in the analysis.

D. <u>Estimated Life Of Landfill</u>

In order to estimate how many more years the Pagosa Springs Landfill can be used, it is necessary to calculate the total capacity of waste the remaining landfill area will hold and compare this to the amount of waste that is being generated now and will be generated in the future. The available landfill capacity refers to the volume of waste that can be contained and not to the additional volume necessary for the cover material. The area of the disposal site available for use is a keystone shaped area beginning at the access cut to the fence line at the bottom of the slope. The site is 500 feet across at the top near the existing fill, 300 feet along the sides, and 400 feet across at the toe of the site. On the unused portion of the landfill the slope is approximately 10 percent. To estimate the life of the landfill, it will be assumed that the slope will be kept at 10 percent. There is a 20-foot drop at the working face of the fill, and it will be assumed that the landfill cells will be stacked in such a fashion as to achieve a 20-foot height for the first stack of cells. Each successive stack of cells will be lowered 8 feet for each 50-foot length to achieve the assumed 10 percent slope. Figure 7 shows a schematic of how the cells will be stacked and the approximate dimensions of each stack. With this configuration, it is estimated that approximately 51,600 cubic yards of refuse can be contained in the unused portion of the Pagosa Springs Landfill. The calculation of this figure is presented in Table 9. The volume of cover material necessary with this layout is computed in Table 10. Approximatley 14,000 cubic yards of cover will be needed during the remaining life of the landfill.

To arrive at the estimated life of the landfill, the number of cubic yards of solid waste that can be contained in the unused portion of the landfill was divided by the number of cubic yards of waste generated per year. It is assumed that in the study area approximately 4.0 pounds of waste are generated per person per day.[12] In the landfill, waste will compact to a standard compaction ratio of 800 pounds per cubic yard.[13]

Using the projected 1985 Pagosa Springs population figure of 5,618, approximately 10,250 cubic yards of refuse will be generated each year for the next five years. The calculation follows:

---

[12] Source: Reference 11.

[13] Source: Reference 2.

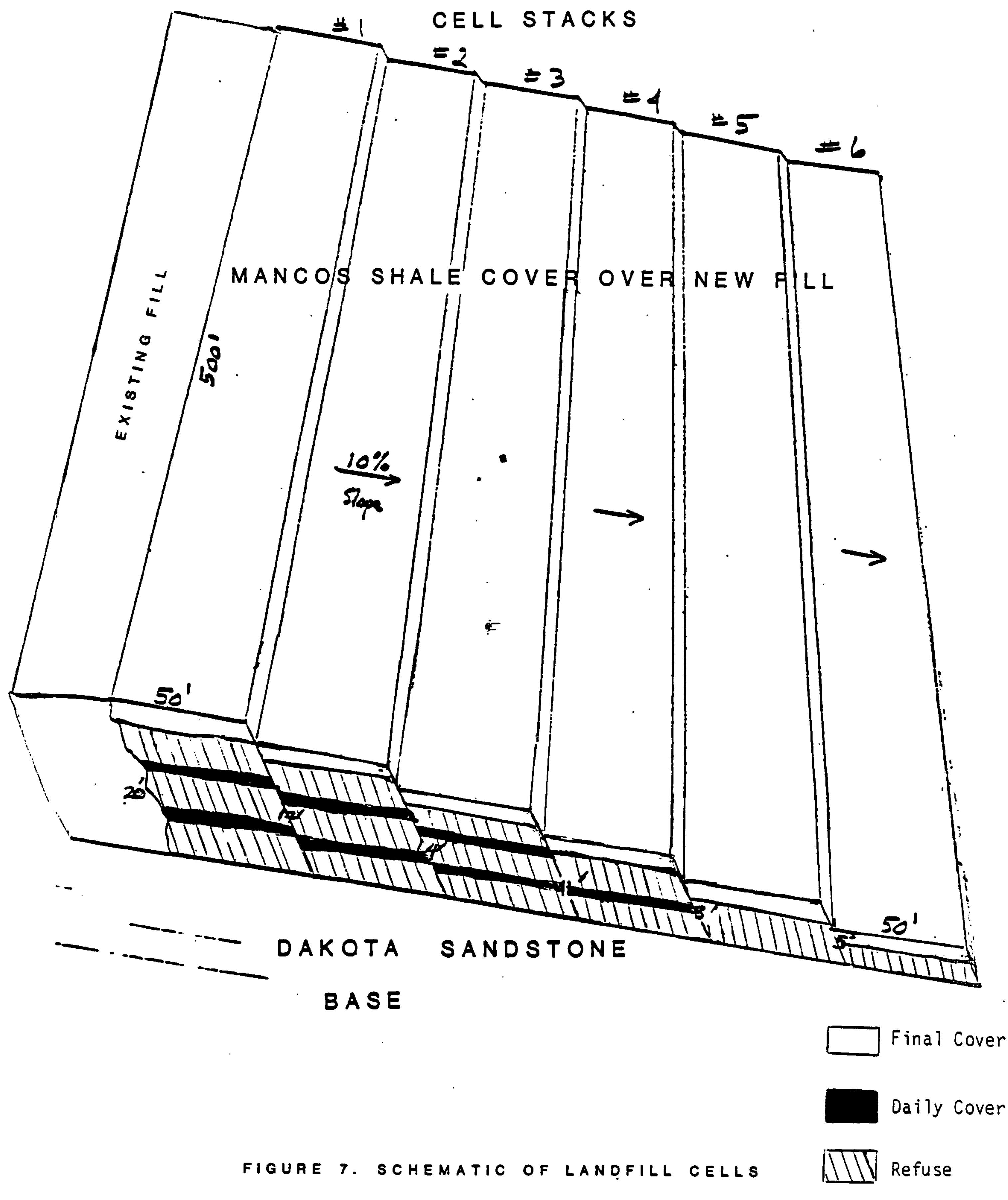


FIGURE 7. SCHEMATIC OF LANDFILL CELLS

TABLE 9

ESTIMATED AVAILABLE LANDFILL CAPACITY (REFUSE)

Cell Stack No.	Number Of Cells and Heights (ft.)	Cell Dimensions (ft.) Height	Length	Width	Number Of Cubic Ft.	Number Of Cubic Yd.
1	3 @ 5.5 each	16.5 x	50 x	500	412,500	15,500
2	3 @ 4.5 each	13.5 x	50 x	500	337,500	12,500
3	3 @ 3.5 each	10.5 x	50 x	500	262,500	10,000
4	2 @ 4.0 each	8 x	50 x	475	190,000	7,000
5	1 @ 5.5 each	5.5 x	50 x	450	124,000	4,600
6	1 @ 2.5 each	2.5 x	50 x	425	53,000	2,000
TOTALS					1,380,000	51,600

TABLE 10

ESTIMATED VOLUME OF COVER MATERIAL

Cell Stack No.	Dimensions (ft.)[a]	Cubic Ft.	Cubic Yd.
1	3.0 x 50 x 500	75,000	2,800
2	3.0 x 50 x 500	75,000	2,800
3	3.0 x 50 x 500	75,000	2,800
4	2.5 x 50 x 475	59,400	2,200
5	2.0 x 50 x 450	45,000	1,700
6	2.0 x 50 x 425	42,500	1,600
TOTALS		372,000	14,000[b]

[a] This dimension includes all daily and final cover requirements in the cell stack.

[b] Approximately 70 percent, or 9,800 $yd.^3$, will be used for final cover.

$$\frac{5{,}618 \text{ persons} \times 4 \text{ lbs/person/day} \times 365 \text{ days/year}}{800 \text{ lbs./yd.}^3}$$

$$= 10{,}250 \text{ yd.}^3\text{/year}$$

This figure computes to a generation rate of roughly 11 tons per day in the study area. If the total refuse capacity of the landfill (51,600 yd.^{3}) is divided by the amount of waste generated each year (10,250 yd.^{3}), the life of the site will be five years:

$$\frac{51{,}600 \text{ yd.}^3}{10{,}250 \text{ yd.}^3\text{/year}}$$

$$= 5 \text{ years}$$

E. **Landfill Operational Plan**

Staffing Needs. The landfill will handle an estimated 11 tons per day between 1981 and 1985 (population 5618 x 4 lbs per day per person). For this size landfill only one operator will be necessary. This operator should be employed on a full-time basis.

Equipment Needs. A crawler dozer will be needed for spreading the waste and grading the site. The dozer should be equipped with a U-shaped blade that has been fitted with a top extension to increase its pushing area. A dozer of this type can perform multiple functions such as compacting, moving heavy materials, and covering and grading the fill. A small gatehouse will be needed to provide a shelter for the landfill operator during inclement weather and to provide a place to store the landfill records and tools. A portable toilet for the sanitary convenience of the operator should also be provided. The toilet could be acquired on a rental or lease agreement. A fire extinguisher, first-aid kit, and hand tools should be kept on site. Additionally, professional engineering services should be procured to assist the town in implementing the continued operation of the landfill. Other equipment needs such as commodities (office supplies, fuel oil, etc.), contractual services (printing, telephone, utilities, etc.) will be itemized in the next section on operating costs.

The Town purchased a used crawler tractor for $13,500 in January 1981 to upgrade the landfill operation. The tractor is a 1974 John Deere Model 450B which has a 65 horsepower engine. The tractor is used exclusively for landfill operation and is kept at the site. It is equipped with a bulldozer pusher blade. This piece of equipment is too old and small for the landfill operation and the County will, therefore, need to purchase at an estimated cost of $32,000 a Caterpillar Model D6 crawler dozer.

The County has supported the Town by loaning a crawler Caterpillar Model D6 and operator on special occasions. (The County dozer is also equipped with a ripper as well as a bulldozer blade). This equipment could still be used as backup if the Town's Model D6 crawler dozer (yet to be purchased) should become inoperative. Other County equipment has been used to haul fill material to the landfill. This equipment includes five dump trucks and a 1 1/2 cubic yard front-end loader.

All of the above items are capital costs; the cost of each item is presented in Table 11. Assuming that the town would secure a loan to pay for the capital costs, and retire the debt over the remaining life of the landfill, the total capital cost is amortized over 5 years using the capital recovery factor (CRF) for a uniform series for 5 years at 12 percent interest (0.277).

Annual Operating Costs. Table 11 also itemizes the costs which will be incurred each year. The hourly wage including fringe benefits for the equipment operator was taken from the Dodge Guide to Public Works and Heavy Construction Cost for 1979. The rate is based on that for the City of Denver, less twenty-five percent to reflect reduced rural wage rates. Costs for commodities and contractural services were taken from one of the Pagosa Springs expenditures budget dated September, 1980. Office Supplies, fuel oil and gravel are all annual costs.

For the daily and final cover, it is assumed that a fifth of the landfill cover will be needed each year to operate the landfill. Therefore a fifth of the total cost for cover material was attributed to the yearly cost.

TABLE 11

PAGOSA SPRINGS ANNUAL LANDFILL OPERATIONS COST[a]

Item	Unit Cost ($)	Quantity	Total Cost ($)
CAPITAL COSTS			
Hand tools	200	1	$200
Signs and posts	100	1	100
Fire extinguisher	50	1	50
Operator building	5,000	1	5,000
Portable sanitation	500	1	500
Crawler dozer	32,000	1	32,000
Office equipment	500	1	500
Engineering fee	3,800	1	3,800
		Total Capital Cost	42,200
	Amortized capital cost (5 years, 12% interest)		11,700
ANNUAL OPERATING COSTS			
Equipment operator (including fee collection	8.48/hr.	2,080 hr.	17,640
Office supplies	300		300
Fuel oil	1,560		1,560
Gravel	500		500
Printing	200		200
Telephone	150		150
Utilities	750		750
Cover material			
Final cover	1.70/yd.^{3}	9,800 yd.^{3}/5 years	3,300
Daily cover	1.70/yd.^{3}	4,200 yd.^{3}/5 years	1,430
Terrace Erosion Protec.	6/linear ft.	2,850 ft. /5 years	3,420
Revegetation	1,170/acre	4 acres/5 years	940
		TOTAL	30,200
		Plus Amortized Capital Cost	11,700
		TOTAL	41,900
Add for groundwater monitoring if required: 2 wells @ $500 per well (includes 2 samples and analyses per year).		1,000	1,000
		TOTAL	42,900

[a] Unit costs were derived from the 1979 Dodge Guide (Ref. 5) and the 1976 Building Construction Cost Data Handbook (Ref. 3). All costs were converted to 1980 dollars using the 1980 Product Price Index 9 (Ref. 9). Revegetation cost developed by Fred C. Hart Associates, Inc.

The transport of cover material is a task that will need to be privately contracted or done using County or Town equipment and personnel other than the landfill operator and the equipment provided at the landfill. Cover would be trucked to the site at a rate which takes into account available storage area on site, cover consumption rate on site, weather, and the hauler's excavation and hauling capability. The cost of delivery is included in the estimated unit cost of cover material, Table 11. The estimated annual rate of delivery of cover material would be on the order of 2,800 cubic yards.

Similarly, revegetation was assumed to occur over a 5-year period; therefore, the annual cost of revegetation was calculated by dividing the total cost by 5 years. Annual costs for ground water sampling and analysis are included if the Town chooses to institute a ground water monitoring program.

Operational Plans. The hours of operation of the landfill should be set at a convenient time for the users taking into consideration that the operator should work a 40 hour-week five days per week with one of these days on the weekend to accomodate persons who are able to haul to the landfill only on their day off. The landfill could then be closed on one week day. One possible work schedule could be at 8:00 a.m. to 12:00 noon and 12:30 p.m. to 3:00 p.m. The operator's hours could be from 8:00 a.m. to 4:00 p.m. with an half hour for lunch at noon when the landfill will be closed. During the time when vehicles are not entering the landfill, the operator should be operating the dozer to spread the waste. At 3:00 when the landfill is closed the operator should apply the daily 6" cover. During the hours the landfill is open to the public, the operator should collect the disposal fees.

F. Methodology For Implementing Proposed Plan

When the decision is made to implement the plan, a logical procedure for its smooth development should be followed. The following is a step by step listing of the surveying, engineering and construction, and ground work which must be done to implement the plan:

Surveying. An engineering survey of the area should be made to establish the exact dimensions of the entire disposal area, and also the dimensions of the unused portion of the landfill. If surveying records exist, they should be utilized. The survey report is the first step toward implementing the plan. Accurate measurements must be made because all subsequent design criteria are based on such data.

Engineering and Construction. The first step toward the engineering implementation of the proposed landfill upgrading must be to obtain suitable daily and final cover material. The success of the operation will hinge on the availability of suitable cover material. All the potential borrow sites discussed in Section C are privately owned, therefore, an initial screening of the owners must be done to determine which are favorable to negotiations for securing cover materials.

The roadway permitting access to the active fill area should be defined and constructed. The roadway need not be paved but should be compacted to allow collection vehicles to pass freely. The filling operation may be started at the southern end of the fill and proceed toward the northern end. Each cell should be filled to about 5 feet high and covered with a 6-inch daily cover of soil. The final cover should be 2 feet deep and should be of a soil type to permit the growth of vegetation. Daily and final cover material should be stockpiled at the site in advance to ensure availability as needed. The diversion ditch should be constructed around the top of the slope to collect and divert run on. The gatehouse should be constructed and equipped with a service window for landfill users. A fence should be constructed around the periphery of the landfill to prevent animals from entering the area, to discourage trespassers, and to delineate the landfill area.

Groundwork. There is a 20-foot drop where the inactive portion of the landfill meets the active face. From this point to the fenceline at the bottom of the landfill area, the ground slopes down 35 feet for the remaining 350 feet. This results in a 10 percent slope for the existing ground. The groundwork should be done in such a fashion as to approximate the existing slope to reduce erosion, to enhance revegetation, and to avoid an excessively steep slope on the working face of the final cell. This means that if the finished area is to adjoin the inactive portion, then the slope line will be 55 feet (35 ft. + 20 ft.) in 350 feet, which results in a 16 percent slope. To accomplish a 10 percent slope the groundwork should be done in a stepwise fashion (see Figure 8) sloping each 50-foot segment 5 feet downward, at which point a 3-foot drop will be constructed. These 3-foot drops will not present subsidence or slope stability problems if proper erosion protection is provided. Several erosion protection methods are potentially appropriate including riprap, stone-filled gabions, and sandbags. The selection of a method depends primarily upon an evaluation of cost, availability, longevity, and aesthetics. For the proposed 3-foot drops, it is estimated that riprap would cost approximately $4 per linear foot, gabions $6 per linear foot, and sandbags $7 per foot[14] predicated on the availability of riprap and gabion material (stones, rocks) from the San Juan River. The engineer chosen by Pagosa Springs to assist in implementing the new operating plan should make the determination as to the most cost-effective method of erosion protection for the 3-foot drops.

Six 3-foot drops will compensate for the additional 28 foot drop created by landfilling and will effectively reduce the slope of the finished surface from 16 percent to 10 percent. (see Figure 7). The proposed terrace arrangement is a common solution to excessive grades. Although the average grade of the land surface (after filling) is 16 percent, the majority of surface area will be graded to 10 percent. An arrangement of three foot benches spaced 50 feet apart, whose faces are adequately supported to prevent erosion damage, is one way to achieve the desired slope. Other configurations and dimensions could be used, but must be evaluated in terms of a cost comparison. The proposed arrangement would cost approximately $17,100, or $3,400 each year over five years (based on utilizing gabions at $6 per linear foot).

G. Review and Comment on the User Charge System

There is a commercial refuse collection firm in Pagosa Springs. The firm owns one 18 cubic yard rear loading compactor, one 20 cubic yard rear loading compactor and one 6 cubic yard side loading truck. According to the firm's owner, Mr. Sam Hill,he delivers about 1 truck load (18-20 cubic yard) per day to the landfill in winter and up to 2 loads per day in summer.

---

[14] Source: Reference 14.

A count of numbers and types of vehicles using the landfill was conducted during the week of July 21st, 1980, at the landfill. The results are detailed in Table 12 and show that a total of 115 carloads, 193 pickup truckloads, 7 commercial trash vehicle loads and one oversize vehicle load were counted over 35 1/2 hours that week.

From this data the Town Manager extrapolated at 5 times the 6 days counted for a 30 day month and estimated the town would realize $2,637 per month if it charged $1.00 for each carload, $1.50 for each pickup truck load, and $5.00 for each full trashtruck load.

The Town budget for 1981 projects an income of $26,000 from user fees. Together with $3,000 from the Town General Fund and an additional $3,000 from the County and an unappropriated surplus of $600 the expected gross revenues total $32,600. This equals the town manager's estimate of annual expenditures to equip and operate the landfill.

The Town initiated a user charge system at the landfill on January 9, 1981. The charges were based on the above evaluation of the number, frequency and method of private and commercial deposits of solid waste at the landfill. Also impacting the selected charges was the subjective judgement of the individual citizen's ability to pay for trash disposal.

TABLE 12

FREQUENCY OF CUSTOMER USE AT PAGOSA SPRINGS LANDFILL

Number of Loads

Date	Time Observed	Car	Pickup Truck	Commercial Trash Truck	Dump Truck
7/21	1:00-8:00	27	36	1	-
7/22	12:30-7:00	33	20	1 3/4	-
7/23	1:30-6:30	22	28	1	-
7/24	1:30-7:30	12	31	1 1/2	1
7/25	10:30-7:00	11	58	1 3/4	-
7/26	2:00-5:30	10	20	-	-
TOTAL 6 days	35.5 hours	115	193	7	1

This report presents a higher estimate of annual operating costs than projected by the Town. The total cost is estimated to be $42,900. The difference in the two estimates lies mostly in the cost of personnel.

Using the $42,900 annual cost estimate it will be necessary to increase the revenues to match the anticipated costs. This report recommends an increase in user fees as the method of increasing revenues. The following are recommended revised fees:

Cars	$ 1.00
Pickups	$ 3.00 (an increase over the $1.50 fee)
Trash Trucks	$15.00 (an increase over the $5.00 fee)

The rationale for these new fees is based on subjective judgement that the current fee for cars is fair. One car load per week should suffice the average family. A pickup truck on the other hand can easily carry about three times the quantity of a car load. One can expect neighbors to pool their trips to the landfill. If so, three families per pickup truck load per week is believed reasonable, thus the $ 3.00 fee. The commercial hauler now has about 160 households from which he collects on a weekly schedule. He delivers on the average 1 1/2 truck loads per day and pays $45 per week fees (1 1/2 loads per day x 6 days per week x $5 per load). The average household pro rata share of the commercial fee is ($45 ÷ 160) or about $ .30 per week. This is less than the average single family carload cost of $1.00 per week discussed above. An increase by three times the current commercial pick up pro rata share would make the fees more equitable (3 x $ .30 approximately equals $1.00). This would bring about a raise in the commercial dumping fee to $15 (3 x $5).

At these new user fees, assuming the same number of car, pickup and trash truck loads counted by the Town, one can estimate the following weekly revenues:

	Weekly Revenue ($)
115 Cars @ $ 1.00	= $115
193 Pickups @ $ 3.00	= $579
8 Trash/Oversize @ $ 15.00	= $120
	$814

The estimated annual revenues (52 x $814 = $42,328) plus the County budget contribution of $3,000 exceeds the projected annual operational cost of $42,900.

IV. MILL CREEK SITE EVALUATION

A. Introduction

Presently the majority of the solid waste generated in Archuleta County is disposed of in the Pagosa Springs landfill, two miles outside of the town of Pagosa Springs. This landfill has been operating many years on an informal basis and has recently been cited for violating Colorado solid waste disposal laws. An upgrading program (see Section C) is currently being designed to upgrade the landfill; however, this will provide only an interim measure (5 year maximum) for disposing of solid waste in the County. A new site must be selected and developed over the next few years before the present site is forced to close. As a part of the siting effort this report presents an initial study of the Mill Creek area as a new landfill site (see Figure 8).

The proposed Mill Creek site, which is located in the Northwest quarter of the Southwest quarter of Section 16, R 1 W T 35N, has a number of factors which make it a good candidate for further study. First, the land is already owned by the State which may allow the county to purchase or lease the land at a significant cost savings over privately owned land. Second, the site seems to have favorable characteristics for a landfill such as (a) its close location to the Town or user population, (b) the site's easy accessibility from Mill Creek Road, eliminating the need for new access road construction; and (c) the land is mildly sloped which should mitigate run-off, run-on, and surface contour problems. Third, the site is not currently under intensive use and it is currently used as a grazing area for cattle.

The Mill Creek area was first identified as a possible landfill site in 1973 when Pagosa Springs Mayor James L. Cloman requested permission from the State Board of Land Commissioners to lease the site for development. At that time the lease was denied and no further action was taken. However, given the current condition of the Pagosa Springs Landfill, and its limited future capabilities, the town has again decided to study the Mill Creek area's potential as a landfill. The remainder of this report addresses a number of issues critical to landfill planning, though no final conclusion is made concerning the suitability

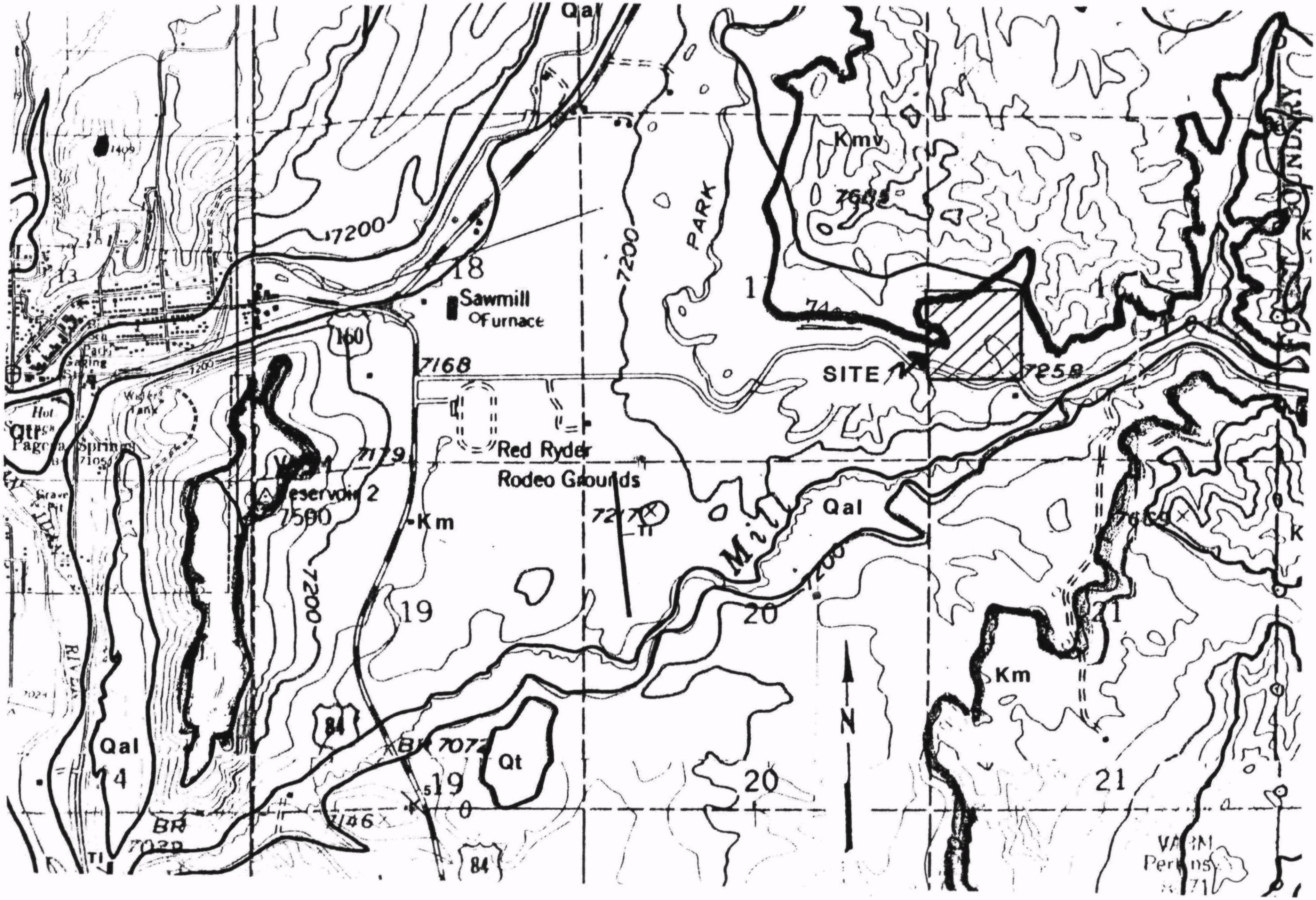


FIGURE 8. MILL CREEK SITE LOCATION

SCALE 1"=2000'

of the Mill Creek site for a landfill. No conclusion can be reached until further studies are done to determine the possible effects of a landfill on the groundwater of the area.

B. **Surface Water.** It is very important that a landfill does not contaminate nearby surface water either by direct run-off into a body of water, or by leaching downward through the soil and working its way laterally through groundwater into adjacent surface water. A number of environmental and design factors can be incorporated at the Mill Creek site to minimize the risk of surface water contamination. First, surface water run-on can be prevented by creating diversion ditches around the landfill where adjacent land is at a higher elevation. The SCS has, in fact, already constructed several retaining dams on the site to control erosion. Second, the soil at Mill Creek has been studied in an inventory and evaluation performed recently by the SCS. The survey indicates that there are predominantly two types of soil in the area being considered for the landfill. Immediately north of Mill Creek Road - in the valley bottoms - the soil is Work loam and clay loam (C2-CD) which has been rated as having moderately slow to slow permeability in the subsoil and substratum. Farther back from the road in a northerly direction, at higher elevations in the upland areas and ridgetops, the soil is Yawdim clay loam and clay (CO-CE) which is rated as slow with respect to infiltration, and which allows for rapid runoff. Under these conditions, water will be less likely to penetrate the landfill cover and form leachate. Third, the climate of the Pagosa Springs area will also help prevent leachate formation and movement. (See water balance discussion in Section III B). The evapotranspiration rate is 36 inches/year[15] which greatly exceeds the annual precipitation rate of 18.74 inches. Assuming the run-off coefficient to be quite high (.35), this would allow for only 12.2 inches a year ((1 - .35) x 18.74) to remain on site which could enter the landfill. Most, if not all of this precipitation will be lost in evapotranspiration, allowing little or no water to enter the landfill material and form leachate.

An additional concern is the possibility that the site may become flooded, saturating the enclosed portions of the site and carrying away any loose mate-

---

15 Source: Reference 13.

rial on the surface. The area proposed for development at Mill Creek has not been identified as an area of flooding in either the SCS analysis of the area or the Pagosa Springs "Plan for Progess" therefore the danger of a flood can be discounted as a problem. While it is true that the bottom bank of Mill Creek is subject to flooding and high water table, this section has not been considered for development and would not directly affect the proposed landfill area.

C. **Hydrogeology.** The proposed landfill area is located in the San Juan Basin. Mill Creek is characterized by two geologic formations: 1) the Mesa Verde Group Undivided (composed of buff to gray, cliff-forming sandstones and interbedded gray shales) (Kmv), and 2) the Mancos Shale (Km), which underlies the Mesa Verde Group. The actual depth to ground water at the site has not been determined, as no wells have been drilled. Wells in the sections surrounding the site are of varying depths, but one of the nearest in Section 17 (about 1 mile away) is a dry well that is over 500 feet deep. The newest well is 240 feet deep and water was reached at 210 below the surface. Assuming that depth to ground water is fairly deep (an assumption that can only be confirmed by testing) and that leachate development and movement will be slow to non-existent, operation of a landfill at this site may be anticipated to have little adverse impact on the hydrogeology of the area. Further study at the site will be needed to confirm this assumption. This study should include the drilling of a test well to determine the level of the ground water table at the site. If it is determined that the depth of the water table is significantly below grade, then this fact coupled with the low rainfall in the area may confirm the suitability of the site.

D. **Other Environmental Constraints.** The Resource Conservation and Recovery Act states that the waste management practices should not have an adverse impact upon prime agricultural land, critial habitat for threatened or endangered species, archeological or historical artifacts, and the geothermal resources. Each of these concerns is discussed below. According to officials at the Soil Conservation Service office in Pagosa Springs, the land in question has not been classified as prime agricultural land. Therefore, construction at the Mill Creek site should have no impact on any prime agricultural land.

The "Plan for Progress" for Pagosa Springs lists the wildlife within a ten mile radius of the Town which includes the Mill Creek area. None of the animals listed are currently on the Federal or State lists of endangered or threatened species. Within and around Pagosa Springs vegetation is typical of the Montane Forest Vegetative Zone . This type of vegetation includes ponderosa pine, mountain mulberry, big sagebrush, serviceberry, and bitterbrush. The more common grasses include Arizona fescue and slender wheatgrass. Neither the woody or herbaceous species in the area have ever been listed on the endangered and threatened species list. From the above data it can be assumed that the Mill Creek site does not provide critical habitat for any animals or plants which are threatened with extinction.

The "Plan for Progress" also quotes a letter from the Office of the State Archeologist which states that there are no known sites of archeological significance in the Town or the planning area. Therefore, we assume that no such sites exist at the nearby Mill Creek Site.

There is no possibility of encountering geothermal resources during construction or operation of a landfill at the Mill Creek site. The Colorado School of Mines has conducted surveys that indicate the thermal reservoir is restricted to about 1.5 miles around the Town's Big Spring which does not include the Mill Creek site.

The area proposed for development is currently used for grazing cattle. The fencing constructed around the site as well as the activities at a landfill would preempt this current use. However, upon final closure of this site, the area could be restored to allow the resumption of cattle grazing. The proposed landfill design is based on grazing as the final beneficial use of the property.

E. **Availability and Suitability of Cover Material.** In order to operate a landfill in the cheapest and most efficient manner, it is desirable to have sufficient cover material available on site to provide for daily and final cover. The Mill Creek site has two predominant types of soil, C2-CD and CO-CE. As previously discussed, the SCS Study has evaluated each with respect to its suitability as cover material (see Table 5). The C2-CD has been rated as good cover material. The top three (3) feet are rated as best for final cover material. CO-CE is rated poor as final cover but adequate for daily cover. Each of these soil types covers about one half of the total area we have assumed will be available for use. We have assumed that the entire Northwest quadrant and a small amount of the Southwest quadrant (North of Mill Creek Road) of Section 16 would be available for use. However, the original request to lease this site in 1973 stated that 40 acres would be requested and 20 developed. Therefore, it was assumed that a similar site would be developed today, though enlarged slightly for a longer life of the landfill.

The analysis of the adequacy of land area in Section F below identifies a need for a landfill about 30 acres in size that would operate for 25 years. Cover material for this 30 acres could largely be attained by excavating 3 feet of soil from the C2-CD area (roughly 20 acres) of the landfill, which would provide for 30 acres of 2-foot final cover. Daily cover material is available at the site in abundance, as only two 6-inch layers are required over the 30-acre site. The landfilling method proposed in Section F includes two 6-inch layers of soil fill in the design, one at the bottom of the landfill and another layer on top of the first cell for a total of 12 inches of poorer quality fill required throughout the site. The existence of on-site cover material of adequate volume to meet the requirements of the landfill provides strong support for developing this site. It will save costs over an alternative site without onsite cover.

F. **Land Area.** To determine if adequate land area is available at Mill Creek, estimates of the waste volume generated over a period of time, and a preliminary landfill design must be prepared for the site. The volume of waste we have projected to be generated in the area served by the landfill is based on waste generated per person per day, population using the site, and a compaction ratio for the waste. A production rate of 4 lb/capita/day was derived from review of a study[16] which estimated waste generation rates ranging from 3.36 to 3.76 lb/capita/ day. This rate includes commercial/institutional wastes in addition to residential wastes. We have adjusted that estimate to 4 lb/capita/day to account for future increases which may occur and allow us to use one

---

16 Source: Reference 11.

production value through the life of the site. This rate is, in part, influenced by the expectation of increased tourist activity in the future.

Population figures were obtained from the "Plan for Progress" for the years 1985-2000 for the entire County. We chose to include the entire county in the calculations, even though a small community at Arboles has its own landfill, because we felt the Arboles landfill would not make a significant difference in our calculations of the landfill requirements for Archuleta County. Beyond the year 2000, population figures were extrapolated forward for the years 2005 and 2010. The year 1985 was selected as the starting date because it is expected that the Pagosa Springs Landfill will begin closure at that time as stated in the landfill compliance schedule prepared by the Town.

A final assumption necessary to determine waste volume is the compaction rate of the material once it is disposed in the landfill. Average compaction rates of 800 lb/cubic yards are attainable without special equipment. (This figure was obtained from the "Sanitary Landfill Design and Operation" document prepared for EPA). The activity of a bulldozer onsite should compact the waste to this volume. The assumptions and calculations used to derive the waste volume are shown below.

Calculations

(1) Solid waste generation rate = 4 lb/person/day

(2) Average population over 25 year period = 9,500

(3) Pounds of waste generated per day

= 9,500 x 4
= 38,000 lb/day

(4) Compaction ratio = 800 lb/yd3

(5) Volume of Waste disposed per day

= 38,000 ÷ 800
= 48 yd^3/day

(6) Volume to be disposed per year

= 48 x 365
= 17,500 yd^3/year

(7) Volume to be disposed in 25 years

= 17,500 x 25
= 438,000 yd^3/25 years

In the 25 year period from 1985-2010 the county will generate and must dispose of approximately 438,000 cubic yards of solid waste.

To dispose of this waste the following general landfill design has been developed. (Figure 9 schematically illustrates the area method of sanitary landfilling which is recommended for the Mill Creek site.) The waste will be placed in two 4 1/2 foot thick cells separated by a 6-inch daily cover. Underneath the bottom cell would be 6 inches of in-situ clayey, relatively impermeable soil to act as a liner. Two feet of final cover will be placed on top of the second cell. Given the waste volume, and assuming the landfill structure defined above is developed, the area required to dispose of the waste can be calculated as follows:

438,0000 x 27 = 11,826,000 cubic feet of refuse
11,826,000 ÷ 9 = 1,314,000 square feet of space needed
1,314,000 ÷ 43,560 = 30 acres of land

This is equal to an area approximately 1,150 feet by 1,150 feet.

Based on this preliminary estimation of waste volume and landfill design, it appears that the Mill Creek site, if developed properly, would be adequate to

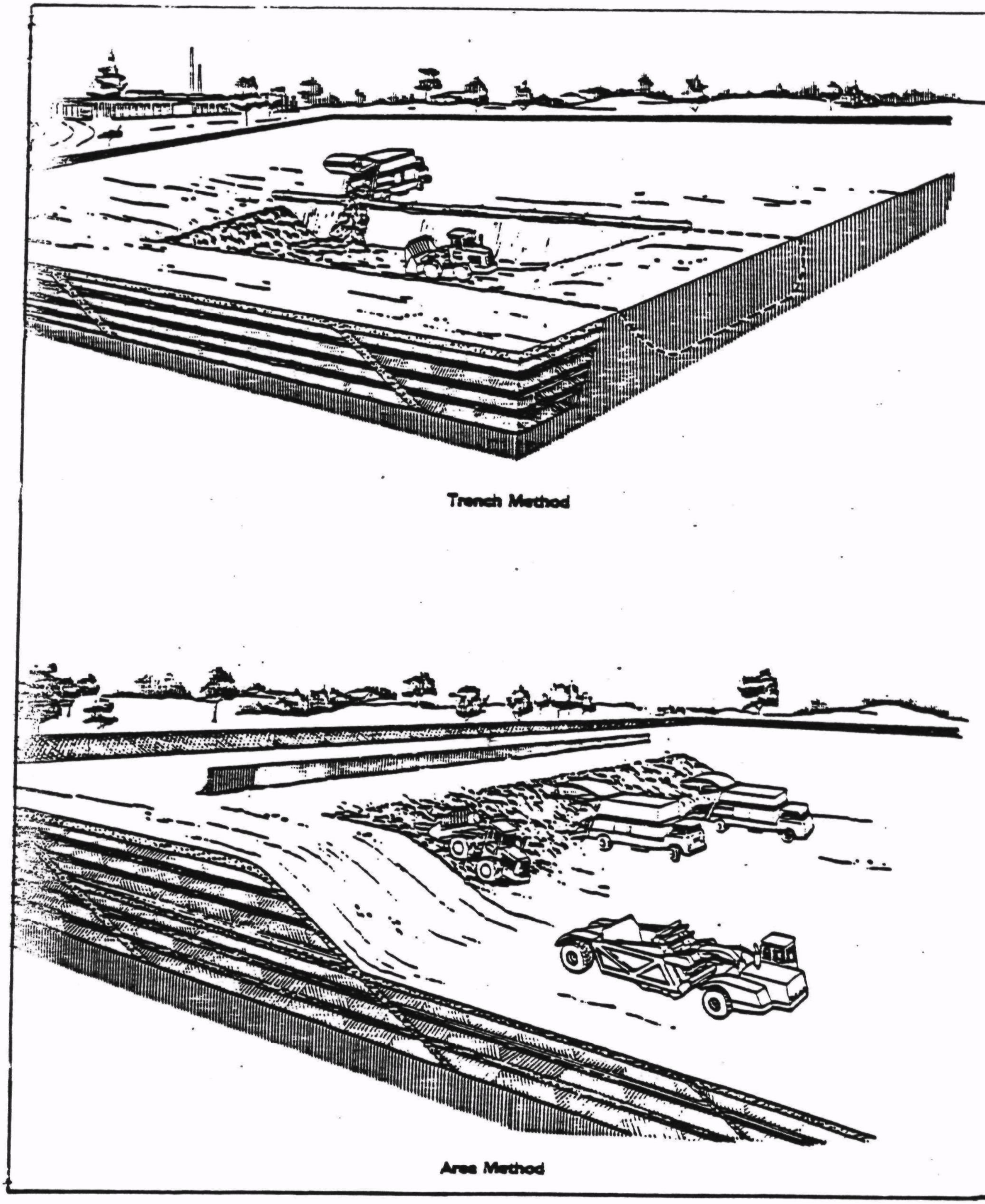


FIGURE 9. TRENCH AND AREA METHODS OF SANITARY LANDFILLING[a]

[a] Source: Reference 2.

act as a landfill for Archuleta County over the next 25 years. It is important to remember that the basic assumption made in these calculations is that the landfill is desired to be somewhat close to the areal size originally proposed in 1973. The landfill's life could be extended beyond 25 years if the landfill is built-up higher than the suggested two, 4 1/2 - foot lifts.

G. Estimated Costs. The costs of developing the Mill Creek site into a landfill can be broken down into three separate areas. First, the cost of the land itself must be considered; second, initial site development costs need to be calculated; and third, the annual operating costs for a landfill need to be estimated. All capital costs are amortized over a 10-year period in this cost analysis.

Land Cost. The value of the land at the Mill Creek site has been estimated to be between $1,200 and $1,500 per acre. This estimate is based on conversations with a local real estate agency and the County Land Board. At that price, buying the Mill Creek site would prove a burdensome expense to a County such as Archuleta.

There is an alternative to buying the land. The land is currently leased by the State for grazing. If the County can arrange to lease the site at the same fee, a substantial savings may accrue over the life of the facility. At the end of the period of its life as a landfill, Mill Creek could be returned to its former use as grazing land once final closure activities and revegetation are completed.

Site Development Costs. Site development costs are characterized as those costs incurred when preparing the site for use as a landfill. These costs are further distinguished by the requirement that they be paid as the necessary goods and services are acquired. Table 13 illustrates the site development costs.

The entire site must be fenced, therefore, the fencing estimate includes the entire forty acres proposed for the site. A gravel road must be constructed back into the site. The estimated $20,700 to construct the gravel road (including the subbase) was derived from the 1976 Means Cost Data and updated to 1980

TABLE 13

SITE DEVELOPMENT COSTS (MILL CREEK SITE)[a]

Item	Unit Cost ($)	Quantity	Total Cost
Fencing	3.30/linear foot	4,600 ft.	$15,200
Diversion Ditching	2.70/linear foot	1,100 ft.	3,000
Road Construction: 30 feet wide, 2,640 feet long, 9 inches deep			
Subbase	0.90/yd^2	8,800 yd^2	7,900
Road	1.45/yd^2	8,800 yd^2	12,800
Groundwater monitoring wells	1,170/well	2 wells	2,300
Engineering fee			4,100
		Total	$45,300
Amortized Site Development Costs (12% interest, 10 years)			$8,000

[a] Costs were derived from the 1979 Dodge Guide (Ref. 5) and the 1976 Building Costruction Cost Data Handbook (Ref. 3). All costs were converted to 1980 dollars using the 1980 Product Price Index (Ref. 9).

cost of the work crew, materials (gravel) and the machinery involved. An engineering fee of $4,100 is included, as professional engineering services should be procured to assist the town in developing the site. Activities which can be undertaken during operation of the site, such as stock piling cover material, are not included as site development costs. They are included as part of the annual operating costs. Total site development costs will be approximately $45,300.

Capital and Annual Operating Costs. Table 14 is an itemized list of the capital and operating costs associated with the Mill Creek Landfill. Capital costs are incurred for such items as a crawler dozer, operator building, portable sanitation facilities, office equipment, etc. The total capital cost of $59,350 was amortized over a 10-year period using the capital recovery factor (CRF) for a uniform series for 10 years at 12 percent interest (0.177). Although the Mill Creek site has a projected life of 25 years, a 10-year period was used to develop the capital and operating cost, as many items have a life-span of 10 years, and 10 years is a more reasonable planning horizon than 25 years.

Annual costs include a full-time operator, office supplies and expenses, fuel oil, and gravel. The hourly wage (including fringe benefits) for the equipment operator was taken from the Dodge Guide (Ref. 5) for the City of Denver; the wage rate was scaled down 25 percent to reflect reduced rural wage rates. For the daily and final cover it was assumed that one twenty fifth of the total cover required in the 25 year life of the site would be utilized each year. Additionally, revegetation is assumed to occur at a constant yearly rate over the life of the landfill. Groundwater monitoring costs includes taking 2 samples at each of two wells once per year. Analyses would be performed for pH, BOD, dissolved solids and one or two additional parameters.

The annual operating cost projected for the Mill Creek site is $26,410. Adding in the amortized site development cost of $8,000 and the amortized capital cost of $10,510 results in a total annual cost of $44,920. Based on an average generation rate of 19 tons per day, the disposal cost per ton equals $6.48.

TABLE 14

MILL CREEK LANDFILL COSTS [a]

Item	Unit Cost ($)	Quantity	Total Cost
CAPITAL COSTS			
Crawler dozer[b]	53,000	1	$53,000
Operator building	5,000	1	5,000
Portable sanitation	500	1	500
Office equipment	500	1	500
Signs and posts, hand tools, fire extinguisher	350	1 each	350
		Total Capital Cost	$59,350
		Amortized Capital Cost (10 years 12% interest)	$10,510
ANNUAL COSTS			
Equipment operator (including fee collection)	8.48/hr.	2,080 hr./year	$17,640
Office supplies, printing, telephone, and utilities	1,400		1,400
Fuel Oil	1,560		1,560
Gravel	500		500
Cover material			
Final cover	0.60/yd^3	96,750/25 years	2,320
Daily cover	0.60/yd^3	24,450/25 years	590
Revegetation	1,170/acre	30 acres/25 years	1,400
Groundwater monitoring (includes 2 samples and analyses at 2 wells each year).	500/well	2 wells	1,000
		Total Annual Cost	$26,410
		Plus Amortized Capital Cost	$10,510
		TOTAL	$36,920

[a] Cost were derived from the 1979 Dodge Guide (Ref. 5) and the 1976 Building Construction Cost Data Handbook (Ref. 3). All costs were converted to 1980 dollars using the 1980 Product Price Index (Ref. 9).

[b] The bulldozer life expectancy is 12,000 hours. At a rate of use of four hours per day the dozer will last approximately 12 years.

H. **Accessibility.** The Mill Creek site is about four miles out side of the center of Pagosa Springs. It has been estimated that 85 percent of the population of Archuleta County lives within 10 miles of the town, so the site should be within relatively short hauling distance for most residents. In comparison, this site is only slightly farther from the center of town than the present dumpsite.

A key to designing an effective landfill is to ensure that it is accessible to the user population and all types of traffic. The road leading to the site (Mill Creek Road) is constructed of gravel and will probably be sufficient to bear the landfill traffic without incurring upgrading costs. It appears to be both wide and durable enough to handle truck traffic. It will be necessary to construct a road approximately 1/2 mile long to allow access to the back of the dumping area.

REFERENCES

1. Briscoe, Maphis, Murray, and Lamont, Inc. Plan for Progress, Pagosa Springs, Colorado, June, 1979.

2. Brunner, D.R., and Keller, D.J., Sanitary Landfill Design and Operation, U.S. Environmental Protection Agency, Report SW-65ts, 1972.

3. Building Construction Costs Data Handbook, 34th Ed., Robert Snow Means Co., Inc., 1976.

4. Dehn, W.J. Solving the Abandoned Car Problem in Small Communities, U.S. Environmental Protection Agency, 1974.

5. Dodge Guide to Public Works and Heavy Construction Costs, McGraw-Hill Information System Co., New York, 1979.

6. Fenn, D.G., et al., Use of the Water Balance Method for Predicting Leahate Generation from Solid Waste Disposal Sites, U.S. Environmental Protection Agency, Report SW-168, Cincinnati, Ohio, 1975.

7. Galloway, M.J., Hydrogeologic and Geothermal Investigations of Pagosa Springs, Colorado, Special publication 10, Colorado Geological Survey, Department of Natural Resources, Denver, 1980.

8. Lutton, J.R., Evaluating Cover Systems for Solid and Hazardous Waste, U.S. Environmental Protection Agency, Report SW-867, Cincinnati, Ohio, 1980.

9. Product Price Index for Finished Goods, 1980.

10. Shaw, D.L., The Farmstead Windbreak, Colorado State Forest Service, Fort Collins, Colorado, 1974.

11. Smith, F.A., Comparative Estimates of Post-Consumer Solid Waste, U.S. Environmental Protection Agency, Report SW-148, 1975.

12. Steven, T.A., Lipman, P.W., Hail, W.J., Barker, F., and Luedke, R.G., Geologic Map of the Durango Quandrangle Southwestern Colorado, U.S. Geological Survey, Miscellaneous Investigations Series, Map I-764, 1974.

13. Thornthwaite, C.W. and Mather, J.R., Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance, Publications in Climatology VX, No. 3, Drexel Institute of Technology, Centerton, N.J., 1957.

14. Engelsman, C., 1981 Heavy Construction Cost File, Van Nostrand Reinhold Co., NY, NY, 1981.

APPENDIX A

Soils Maps

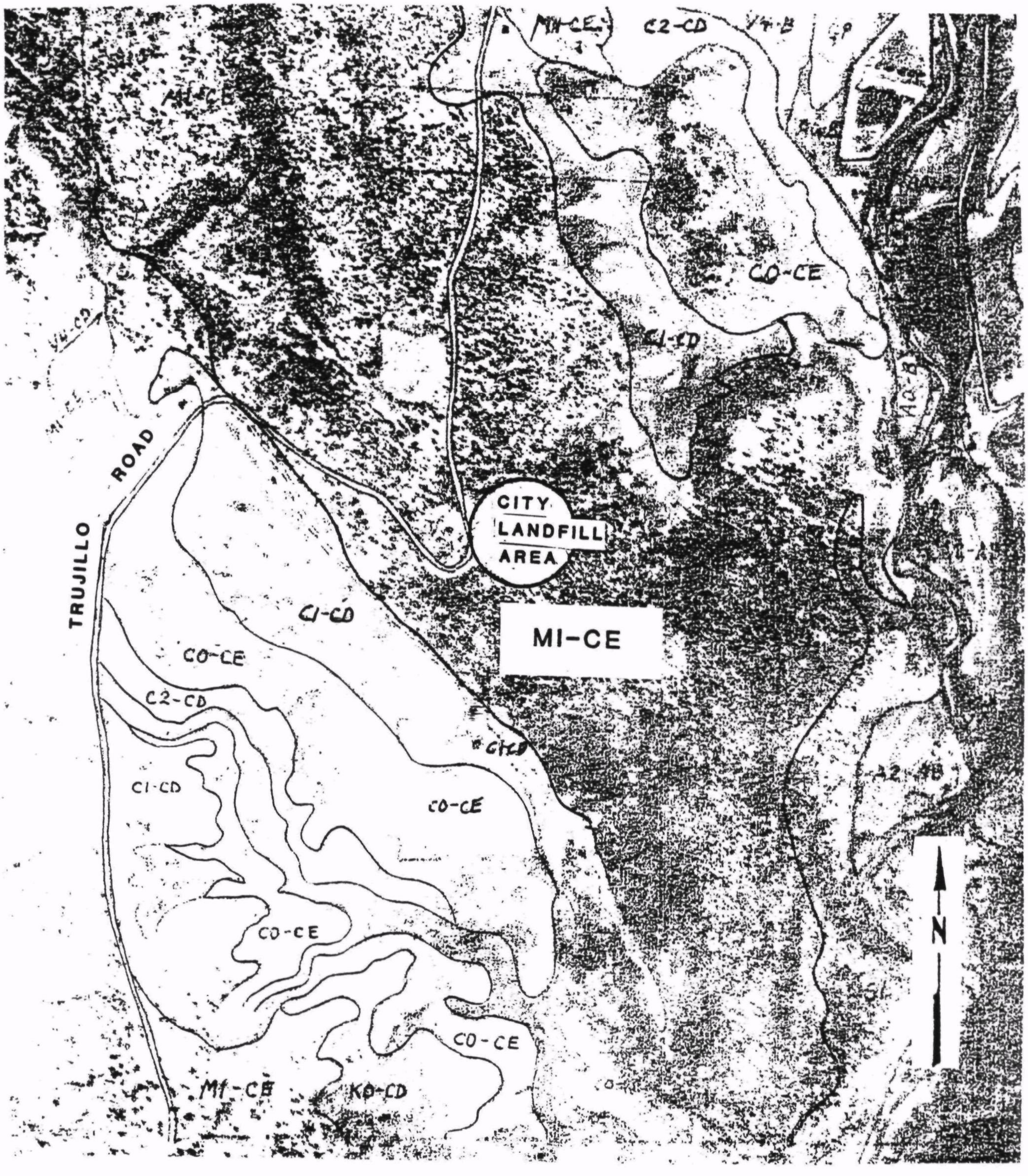


FIGURE A-1

SOILS MAP, OLD LANDFILL AREA

FIGURE A-2

SOILS MAP, MILL CREEK SITE AREA