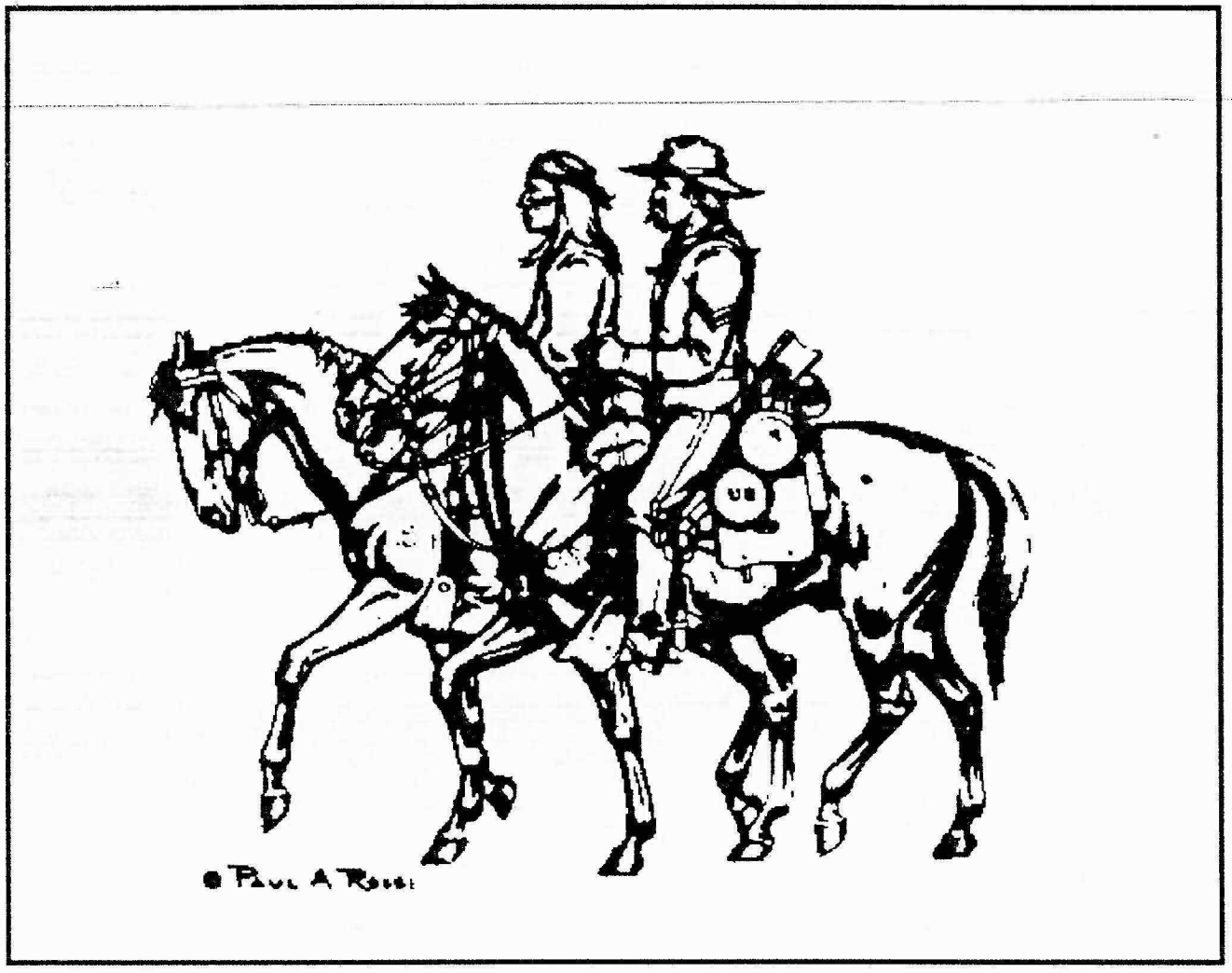

October 1991
Final Submittal

Future Development Master Plan

Fort Huachuca, AZ
Master Plan Narrative

Prepared Under the Direction of

US Army Corps of Engineers

Sacramento District

Prepared by

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brings sudden, sporadic thunderstorms, typically during afternoon hours. The generally dry climate causes water to evaporate at a rate of about 120 inches/year, leaving only a precious small amount of surface water to contribute to the hydrologic system. Less than one inch of precipitation in the San Pedro Basin is recorded in the annual stream flow, a relatively small amount when compared with the 15.24 inches of average annual precipitation recorded at Fort Huachuca.

The prevailing winds are from the southwest, ranging from 4 to 7 miles per hour. Occasional northeasterly winds, blowing more than 50 miles per hour, can occur during any month.[5]

1.2.3.2 Surface and Subsurface Geology.[6] The northwest-trending Huachuca Mountains, a faulted complex of granite, carbonate rocks, conglomerate and claystone, ranging in age from Precambrian to Cretaceous, forms the southwestern part of the Fort Huachuca area. The southern segment of the San Pedro basin is chiefly underlain by unconsolidated gravel, sand, sandstone and silt deposits which are Tertiary to Quaternary in age. This southern segment forms the eastern and northern part of the area.

The lower slopes of the northeastern flank of the Huachuca Mountains are composed of Precambrian granite; higher on the slope and extending almost to the crest are limestone, dolomite and claystone of Paleozoic age. The northwest-trending Crest Line fault separates these rocks from the mudstone and sandstone of Cretaceous age that form some of the crest and most of the southwestern slope of the Huachuca Mountains. In the general area of Sawmill Canyon and Lyle Peak, the headwater area of Garden Canyon, a northwest-trending block of Paleozoic rocks forms the crestal part of the mountains. This block is elevated west of the steeply dipping Lyle Peak fault.

The San Pedro basin, northeast of the Huachuca Mountains, is filled with about 850 feet of unconsolidated sediments, which are divided into an upper and a lower unit of basin fill. The basin fill unconformable overlies a conglomerate referred to as the Pantano Formation (Miocene) (USGS Survey 1819- D).

Soils.[7] A detailed description of soils can be reviewed in 'Natural Resources Management Plan, Fort Huachuca, 1981'. This section only list soils common to the Installation. They are as follows:

Bernardino - White House Hathaway Association. Deep, fine textured and gravely, moderately coarse-textured soils of the semi-arid rolling

---

[5] Source: Natural Resource Management Plan, Fort Huachuca, 1981; Fort Huachuca Environmental Quality Award Report, 1989

[6] Source: Analytical/Environmental Assessment Report, Fort Huachuca, April 1985

[7] Source: Natural Resource Management Plan, Fort Huachuca, 1981

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plains. Soils of this association have been used mainly for grazing, riding stables, animals and wildlife.

Karro Association. Well-drained, light colored, nearly level to strongly sloping, calcareous soils found on the valley floors. The natural vegetation is Rothrock grama, blue grama, black grama, burrow weed, scattered yucca, and scattered mesquite.

White House, Caralampi, Tubac Association. Deep, fine textured and gravellymn moderately coarse, textured soils on valley slopes in the semi-arid zone. Soils of this association are used mainly for grazing by wildlife.

White House, Tubac, Forest Association. Deep, well drained, nearly level to hilly, fine textured soils found on the valley slopes. the natural vegetation is Rothrock grama, black grama, blue grama, tobosa, threeawn, broomweed, scattered yucca, and scattered mesquite.

Graham Lampshire Association. Shallow and very shallow, dark colored, moderately steep to steep, cobbly and gravely soils over andesitic and rhyolitic bedrock found on the foothills. The natural vegetation is primarily sideoats grama, tangelhead, cane beardgrass, bush muhly, ocotillo, scattered yucca, and scattered mesquite.

Tortugus Association. Shallow and very shallow, dark colored, steep to very steep, cobbly and stony loams over limestone, which is found in the mountains. Below elevations of about 6,200 feet, the natural vegetation is oak-juniper with sideoats grama, black grama and blue grama being the dominant grasses in understory. Above about 6,200 feet, the natural vegetation is pine-oak with abundant juniper.

1.2.3.3 Topography. The terrain raises from a rolling desert thornbush area of 4,000 feet elevation, to a mixed conifer territory extending beyond the 8,400 feet elevation. The abrupt change in elevation occurs at 5,200 feet, where the foothills transcend the grassy desert plain into steep brush and tree covered mountains.

1.2.3.4 Hydrology. Water sources are of utmost importance for the region and the Fort. The discussion of hydrology in this section has to extend beyond Fort Huachuca's borders to include nearby creeks, perennial streams and river basins.

The upper San Pedro groundwater basin occupies the San Pedro River valley which extends north from the Mexican border (see *Figure 1-3 Fort Huachuca San Pedro River Basin*). The water-bearing deposits in the basin consists of alluvial valley-fill material of over 1,000 feet thickness. Depending on locations, normal well yield ranges between 100 and 2,800 gallons per minute (GPM). The aquifer is maintained by recharge that enters as a mountain front recharge from the Huachuca Mountains as run-off flows northeasterly towards the Babocomari and San Pedro

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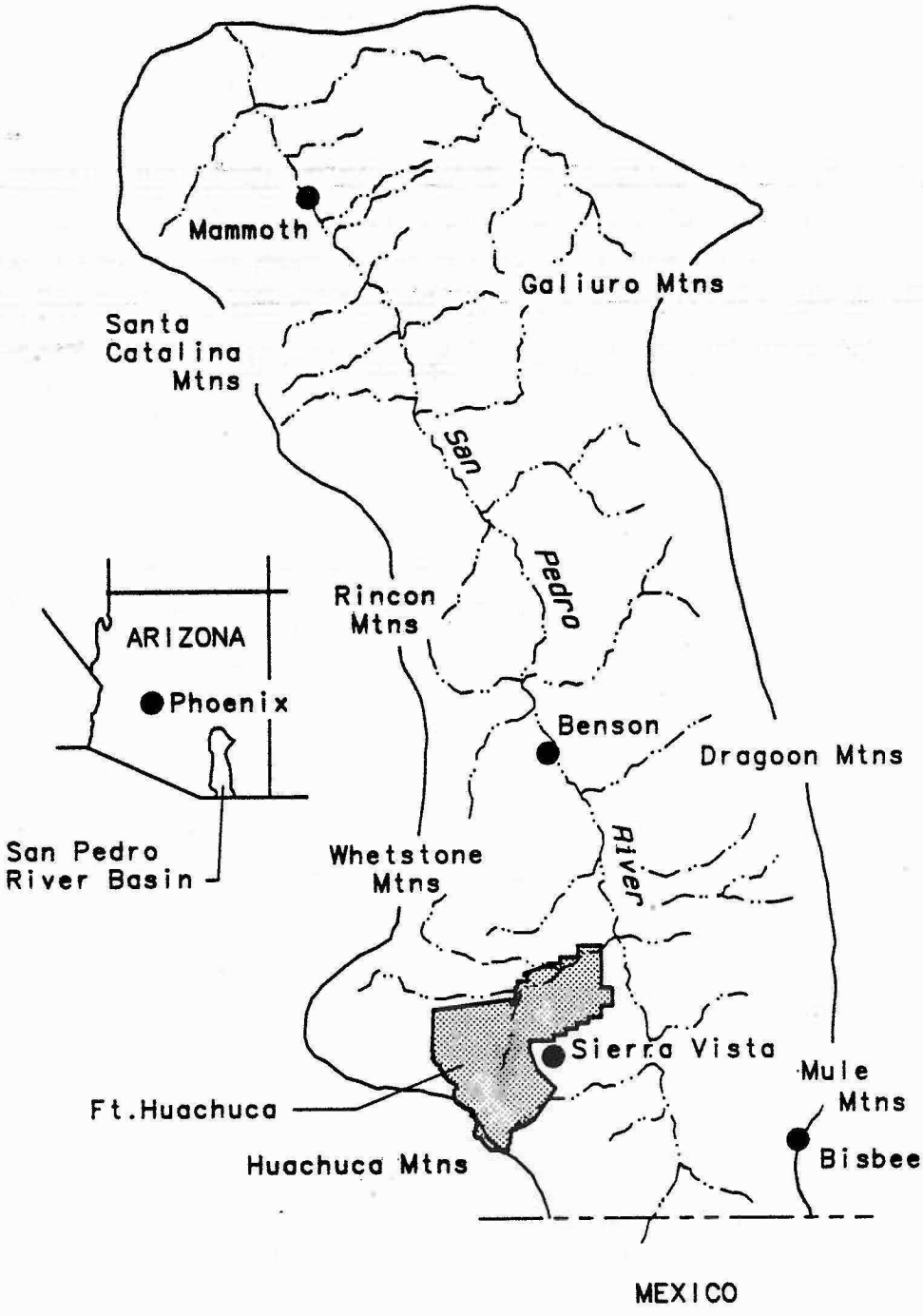

Figure 1-3

Fort Huachuca
San Pedro River Basin

0 15 30
SCALE IN MILES

Rivers. Groundwater underflow also contributes to the recharge of the aquifer. Conservative estimates place the capacity of this aquifer at 13.4 million acre-feet. The principal use for groundwater is for irrigation (36,000 acre-feet per year). Industrial, public supply, domestic and livestock use approximately 30% of the total consumption of 51,000 acre-feet per year.

The mountain areas adjacent to the upper San Pedro groundwater basin are underlain by essentially nonwater-bearing granite and consolidated sedimentary rocks. Although springs occur, most yield only a few gallons per minute. Higher flows originate from springs in the Huachuca Mountains, but the yields seasonally fluctuate and cannot provide a dependable source of water.

Low rainfall and high water evaporation combined with fast infiltration rates of rainwater into the ground have prevented the creation of true marshes. Also, there is no recent history of damage from flooding in the built-up areas. During periods of high rainfall the mountain run-off in the built-up areas follow the very rocky and well defined Huachuca Greek bed.

1.2.3.5 Vegetation.[8] Some vegetation occurring on the Installation was discussed earlier in relationship with soils associations. These soil associations together with varying elevations, precipitation amounts, and exposures are the controlling growth factors for botanical features.

The forest lands (24,449 acres) of Fort Huachuca begin at 5,000 feet elevation, rising to the foothills of the Huachuca Mountains at 5,200 feet elevation and continue to the highest part of the Post at the crest of Huachuca Peak (8,410 feet elevation). The Fort Huachuca forest lands adjoin the Coronado National Forest at the Fort's southeastern boundary continuing clockwise to the northwestern boundary. The major forest cover types of Fort Huachuca principally encompass only two biotic communities: Upper Sonoran and Transition. More information about these communities can be reviewed in the "Natural Resource Management Plan, Fort Huachuca 1989".

The Arizona Nature Conservancy was contracted in 1989 to conduct a survey for 13 rare plant species on the Fort. Two previously undocumented populations, of the endangered candidate species lemon lily, including the second largest known Arizona population, were discovered on Post in 1989. In addition, there are ten other endangered candidate species and the rare Huachuca milk vetch. Poisonous plants can also be found on the Post. The U.S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department (AGFD) keep a current list of threatened and endangered species. The list should be reviewed during every project planning phase.

[8] Source: Natural Resource Management Plan, Fort Huachuca, 1981; Fort Huachuca Conservation Award Report, 1989

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2.5 AIRFIELD/AIR OPERATIONS PLAN. There is presently no 'component' Airfield/Air Operation Plan existing for the Libby Army Airfield (LAA). The Arizona Air National Guard is in the process of preparing a master plan for the airfield which in all probability will also address air operations.

LAA is an auxiliary airfield for daytime operations supporting roughly 50,000 annual operations for light fixed-wing aircraft and 13,000 operations for rotary wing aircraft. The latter include UH-1 (Bell Huey), and UH-60 (Sikorsky Black Hawk). LAA has three runways. The primary runway is 12,000 feet long and lighted, and the two others are 5,300 and 4,700 feet long respectively and not lighted.

Tactical aircraft, from different military airfields exercise low approaches and touch-and-go landings. The average number of monthly operations are approximately 4,500. These figures do not represent the number of aircraft involved. Most of the Air Force/Air National Guards flights are student flights chased by an instructor in a two-plane formation. One low approach or touch-and-go with an instructor would count as four flight operations. On an average day, more than fifty pair of aircraft would approach and leave the airfield. This translates into one low approach each 11 minutes over a ten hour day. Flight operations are typically scheduled between 8 and 11 a.m. and 2 and 4 p.m. Depending on wind directions, most flights approach the main runway from the east.

LAA is the single largest landuse district in the developed portion of the installation. The airfield location is isolated enough so that the imaginary surface remain unobstructed and the approach and departure routes are not encroaching or are in conflict with adjacent landuses.

The TAB (see Appendix "A") identifies space deficiencies for the flight control tower (cat code 133 15), and the airfield fire and rescue station (cat code 141 11).

2.6 TRAINING RANGE DEVELOPMENT PLAN. There is no 'component' Training Range Development Plan existing in a single document form for the Fort. However, range operations and associated landuse issues are extensively addressed in the component Landuse Plan. A synopsis of the Landuse Plan is provided in Section II, 2.5 of this narrative.

2.7 UTILITIES PLAN. A 'component' Utility Plan for the Installation does not exist in a single document form. In lieu of that deficiency, an attempt is made in this section to provide utility capacity figures with current consumption data, and derive residual capacity figures based on the 1990 "effective population" (EP) of the Fort.

- The total potential capacity that can be achieved based on existing systems;

- the current and historical used capacity;

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- the residual capacity of the system.

2.7.1 Effective Population (EP). In assessing the capabilities of facilities at Fort Huachuca, it is practicable to express quantities on a per capita basis. The total population on the Installation includes assigned military personnel and their dependents living on the Installation. The authorized population also includes the nonresident civilian employees. To compensate for employees who are on-Post for only the regular working hours, facility capacities are measured against "effective population" (EP), rather than total population. EP is computed by counting each individual who lives and works on-Post as one, and each individual who works or attends school on-Post but lives off-Post as one-third. The total EP will, of course, be less than the actual population, but it is considered a realistic unit of measure for calculating system capacities. The EP used in the Fort's evaluation is derived from the projected population strength in the Army Stationing and Installation Plan (ASIP) as of December 1990. The EP of the Fort is 11,935 and tabulated in Section IC, *Table 1-6.*

2.7.2 Water

2.7.2.1 Water Resources and Supply. The Fort maintains systems for water, sewer, drainage and fire protection services which are independent from the City of Sierra Vista utility services. Water within the City is furnished by four independent water systems.

- Ft. Huachuca
- Belle Vista
- Cochise Water Company
- Pueblo del Sol

All of the City's water systems depend on wells of various depths averaging about 700 feet. None are interconnected with the Ft. Huachuca water system. However, consideration has been given to a plan to obtain additional supply from local water companies. This plan is possible but is considered neither necessary nor feasible at this time, mainly because Fort Huachuca occupies the higher elevations.

Water Supply. Six wells at the East Gate and the Main Gate to the Fort together with two wells northeasterly of Libby Army Air Field furnish water to a 450,000 gallon reservoir complex (upper pressure zone), a 1,500,000 gallon reservoir (middle pressure zone, and a 3,000,000 gallon Reservoir (lower pressure zone). All zones are interconnected for an "As Needed" transfer of supply. The zones are in different geographical areas on the Installation, and the altitude of the reservoirs determine the water pressure in each zone. Total reservoir storage is 4,950,000 gallons. The majority of the Post population, about 55% - 65%, is now located in the middle pressure zone. Post expansion, including BRAC, will take place in the lower pressure zone and in the western portion of the

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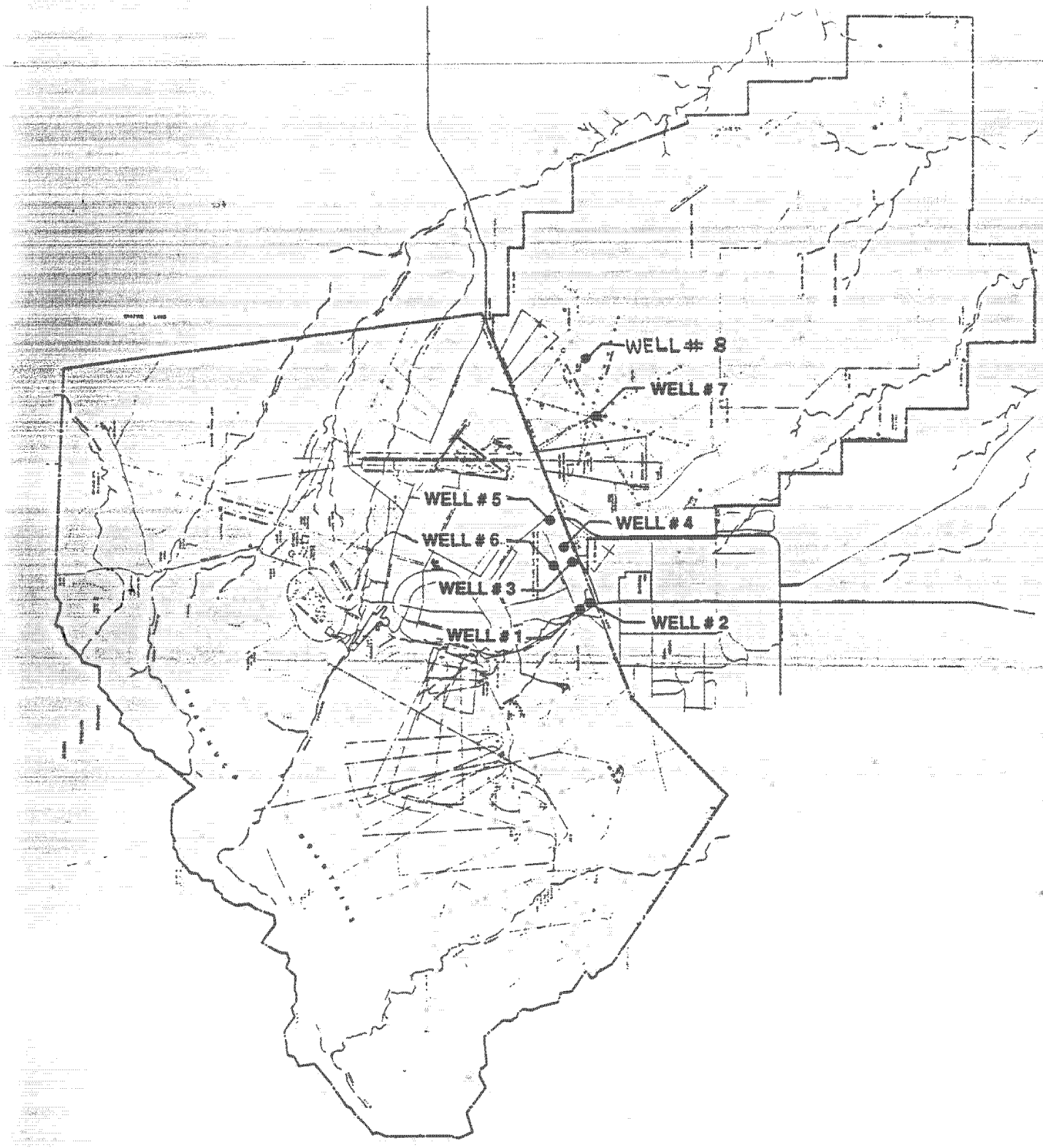

Figure 2-8

Fort Huachuca Well Locations

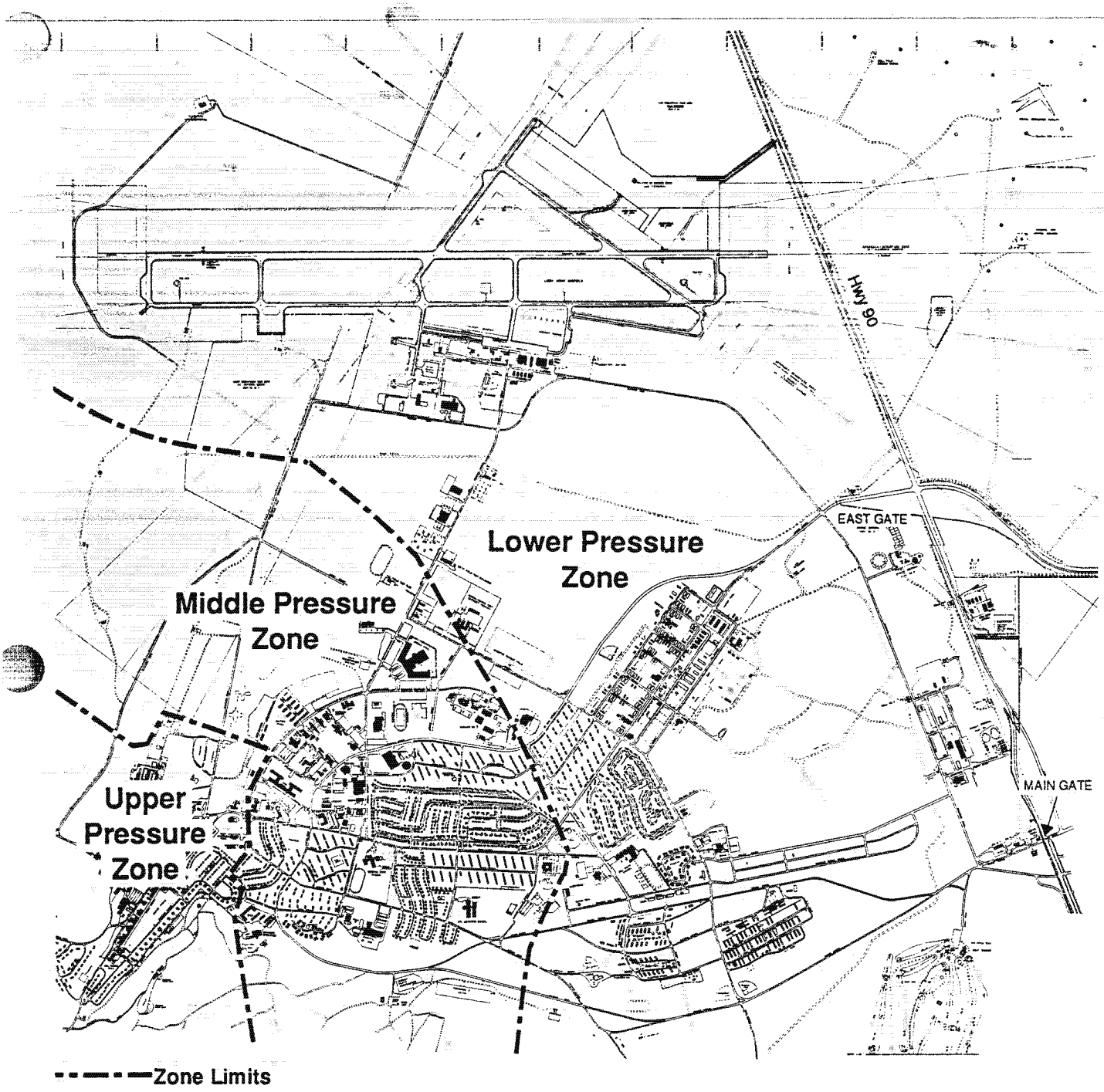

Figure 2-9

Utility Zone Delineation Map

middle pressure zone. Well locations and the pressure zone are illustrated in *Figure 2-8* and *Figure 2-9* respectively.

Well Pumping Capacity.[3] The rated pumping capacity for the individual wells is shown in Table 2-3.

Table 2 - 3
Rated Well Pumping Capacity

Well	Rated Pumping(GPM)	Location
1	500	Main Gate
2	750	Main Gate
3	700	East Gate
4	700	East Gate
5	700	East Gate
6	750	East Gate
East Range	750 est.	Air Field
Total	**4,850**	

The estimated total pumping capacity at 4000 GPM is equal to 5.760 million gallons per day (MGD), but less than the rated capacity of 4,850 GPM to account for downtime or maintenance and repair of the pumps.

Well Production. Well production for the Years 1988, 1989 and 1990 are shown on Table 2-4.

Table 2-4
Well Production - 1990[4]

	WELL #1	WELL #2	WELL #3	WELL #4	WELL #5	WELL #6	EAST RANGE	TOTAL KGALS
JAN	5397	13351	273	22697	0	12315	121	55861
FEB	4077	14189	24337	37	0	11589	0	54229
MAR	5175	14383	11466	18372	3642	19556	0	75040
APR	2522	17778	21304	16963	14012	19726	0	92305
MAY	749	18430	24271	17936	14509	18463	0	97912
JUN	0	23518	27222	19661	13577	18757	17175	119910
JUL	0	14935	28336	19248	7011	4147	858	78159
AUG	0	14800	26656	21436	465	4595	0	70370
SEP	0	19600	700	21849	16346	11509	0	70004
OCT	0	20100	0	22106	16815	9484	0	70708
NOV	0	15660	0	21119	18083	1892	0	56754
DEC	600	1680	3223	21643	17763	7263	0	54239
TOTAL	18520	188424	167788	223067	122223	139296	18154	895491

(or 2.49 MGD)

[3] Source: Condensed TAB, June 1989

[4] Source: DEH, Nov 1989, Jan 1990; unit measure in thousand gallons

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Table 2-4 (continued)

Well Production - 1989

	WELL #1	WELL #2	WELL #3	WELL #4	WELL #5	WELL #6	EAST RANGE	TOTAL KGALS
JAN	17319	14417	697	14567	1077	30851	0	78928
FEB	14591	11218	4210	8060	0	18979	0	57058
MAR	15969	12472	15376	11088	937	20014	28242	104098
APR	10877	7647	9457	15091	6178	20259	31205	100714
MAY	14475	8298	14700	16323	11569	22440	26310	114115
JUN	2535	21479	19302	18655	8524	24080	33371	127946
JUL	7360	16185	16874	16137	9247	17884	10014	93701
AUG	4405	15934	15019	11945	14105	11899	936	74243
SEP	6009	21053	20215	14916	10873	19379	4274	96719
OCT	7473	14406	11481	11122	4809	29201	1357	79849
NOV	7241	16945	7140	8287	605	22570	0	62788
DEC	5263	14441	351	22083	0	11421	0	55388
Total	113517	174495	134822	168274	67924	248977	135709	909561

(or 2.53 MGD)

Well Production - 1988

	WELL #1	WELL #2	WELL #3	WELL #4	WELL #5	WELL #6	EAST RANGE	TOTAL KGALS
JAN	9499	0	0	10161	1390	6807	30537	58394
FEB	6382	0	0	9365	1096	0	43&2932	60775
MAR	6639	0	0	18454	9638	25520	32066	92317
APR	4744	15660	0	18578	0	28957	27724	95663
MAY	1781	21029	231	20054	0	29464	44382	116941
JUN	997	20593	0	19907	0	28268	56774	126539
JUL	3658	17184	0	12140	1061	29912	33814	97769
AUG	7850	0	6303	12092	0	4920	47673	78838
SEP	12001	360	22160	20074	0	28295	0	82890
OCT	11105	18008	26078	10692	420	16813	0	83116
NOV	14477	8214	21681	10519	559	18777	0	74227
DEC	10917	19404	1382	16053	0	27973	0	75729
Total	90050	120452	77835	178089	14164	245706	316902	1043198

(or 2.89 MGD)

The average well production for the last three years amounts to **2.64 MGD** [(2.49 + 2.53 + 2.89)/3 = 2.64].

Projected Domestic Demand. The total demand based on the projected effective population of 11,935 is 1.79 MGD, calculated as follows:

11,935 EP x 1.0 Capacity Factor* = 11,935 Design Population

11,935 Design Population x 150 Gallons/Person/Day = 1.79 MGD

or 1,243 GPM (1,790,000/(24x60)

* TM 5-813-1, Par 3.5, Water Supply, General Considerations

The following quantity data will be used in the analysis of the water system:

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Pumping Capacity	5,760 MGD
Well Production (average 1988-90)	2,640 MGD
Domestic Demand (projected)	1,790 MGD
Reservoir Storage	4,950 MGD
Wastewater Treatment	1,700 MGD Day[5]

Water Uses

Domestic	64%	
Other Uses	36%	(fire flushing, testing, commercial, industrial, irrigation)

$$\text{Domestic Use} = \frac{\text{Waste Water Treatment } 1.7 \text{ MGD}}{\text{Well Production} = 2.64 \text{ MGD}} = 64\%$$

$$\text{Projected Use} = \frac{2.64 \text{ MGD}}{11{,}935 \text{ (EP)}} = 221 \text{ GPCD}$$

Projected Use (64% x 221) = 141 GPCD

Impact of the Water System on Future Developments. The water supply, pumping capacity, and reservoirs are more than adequate for the projected average daily use. The pumping capacity exceeds the well production for 1988-1990 by a factor of 2.18 (5.76/2.64 = 2.18). Pumps can operate at 100% capacity for 24 hrs or more allowing maintenance and repairs on other parts of the system. Excess pumping capacity exists for replacing reservoir storage. Reservoir storage is approximately 2.8 times the daily domestic demand (4.95/1.79 = 2.77).

According to the Base Realignment-Utility Analysis/Landuse Plan, which was briefly described earlier, the existing water distribution system is adequate, and the water demands for BRAC can be met by extending the existing piping system into the areas considered for future development. Except for the possibility of diminished pressure, in the event of two simultaneous hangar fires, the water system expansion will provide an adequate supply.

2.7.2.2 Wastewater. The Fort is served by a sewage collection and treatment systems. The sewer network in the cantonment consists of 6-inch and 8-inch collector lines which discharge into 12-inch and 15-inch mains leading to the treatment plants. Except for one small lift station, all flows are gravity. Septic tanks and a package treatment plant treat sewage flow in the outlying areas.

[5] Source: Base Realignment-Utility Analysis/Landuse Plan, Fort Huachuca, AZ, by HZA, Feb 1990

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Plant 1 and Plant 2 are the treatment plants on the Installation. Plant 1 is not in operation and used for water storage. Both plants are based on the trickling filter principle of aerobic wastewater treatment. The flowsheet of both plants includes the following treatment stages:

- bar screen and grit chamber
- primary clarifier
- trickling filter
- secondary clarifier
- digester (for clarifying solids)

Zero discharge system standards are met by sending effluent waters from the plants to the East Range lagoon which overflows to a dry arroyo. Sludge from the primary and secondary clarifiers is treated in anaerobic digesters and then dried in drying beds and used as soil conditioners throughout the Installation. Grease, skimmings and grit are sent by truck to a landfill operated by Huachuca City. The two holding ponds from inactive Plant 1 are used for non-potable water distribution.

Flow records into Plant 2 which are shown in Table 2-5 and which were furnished by DEH indicate the plant's capacity and the periods of high and low flows. Subtracting the estimated average inflow from the estimated water production leaves a remainder which accounts for water used for irrigation, fire, leaks, and other water uses which do not enter the sewer system. No allowance is made for infiltration.

Water Production (1988)	2.89 MGD
Average inflow into Plant 2	1.70 MGD
Remainder	1.29 MGD

Table 2 - 5
Fort Huachuca - Highest Seasonal Flow Rate, *
Sewage Treatment Plant 2

Time	June '88		July '88		Aug '88	
	Workday	Non-Wkday	Workday	Non-Wkday	Workday	Non-Wkday
000	1.502647	1.346621	1.112399	1.281582	1.229539	1.346621
100	1.216526	1.008221	0.943081	1.047294	1.034270	1.177484
200	1.112399	0.877918	0.825769	0.917019	0.903986	0.434002
300	1.047294	0.864882	0.956111	0.877918	0.864882	0.473243
	1.060317	0.877918	0.812729	0.877918	1.047294	0.434002
	1.372631	0.943081	0.825769	0.851846	1.112399	0.394743
	1.944288	1.229539	1.242551	1.281582	1.632604	0.289945
	2.476161	1.086360	1.892360	1.788481	1.892360	0.447085
	2.242738	1.372631	2.216794	2.048122	2.566905	1.489648
	2.372432	1.918325	1.892360	2.087052	2.320559	1.892360
	2.255709	2.346496	2.307590	2.346496	1.892360	1.996208
	2.125979	2.190849	2.061099	2.100029	1.866393	2.087052

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Table 2-5 continued.....

Time	June '88		July '88		Aug '88	
	Workday	Non-Wkday	Workday	Non-Wkday	Workday	Non-Wkday
1200	2.113004	2.125979	1.918325	2.100029	1.866393	1.957268
	2.100029	1.905342	2.035144	2.022166	1.736530	1.827439
	2.100029	1.957268	1.762507	1.801468	1.762507	1.749519
	1.931306	1.905342	1.684571	1.658589	1.476649	1.632604
	1.944288	1.710552	1.580628	1.645597	1.606617	1.879377
	1.996208	1.827439	1.567633	1.671580	1.567633	1.853409
	1.931306	1.892360	1.853409	1.970249	1.632604	1.892360
	1.866393	1.749519	1.905342	2.074076	2.138954	1.957268
	1.723541	1.788481	1.892360	1.918325	2.087052	2.216794
	1.853409	1.827439	1.879377	2.087052	1.866393	1.957268
	1.736530	1.892360	1.892360	1.970249	1.697562	1.762507
2300	1.736530	1.697562	1.398639	1.697562	1.515645	1.606617
AVG.	1.823404	1.597604	1.602454	1.671762	1.638254	1.448118

* Flow rate in MGD; influent flow adjusted from "9" to a 12" flume.

The residual capacities of the Plant 2 and of the sewer collection systems are addressed in Section II, 2.14.2 of this narrative.

2.7.2.3 Solid Waste Disposal. Solid waste generated by the Fort is collected under contract with Huachuca City and disposed of in a landfill area outside the Installation. Approximately 120 tons of waste per day can be handled by the landfill which has a total capacity of 430,000 refuse tons and is jointly owned by the State and the private sector. At that rate of use the landfill will reach its capacity in three years. The Installation purchased in the landfill area 108,360 refuse tons.[6] One third of that capacity was used up in 1988. The landfill operations serve a population of approximately 40,000. The Installation has also initiated a paper and scrap metal recycling program which will help to reduce waste disposal. Waste management is also discussed in Section II, 2.2.1 of this narrative.

2.7.2.4 Storm Drainage. The tributary area for surface drainage on the entire Fort is shown on the 1:62500 scale USGS 15 minute quadrangle maps titled "Fort Huachuca, Ariz" and Sunnyside, AZ" which were taken from aerial photographs taken in 1946. *Figure 2-10* shows an excerpt from these maps. The topography of the developed portions of the Fort is also shown in more detail on the 1"=400' scale May 4, 1983 Master Plan Basic Information Maps titled, "General Storm Drainage Map", sheets 2, 3, 4, and 5 of 5 sheets.

[6] Source: DEH, Contract Management Division, Fort Huachuca

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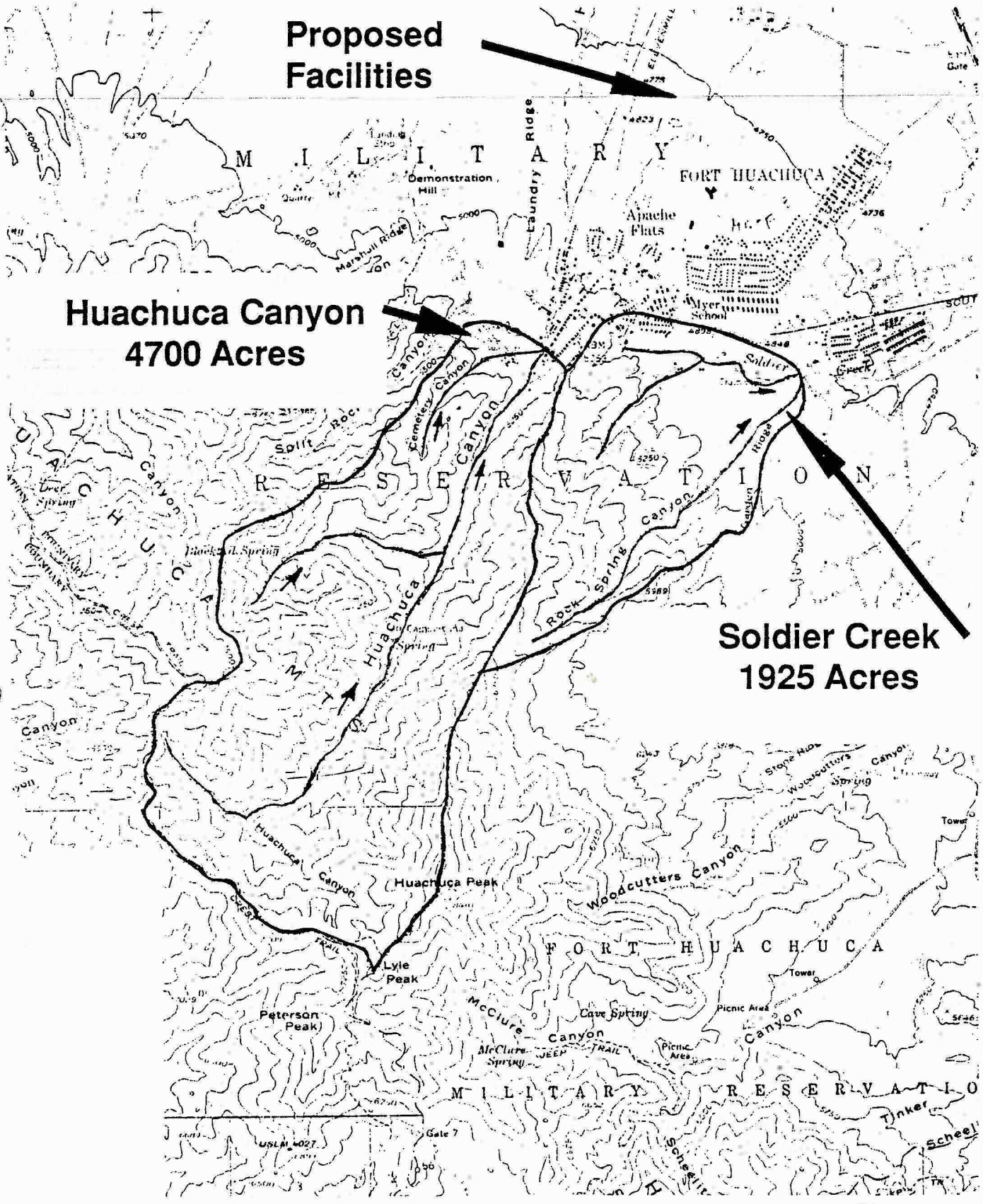

Figure 2-10

Regional Tributary Areas

These maps indicate that water from the Huachuca Mountains is intercepted in the Huachuca Canyon watercourse and the Soldier Creek watercourse which run along the periphery of the developed areas. These two watercourses plus the Greely Hall watershed and the runway watershed could pose flooding situations. Several flood hazardous sites have been identified along the Huachuca Canyon wash. One is in the vicinity of the facilities near Butler Road and Clarkson Street, and the other most prominent flood site is the old power plant north of Butler Road and west of Clarkson Street. If the water has not already evaporated or percolated, the runoff will eventually reach the Babocomari and San Pedro River.

The runway watershed is adequately protected from floods by a system of storm sewers and a detention basin. Drainage from the Huachuca wash is channeled under the west end of the primary runway, and drainage down Arizona Street from Greely Hall is diverted and drained to the east of the airfield.

The Base Realignment Utility Analysis addresses the impact storm water will have on future developments east of Greely Hall and recommends a system of channels to divert the runoff.

The Fort does not have any hydrologic or hydraulic studies that would substantiate the flood boundary lines shown on the maps mentioned above. Although there is no recorded flood history on the Base, a flood study is highly recommended, so facilities can be sited out of potential flood plains.

2.7.3 Electrical Distribution System. The primary power for the Fort is obtained from a Tucson Electric Power Company (TEP) 138/46/14 KV Substation. This station is located 800 feet due west of Greely Hall. Power is delivered from TEP's Vail Substation via a 54 mile long 138 KV transmission line. Back-up power is available from TEP's South-end Substation near Nogales, Arizona, via a 70 mile long 46 KV transmission line and a 46/14 KV transformer that has recently been installed at the TEP substation. The capacities available to the Fort is shown in *Table 2-6*.

Table 2-6
Electrical Capacity

FACILITY	AVAILABLE CAPACITY AT FORT	PRESENT LOAD	KVA ESTIMATED 1993 LOAD	1993 % LOAD'G
138 KV line	124,000 KVA	18,898 KVA	26,000	21%
46 KV line *	25,000 KVA	18,898 KVA	26,000	104%
138/14 KV XFMR	42,000 KVA	18,898 KVA	26,000	62%
46/14 KV * XFMR	28,000 KVA	18,898 KVA	26,000	93%

* available stand-by power via 46 KV transmission line from south-loop

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14KV Switching Station-Existing. The existing 14KV switching station at the Fort was installed in 1987. The station is double ended. One half is served from TEP Bus "A", while the other half is served from TEP Bus "B". A normally open bus tie circuit breaker can transfer one half of the switching station to the other in case of a failure on TEP Bus "A" or "B". Since both TEP buses A & B are served by an independent breaker, the double-ended scheme is considered very reliable in the industry.

Capacity of the switching station for future growth (2000A) is not the problem. The issue is the space limitations. Expansion of the "A" Bus of the station to the west is blocked by the TEP Substation, while expansion of the "B" Bus to the east is blocked by a major underground electrical ductbank. Relocating existing facilities to allow east and west expansion of the present station is extremely expensive and also disruptive. To serve the additional loads and feeders for future developments, such as the expanded Campus, another switching station should be planned just south of the existing one.

14KV Distribution, Existing and Proposed. Presently the Fort is served by six (6) distribution circuits. Each circuit emerges from the switching station with 500 MCM underground cable. Some distance from the station each circuit converts to an overhead pole line, consisting of 336 MCM (thousand circular mils) aluminum mains. The peak loads and emergency loads of the existing circuits are shown in Table 2-7.

Table 2-7
Peak Loads and Emergency Loads - Existing Circuits

CIRCUIT NO	CAPACITY IN AMPS*	PEAK LOAD IN AMPS	EMERGENCY LOAD IN AMPS	% CAPACITY AT EMERGENCY	NOTES
AF-1	270	212	234 (Cir BF-1)	87	
AF-2	270	169	413 (Cir BF-2)	153	
AF-3	270	95	212 (Cir BF-3)	79	
BF-1	270	22	234 (Cir AF-1)	87	
BF-2	270	244	413 (Cir AF-2)	153	Load will be transferred to new switching station
BF-3	270	117	212 (Cir AF-3)	79	
Total		**859**			

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To serve new loads for future developments, it is recommended that new 14KV circuits be extended into the new areas, via underground ductbanks.

Reliability of Power Source/Supply. A history of outages, affecting the power supply to the Fort was assembled for the last 6 years (see Table 2-8). Out of a total of nine outages, three were of long duration and considered extremely disruptive to the Fort. With the addition of the new 12KV switching station in 1987; the installation of a "TEP" 46/14 KV transformer in April 1991; and the recent replacement of the exterior busduct, which connects the TEP 138/14KV power transformer to TEP 14KV switchgear, the reliability at the TEP substation should markedly improve. To improve the reliability beyond 1993, when the load exceeds the 46 KV transmission line capacity of 25 MVA, reconductoring of the 46KV transmission line by TEP is recommended in 1993. To improve reliability beyond 1997, when the load exceeds the 46/14KV transformer capacity of 28 MVA, the increase of 46/14 KV transformer capability by TEP is recommended.

Table 2-8
History of Outages Effecting Power Supply to Fort Huachuca

DATE	OUTAGES	DESCRIPTION OF CAUSE	TYPE OF OUTAGE	DURATION
1984	138KV supply line to Fort Huachuca	Capacitor bank failure	very short time	2 minutes
1984	138KV supply line to Fort Huachuca	lighting striking Tucson Electric Power Co (TEP) transmission line	instantaneous	10 seconds
1985	138KV supply line to Fort Huachuca	Lighting striking TEP transmission line	instantaneous	10 seconds
1985	TEP 14KV main circuit breaker feeding Fort	Lack of relay coordination between circuit breakers of Fort and TEP	short time	1 hour 19 minutes
1986	TEP 14KV supply to Fort	Busduct between TEP 14KV switch-gear and trans-former shorted	long time	3 hours and 37 minutes
1986	TEP 14KV supply to Fort	After 3 hours of service busduct shorted again	very long time	24 hours

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Table 2-8 continued.....

DATE	OUTAGES	DESCRIPTION OF CAUSE	TYPE OF OUTAGE	DURATION
1987	TEP 14KV supply to Fort	Lack of relay coordination between Fort and TEP	short time	5 minutes
1988	TEP 138KV supply to Fort	TEP electrician inadvertently tripped circuit breaker	short time	6 minutes
10/5 1989	TEP 14KV supply to Fort	Busduct between TEP 14KV switchgear and transformer flooded during rainstorm	long time	8 hours and 30 minutes
1/22 1991	TEP 14KV supply to Fort	Differential relay in TEP switchgear tripped	short time	1 hour and 30 minutes

System Capabilities. As discussed earlier, the 46 KV line to the Fort has a firm capacity of 25,000 KVA, and the 46/14 KV transformer of 28,000 KVA. The power consumption and the demand on the system for the last three years is shown in *Table 2-9*. The three month high average load for 1988 through 1990 is recorded as 18,509 KVA which establishes a load of 1.65 KVA per effective population (19,681 KVA/11,935 EP = 1,65 KVA/EP). The effective population (EP) that can be supported by the existing capacity is determined as follows:

$$EP = \frac{\text{Available KVA}}{\text{Per Capita Peak Demand}} = \frac{42{,}000 \text{ KVA}}{1.65 \text{ KVA/EP}} = 27{,}096 \text{ EP} > 11{,}935 \text{ EP}$$

Based on this very simple calculation, which cannot be applied in all situations, the Fort can sustain a population growth of about 13,000. This potential expansion can only be predicated on the assumption that the Installation growth is in kind, which means that a mission change would not simultaneously require an unproportional surge in facilities or process power.

Back-Up Power Supply to the Fort. The power supply to the Fort depends on the reliabilities and capacities of TEP's transmission lines to Fort Huachuca substation and transformers at this station.

The worst condition occurs when the 138KV line from Vail substation to the Fort or the 138/46/14KV 42 MVA transformer at Fort Huachuca substation fails.

In both cases the Fort's power supply depends entirely on the TEP 46 KV line from Nogales, Arizona to Fort Huachuca and the 46/14KV 28 MVA transformer at this station.

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Table 2-10
Overview of Back-Up Options

OPTION	DESCRIPTION	MAX. FIRM DELIVERED POWER	COST $	NOTES
1.	SHED Non-Critical	25.0 MVA	100,000	Cost for re-laying and controls to drop circuit(s) with non-critical loads
2.	Upgrade 46 KV line and 46/14KV XFMR	37.5 MVA	1,700,000	Cost to be paid by Fort
3.	Bring in power from SSVEC	53.0 MVA	2,200,200	Entire expense to be born by Fort

From the metering stations, gas is distributed throughout the Installation in a government-owned system of piping which is based largely on 4-inch mains along the principal thoroughfares. Operating pressure is 45 psi, with reducing stations at several points for the purpose of balancing flows, especially in loops.

The total energy consumption of natural gas for 1989 was 4,872,298 CCF or 502,334 MBTU and for 1990 5,903,839 CCF or 608,685 MBTU. The use of propane gas for 1989 was 36,973 gallons or 3,531 MBTU.

Major gas consuming facilities include the following: Bldg 22528 shop, Bldg 45001 hospital, Bldg 51001 barracks, Bldg 51005 Riley Barracks, Bldg 52004 dining hall, Bldg 52107 mess, Bldg 52204 barracks, Bldg 61801 Greely Hall, Bldg 72908 maintenance shop, and Bldg 90201 laundry.

Limitations on gas supply do not exist at this time, and demands to satisfy requirements for future developments can be met.

2.8 TRANSPORTATION PLAN

2.8.1 Access and Circulation. Arizona State Routes 90 and 92 provide access to the Fort via the Main, East and North Gates. State Route 83 brings traffic to the West Gate via Canelo Road. This gate is regularly used, except during inclement weather when the washes run heavily.

Internal Road Network. The internal roads and streets are stratified into the categories of primary, secondary collectors, local and residential. The definition for these categories is in accordance with *TM 5-822-2 General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas*, and as follows:

Primary. Primary collectors include all installation roads and streets which serve as the main distributing arteries for all traffic originating outside and within the installation and provide access to, through, and

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To back-up loads at the Fort, three options are available. They are as follows:

1. Install relaying and controls to initiate shedding of "non-critical" loads until the load at the Fort does not exceed 25MVA.

2. Request TEP to reconductor 40 miles of the 46KV transmission line from 2/0 copper to 336 MCM ACSR and install additional capacitors to partially compensate for voltage drops.

3. Bring in 69KV transmission line from the Sulphur Springs Valley Electric Cooperative (SSVEC). With a 28 MVA 69/14KV transformer at its terminal near the existing switching station. The back-up capability to the Fort will be increased to 53MVA, 25MVA from TEP and 28MVA from SSVEC.

The first option should not be costly, especially if there are circuits available with non-critical loads that can be entirely dropped at the Fort's switching station.

The second option is expensive. TEP would probably heave to spend close to $1,000,000 to upgrade the 46KV line. Besides, even when the 46KV line is upgraded, in 1997 the Fort's peak load will exceed the TEP 46/14KV transformer capacity of 28MVA at Fort Huachuca substation.

If load shedding is not applied, another expenditure of $700,000 is needed by TEP to increase the 46/14KV transformer capacity at the above substation. The cost for reconductoring the 46 KV transmission line and upgrading the 46/14 KV, 28 MVA transformer will be passed on to the Fort.

TEP will only carry the maintenance cost for both above items and the costs for upgrading the main 138 KV service to the Fort, when needed.

The third option is very expensive. It will cost the Fort approximately $2,200,000 in 1993.

An overview of the back-up options is shown in *Table 2-10.*

2.7.4 Natural Gas System. Natural gas is supplied to the Installation by Southwest Gas Company through two high pressure mains (400 psi) which are owned by the El Paso Natural Gas Company. One main parallels Whitside Road to pressure regulating and metering stations north of the cold storage area, and the other parallels Highway 90 to a regulating metering station located at Brainard Road and Carter Street. Both mains originate from a single branch line with branches from the pipeline along Interstate, 10, 28 miles to the north, and which ties into the two 400 psi mains inside the north corner of the Reservation.

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