STUDY REPORT
WATER CONSUMPTION PLANNING FACTORS

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The Ultimate Weapon Runs On
WATER

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STUDY REPORT

1. **Purpose**. To provide current water consumption planning factors for tactical and force structure planning, and to document the basis of those factors so that they may be tailored to fit specific circumstances.

2. **Introduction**. The last comprehensive water consumption planning factors study was conducted in 1983 and revised in 1988 and 1994. The US Army requires current, accurate planning factors to determine force structure and for combat planning. Force structure developers must determine the number and types of units required to support the total Army in world-wide commitments. Combat planners must determine the number and type units required to support specific operational plans and establish a phased deployment plan to ensure that support is available for deploying forces. This study revisited the factors currently in force, and challenged proponents of water consuming processes to validate or revise those factors.

3. **Assumptions**

a. Water for drinking, medical treatment, personal hygiene, field feeding, and heat casualty treatment will not be compromised.

b. Centralized showers and laundry are located to the rear of the brigade support area (BSA) and throughout the corps area.

c. Hospitals are located to the rear of the division support area (DSA) and in the corps/theater army area.

d. Ration cycle will continue to be one “A/B” ration, one tray ration, and one meal, ready-to-eat (MRE) per day.

e. In cold, temperate, and tropical environments potable water will be provided only where required.

f. **All water used in a hot arid environment will be potable due to restricted availability of water sources.**

g. Minimum factors are sufficient for a force to survive for periods of up to one week.

h. Sustaining factors are used for periods exceeding one week.

i. Two showers and 15 pounds of laundry are provided per person per week.

j. A 10% loss factor, comprised of 4% evaporation and 6% waste/spillage is required through all environments.

k. Disposable dinnerware is used for all meals.

4. **Definitions**

a. Hot (tropical and arid). Areas of the world with an annual mean daily temperature (AMDT) of more than 80° F.

b. Temperate. Areas of the world with an AMDT ranging from 32° F to 80° F.

c. Cold (arctic). Areas of the world with an AMDT of less than 32° F. These are seasonally frozen regions that do not support vegetation and include adjacent lakes, seas, and oceans.

d. Potable water. Water suitable for drinking without producing adverse affects; sufficiently pure in mineral content; and free of nuclear, biological, and chemical (NBC) contamination.

e. Treated water. Disinfected or processed non-potable water, free of NBC contamination, and made safe for showers.

f. Non-potable water. Water that has not been disinfected, processed, or approved by appropriate authorities as being safe for human consumption. All water is considered non-potable until declared potable.

g. Raw water. Water used as a source of supply taken from natural or impounded bodies of water such as streams, lakes, ponds, or ground water.

h. Fresh water. Water containing less than 1,500 parts per million (ppm) of dissolved solids and/or chemicals, chlorides, sulfates, and alkalis.

i. Brackish water. Water containing between 1,500 and 15,000 ppm of dissolved solids. This water is unfit for drinking because of salty or unfit taste.

j. Salt water. Water containing more than 15,000 ppm of dissolved solids.

k. Integrated battlefield (IBF). Theater in which one or more opponents have available NBC weapons and employment is anticipated. Planning factors apply to areas of the battlefield subject to NBC attack.

l. Conventional battlefield. Theater in which no use of NBC weapons is anticipated. These planning factors also apply to areas of the IBF not subject to chemical attack.

5. **Rationale Used in Developing Factors**

a. There are seven functions of water use, which are directly related to the number of people in a force structure, which will contribute to a per capita planning factor.

(1) Drinking. This function includes all fluids consumed by individuals to satisfy bodily needs for internal water. The water must be potable. The amount of water required by the human body is related to the climate, intensity of work, and type of battlefield. Since the water reserve of the body is small, maintenance of individual effectiveness requires replacement of water to keep pace with losses. Appendix A details the development of the factors for this function.

(2) Heat treatment. This function includes cooled water used to rapidly reduce the body temperature of a heat stroke patient. It must be disinfected and should be potable. Appendix B explains the development of this requirement.

(3) Personal hygiene. This function includes water used for shaving, brushing teeth, washing hands, and taking sponge baths. It must be potable. Appendix C details the development of the personal hygiene factor.

(4) Centralized hygiene. This function includes water used in showers, which are taken in conjunction with laundry. Potability is not mandatory, but in some areas water quality will be such that local medical personnel may determine the need for water treatment. The study uses both the 12-head shower and the small unit shower. Appendix D contains details on the development of this factor.

(5) Food preparation and Sanitation. Potable water is required for food preparation and sanitation of kitchen utensils. Appendix E details the development of the food preparation factor.

(6) Laundry. This function is conducted at a frequency corresponding to that of showers. Potable water is not required for laundry, however in some areas water may require treatment. This laundry factor includes only the field uniform. Laundering of other items such as hospital linens and medical staff smocks is calculated in medical treatment facilities consumption. Appendix F details the development of the planning factor for laundry. Computations include factors for both the current M-85 Field Laundry and the future Laundry, Advanced System (LADS).

(7) Divisional medical treatment. Water is used by division medical personnel for washdown of ambulance interior, litter washdown, patient cleanup, instrument wash, and treater handwash. Only potable water should be supplied for medical use. See Appendix G for details.

b. Table 1 contains a table extracted from the "Potable Water Planning Guide" that provides a summary of water consumption planning factors related to military personnel in a conventional theater.

TABLE 1

CONVENTIONAL THEATER

WATER CONSUMPTION PLANNING FACTORS RELATED TO MILITARY PERSONNEL IN FORCE STRUCTURE

(GALLONS PER MAN PER DAY)

FUNCTION	HOT				TEMPERATE		COLD	
	TROPICAL		ARID					
	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum
Universal Unit Level Consumption [1]	**7.51**	**4.76**	**7.71**	**4.96**	**6.01**	**3.26**	**6.51**	**3.76**
Level I and II Medical Treatment	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Central Hygiene, Shower and Laundry [2] (w/M-85)	*8.30*	*0*	**8.30**	**0**	*8.30*	*0*	*8.30*	*0*
Central Hygiene, Shower and Laundry [2] (w/LADS)	*2.05*	*0*	**2.05**	**0**	*2.05*	*0*	*2.05*	*0*
Level III and IV Medical Treatment	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**
Mortuary Affairs Operations	*0.01*	*0.01*	**0.01**	**0.01**	*0.01*	*0.01*	*0.01*	*0.01*
Engineer Operations	*1.20*	*0*	**1.20**	**0**	*1.20*	*0*	*1.20*	*0*
Aircraft Maintenance Operations	*0.20*	*0.20*	**0.20**	**0.20**	*0.20*	*0.20*	*0.20*	*0.20*
Potable Water Planning Factor (w/M-85)	**8.75**	**6.00**	**18.66**	**6.41**	**7.25**	**4.50**	**7.75**	**5.00**
Potable Water Planning Factor (w/LADS)	**8.75**	**6.00**	**12.41**	**6.41**	**7.25**	**4.50**	**7.75**	**5.00**
Nonpotable Water Planning Factor (w/M-85)	*9.71*	*0.21*	*0.00*	*0.00*	*9.71*	*0.21*	*9.71*	*0.21*
Nonpotable Water Planning Factor (w/LADS)	*3.46*	*0.21*	*0.00*	*0.00*	*3.46*	*0.21*	*3.46*	*0.21*
10% Loss Factor w/M-85	**0.88**	**0.60**	**1.87**	**0.64**	**0.73**	**0.45**	**0.78**	**0.50**
10% Loss Factor w/LADS	**0.88**	**0.60**	**1.24**	**0.64**	**0.73**	**0.45**	**0.78**	**0.50**
Total Theater w/M-85 (Potable & Nonpotable)	**19.34**	**6.81**	**20.53**	**7.05**	**17.69**	**5.16**	**18.24**	**5.71**
Total Theater w/LADS (Potable & Nonpotable)	**13.09**	**6.81**	**13.65**	**7.05**	**11.44**	**5.16**	**11.99**	**5.71**

[1] Includes Gal/Man/Day and/or per capita requirements for drinking, personal hygiene, field feeding, heat injury treatment, and vehicle maintenance as described in Section II-

[2] Bassed on a central hygiene standard of 2 showers and 15 pounds of laundry per soldier per week as described in Section II-

c. Table 2 contains a table extracted from the "Potable Water Planning Guide" that provides a summary of water consumption planning factors related to military personnel in an integrated theater.

TABLE 2

INTEGRATED THEATER

WATER CONSUMPTION PLANNING FACTORS RELATED TO MILITARY PERSONNEL IN FORCE STRUCTURE

(GALLONS PER MAN PER DAY)

FUNCTION	HOT				TEMPERATE		COLD	
	TROPICAL		ARID					
	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum
Universal Unit Level Consumption [1]	**8.01**	**5.26**	**8.21**	**5.46**	**6.76**	**4.01**	**6.51**	**3.76**
Level I and II Medical Treatment	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Central Hygiene, Shower and Laundry [2] (w/M-85)	*8.30*	*0*	**8.30**	**0**	*8.30*	*0*	*8.30*	*0*
Central Hygiene, Shower and Laundry [2] (w/LADS)	*2.05*	*0*	**2.05**	**0**	*2.05*	*0*	*2.05*	*0*
Level III and IV Medical Treatment	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**
Mortuary Affairs Operations	*0.01*	*0.01*	**0.01**	**0.01**	*0.01*	*0.01*	*0.01*	*0.01*
Engineer Operations	*1.20*	*0*	**1.20**	**0**	*1.20*	*0*	*1.20*	*0*
Aircraft Maintenance Operations	*0.20*	*0.20*	**0.20**	**0.20**	*0.20*	*0.20*	*0.20*	*0.20*
NBC Decontamination Operations [3]	*2.70*	*2.70*	**2.00**	**2.00**	*2.70*	*2.70*	*2.70*	*2.70*
Potable Water Planning Factor (w/M-85)	**9.25**	**6.50**	**21.16**	**8.91**	**8.00**	**5.25**	**7.75**	**5.00**
Potable Water Planning Factor (w/LADS)	**9.25**	**6.50**	**14.91**	**8.91**	**8.00**	**5.25**	**7.75**	**5.00**
Nonpotable Water Planning Factor (w/M-85)	*12.41*	*2.91*	*0.00*	*0.00*	*12.41*	*2.91*	*12.41*	*2.91*
Nonpotable Water Planning Factor (w/LADS)	*6.16*	*2.91*	*0.00*	*0.00*	*6.16*	*2.91*	*6.16*	*2.91*
10% Loss Factor w/M-85	**0.93**	**0.65**	**2.12**	**0.89**	**0.80**	**0.53**	**0.78**	**0.50**
10% Loss Factor w/LADS	**0.93**	**0.65**	**1.49**	**0.89**	**0.80**	**0.53**	**0.78**	**0.50**
Total Theater w/M-85 (Potable & Nonpotable)	**22.59**	**10.06**	**23.28**	**9.80**	**21.21**	**8.69**	**20.94**	**8.41**
Total Theater w/LADS (Potable & Nonpotable)	**16.34**	**10.06**	**16.40**	**9.80**	**14.96**	**8.69**	**14.69**	**8.41**

[1] Includes Gal/Man/Day and/or per capita requirements for drinking, personal hygiene, field feeding, heat injury treatment, and vehicle maintenance as described in Section II-A.

[2] Bassed on a central hygiene standard of 2 showers and 15 pounds of laundry per soldier per week as described in Section II-A.

[3] Includes Per Capita requirements for individual soldier and small equipment, and major end item operational & deliberate decontamination operations as described in Section II-B (para 4b&4c).

d. Table 3 contains a table extracted from the "Potable Water Planning Guide" that provides the potable water planning factors for universal unit level consumption for all theater

environments for a conventional theater.

Universal Unit Level Water Requirements (Conventional Theater)

(In Gal/soldier/day)

Potable water planning factors for Universal Unit Level consumption are applicable to all theater environments. Factors for Drinking, Personal Hygiene, and Field Feeding reflect average direct Gal/Man/Day consumption. Factors for Heat Injury Treatment and Vehicle Maintenance are Per Capita estimates.

(1) **Drinking, personal hygiene, and field feeding factors are applicable to all theater environments** and are derived directly from individual Gal/Day consumption requirements.

(2) **Heat Injury Treatment factors are applicable to all theater environments** and represent the Per Capita share of the 30 Gal/Patient chilled water treatment for expected daily heat stroke casualties.

(3) **Vehicle Maintenance factors are normally applicable only in HOT, ARID theater planning. However, if raw water from available sources in any other theater environment requires ROWPU processing to meet minimal vehicle maintenance quality standards, the water requirement should be considered POTABLE and logistics planners must modify the table below as follows:**

For HOT, TROPICAL theater environments change the Standard Planning Factor from "N/A" to ".20".
For TEMPERATE and COLD theater environments change the Standard Planning Factor from "N/A" to ".10".

Factors were derived by multiplying average divisional ground vehicle density times the FM 101-10-1/2 per vehicle consumption estimate and dividing the product by average division personnel strength.

	HOT				TEMPERATE		COLD	
	TROPICAL		ARID					
	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum
Drinking Water	**3.00**	**3.00**	**3.00**	**3.00**	**1.50**	**1.50**	**2.00**	**2.00**
Personal Hygiene	**1.70**	**1.00**	**1.70**	**1.00**	**1.70**	**1.00**	**1.70**	**1.00**
Field Feeding	**2.80**	**0.75**	**2.80**	**0.75**	**2.80**	**0.75**	**2.80**	**0.75**
Heat Injury Treatment	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**
Vehicle Maintenance	N/A	N/A	**0.20**	**0.20**	N/A	N/A	N/A	N/A

UNIVERSAL UNIT LEVEL POTABLE WATER PLANNING FACTORS	HOT				TEMPERATE		COLD	
	TROPICAL		ARID					
	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum	Sustaining	Minimum
	7.51	**4.76**	**7.71**	**4.96**	**6.01**	**3.26**	**6.51**	**3.76**

Table 3. Universal Unit Level Requirements for a Conventional Theater

Appendix A
Planning Factors for Drinking

1. Description of Function. Potable water is essential for life, survival, and good health. It is necessary for the digestion and absorption of food, helps maintain proper muscle tone, supplies oxygen and nutrients to the cells, rids the body of wastes, and serves as a natural air conditioning system. Water utilized for these functions includes all fluids consumed by an individual (including soups, hot and cold drinks, as well as plain water) to satisfy bodily needs for internal water. It replaces fluids lost by urination, perspiration, and respiration. Replacement is required to prevent acute dehydration and subsequent debilitating effects.

2. Water Quality Requirements. Minimum standards for drinking water potability are set as maximum concentrations for biological, chemical, and radiological contaminants. In the US Army, water is disinfected by chlorinating to levels which provide reasonable assurance that no pathogenic organisms are present. Human consumption requires water of the highest quality available because of the potential for immediate and extended adverse effects on soldiers in carrying out their missions.

3. Basis for Estimates. Estimates are based on research done by the US Army Research Institute of Environmental Medicine in Natick, MA.

a. Water is an essential component of the human body, and although the body maintains a reserve, it is small and easily depleted. A person with a water deficit equivalent to 3-4 percent of his body weight (2-3 quarts) loses a significant part of his ability to function successfully; a deficit of 6-8 percent (4-6 quarts) renders a soldier completely ineffective. Therefore, retention of individual effectiveness requires that replacement of water keeps pace with losses.

b. Water loss from waste elimination is relatively constant and uncontrollable. Water lost with excrement is roughly balanced by water ingested with solid food, except when intestinal upset produces diarrhea. Water lost with urine is relatively constant, between 750 ml and 1250 ml (25-42 fl oz) per day, for healthy individuals. Excessive water consumption increases urinary output, but under water-deprived conditions, urinary output is not significantly reduced until the individual is dangerously dehydrated. Replacement of water lost to urinary output is estimated to average one quart per man per day.

c. The major portion of body water loss is due to perspiration. This loss can range from almost nothing in a perfectly controlled environment with no work to 1 1/2 quarts per hour in a very hot environment performing strenuous work. The body produces sweat to dissipate heat. Sweat rates increase with ambient temperature and with the physical intensity of work. The wide range of water requirements shown below results from the wide variation in sweat rates over the range of work intensity from light to heavy. The three categories of work are defined as follows:

(1) Heavy work. Forced marching, stevedoring, entrenching, route marching with heavy loads, or wearing NBC protective clothing.

(2) Moderate work. Route marching, working with moderate lifting, or

pushing.

(3) Light work. Deskwork, vehicle driving, or light bench work.

Ambient temperatures cause a base sweat rate. This base rate is included in the estimates for light work.

d. Water loss due to respiration is usually low but increase with increasing exercise intensity. Coincidentally, the water produced by cell metabolism is approximately the same magnitude as respiratory water loss at any given oxygen uptake (in temperate and hot climates) and therefore cancel the need for oral fluid intake to replace respiratory water losses. The exception to this situation is in extreme cold where the humidity of air inhaled is essentially zero, but expired air is 98 percent saturated at body temperature. This creates a water loss, estimated at 0.4 quarts per day.

e. Work in current NBC protective clothing prevents evaporation of perspiration. The body continues to perspire, although it ceases losing heat by this mechanism. Introduction of nuclear or biological warfare to the battlefield will not produce any significant change to individual consumption over that imposed by chemical warfare.

4. Planning Factor Estimates. The estimates are based upon calculations shown in paragraph 5. The recommended planning factor is based on a force mixture of 15 percent light work, 65 percent medium work, and 20 percent heavy work. Due to the subjective nature of this assumption, and the fact that minor water losses have not been considered, all figures are rounded to the next higher number of quarts.

Water Planning Factors for Individual Consumption (Drinking)
(Gallons per person per day)

	Conventional Battlefield			Integrated Battlefield		
	Min	Max	Recommended Planning Factor	Min	Max	Recommended Planning Factor
Hot	2.0	3.5	3.0	3.5	3.5	3.5
Temperate	1.0	2.0	1.5	2.25	2.25	2.25
Cold	1.5	2.5	2.0	2.0	2.0	2.0

5. Individual Consumption (Drinking) Calculations

a. Hot Environment

(1) Components Independent of Work

(a) 1 qt/12 hr rest period (perspiration) 1

(b) 1 quart for urination 1

(c)	Total		2.0

(2) Work Related Components

(a)	Light Work	.5 qt/hr x 12 hrs	6
(b)	Moderate Work	.75 qt/hr x 12 hrs	9
(c)	Heavy Work (sustainable)	1 qt/hr x 12 hrs	12
(d)	Heavy Work (maximum)	1.5 qt/hr x 12 hrs	18

(This is the maximum effort possible for a person on a very hot day.)

(3) Total Drinking Requirements

(a)	Light Work	2 + 6 =	8 qts/soldier/day
(b)	Moderate Work	2 + 9 =	11 qts/soldier/day
(c)	Heavy Work (sustainable)	2 + 12 =	14 qts/soldier/day
(d)	Heavy Work (maximum)	2 + 18 =	20 qts/soldier/day

(4) Operations in mission oriented protective posture (MOPP) -3 or -4 are considered to be in the heavy work category, regardless of the intensity of labor performed, and therefore produce maximum sweat rates (20 qts/soldier/day). Since this perspiration is trapped and produces no cooling effect, individuals will rapidly succumb to heat injuries unless additional time is allowed to perform tasks, body water is replaced, and sufficient rest breaks permitted. Therefore, daily requirements are not substantially different than conventional requirements. Greatest daily amount would be 14 qts/soldier/day (3.5 gallons/soldier/day).

(5) As stated in Appendix A, paragraph 4, the recommended planning factor is based on a force mixture of 15 percent light work, 65 percent medium work, and 20 percent heavy work. Applying these factors to the quantities above: (.15 x 8) + (.65 x 11) + (.20 x 14) equals 11.1 or 12 quarts. Therefore, the recommended planning factor for individual consumption (drinking) on hot conventional battlefields is 12 quarts or 3.0 gallons per soldier per day. This quantity permits the continued sustainment of work without significant numbers of heat casualties. This quantity is less than the planning factor of 16 quarts used by the Israeli Defense Forces on hot battlefields, but is consistent with documented US exercises.

b. Temperate Environment

(1) Components Independent of Work

(a)	1 qt/12 hr rest period (perspiration)		1
(b)	1 quart for urination		1
(c)	Total		2

(2) Work Related Components

(a)	Light Work	1 qt x 12 hr work period	1
(b)	Moderate Work	.25 qt/hr x 12 hr work period	3
(c)	Heavy Work (sustainable)	.5 qt/hr x 12 hr	6
(d)	Heavy Work (maximum)	1 qt/hr x 12 hr.	12

(This is the maximum effort possible for a person on a hot day.)

(3) Total Conventional Battlefield Drinking Requirements

(a)	Light Work	2 + 1 =	3 qts/person/day
(b)	Moderate Work	2 +3 =	5 qts/person/day
(c)	Heavy Work (sustainable)	2 + 6 =	8 qts/person/day
(d)	Heavy Work (maximum)	2 +12 =	14 qts/person/day

(4) Recommended Temperate Conventional Battlefield Planning Factor

(.15 x 3) + (.65 x 5) + (.20 x 8) = 5.3 or 6 qts)

The recommended planning factor for individual consumption on the temperate conventional battlefield is 6 quarts or 1.5 gallons per man per day. Operations in MOPP-3 or -4 are considered to be in the heavy work category because as in hot climates perspiration is trapped and produces no cooling effect. As a consequence, work-rest ratio is reduced to avoid heat exhaustion. This lowers amount of heat produced and hourly water requirements. At 73^{o}F (23oC), 35% relative humidity, partly cloudy, and 2 mph wind speed, dressed in BDU and MOPP, the following is approximate water required:

(a)	Light Work	0.2 qt x 12 hr work period	2.4
(b)	Moderate Work	0.6 qt x 12 hr work period	7.2
(c)	Heavy Work	1.0 qt x 12 hr work period	12.0

(d) Recommended Temperate Integrated Battlefield Planning Factor

(.15 x 2.4) + (.65 x 7.2) + (.20 x 12.0) = 7.44 +1.5 = 8.94 or 9 qt/day

c. Cold Environment

(1) Components Independent of Work

(a)	1 qt/12 hr rest period (perspiration)	1
(b)	1 quart for urination	1
(c)	2 qt/day lost to respiration	2
(d)	Total	4

(2) Work Related Components

(a)	Light Work	1 qt per 12 hr work period	1
(b)	Moderate Work	.25 qt/hr x 12 hr work period	3
(c)	Heavy Work (sustainable)	0.5 qt/hr x 12 hr	6
(d)	Heavy Work (maximum)	1 qt/hr x 12 hr	12

Note: Six hours of sustained heavy work in arctic clothing is expected to exhaust the individual. The maximum heavy work would only be done in extreme cases. Arctic clothing is designed to keep an individual warm with minimal activity. During periods of heavy work there is a significant heat buildup inside the suit, creating a hot microclimate. Under conditions of extreme cold, opening arctic clothing to reduce heat load can produce frostbite and removing layers of clothing is too cumbersome to be a reasonably expected option.

(3) Total Conventional Battlefield Drinking Requirements

(a)	Light Work	4 + 1 =	5 qts/person/day
(b)	Moderate Work	4 + 3 =	7 qts/person/day
(c)	Heavy Work (sustainable)	4 + 6 =	10 qts/person/day
(d)	Heavy Work (maximum)	4 + 12 =	16 qts/person/day

(4) Recommended Arctic Conventional Battlefield Planning Factor

(.15 x 5) + (.65 x 7) + (.20 x 10) = 7.3 or 8 qts.

Operations in MOPP-3 or -4 will not produce a significantly greater individual burden above that of arctic clothing with the exception of the degradation caused by the protective mask. The recommended planning factor for individual consumption on the arctic conventional and integrated battlefields is 8 quarts or 2.0 gallons per man per day.

Appendix B
Planning Factors for Heat Stroke Treatment

1. Description of Function. Extreme heat degrades physical performance and places each soldier at risk for heat illness. For optimum performance, body temperatures must be maintained within normal limits. It is important that the body loses the heat it gains from physical work or from the environment. Heat stress depends on physical activity, hydration, heat acclimatization, clothing, load carried, terrain, and climatic conditions. Excess body heat is reduced by numerous physiological mechanisms, but when air temperature is above skin temperature, evaporation of sweat is the only mechanism for heat loss. Following the loss of sweat, water must be consumed to replace the body's loss of fluids. If the body fluid lost through sweating is not replaced, dehydration will follow. Dehydration leads to heat illness which must be treated immediately. Water used for heat stroke treatment should be in the form of a cold water bath to quickly reduce the body temperature of patients exhibiting symptoms of heat stroke.

2. Water Quality Requirements. Water for treatment of heat casualties must be disinfected and should be potable. It should be supplied for use in medical treatment facilities at a maximum of 65^{o} F.

3. Basis for Estimate. The amount of water required for treatment of heat stroke in a theater of operations is minimal.

a. It requires approximately 30 gallons of chilled water to reduce body temperature to an acceptable level.

b. For major regional contingencies (MRC), the US Army Medical Department Center and School (AMEDDC&S) casualty modeling program projects peak (30 day) heat casualties (based on TAA05 data) as follows:

(1) MRC-East (MRCE) - 126 per month or 4.2 per day at 30 gallons of water for a total of 126 gallons per day. With a population at risk of 332,574 in theater, the daily per person rate is only 0.0004.

(2) MRC-West (MRCW) - 4 per month or 0.13 per day at 30 gallons of water for a total of 4 gallons per day. With a population at risk of 298,760 in theater, the daily per person rate is only 0.000,01.

c. The planning factor, coordinated with AMMEDDC&S is 0.01 gallon per soldier per day.

Appendix C
Planning Factors for Personal Hygiene

1. Description of Function. Water used for this function includes all water used for shaving, brushing teeth, washing hands and taking sponge baths. It does not include drinking water or laundry and shower water, which are covered in other appendices. Personal hygiene consumption is directly related to the number of personnel in the unit/theater.

2. Water Quality Requirements. All water for personal hygiene consumption must be potable. In cold climates it may require warming. In hot climates cooling may be necessary.

3. Basis for Estimate. The primary water users in this group are shaving, brushing teeth, washing hands, and taking sponge baths. A soldier should brush his teeth three times per day, shave once per day, wash hands after use of latrines and before meals, and take a sponge bath each day showers are not available.

a. A soldier uses .5 of a 1 pint canteen cup each time he brushes his teeth, for a daily requirement of .2 gallons of water per day for brushing teeth.

b. A soldier uses 1 quart (.25 gallon) of water per day for shaving.

c. Washing hands uses 1 pint of water times 6 handwashings equals .75 gallons of water.

d. A sponge bath consumes 2 quarts of water, 1 for washing and 1 for rinsing.

e. The total daily use of water for personal hygiene is 1.7 gallons.

$$0.2 + 0.25 + 0.75 + 0.5 = 1.7 \text{ gallons per soldier per day.}$$

		Sus.	Min.
Teeth		0.2	0.07 (Once)
Shave		0.25	------
Hands		0.75	0.38 (3 Times)
Sponge		0.5	0.5 (Once)
	Total:	1.70	0.95

Appendix D
Planning Factors for Centralized Hygiene

1. Description of Function. Centralized hygiene (shower) is conducted in conjunction with clothing exchange. This appendix deals only with showers. This function is the mission of a support unit normally operating only as far forward as the division rear area.

2. Water Quality Requirements. Potable water is not required for showers, although the local medical authority may require disinfection of water prior to use. In some areas of the world where schistosomes (tropical parasites) are present, water must be disinfected with chlorine before it is safe to use for showers. The water should also be colorless, odorless, have minimal turbidity, and be free from the effects of industrial or municipal discharges.

3. Basis for Estimate. This estimate was computed in coordination with the Chief, Quartermaster Field Services Division. Water consumption for showers is a function of how many showers are taken and how much water is used per shower. The Army goal is for two showers per week; one under central hygiene at a field service company shower point and one at the unit using the small unit shower or field expediency such as the Australian shower.

a. Shower Point Operation. Field service companies are equipped with a 12-head shower unit. The total water usage is 1200 gallons per hour (gph).

(1) Each soldier is authorized a 7 minute shower.

(2) The 12-head shower unit delivers 1.7 gallons per minute (gpm) per shower head or 11.9 gallons per seven minute shower, **which equals 1.7 gal per soldier per day.**

1200 gph/60 min = 20 gpm

20 gpm/12 heads = 1.7 gal per head per min

1.7 gal x 7 min shower = 11.9 gal per shower

11.9 gal/seven days = 1.7 gal per soldier per day

b. The small unit shower has four showerheads.

(1) Each showerhead has a “dead-man” button, which allows water flow only when depressed.

(2) The shower holds 5 gallons of water for the 4 showers or 1.25 gal per soldier.

(3) If each soldier receives one field expedient shower a week, usage amounts to only **0.2 gal per soldier per day**.

b. **The total requirement for showers equals 1.7 gal + 0.2 gal = 1.9 or 2 gal/soldier/day.**

Appendix E
Planning Factors for Food Preparation

1. Description of Function. Water is used for feeding operations for two main functions: food preparation and sanitation. The amount of water required per day is dependent on the command policies concerning the type ration served and the type of mess gear used. If disposable eating utensils are used, mess kit laundries will not be required.

2. Water Quality Requirements. Water for use in food preparation must be potable.

3. Basis for Estimates. This water consumption data was coordinated with the Quartermaster School's Army Center of Excellence, Subsistence.

a. Water required to prepare one A/B ration meal is 0.5 gallons per person.

b. A "T" ration meal requires 0.5 gallons per person.

c. The MRE requires up to one quart of water for preparation. Of that amount, one pint is used for rehydrating and one pint is used to heat the entree.

d. Water used to mix hot or cold drinks consumed with meals both in the dining facility and with MREs is included in the drinking factor.

e. If disposable eating utensils are used, mess kit laundries are not required. If individual mess kits are used, an additional 0.75 gallons of water per person per meal is required. One laundry line is required for each 80 personnel. A line consists of three 32-gallon cans with 20 gallons of water in each. The first can, containing hot soapy water, is used for washing. The second can, containing boiling clear water, is used for rinsing. The third can, filled with boiling clear water, and is used to sanitize the mess kit. That is 60 gallons of water for 80 soldiers or 0.75 gal per solder per meal.

f. The current field feeding ration policy is one A/B ration, one "T" ration and one MRE per day. Therefore, the field feeding water consumption factor is 1.25 gallon per person per day. See Table E-1.

g. The current sanitation center requires 60 gallons of water to sanitize equipment used during the preparation and serving of food. That equates to .75 gal per soldier per meal.

Types of Meals Per Day				
Gal Per Soldier Per Day	MRE Qty @ 0.25 Gal per Soldier	A Ration Meal Qty @ 0.5 Gal per Soldier	T-Ration Meal Qty @ 0.5 Gal per Soldier	Sanitation of Kitchen Equipment
0.75	3	-	-	0.00
1.75	2	-	1	.75
2.75*	1	-	2	1.5
3.75	-	-	3	2.25
1.75	2	1	-	0.75
2.75*	1	2	-	1.55
3.75	-	3	-	2.25

* For planning factor purposes, 2.75 is rounded up to 2.80.

Table E-1
Food Preparation Water Consumption Planning Factors

Appendix F
Planning Factors for Laundry

1. Description of Function. Field laundry is conducted in conjunction with showers. The planning factors in this appendix are for work uniforms and do not include hospital linens, which are treated in the medical facilities appendix.

2. Water Quality Requirements. Potable water is not required for laundry. Water for this purpose may require some treatment for removal of foreign matter and disinfection in some areas.

3. Basis for Estimate. This estimate was computed in coordination with the Chief, Field Services Division, US Army Quartermaster School.

a. The current laundry unit is the M85 Laundry (water consumption rate of 300 gals/hr).

(1) A soldier is authorized 15 pounds of laundry per week. This equates to two sets of battle dress uniforms, one week's worth of underwear, socks and handkerchiefs, and two towels.

(2) Three gallons of water per pound of laundry is required.

(3) 15 lbs x 3 gal/lb = 45 gallons of water per soldier per week or 6.4 gal/soldier/day.

b. The Laundry Advanced System (LADS) is scheduled to begin fielding in fiscal year 2000.

(1) It will replace the M85, 1 LADS for 4 M85s.

(2) LADS will use 580 gallons of water for 8,000 lb. of laundry or 0.07 gal/lb.

(3) 15 lbs x 0.07 gal/lb = 1.05 gal per soldier per week, 0.15 gal/soldier/day.

Appendix G
Planning Factors for Division Medical Treatment

1. Description of Function. These factors include water used for washdown of ambulance interior, litter washdown, patient cleanup, instrument wash, and treater handwash. It does not include staff requirements common to all units which are computed in other appendices.

2. Water Quality Requirements. Only potable water should be supplied to division medical treatment facilities because of the increased susceptibility of patients to infections. This will eliminate the possibility of mistakenly using non-potable water for a function requiring potable water only.

3. Basis for Estimate

a. The following is a per patient minimum:

(1)	Washdown of ambulance interior	1 gallon
(2)	Litter washdown	1 gallon
(3)	Medical instrument wash	.25 gallon
(4)	Medical treater handwash	.5 gallon
(5)	Patient wash	1 gallon
		3.75 gallons

b. AMEDDC&S casualty modeling (based on TAA05 data) reflects the following:

(1) MRCE - With a total population at risk (divisional and non-divisional) of 113,334 located in division areas, casualty modeling program projects a peak 30 day casualty rate of 34,925 which yields a 1,164 daily rate. Based on a daily patient to total population ratio (1,164/113,334) of 0.01, then the average gallons per soldier per day would be 3.75 gallons/patient x 0.01 or 0.0375 or 0.04. If the patient to total population changes, then a re-computation is required.

(2) MRCW - With a total population at risk (divisional and non-divisional) of 128,015 located in division areas, casualty modeling program projects a peak 30 day casualty rate of 39,658 which yields a 1,322 daily rate.

Appendix H
Planning Factors for Medical Treatment Facilities

1. Description of Function. Water utilized for this function includes all water used for patient bed baths or showers and food preparation plus surgery scrubup, instrument wash, operating room cleanup, bedpan wash, hospital linen laundry, extra staff showers, sterilizers, and laboratory and x-ray processing.

2. Water Quality Requirements. Only potable water should be supplied to medical treatment facilities because of the increased susceptibility of patients to infections. This will eliminate the possibility of mistakenly using non-potable water for a function requiring potable water only.

3. Basis for Estimate. These estimates resulted from coordination with AMEDDC&S. The water requirements in this appendix are over and above the water listed in other appendices for consumption by each soldier. Requirements vary by hospital type.

a. Patient care (in addition to other programmed water consumption)

(1) Food preparation. By field feeding doctrine, theater hospitals will serve only medical B rations three times per day. Water for one A/B meal, one T ration, and one MRE is already allocated under the food preparation function. There is an additional one gallon of water per bed for the additional medical meals.

(2) Bed bath. Patients confined to bed will receive a daily bed bath. Two standard 7-liter plastic basins will be used, one for wash and one for rinse. The basins will contain only about 5.5 quarts each for a total of 2.75 gallons of water per bed.

(3) Showers. From an infection control perspective and for patient morale, ambulatory patients will be provided with three showers per week. One shower weekly for all personnel in theater has already been factored, so this is an additional two showers. The standard field service company's 12-head shower has a flowrate of 1.7 gpm per head. 1.7 gpm x 7 minutes x 2 showers/7 days equals 3.4 gallons of water per day per ambulatory patient.

(4) Bedpan wash. Bedpans for bed patients must be washed daily using about 1.5 gallons of water.

(5) Laboratory. Historical estimate for laboratory requirements average about 0.2 gallons per bed per day.

(6) Sterilizer. A sterilizer holds five gallons of potable water and requires refill after two cycles. Estimate 18 cycles or 9 refills in a 24-hour period for a daily consumption of 45 gallons per sterilizer.

(7) X-ray. The X-ray processor is a closed system which requires five

gallons of potable water. Water will be changed based on the number of films processed which could vary greatly. A good planning factor would be daily refill or 5 gallons per day.

(8) Treater handwash. Medical personnel are required to wash hands before and after treating each patient. A good estimate is two gallons of water per bed per day.

(9) Cleanup. Each treatment area around a patient's bed must be cleaned daily. This uses about one gallon of water per bed.

b. Surgical

(1) Scrub. It takes a 5 - 10 minute scrub to ensure cleanliness prior to surgery. Some surgical cases may require as many as 5-6 medical personnel to scrub while others may require only 2-3. Assume an average of 4 personnel per surgical case. Flowrate for the surgical sinks is 4 gpm, however they have an on/off switch so water will be turned on and off during the scrub. Estimate five minutes of water flow per a ten minute scrub. 4 gallons x 5 minutes x 4 personnel equals 80 gallons of water per surgical case.

(2) Instrument wash. Following surgery, a manual rinse of all instruments is done in the surgical sinks, a five minute rinse at 4 gal/min or 20 gal/surgical case. The instruments are then placed in an ultrasonic cleaner which uses 17.5 gallons of water. Water must be replaced an average of 4 times per day for a total daily usage of 70 gallons for each cleaner.

(3) Operating room cleanup. The operating room must be completely washed down and disinfected after each operation. This requires about three gallons of water per surgical case.

(4) Total water required for each surgical case is 103 gallons plus the ultrasonic cleaners.

c. Hospital Laundry

(1) An analysis of linens in all medical material sets by hospital functional areas was conducted. Per Deployable Medical Systems (DEPMEDS) assumptions, policies, and guidelines, the medical material sets were designed to support three days of operation. One third of the linen will be used daily and require laundry support at 3 gallons per pound.

(a) Combat support hospital - 886.8 pounds per day.

(b) Field hospital - 546.2 pounds per day.

(c) General hospital - 1,153.7 pounds per day.

(2) From an infection control perspective and patient morale, staff performing direct patient care should change uniforms three times per week. The laundry

water consumption factor includes two uniforms per soldier for all personnel in theater. This is one extra change of clothes for a daily water consumption of 3.2 gallons per direct patient care staff.

d. Staff

(1) Food preparation. The hospitals serve three medical "B" rations daily. This is an additional one gallon per person over the theater rate.

(2) Extra showers. From an infection control perspective, staff performing direct patient care will be provided with three showers per week. As all personnel in theater are allowed one shower weekly, this is an additional two showers for an average of 3.4 gallons per direct care staff per day.

e. Combat Support Hospital (CSH). Each CSH in the theater is equipped with 296 beds and 602 staff members of which 447 are involved in direct patient care. The daily water requirement for each CSH in the theater is 16,281.8 gallons or 16,281.8/296 = 55.01 Gals/Bed/Day.

(1) Food preparation. 1.0 gallon per day for each of the 296 beds and for the 602 staff members for a total of 898 gallons per day.

(2) Bed bath. The CSH is designed for 256 of the 296 patients to be bed patients and these patients will receive daily bed baths at 2.75 gallons each for a total of 704 gallons per day.

(3) Showers. The CSH design assumes that 40 of the 296 patients will be ambulatory patients and receive three showers per week. The additional 3.4 gallons per day x 40 equals 136 gallons per day plus 3.4 x 447 direct care staff equals 1,519.8 gallons for a total of 1,655.8 gallons per day.

(4) Bedpan wash. The remaining 256 bed patients will use bed pans which require 1.5 gallons of water per day for washing. 256 x 1.5 gallons equals 384 gallons of water per day.

(5) Laboratory. Daily lab work will be performed for all patients at 0.2 gallons of water per patient. This requires (0.2x296) 59.2 gallons of water per day.

(6) Sterilizer. Each of the 16 sterilizers in the hospital must be filled daily. 16 sterilizers x 45 gallons equals 720 gallons of water per day.

(7) X-ray. Each of the two X-ray developers in the hospital must be filled daily. 2 developers x 5 gallons equals 10 gallons of water per day.

(8) Treater handwash. Medical personnel must wash hands after treating each patient. It takes one gallon of water to wash and one to rinse for 2.0 x 296 beds or 592 gallons per day.

(9) Cleanup. Daily cleanup of each patient's bed and surrounding area uses one gallon of water for 296 gallons per day.

(10) Surgical. Each CSH is designed to support 64 surgical cases daily. (64 x 103) + 4 ultrasonic cleaners at 70 gallons each equals 6,872 gallons per day.

(11) Laundry. The CSH has an organic laundry for hospital linen. 886.8 pounds of hospital linen at 3 gallons per pound or 2,660.4 gallons of water. In addition, supporting laundry units will have an additional 447 direct care staff uniforms at 3.2 gallons per day for 1430.4 gallons (476.8 lbs) which yields a daily requirement of 4,090.8 gallons (1,363.6 lbs) of water. One M-85 can wash 2,000 lbs/Day (100 lbs/hr x 20 hrs). Unit has 2 M-85's w/total cap. of 4,000 lbs.

f. Field Hospital. Each field hospital in the theater is equipped with 504 beds and 426 staff members of which 288 are involved in direct patient care. The daily water requirement for each field hospital in the theater is 9,876.2 gallons or 19.60 Gal/Bed/Day.

(1) Food preparation. 1.0 gallon per day for each of the 504 beds and for the 426 staff members equals 930 gallons per day.

(2) Bed bath. The field hospital is designed for 224 of the 504 patients to be bed patients. These patients will receive daily bed baths using 2.75 gallons each for a total of 616 gallons per day.

(3) Showers. The remaining 280 will be ambulatory and receive three showers per week. The additional 3.4 gallons per day x 280 equals 952 gallons per day plus 3.4 gpd x 288 direct care staff for 979.2 gallons gives a total of 1,931.2 gallons per day.

(4) Bedpan wash. The 224 bed patients will use bed pans which require 1.5 gallons of water each for washing. 224 x 1.5 gallons of water equals 336 gallons per day.

(5) Laboratory. Daily lab work will be performed for all patients at 0.2 gallons of water per patient. This requires 100.8 gallons of water per day.

(6) Sterilizer. Each of the four sterilizers in the hospital must be filled daily. 4 sterilizers x 45 gallons equals 180 gallons of water per day.

(7) X-ray. Each of the two X-ray developers in the hospital must be filled daily. 2 developers x 5 gallons equals 10 gallons of water per day.

(8) Treater handwash. Medical personnel must wash hands after treating each patient. It takes one gallon of water to wash and one to rinse for 2.0 x 504 beds or 1,008 gallons per day.

(9) Cleanup. Daily cleanup of each patient's bed and surrounding area uses

one gallon of water for 504 gallons per day.

(10) Surgical. Each field hospital is designed to support 16 surgical cases daily. (16 x 103) + 1 ultrasonic cleaner at 70 gallons equals 1,718 gallons per day.

(11) Laundry. The field hospital does not have an organic laundry. All laundry must be washed by a supporting unit. 546.2 pounds of hospital linen at 3 gallons per pound or 1,638.6 gallons of water plus 288 direct care staff uniforms at 3.2 gallons per day for 921.6 gallons which yields a daily requirement of 2,560.2 gallons of water.

g. General Hospital. Each general hospital in the theater is equipped with 476 beds and 753 staff members of which 558 are involved in direct patient care. The daily water requirement for each general hospital in the theater is 19,487.1 gallons or 40.94 Gal/Bed/Day.

(1) Food preparation. 1.0 gallon per day for each of the 476 beds and for the 753 staff members equals 1,229 gallons per day.

(2) Bed bath. The general hospital is designed for 436 of the 476 patients to be bed patients. These patients will receive daily bed baths at 2.75 gallons each for a total of 1,199 gallons per day.

(3) Showers. The remaining 40 patients will be ambulatory and receive three showers per week. The additional 3.4 gallons per day x 40 equals 136 gallons per day plus 3.4 gpd x 558 direct care staff or 1,897.2 gallons gives a total of 2,033.2 gallons per day.

(4) Bedpan wash. The 436 bed patients will use bed pans which require 1.5 gallons each for washing. 436 x 1.5 gallons of water equals 654 gallons per day for washing.

(5) Laboratory. Daily lab work will be performed for all patients at 0.2 gallons of water per patient. This requires 95.2 gallons of water per day.

(6) Sterilizer. Each of the 16 sterilizers in the hospital must be filled daily. 16 sterilizers x 45 gallon equals 720 gallons of water per day.

(7) X-ray. Each of the two X-ray developers in the hospital must be filled daily. 2 developers x 5 gallons equals 10 gallons of water per day.

(8) Treater handwash. Medical personnel must wash hands after treating each patient. It takes one gallon of water to wash and one to rinse for 2.0 x 476 beds or 952 gallons per day.

(9) Cleanup. Daily cleanup of each patient's bed and surrounding area uses one gallon of water for 476 gallons per day.

(10) Surgical. Each general hospital is designed to support 64 surgical cases daily. (64 x 103) + 4 ultrasonic cleaners at 70 gallons each equals 6,872 gallons per day.

(11) Laundry. The general hospital does not have an organic laundry. All laundry must be washed by a supporting unit. 1,153.7 pounds of hospital linen at 3 gallons per pound or 3,461.1 gallons of water plus 558 direct care staff uniforms at 3.2 gallons per day for 1,785.6 gallons which yields a daily requirement of 5,246.7 gallons of water.

h. Standard Medical Planning Factors (Gal/Bed/Day) (Based on TAA-03).

CSH	18 Hospitals X 16,281.8 Gal/Day	= 293,072.4 Gal/Day
FH	4 Hospitals X 9,876.2 Gal/Day	= 39,504.8 Gal/Day
GH	7 Hospitals X 19,487.1 Gal/Day	= 136,409.7 Gal/Day
	Total Hospitals Daily Consumption	= 468,986.9 Gals

CSH	18 Hospitals X 296 Beds	= 5,328 Beds
FH	4 Hospitals X 504 Beds	= 2,016 Beds
GH	7 Hospitals X 476 Beds	= 3,332 Beds
	Total Hospitals Beds	= 10,676 Beds

Total Gals/Bed/Day = 468,986.9 Gals per Day/10,676 Beds = 43.93

<u>Planning Factor Calculation</u>
296 Bed X 34 CSHs (TAA 05 MRC-E or W uses CSH) = 10,064 Beds
10,064 Beds X 43.93 Gals/Bed/Day = 442,112 Gals/Day
(442,112 Gals/Day)/(376,995 Total Population) = **1.2** Gals/Man/Day

Future Hospital Structure

1. The AMEDD Center & School, through a Medical Reengineering Initiative (MRI), has designed a new hospital structure for the future with tentative fielding beginning in 2000. It consists of two basic modules, a 164 bed module and an 84 bed module. These modules can be used alone or combined for a 248 bed hospital. All patients in the basic hospital will be bed patients. The initiative also establishes minimal care (MC) detachments of 120 beds to serve as wards for ambulatory patients. From one to six MC detachments will be attached to each hospital. The MRI hospital will replace the current Combat Support Hospital, Field Hospital, and General Hospital.

2. The water planning for these new hospitals will use the same consumption factors as the current hospitals.

a. The 248 bed hospital has a staff of 444 with 365 giving direct patient care. It is designed for a surgical case load of 48 daily. The total water usage will be 13,115.35 gallons per day.

b. The 164 bed hospital has a staff of 268 with 225 giving direct patient care. It's surgical case load will be 32 per day. The total water usage will be 8,503.57 gallons per day.

c. The 84 bed hospital has a staff of 176 with 140 giving direct patient care. The surgical case load will be 16 per day. The total water usage will be 4,611.78 gallons per day.

d. Each minimal care detachment will have 120 beds for ambulatory patients. All 40 staff members will be giving direct patient care. Water usage for each detachment will be 1,678.78 gallons per day.

3. A headquarters and headquarters detachment consisting of 68 personnel will provide command, control, and administrative/messing support for each hospital and for the attached multiple minimum care detachments.

4. There will be no organic laundry capability in the system.

Appendix I
Planning Factors for NBC Decontamination

1. Description of Function. Water is used in the decontamination process to remove biological and radiological contamination hazards from exposed skin of personnel and chemical, biological, and radiological hazards from contaminated individual and unit equipment.

a. Water and showers are not required for removal of chemical contamination from the body. Emergency decontamination is performed by the individual using his individual decontamination kit to remove or neutralize chemical contaminants on exposed portions of the skin. Following the individual decontamination, showers or water for rinsing are unnecessary other than for morale or hygienic purposes. If he fails to conduct emergency decontamination immediately, the rapid absorption of lethal agents through the skin will produce death or incapacitation before showers or rinsing become available.

b. Since biological agents and radioactive particles are not absorbed into the body, the urgency for removal of these contaminants is not as great. However, as soon as the situation allows, showering is necessary as the most effective means to remove biological and radiological contamination hazards.

c. Water is essential to current systems for decontaminating individual and unit equipment. Uniforms and web gear must be laundered or rinsed to remove NBC contaminants. Although chemical based decontaminates are used on all major pieces of equipment, water is still required in the initial and final rinse steps of the equipment decontamination process.

2. Water Quality Requirements. Water used to decontaminate personnel contaminated by biological and radiological agents should meet the same standards as water used for routine showers. Water used to decontaminate weapons, vehicles, and equipment should be free of any contaminants, but may otherwise be of a lesser quality.

3. Basis for Estimate. Data to compute water consumption rates was extracted from FM 3-5, *NBC Decontamination*, 17 November 1993, and confirmed by the US Army Chemical School.

a. There are two types of vehicle decontamination processes.

(1) Operational decontamination is a quick wash to remove the gross contaminate. Operators must continue to wear MOPP clothing but the contaminate will not be able to spread. It will require about 150 gallons of water for each wheeled vehicle and about 200 gallons of water for each tracked vehicle.

(2) Deliberate or detailed decontamination is the complete cleaning and removal of all contaminate from vehicles and equipment. Wheeled vehicles require a primary

wash using 250 gallons of water and 200 gallons for rinse; tracked vehicles use 300 gallons for primary wash with 200 gallons for rinse.

b. Deliberate troop decontamination requires 288 gallons of water for 10 personnel or 28.8 gallons per person.

Appendix J
Planning Factors for Ground Vehicle Maintenance

1. Description of Function. Water usage for vehicles is limited to vehicle coolant replacement and safety requirements (washing of windshield and lights). No allowance is considered for other vehicle use such as washing.

2. Water Quality Requirements. Water for vehicle maintenance does not have to be potable. However, water with high salt content may cause corrosion or deposits in cooling systems. It may require some limited treatment, such as filtering, to remove foreign material.

3. Basis for Estimate. Data from this estimate was established in coordination with Combined Arms Support Command (CASCOM), Directorate of Combat Developments for Ordnance (DCD-ORD).

a. The most accurate way of estimating required water for vehicle cooling systems is to determine the number of each type of vehicle in the theater. By multiplying the total number of each type of vehicle by the radiator capacity of that type vehicle and totaling all products for the force structure, a total radiator capacity for the force structure can be derived. In the past a loss or replacement factor of 25 percent has been used. In an arid environment, this still appears valid.

b. Establishing a per soldier per day factor is not practical because some units have a great many more vehicles than other units. Using a general planning factor of 0.2 gal/soldier/day for vehicle maintenance would not be unrealistic.

Appendix K
Planning Factors for Watercraft Maintenance

1. Description of Function. Water used in watercraft maintenance operations is that required to prevent vessel deterioration because of constant exposure to salt water.

2. Water Quality Requirements. Potable water is not required for watercraft maintenance, however, fresh water is required since salt water causes corrosion.

3. Basis for Estimates. The data used in making these estimates was developed in coordination with the CASCOM Directorate of Combat Developments for Transportation (CASCOM, DCD-TC).

a. The following vessels in the inventory require wash down about every three or four days as the mission permits.

(1) Logistical support vessel (LSV) requires about 2,000 gallons per wash.

(2) The landing craft, mechanized (LCM) uses about 1,200 gallons per wash.

(3) A landing craft, utility (LCU) needs about 1,500 gallons per wash.

(4) A lighter amphibious resupply ship requires about 800 gallons per wash.

(5) The large tug (128 ft or 100 ft) uses about 1,000 gallons per wash.

(6) Small tugs require about 500 gallons per wash.

b. The Army Watercraft Master Plan, November 1996, established a pre-positioned package to support worldwide deployment. The watercraft in this package are either pre-positioned afloat, area pre-positioned, or forward-based. The watercraft deployment package consists of the following:

(1) Two LSVs.

(2) Eight LCMs.

(3) Nine LCUs.

(4) Two lighters, amphibious resupply cargo (LARCs).

(5) Three large tugs (100 ft).

(6) Six pusher tugs.

c. Every four days, 34,700 gallons of water are required for washdown of watercraft, for an average of 8,675 gallons per day.

Appendix L
Planning Factors for Aircraft Maintenance

1. Description of Function. Water is used for turbine wash, aircraft wash, and flight operations. Engines of aircraft operating over salt water or in dusty conditions should be flushed after each day's flight.

2. Water Quality Requirements. There is no requirement for potable water for aircraft use, however clean fresh water is required to avoid corrosion.

3. Basis for Estimate. The data used for this estimate was coordinated with the US Army's Aviation Logistics School. A per man per day consumption planning figure is unrealistic for aircraft usage. For example, the air assault division and the light division have a higher density of aircraft than the heavy division. The UH-60 and other aircraft with on-board auxiliary power units (APU) require more water than single engine aircraft with no APU. The consumption planning factor for aircraft is 10 gallons per engine per day and for aircraft with on-board APU an additional five gallons per aircraft per day. All deployed aircraft are counted regardless of maintenance status. Given the number of engines and the number of aircraft with and without on-board APUs in the force structure, water consumption can be estimated.

a. The following aircraft are multi-engine with an on-board APU requiring daily consumption of 25 gallons of water for engine flush.

(1) CH-47

(2) AH-64/UH-60

(3) RAH-66

b. The AH-1/UH-1 and the OH-6/OH-58 are single engine aircraft and require only 10 gallons of water per day for engine flushing.

c. Aviation maintenance units consume water during maintenance activities.

(1) The aviation unit maintenance (AVUM) company requires four gallons for each scheduled maintenance and two gallons for each unscheduled maintenance operation and an additional two gallons per aircraft for maintenance clean-up.

(2) The Aviation Intermediate Maintenance (AVIM) company requires two gallons for each scheduled maintenance and four gallons for each unscheduled maintenance operation and an additional two gallons per aircraft for maintenance clean-up.

(3) Both units require about 10 gallons per day for shop clean-up and two gallons per man per day for mechanic clean-up.

d. In addition to daily engine and APU flushes, each aircraft should be washed down weekly. The amount of water varies with aircraft size.

(1) AH-1/UH-1 - 150 gallons per aircraft.

(2) CH-47 - 400 gallons per aircraft.

(3) OH-6/OH-58 - 150 gallons per aircraft.

(4) AH-64 - 250 gallons per aircraft.

(5) UH-60 - 250 gallons per aircraft.

(6) RAH-66 - 250 gallons per aircraft.

Appendix M
Planning Factors for Engineer Construction

1. Description of Function. Water utilized for this function includes all water used for road and airfield construction, quarry operations, asphalt plant operations, well drilling, concrete construction, and pipeline testing.

2. Water Quality Requirements. Most engineer activities do not require potable water. However, water with high salt content may cause long term corrosion. In most cases, the amount of organic matter in the non-potable water must be minimized. In cold climates, some heating of water may be required for use.

3. Basis for Estimates. Estimates were coordinated with the US Army Engineer School. Water planning factors for engineer construction functions are based on table of organization and equipment (TOE) mission capabilities. These factors may be modified for local use depending upon actual field conditions in various theaters and climates. See Table M-1.

ACTIVITY	TEMPERATE ENVIRONMENT	ARID ENVIRONMENT
1. Road Construction		
a. Compaction[1] (Class A road)	24,500 - 122,000 gal/mile	122,000 - 245,000 gal/mile
b. Soil Stabilization[1] (Class A road)	100,000 - 850,000 gal/mile	100,000 - 850,000 gal/mile
c. Paving Operations[2]		
(1) Class A road	1,800 gal/mile	1,800 gal/mile
(2) One layer	200 gal/mile	200 gal/mile
d. Dust Control[3] (Class A road)	18,800 gal/mile	18,800 gal/mile
2. Airfield Construction		
a. Compaction[1] (Medium Lift Support Area)	30,000 - 150,000 gal/medium lift support area (MLSA)	150,000 - 300,000 gal/MLSA
b. Soil Stabilization[1]	140,000 - 700,000 gal/MLSA	140,000 - 700,000 gal/MLSA
c. Dust Control[3]	23,400 gal/hr/MLSA	93,400 gal/hr/MLSA
3. Quarry Operations		
a. Washing/Screening[1] Crusher		
(1) 75 ton/hr	45,000 gal/hr	45,000 gal/hr
(2) 225 ton/hr	135,000 gal/hr	135,000 gal/hr
b. Dust Control[4]	60 gal/hr	60 gal/hr
4. Asphalt Plant Operations[2]		

ACTIVITY	TEMPERATE ENVIRONMENT	ARID ENVIRONMENT
Plant (single fill)	80,000 gal	80,000 gal
5. Well Drilling and [2&5] Development		
a. Rotary Drilling[6] (hydraulic)	3 times the volume of the hole being drilled	3 times the volume of the hole being drilled
b. Cable Tool	4 gal/ft (6" hole) 5 gal/ft (8" hole)	4 gal/ft (6" hole) 5 gal/ft (8" hole)
6. Concrete Construction [2&5]		
All operations[7]	50 gal/cubic yard	60 gal/cubic yard
7. Pipeline Testing[2]		
a. 6" dia. Pipe	9,000 gal/mile	9,000 gal/mile
b. 8" dia. Pipe	14,000 gal/mile	14,000 gal/mile
8. Topographic Operations[8]		
Film Processing	750 - 1,000 gpd	750 - 1,000 gpd

NOTES

[1] Salt water acceptable, nonpotable fresh water preferred.

[2] Nonpotable fresh water required.

[3] Dust palliatives, such as old oil, contaminated fuel, or Penoprime should be used before water. The use of Coherex reduces water requirements to 6,700 - 8,900 gal/mile for Class A road and to 8,100 - 10,250 gal/MLSA airfield.

[4] Quarry operations dust control is based on using water to spray rock during its entry into the crusher. Dust control of roads within the quarry is not included.

[5] Operations in arctic environment require water to be heated prior to use.

[6] Hole (cylinder) volume is calculated by the equation:

$V = (a)(Pi)(r2)$ Where V = volume in cubic feet, a = well depth in feet, Pi = 3.1416 and r = radius in feet

[7] Includes water required for equipment cleaning.

[8] Potable water required.

Table M-1.Water Requirements for Engineer Construction

Assumptions For Engineer Construction

1. Road Construction

a. Compaction

(1) Water requirements based upon one 6-inch compaction effort on a one-mile section of Class A road.

(2) Maximum dry density is 120 lbs/cubic foot.

(3) Construction is on level terrain.

(4) Temperate environment.

(a) Sub-base will be compacted to six inches.

(b) Soil moisture variance between desired and actual moisture content is best at 2 percent, worst at 5 percent.

(5) Arid environment.

(a) Dry compaction will not be performed.

(b) Soil is at or near zero moisture content; required moisture content ranges between 10 percent - 20 percent.

b. Soil Stabilization

(1) Water requirements based upon one 6-inch stabilization effort on a one-mile section of Class A road.

(2) Soil density equals 100 lbs/cubic foot.

(3) Stabilizing agent.

(a) When only water is used, apply factors outlined in paragraph 1.a. above.

(b) The amount of stabilizing agent (lime, cement, etc.) ranges from 2 percent (best case) to 16 percent (worst case).

(c) The amount of water required equals 1/2 percent for each 1 percent of stabilizing agent by weight.

c. Paving Operations

(1) Wet roller drums required.

(2) Class A road is paved with three lanes, each eight feet wide.

d. Dust Control

(1) Requirements based upon a one mile section of Class A road.

(2) Control agents.

(a) Water alone will provide control for only one hour.

(b) Other dust control agents, such as Coherex or Penoprime, require less water.

(c) Coherex use reduces water application rate to .33 - .66 gal/sq yd.

(3) Climate variations.

(a) Temperate environment requires 1 gal/sq yd (worst case).

(b) Arid environment requires 3 - 5 gal/sq yd due to low soil moisture content.

2. Airfield Construction

a. MLSA based upon length of 3,500 feet and width of 60 feet.

b. Assumptions for compaction, soil stabilization, and dust control are the same as those for road construction.

3. Quarry Operations

a. Based upon data contained within TM 5-331C.

b. For dust control, assume 1 gal/min.

4. Asphalt Plant Operations

a. Based upon a one-time filling of a centrifugal wet scrubber.

b. No water is required if a dry baghouse is used instead of a centrifugal wet scrubber.

5. Well Drilling Development

a. Requirements based upon factors in, *Well Drilling Manual*, National Water Well Association.

b. Requirements do not include water lost due to seepage from the settling pit into the soil.

6. Concrete Construction. Requirements include water used in mixing, finishing, and curing.

7. Pipeline Testing

a. Requirements based upon complete filling of the pipeline following by one complete flushing.

b. Pressure testing.

(1) If fresh water is used, flushing can be eliminated if water supply is restricted.

(2) If salt water is used, one complete fresh water flushing is necessary.

Appendix N
Planning Factors for Mortuary Affairs

1. Description of Function. Water used in the mortuary affairs function is that required to clean the remains prior to transportation and to clean mortuary affairs personnel and equipment after handling.

2. Water Quality Requirements. Mortuary affairs operations do not require potable water.

3. Basis of Estimate. These estimates were computed in coordination with the Director of the US Army Quartermaster School's Mortuary Affairs Department. Killed-in-action (KIA) planning factors were provided by CASCOM.

a. Full mortuary processing of remains will not be accomplished in the theater of operations. Remains will be returned to the continental United States for processing.

b. The use of water will be limited to washing the face and hands of remains for identification and fingerprints, and to clean up after processing. **Estimate four gallons per remains**.

c. Contaminated remains require approximately 15 gallons of water for decontamination.

d. The SIM Model, using TAA03 data reflects the following KIA factors portrayed in 10 day increments. Unit of measure is factor per 1,000 per day. See Tables N-1 and N-2.

PERIOD	FACTOR	PERIOD	FACTOR
1	1.14	7	0.57
2	0.62	8	0.45
3	0.40	9	0.58
4	0.17	10	1.01
5	0.45	11	0.64
6	0.71		

Table N-1
MRC WEST

PERIOD	FACTOR	PERIOD	FACTOR
1	0.07	7	0.06
2	0.19	8	0.07
3	0.13	9	0.05
4	0.11	10	0.21
5	0.10		
6	0.06		

Table N-2
MRC EAST

e. In the MRCW scenario, the worst 10-day increment is the first 10 days. An 18,000 soldier division would expect an average of 20.52 KIA per day. At four gallons per remains, this would require 82.08 gallons of water or 0.005 gal/soldier/day in the division.

f. In the MRCE scenario, the worst 10-day increment is the last 10 days. An 18,000 soldier division would expect an average of 3.78 KIA per day. At four gallons per remains, this would require 15.12 gallons of water or 0.0008 gal/soldier/day in the division.

g. There was no data available on percentage of remains that were contaminated, however, if all remains are treated as contaminated using 15 gallons of water each for processing, the MRCW consumption factor would be 0.009. The MRCE consumption factor would be 0.0016.

Appendix O

Planning Factors for Evaporation, and Waste/Spillage

1. Description of Function. The loss factor must be considered when computing consumption for any field force to cover evaporation and waste/spillage, over the planning factor in any category. Water is not accounted for as petroleum products are and do not cause environmental hazards when spilled. Evaporation occurs in all climates. Until a study is completed (tentative start will be in 2nd Quarter FY99), that looks at losses through evaporation and waste/spillage throughout the theater in all climates, a factor of 10% of the total potable water used in the theater should be used. This factor is comprised of 4% evaporation and 6% waste/spillage.

2. Water Quality Requirements.

3. Basis of Estimate. These estimates were computed in coordination with the science and technical journals, subject matter experts, and field observations.

a. Evaporation: Water is lost through all climates due to the effects of evaporation. This is true, even in Arctic environments. Water is especially vulnerable to evaporation effects when stored in 3,000 gallon onion tanks. The popularity of these tanks have them being used throughout the force structure in such many missions, including water purification, laundries, showers, and engineer operations.

b. Waste/spillage: Since water does not have any of the hazards associated with petroleum, seepage from tanks, couplings, water buffaloes, and other water containers are not repaired immediately. Additionally, canteen filling operations from water buffaloes and five gallon cans are usually accompanied with waste. During unit movement, water contained in onion tanks and other grounded containers is usually "dumped" in preparation for a movement to a new location. Again, this is because of the lack of environmental and safety hazards associated with water. Semi-trailer fabric tanks (SMFTs) to distribute water are also a contributor to waste. Since the Army does not have hardwall tankers that can be used to make multiple stop deliveries, a SMFT must dump its entire load when it is delivered. If the location can not use the entire 3,000 gallons, it must be dumped prior to the transport vehicle moving .

Appendix P
Planning Factors for Enemy Prisoners of War/Civilian Internees

1. Description of Function. Water is required for drinking, food preparation, personal hygiene, centralized hygiene, laundry, and medical treatment.

2. Water Quality Requirements. Except for laundry, all water should be potable.

3. Basis for Estimate. These estimates were coordinated with the US Army Military Police School.

a. The Third Geneva Convention, Protection of Prisoners of War, requires humane treatment of enemy prisoners of war (EPW) at all times. It also sets forth requirements as to quarters, food, clothing, hygiene, and medical attention.

b. The US Army's goal is to provide EPWs and civilian internees support equal to that of US Forces whenever possible. The same water consumption factors used for US Army personnel are applicable for EPWs. These may require modification because of local ethnic, cultural, dietary, sanitation, or religious beliefs.

FUNCTION	HOT CLIMATE	TEMPERATE CLIMATE	COLD CLIMATE
Drinking[1]	2.00	0.75	1.25
Personal Hygiene	1.70	1.70	1.70
Centralized Hygiene[2]	1.70	1.70	1.70
Food Preparation[3]	2.80	2.80	2.80
Laundry (w/M-85)[4]	3.10	3.10	3.10
Medical Aid	1.24	1.24	1.24
Total	12.54	11.29	11.79

1. Based on 100% of light physical exertion. Should it be the same as U.S. Troops, then factors would be 3.00, 1.50, and 2.00.
2. Based on one shower per week (Section II-C).
3. Based on 1 A/B, I T, and 1 MRE (as for U.S. Troops).
4. Based on 7.2Ib of laundry/EPW/wk which is (7.2 lbs x3 gal per lb/7 dsys) or 3.1.

Appendix Q
Planning Factors for Force Provider

1. Description of Function. Force Provider gives the Army a capability to provide front-line soldiers a brief respite from the rigors of duty in a front-line area. It gives up to 3,300 resident soldiers climate controlled billeting, feeding, laundry, shower, latrine, and morale, welfare, and recreation (MWR) facilities. Force Provider can also be employed during initial theater reception or redeployment as well as in support of reconstitution, noncombatant evacuation, humanitarian aid, and disaster relief missions. Force Provider is organized with six modules, each capable of supporting 550 soldiers.

2. Water Quality Requirements. Although non-potable water can be used for some functions, the single water supply system requires all potable water.

3. Basis for Estimate. There is no empirical data available to verify water usage in Force Provider. The following data was derived from FM 42-424, *Force Provider Company* (Coordinating Draft), 9 December 1996; TM 10-5419-200-12, *Force Provider*, 25 December 1996, the LOGCAP Support Plan, *Force Provider*, 13 August 1996; and in coordination with CASCOM DCD-QM.

a. Laundry. The laundry will provide service for 15 pounds of laundry per soldier every three days. In addition, the laundry must wash many extra towels per day since towels are provided with showers. In some cases, sleeping bags of transient soldiers will be washed prior to departure. Estimated water usage for one 550 person module is 15,360 gallons per day.

b. Latrines. Flush type latrines are provided with an estimated usage of 2,700 gallons per day for each module.

c. Showers. Each individual will have the opportunity to shower daily. The estimated water required is 11,000 gallons per day for each module.

d. Food service. Force Provider can serve three cook-prepared meals per day with an estimated usage of 1,925 gallons of water per day per module.

e. The total water requirement for each module is 30,985 gallons per day or 56.3 gallons per soldier per day.

f. The following factors are used for each person in the force structure, which reduces the Force Provider planning factor to (56.3 from para 3e - 12.9 below) or 43.4 gallons per person per day.

(1)	Personal Hygiene	1.7 gal/day
(2)	Centralized Hygiene	2.0 gal/day
(3)	Field Feeding	2.8 gal/day
(4)	Laundry	6.4 gal/day

g. Force Provider – Tropical/Arid

Drinking* – 100% Moderate Physical Activity = 11 qts/soldier/day or	2.75 G/S/D
Personal Hygiene* (minus sponge bath) = 1.7 – 0.5 or	1.2 G/S/D
Central Hygiene (S & L) = (15,360 gals/day + 11,000 galsday)/550 =	47.93 G/S/D
Level I & II Medical Ops. –	0.04 G/S/D
Latrine Ops. – (2,700 gals/day)/550 =	4.91 G/S/D
Food Service* – (1,925 gals/day)/550 =	3.5 G/S/D
	Total = 60.33 G/S/D

Tropical (minus potable water already provided)=> 60.33-(8.75+0.88+0.04)** =	50.7 G/S/D
Arid (w/M85) => 60.33-(18.66+1.87) =	39.8 G/S/D
Arid (w/LADS)=> 60.33-(12.41+1.24) =	46.68 G/S/D

* Universal Unit Level: Hot = 2.75+1.2+3.5 = 7.45, Temp. = 1.25+1.20+3.5 = 5.95, Cold = 1.75+1.2+3.5 = 6.45

** See Table 1 (Potable Water Planning Factor w/M-85, 10% Loss Factor, Level I and II Medical Treatment)

Appendix R
Planning Factors for Vehicle Wash Rack Operations

1. Description of Function. US military forces may be required to deploy to virtually anywhere in the world. Associated with this deployment requirement is a great potential for forces to inadvertently introduce exotic plants and animal pests when they redeploy back to CONUS. Such introduced exotic pests can cause irreparable damage to public health, agriculture, or the environment. Special precautions are necessary to prevent the introduction of harmful public health or agricultural agents from entering the United States on military equipment. Although water usage during wash rack operations can not be used to determine force structure, planners must be aware of the requirement.

2. Water Quality Requirements. Water used at overseas wash racks need not be potable, however some treatment may be necessary to ensure equipment is not contaminated with unwanted organisms. Salt water should be avoided because of corrosion problems.

3. Basis for Estimate.

a. The US Army has conducted pre-redeployment wash rack operations many times in the past, however water consumption data was not captured.

b. The Armed Forces Pest Management Board Technical Information Memorandum No. 31, *Contingency Retrograde Washdowns: Cleaning and Inspection Procedures*, December 1993, states that approximately 250,000 gallons of water are required for an average Army battalion size force with 300 wheeled vehicles using 2 1/2 inch fire hoses operating at the minimum recommended pressure of 90 psi.

c. Deliberate NBC decontamination is the complete cleaning and removal of all contaminate from vehicles and equipment. FM 3-5, *NBC Decontamination*, states that 450 gallons of water are required to decontaminate wheeled vehicles and 500 gallons for tracked vehicles. These figures represent the minimum water requirement for wash rack operations.

Appendix S
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