IWRAPS

Planning and Management Consultants, Ltd. Carbondale submitted "Final Report" of June 1993 to the Institute for Water Resources U.S. Army Corps of Engineers, Fort Belvoir, VA, Ill

"IWRAPS is a tool that has been designed to suit the specific needs of military water planners in forecasting water requirements." Final Report at 1.

"The Army Advisory Committee for Installation Water Planning and Conservation has accepted the results of the planning series. IWRAPS has also been recommended for application at military installations by the BRAC National Environmental Policy Act support team." Final Report at 1.

The objectives of the Report:

[1] "To develop seasonal disaggregated forecasts of potable and nonpotable water requirements at FHMR for the years 1995, 2000, 2005, 2010, 2020, and 2025 under unrestricted conditions;
[2] to develop restricted forecasts under conservation and mobilization scenarios;
[3] to summarize the findings of this study and its implications on water management at FHMR.

Report at 2.

The key part of the Report is in Table 1 that is at p. xvii, and is a summary of water requirements at FHMR, in acre-feet, from 1995 to 2025 with certain scenarios built into the projections. A copy of the Table is attached. Table 1 has the following caveat: "Possible **additional** water requirements could result from contingencies for changing mission, extreme weather, and supply reliability." (emphasis added)

In the Executive Summary the Final Report says the following about projected mobilization:

> "FHMR has a mobilization mission. However, this contingency will not require any additional building construction and the mobilized troops will be housed in the existing structures." Final Report at p. xvi.
>
> "The largest water requirements are needed during mobilization conditions varying from 3,655 acre-feet in 1995 to 3,873 acre-feet in 2015 and onward."
>
> "[I]it is recognized that the post may need water to accomplish its mobilization mission that can occur any day and at a time when conservation measures have not been implemented. Assuming this worst-case scenario, the post should plan for adequate water supplies for full mobilization with no conservation measures in effect. This situation warrants potable water supplies of about 3,873 acre-feet by the year 2015 and onward." Final Report at xvi.

As further noted at page 39 of the Final Report:

> FHMR has a mobilization mission that is documented in Fort Huachuca, AZ Mobilization Master Plan Report (March 1992). This mission includes preparation for receiving incoming mobilized troops and distributing assigned tasks to them. FHMR personnel indicated no planned construction due to mobilization mission because the installation has sufficient existing building space to house the incoming mobilized troops. Hence, no mobilized troops will live in a bivouac setting. The normal and buildup troop strengths have been reported as 8, 159 and 13,396 respectively."

The Final Report has a chapter enumerated and entitled "VIII. WATER REQUIRMENTS DURING MOBILIZATION" at page 65. Attached is the narrative portion of the Final Report without the tables that were part of this section.

The following is an outline and excerpts of what that chapter states:

> "FHMR is a Training and Doctrine . . . installation with a mobilization mission documented in the Fort Huachuca Mobilization Plan Report (1992). This chapter examines the additional potable water requirements necessary to meet FHMR's **planned** mobilization. IWRAPS mobilization forecasts can be used by the post's water utility for planning to fulfill mobilization requirements for the years 1995 through 2025. The results of these forecasts are related to the **expected conditions** at FHMR for absorbing additional military personnel into existing buildings and the consequent impact on . . . water use. **If the assumptions change** due to revised or supplemental contingency missions, than [sic] **the forecasts must be recalculated** with new input date from post mobilization planners." (emphasis added)

As stated in the Final Report at 65, "Mobilization water requirements forecasts including the following assumptions:"

1. Mobilization can occur at any time. "The additional water requirements needed to sustain the total mobilization force for a minimum of one year, regardless of start time, is the ultimate forecast objective." (emphasis in the original)
2. "Mobilization troops and support personnel will be housed and serviced by three sectors: [1] existing structures . . . [2]new construction . . . [3] filed bivouac sites . . . ."
3. "Mobilization water needs will increase during the short term . . . and stabilize during the long term. . . ."
4. "Although mobilization can occur at any time, the amount of additional water use must be coupled with unrestricted or restricted (conservation) peacetime water use projections for all time horizons to determine total installation water requirements."

Furthermore,

> "It is reported that the troop strength will increase from a normal level of 8,159 to at buildup level of 13,396. The critical planning value, which will be referred to as the mobilization factor, is the change in troop strength of 5,237, which represents a 64 percent increase in the intensity of water use in applicable water use sectors. Since there is no planned additional construction during mobilization, water requirements in IWRAPS for selected sectors are assumed to increase proportional to the increase I troop strength and the expected impact on water use in each of those selected sectors. . . . Other sectors may have to withstand an impact in additional water use from 1 to 100 percent of the 64 percent mobilization impact is referred to as mobilization coverage."

"Mobilization can occur at any time, and planners should apply a worst-case scenario to compute mobilization water needs by using unrestricted water use in the base year [1991] and forecast years."

Report at 66.

"Ideally arriving soldiers would backfill the building space vacated by departing (deployed) soldiers, resulting in water use trade offs. However, such a plan can easily be interrupted by lack of sea or airlift capability or adjustments of theater buildup in the war zone, as evidenced by the delay in the deployment of the 11th Signal Brigade during the recent Middle East Operation Desert Storm. The scenario of a complete buildup without deployment is appropriate in this case for planning purposes."

Report at 66.

"The increase in water use due to mobilization should be represented as added water requirements . . . . These quantities are computed by multiplying the mobilization coverage values and the mobilization factor which represents the increase in water use intensity to the seasonal unrestricted water requirement for each sector, sow in Table VII-1. The total Water requirements for mobilization buildup of a minimum of one year combine the added mobilization water requirements with the unrestricted water requirements that would have been need in any event. Table VIII-2 provides the results of this procedure [.]"

Report at 68-69.

Summary of the Findings:

"Table IX-1 [which is the same as Table 1] summarizes the projected annual potable, nonpotable, and effluent water requirements for the years 2995-2025. The potable water requirement has been analyzed under unrestricted and restricted conditions of conservation and mobilization. The potable water use forecasts represent the composite of both the IWRAPS and the tent city estimates. The increase in the projected unrestricted potable water use from 1995-2025 is largely explained by the mission-related BRAC construction projects at FHMR." "The largest water requirements are apparent during mobilization conditions varying from 3,655 acre-feet in 1995 to 3,873 acre-feet in 2015 and onward, for an increase of about 24 percent above unrestricted water needs. The increments in water use due to mobilization at FHMR are solely due to increase troop strength occupying existing facilities during the forecast years and do not require any additional building construction."

Report at 71

"However, it is recognized that the post may need water to accomplish its mobilization mission that can occur any day and at a time hen conservation measures may not have been implemented. **Assuming this worst-case scenario, the post may need water with the assumption of full mobilization and no conservation measure in effect. This situation can warrant annual potable water needs of about 3,873 acre-feet by the year 2015.**"

Report at 71.

"The baseline estimate of 2,743 acre-feet is the most accurate estimate of combined potable and nonpotable annual water requirements for the baseline year (FY91). All forecast horizons are based on this value. From a management perspective though, contingencies for changing mission, extreme weather, and supply reliability should be considered before the water management plan is finalized."

Report at 73.

The Report contains "Chapter VIII. MOBILIZATION ANLYSIS"

In the chapter, the Report at A-39 said the following:

"Military installations involved in mobilization contingencies are required to prepare "mobilization plans." **IWRAPS uses data from these plans** to provide an estimate of water requirements under mobilization conditions. The assumptions and algorithm for the mobilization analysis are presented below." (emphasis added)

Attached is a copy of Chapter VIII, an appendices to the Report.

TABLE 1

SUMMARY OF WATER REQUIREMENTS AT FHMR
(In Acre-Feet)

	1995	2000	2005	2010	2015	2020	2025
Annual potable unrestricted water requirements	2,963	3,026	3,083	3,115	3,128	3,128	3,128
Annual potable unrestricted water requirements (with mobilization)	3,655	3,747	3,824	3,858	3,873	3,873	3,873
Annual potable restricted water requirements (with conservation)	2,750	2,614	2,495	2,351	2,287	2,287	2,287
Annual potable restricted water requirements (with conservation and under mobilization)	3,400	3,247	3,109	2,931	2,848	2,848	2,848
Nonpotable water	83	83	83	83	83	83	83
Effluent water	2,125	2,125	2,125	2,125	2,125	2,125	2,125

This report emphasizes only those nonpotable water uses that were quantifiable. However, it should be recognized that FHMR may have additional nonpotable water needs. These requirements were not supported by explicit data and, therefore, could not be measured. Possible additional water requirements could result from contingencies for changing mission, extreme weather, and supply reliability.

VIII. WATER REQUIREMENTS DURING MOBILIZATION

FHMR is a Training and Doctrine (TRADOC) installation with a mobilization mission documented in the Fort Huachuca Mobilization Plan Report (1992). This chapter examines the additional potable water requirements necessary to meet FHMR's planned mobilization. IWRAPS© mobilization forecasts can be used by the post's water utility for planning to fulfill mobilization requirements for the years 1995 through 2025. The results of these forecasts are related to the expected conditions at FHMR for absorbing additional military personnel into existing buildings and the consequent impact on sectoral water use. If the assumptions change due to revised or supplemental contingency missions, than the forecasts must be recalculated with new input data from post mobilization planners.

IWRAPS© MOBILIZATION PROCEDURE AND ANALYSIS

A detailed description of the mobilization analysis procedure is included in Appendix A. This section summarizes the salient features of mobilization in IWRAPS© and presents data analysis with mobilization water use forecasts. Mobilization water requirements forecasts include the following assumptions:

- Mobilization can occur at any time of the year. The additional water requirements needed to sustain the total mobilization force for a minimum of one year, regardless of start time, is the ultimate forecast objective.

- Mobilization troops and support personnel will be housed and serviced by three sectors: (1) existing structures, which will require water use intensities to be adjusted based upon the proportional increase in the allowed-to-actual ratio; (2) new construction, which will drive use intensities to full utilization for the building and special-purpose sectors receiving the added square footage; and (3) field bivouac sites, where soldiers are expected to utilize about 150 gallons of water per day.

- Mobilization water needs will increase during the short term (initial 180 days) and stabilize during the long term (beyond 180 days). Plans should be developed for long-term needs, which facilitate and support the mobilization mission.

- Although mobilization can occur at any time, the amount of additional water use must be coupled with unrestricted or restricted (conservation) peacetime water use projections for all time horizons to determine total installation water requirements.

At FHMR, the mobilized troops will be housed in the existing buildings, and therefore there will be no additional construction. Also, field bivouac sites will not be needed for the

planned mobilization. It is reported that the troop strength will increase from a normal level of 8,159 to at buildup level of 13,396. The critical planning value, which will be referred to as the mobilization factor, is the change in troop strength of 5,237, which represents a 64 percent increase in the intensity of water use in applicable water use sectors. Since there is no planned additional construction during mobilization, water requirements in IWRAPS© for selected sectors are assumed to increase proportional to the increase in the troop strength and the expected impact on water use in each of those selected sectors. Some sectors will sustain no impact (i.e., *family housing*, *schools*, and *golf course*). Other sectors may have to withstand an impact in additional water use from 1 to 100 percent of the 64 percent mobilization impact, as determined by post planners of mobilization contingencies. This percent of impact is referred to as mobilization coverage. Unaccounted water continues to be 15 percent of total water use.

Installation DEH personnel provided data regarding the expected impact of added mobilization on each water use sector, both building and special-purpose, as a percent of expected coverage or impact on that sector. For example, Table VIII-1 shows that mobilization will impact on 100 percent of the *administration/operations* and *barracks* sectors, 20 percent on the *exchange* and *gymnasium* sectors, and 0 (zero) percent on *family housing* and *schools*.

Mobilization Impact on Unrestricted Water Use

Mobilization water requirements are calculated for both the summer and winter periods. Mobilization can occur at any time, and planners should apply a worst-case scenario to compute mobilization water needs by using unrestricted water use in the base year and forecast years. Although a water conservation program may be planned for implementation in the future, a mobilization event could occur before it is put in place. Therefore, the installation must plan for satisfying water needs to cope with the most intense water use situation.

Normally, full buildup requires 180 days regardless if the arriving troops live in a bivouac setting, new construction, or in existing buildings. For this study, the breakout by percent of arriving troops in 30-day increments is not known. Therefore, the computed water requirement values assume the full mobilization number will occupy existing buildings within the initial 30 days. Ideally, arriving soldiers would backfill the building space vacated by departing (deployed) soldiers, resulting in water use trade offs. However, such a plan can easily be interrupted by lack of sea or airlift capability or adjustments of theater buildup in the war zone, as evidenced by the delay in deployment of the 11th Signal Brigade during the recent Middle East Operation Desert Storm. The scenario of a complete buildup without deployment is appropriate in this case for planning purposes.

The increase in water use due to mobilization should be represented as added water requirements for the winter and summer seasons and for the composite year. These quantities are computed by multiplying the mobilization coverage values and the mobilization factor which represents the increase in water use intensity to the seasonal unrestricted water requirements for each sector, shown in Table VIII-1. The total water requirements for mobilization buildup of a minimum of one year combine the added mobilization water requirement with the unrestricted water requirements that would have been needed in any event. Table VIII-2 provides the results

of this procedure and displays the forecast increases in seasonal and annual water use attributed to mobilization. It should also be noted that added water for mobilization will also increase volumetrically the amount of unaccounted water in order to maintain a 15 percent value for the sector. Since there is no additional construction, and the increase in water use is solely due to troop buildup during mobilization, the percent increase of unrestricted water use remains constant at about 24 percent from the years 1995 through 2025. The total annual increase for the forecast years remains fairly stable, varying from about 226 mgals to about 243 mgals. The total annual water requirement with mobilization also shows a similar pattern and ranges from 1,191 mgals (3,655 acre-feet) to 1,262 mgals (3,873 acre-feet). These quantities should be assured water supplies available to the installation and must be unconditionally guaranteed to ensure the success of the mobilization contingency.

Mobilization Impact on Restricted Water Use

If mobilization occurs during or after the successful implementation of specific conservation measures, then the projected sectoral water reductions must be considered as mitigation measures to reduce the total amount of required water. Because conservation measures are targeted at specific water use sectors, only those sectors adopting a measure will be effected.

To compute the influence of water conservation in reducing water use, it is assumed that the arriving mobilization troops are affected by all ongoing and proposed measures. Chapter VII explained that the implementation of specific water conservation measures restricts water use by sector, and conservation effectiveness (E) is determined by the product of coverage (C), reduction (R), and unrestricted water use (Q). Conservation effectiveness under mobilization conditions is determined the same way, but the sectoral unrestricted water use includes the impact of mobilization, i.e., the added water requirements.

Table VIII-3 presents the results of this procedure and compares the increases due to mobilization, countered by reductions attributed to conservation effectiveness. Seasonal and annual forecasts are given for the years 1995 through 2025. Initially, there is a 14.8 percent increase to unrestricted water requirements by the year 1995. By the year 2005, mobilization needs are met almost entirely by the water reductions caused by the implementation of a successful conservation program. Continuation of water conservation actually decreases annual water requirements (even though mobilization occurs) by 8.9 percent in the year 2015 and thereafter.

CHAPTER VIII. MOBILIZATION ANALYSIS

Added water requirements under mobilization can be viewed as a unique situation that the military water utility planner must consider. It is a very real possibility, and mobilization water needs must receive consideration in utility design and emergency management. Military installations involved in mobilization contingencies are required to prepare "mobilization plans." IWRAPS© uses data from these plans to provide an estimate of water requirements under mobilization conditions. The assumptions and algorithm for the mobilization analysis are presented below.

MOBILIZATION ALGORITHM IN IWRAPS©

During full mobilization, many factors cause the buildup time and the total mobilization period to vary. The primary determination of mobilization requirements is the degree of mobilization taking place. It is recommended that conditions of full mobilization be evaluated. A buildup period of about 180 days takes place during which the magnitude of troop buildup and training is increased and planned mobilization construction takes place. Beyond the buildup period, an equilibrium point will be approached, and all designed assets will be constructed. A steady influx of new trainees will continue, but soldiers will also be leaving as they are deployed to the war zone. Water requirements must be forecast based on the following assumptions:

- Mobilization can occur at any time, and therefore, the additional water requirements needed to sustain the total mobilization force for a minimum of one year regardless of start time is the ultimate forecast objective.

- Mobilization troops and support personnel will be housed and serviced by three sectors: (1) existing structures, which will require use intensities to be adjusted based upon the proportional increase in the actual-to-allowed ratio; (2) new construction, which will drive use intensities to full utilization for the building and special purpose sectors receiving the added square footage; and (3) field bivouac sites, where soldiers are expected to utilize about 150 gallons of water per day (gpd).

- Mobilization water needs will increase during the short term (initial 180 days) and stabilize during the long term (beyond 180 days). Plans should be developed for long-term needs, which facilitate and support the mobilization mission.

- Although mobilization can occur at any time, the amount of additional water must be coupled with unrestricted or restricted (conservation) peacetime water use projections for various time horizons to determine total installation water requirements.

The water requirements for those housed in new or existing buildings are estimated using building square footage. All sectors requiring construction under mobilization are assumed to operate at maximum-design mobilization level, thus the activity level is 1.0. Water requirements for the remaining sectors are assumed to increase proportionally to the mobilization impact or coverage on applicable sectors and to the added installation population attributed to mobilization.

Water requirements for the portion of population housed in the field are calculated using 150 gallons per capita per day (Smith 1984, U.S. Army 1984). This portion of the mobilization population should be netted out of the calculation of non-mobilization construction sectors. In some cases, such as Fort Bliss, it is planned that all mobilization personnel will eventually be accommodated in existing or new buildings. All water requirements are therefore based on an assessment of the resultant building areas.

The first phase or short-term planning consideration prorates the long-term mobilization water requirements to reflect water needs during the buildup. This exercise is directly dependent on the rate of mobilization construction completion. Potential temporary water shortages and other important demand management issues can be pinpointed through this type of analysis.

To summarize, the following steps should be followed in estimating water requirements under mobilization:

(1) Determine additional mobilization troop population as a fraction of the pre-mobilization troop population. This fraction is referred to as the ***mobilization factor.***
(2) Identify building-related sectors which require additional construction.
(3) Determine the fractional impact of mobilization on all water-using sectors where new construction is not required. This fraction is referred to as the ***mobilization coverage.***
(4) Estimate the percent of additional mobilization troop population to be housed in bivouac setting in the short and long term.
(5) Calculate water requirements for sectors identified in Step 2 based upon an activity ratio of 1.0.
(6) Calculate water requirements for sectors not identified in Step 2 by multiplying baseline unrestricted water use by the mobilization factor and coverage values and adding the product to the pre-mobilization unrestricted water use.
(7) Calculate the field component water requirement based upon 150 gpcd.
(8) Add Steps 5-7 to obtain total mobilization requirement.
(9) Calculate conservation effectiveness and the resulting reduction in water use based on the results of Step 8.

The following equation summarizes the mathematical operation of the mobilization module.

$$QM_j = \left[QM_F \left(FLD_t \right) + \sum_{i=1}^{21+N} QM_{i,j} \right] \qquad \text{(A.8.1)}$$

where:

QM_j = total mobilization water use, gpd, for either summer or winter
FLD_t = fraction of mobilization troops in field setting at mobilization stage t
$QM_{i,j}$ = water use under mobilization for sector i in time period j, gpd, for either a winter day or a summer day
N = the number of special purpose sectors
QM_F = water use by troops in field setting, gpd

$$= TRP * Q_F$$

where:

TRP = number of arriving mobilization troops
Q_F = water use per field troop, 150 gallons/troop/day

New construction required by mobilization can be identified by sector and is represented by the term $MCONS_i$. If $MCONS_i > 0$ for any building or special purpose sector, then

(A.8.2)

$$QWM_j = \sum_{i=1}^{21} \left[AC_{i,j} + MCONS_i \right] * \left[\frac{B_{ai} + MCONS_i}{AC_{i,j} + MCONS_i} + \frac{\sum_{k=89}^{j} CONS_{i,k}}{AC_{i,j} + MCONS_i} * \left(1 - \frac{e_{i,k}}{100} \right) \right] * \left[\frac{AL_{i,j} + MCONS_i}{AC_{i,j} + MCONS_i} * C_{NI} \right] + SPEC$$

(A.8.3)

$$QSM_j = \sum_{i=1}^{21} \left[AC_{i,j} + MCONS_i \right] * \left[\frac{B_{ai} + MCONS_i}{AC_{i,j} + MCONS_i} + \frac{\sum_{k=89}^{j} CONS_{i,k}}{AC_{i,j} + MCONS_i} * \left(1 - \frac{e_{i,k}}{100} \right) \right] * \left[\frac{AL_{i,j} + MCONS_i}{AC_{i,j} + MCONS_i} * C_{NI} \right] * QRATIO_j + \left[SPEC * QRATIO_j \right]$$

If $MCONS_i = 0$ for any building or special purpose sector, then

$$QWM_{ij} = \left[(QW_{ij} * MFAC_{ij} * MCOV_{ij}) + QW_{ij} \right] \quad \textbf{(A.8.4)}$$

$$QSM_{ij} = \left[(QS_{ij} * MFAC_{ij} * MCOV_{ij}) + QS_{ij} \right] \quad \textbf{(A.8.5)}$$

where:

$MCONS_i$	=	mobilization construction for water use sector *i* in square feet
QW_{ij}	=	winter unrestricted water use for sector *i* in time period *j*, gpd
QS_{ij}	=	summer unrestricted water use for sector *i* in time period *j*, gpd
QWM_{ij}	=	winter mobilization water use for sector *i* in time period *j*, gpd
QSM_{ij}	=	summer mobilization water use for sector *i* in time period *j*, gpd
$MFAC_{ij}$	=	mobilization factor, which is the fractional increase in troop strength caused by added mobilization troops for sector *i* in time period *j*
$MCOV_{ij}$	=	mobilization coverage, which is the fractional value of expected impact on unrestricted water use for sector *i* in time period *j*

The remaining variables were defined in Chapter VII.

The main inputs required in the IWRAPS© software are the change in troop strength by the added mobilization population, new construction, buildup rate, and the mobilization factor and coverage values for each sector. These inputs may vary, but this optional analysis can provide useful planning information under many specified mobilization scenarios.

For installations that have prepared a program to implement specific conservation measures across time, a mobilization event could occur simultaneously during the execution of the conservation program. If the program is achieving expected reductions in water use, it can tend to attenuate the impact of mobilization which requires more water. It can be assumed that arriving mobilization troops will be subject to the active and ongoing conservation program as well.

Although water utility managers must plan for the worst-case scenario, i.e., no active water conservation program, it appears that the potential reductions in water loss and waste could enhance the mobilization effort, especially at installations where water could be a limiting factor. Savings attributed to conservation effectiveness could reduce, if not completely satisfy, mobilization water needs.

Computation of conservation effectiveness (E) under mobilization is identical to the procedures described in Chapter VI with the exception that the unrestricted sectoral water use quantity (Q) includes the added water needs to sustain mobilization. In other words,

conservation effectiveness is determined after the computation of total mobilization water requirements. Field water use by troops in a bivouac setting are assumed to be unaffected by ongoing water conservation. The adjusted algorithm is represented by the following:

$$E_{mij} = R_{mi} \cdot C_{mij} \cdot QM_{ij} \qquad \textbf{(A.8.6)}$$

where:

QM_{ij} = mobilization water use for sector *i* in time period *j*, gpd, for either a summer or a winter day

It should be noted that the special purpose sector, referred to as unaccounted water, is subject to fluctuations caused by mobilization and/or conservation or both. However, the percent of total water use attributed to this sector is maintained throughout each forecasted period, regardless of the scenario. The percent can change only if specific conservation measures are applied to obtain such a decrease, or if installation utility managers realize that greater water losses are occurring across time.