NON-POTABLE WATER SUBSTITUTION AND REUSE IN THE FIELD

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PURPOSE. The purpose of this information paper is to provide guidance for non-potable water substitution and reuse in the field.

REFERENCES. See Appendix A for reference information.

POINTS OF MAJOR INTEREST AND FACTS.

BACKGROUND.

Non-potable water can be used to satisfy a portion of the total water demand when potable water quality is not required. This substitution, the replacement of high quality water with lower-grade water, is especially beneficial in arid regions where water is scarce; however, this replacement water might require some treatment depending upon the quality of the source water and the intended use.

Water reuse is generally defined as the use of treated wastewater for a beneficial application; in the United States, water reuse is controlled by state regulatory agencies. In deployment situations and in the absence of any host nation requirements, the Army is guided by these same state regulations and federal guidelines. Much of this guidance addresses public health protection and the control of pathogenic microorganisms for non-potable water reuse. The primary pathways for disease transmission with water reuse are ingestion, skin contact, and inhalation of aerosols. Chemical contamination is much less important from an acute health perspective; however, it can affect the acceptability of the source water for certain reuse applications and hinder the disinfection process.

The primary factors that influence water substitution and reuse are water demand, water scarcity, and the protection of human health. Health problems have arisen primarily when contaminated raw water or inadequately treated wastewater has been used.

SOURCE WATER.

In the United States, the source water that is employed for reuse is primarily treated municipal wastewater. It is readily available in municipalities where the water shortage is sometimes acute and the opportunities for reuse are available. There is the presumption in state regulations and federal guidelines that the source water is treated wastewater

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In deployment situations, Soldiers have a choice of several source waters. Most likely, they will not have access to tertiary treated wastewater, and in some cases, they might not even have access to a steady stream of secondary treated wastewater. Other source waters need to be considered, such as local waters (surface, ground water, and host nation potable water), Army-generated gray water, and reverse osmosis water purification unit's (ROWPU) prefiltered water and brine. Table 1 provides a limited comparison of the physical and microbial quality of some of these waters.

TABLE 1. LIMITED COMPARISON OF SOURCE WATERS

Source	Reference	BOD_5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Total coliforms (#/100 mL)	Fecal coliforms (#/100 mL)	E. coli (#/100 mL)
Ground Water	Literature			<2	<1		0
Surface Water	Maryland samples*			.8-16	46-870		1-123
Treated Wastewater	Literature (secondary)	5-25	5-25	2-5	10,000-100,000		
	Literature (tertiary)	<5-20	2-8	.5-4	1,000-100,000		
Gray Water	Literature	90-290	45-330	22-200		10^4-10^6	
	Force Provider ^	149	162				
Raw Wastewater	Literature	110-400	100-350			10^7-10^{10}	

Notes:
BOD_5 - Biochemical Oxygen Demand; TSS - Total Suspended Solids
mg/L - milligrams/liter; NTU - Nephelometric Turbidity Units; #/100 mL - number of colony forming units per 100 mL
* - Local Maryland waters (Harford County) - range of 12 samples.
^ - Typical gray water characteristics, Force Provider Demonstration Project, November 1993

A. GROUND WATER. Ground water is usually the cleanest water source. Its chemical and biological composition makes it acceptable for almost all uses, including potable water. Ground water tends to have much less bacterial pollution than surface water because the soil and rocks through which ground water flows screen out most of the bacteria.

B. SURFACE WATER. Surface water (streams, rivers, and lakes) tends to be more contaminated than ground water. Municipalities and industries discharge their treated sewage into these water courses, while storm water deposits mud, leaves, decayed vegetation, and human and animal refuse. The end result is much more turbid water with varying levels of pollution and microbial contamination.

c. Filtered Water and ROWPU Brine. The ROWPU is the Army's workhorse for providing potable water in the field. The normal treatment scheme includes a prefilter, followed by the reverse osmosis unit, and then chlorination of the product water. The prefilter removes the larger particles in the raw water. The reverse osmosis unit has two discharges. One is the product water—the water that passes through the membrane filters. The other is the reject water or brine. In comparison to the raw source water, the brine will have lower suspended solids because of the prefilter and higher dissolved solids, alkalinity, metals, and chloride concentrations due to the rejection by the reverse osmosis membranes. Both the prefiltered water and the ROWPU brine are available for use as non-potable water.

d. Gray Water. Gray water is the designation for untreated household wastewater, which has not been contaminated by toilet waste. Based on the level of contamination, discharges from bathtubs, showers, bathroom sinks, and laundries are the preferred source water for gray water reuse. Black water refers to wastewater discharged from toilets and urinals. Most facilities in the United States have plumbing systems that collect gray and black water together for treatment; this is sanitary sewage. In deployment situations, the Army often collects gray water and black water separately. Self-contained showers and bathrooms (such as, Force Provider) are examples of separate wastewater systems. This segregation allows for separate collection, treatment, and possible reuse of the gray water.

Table 2. Source Waters, Contaminants, and Risks

	Possible Contaminants	Potential Risks
Shower, Sinks and Bath	· Fecal contamination and urine · Chemicals from soaps, shampoos, dyes, mouthwash, toothpaste and cleaning products · Hair, lint, body cells, oils, and dirt . Blood and other wound exudates · Trace amounts of pharmaceuticals	· Fecal contamination is the greatest gray water risk to human health. · Urine is generally sterile, unless a person suffers from a severe urinary tract infection. · Bathroom gray water is generally well-diluted, reducing the immediate effects of chemicals in soaps and shampoos.

TABLE 2. SOURCE WATERS, CONTAMINANTS, AND RISKS (CONTINUED)

	Possible Contaminants	Potential Risks
Laundry	· Laundry detergents: - contain ammonia, other forms of nitrogen, phosphorus, and boron - high sodium and salinity - may have high levels of alkalinity - may increase pH levels · Bleaches and disinfectants may be present in laundry wastewater	· Fecal contamination (and associated bacteria and viruses) may be present in wastewater from laundries washing soiled clothing. · Laundry rinse water carries dilute soaps and dirt. · Detergents, bleaches, and disinfectants are a significant risk to plants and soils, while some laundry contaminants (nutrients) can be beneficial.
Kitchen	· May be heavily contaminated with food particles, cooking oils, grease, detergents and caustic dishwashing powders	· Kitchen wastewater is difficult to reuse: - high concentration of contaminants; - fats are not readily broken down by soil organisms.
Treated Wastewater	· Pathogens and viruses · Chlorine residual	· Most contaminants should be removed during treatment of wastewater; however, some contaminants could remain: - bacteria and viruses endanger public health - excessive amounts of free chlorine can damage crops.
Surface Water	· Depends on surface water quality. · Possible contaminants: - suspended solids - organics - salinity - bacteria	· Bacteria and viruses endanger public health
Brine from ROWPU	· Salinity · Phosphates (if hexametaphosphate is used) · Dissolved solids · Metals	· Excessive salinity or dissolved solids can cause damage to crops.

<u>WATER QUALITY</u>.

To determine the quality of source waters requires the use of certain standard analytical methods. The U.S. Environmental Protection Agency (U.S. EPA) defines secondary treated wastewater with two analytical procedures: Biochemical Oxygen Demand (BOD_5) and Total Suspended Solids (TSS). Unfortunately, both of these methods, like many other laboratory procedures, are impractical for field use.

A. Turbidity. One tool that is available to Soldiers for measuring physical water quality is turbidity. Turbidity is defined as the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye. The higher the suspended solids, the murkier the water, and the higher the turbidity. Turbidity is generally measured in the field with a turbidimeter.

Why is turbidity an important parameter for determining water quality? There are two reasons. High-suspended solids and measured turbidity generally translate into higher concentrations of microorganisms in the source water. Viruses and bacteria tend to attach themselves to the solids. As a result, there is a greater risk of contacting disease-causing organisms when individuals are exposed to turbid waters. Reducing turbidity through filtration usually reduces the microbial population. In addition, suspended solids tend to interfere with the disinfection process, shielding the viruses or bacteria from deactivation. Thus, turbid waters require larger amounts of disinfectants to kill pathogens and provide less certainty regarding pathogen destruction.

Turbidity is particularly useful in comparing similar type waters. It allows the source waters to be ranked in an order of preference. A search of the literature produced the following relationships for treated wastewaters:

- *Secondary effluent: TSS (mg/L) = (2 to 2.4) x turbidity units*
- *Tertiary effluent: TSS (mg/L) = (1.3 to 1.6) x turbidity units*

Unfortunately, the relationship between suspended solids, turbidity, and microbial contamination is not as meaningful when comparing dissimilar source waters. Although turbidity is still an approximation for suspended solids, the source of these solids makes a difference in the comparison. For example, phytoplankton, storm water sediment, and urban runoff contribute much to the turbidity of open waters, while the suspended solids measured in treated wastewater effluent are the end result of biological oxidation and sedimentation of sewage. Thus, surface waters tend to show higher turbidity levels but lower microorganism concentrations, while treated wastewater tends to have lower turbidity and higher coliform counts.

B. Microbial Quality. Historically, coliform bacteria have been used to measure the microbial quality of water. Today, two of the more commonly used tests are total coliforms and *Escherichia coli* (*E. coli*). Total coliforms are a measure of closely related, mostly harmless bacteria that live in soil, water, and the intestines of warm blooded animals. It is a common indicator of possible pollution and is often used to determine the effectiveness of potable water disinfection. Fecal coliforms are indicator bacteria which occur naturally in the intestines and feces of warm blooded animals. *E. coli* are a member species of the fecal coliform group, and it has been listed by the U.S. EPA as a more accurate indicator of the harmful microorganisms that cause intestinal illness. In the field, both the total coliforms and *E. coli* analyses are performed with bacteriological test kits, such as IDEXX's Colilert and Quanti-Tray. This testing entails a 24-hour incubation period.

DISINFECTION.

Disinfection in the field is normally accomplished by adding a chlorine product, such as calcium hypochlorite (powder) or sodium hypochlorite (liquid bleach), in sufficient quantity to kill microbial pathogens. Ultraviolet light is not considered a good candidate for disinfection because of its lack of portability and its failure to produce a residual that can easily be measured.

The goal of disinfection is to produce a detectable chlorine residual (total) in the source water 30 minutes after the chlorine addition. Total chlorine residual is defined as the sum of free and combined chlorines present in the water after the chlorine demand has been satisfied. Chlorine demand is that amount of chlorine that is consumed by particles and microorganisms in the water. As a general rule, the higher the turbidity, the more chlorine will be needed to satisfy the chlorine demand and produce a residual. If the turbidity is too high, the solids in the source water will overwhelm the chlorine addition, and a chlorine residual will not be maintained. The DPD method[*] is normally used to measure chlorine residual in the field.

Chlorine is an effective disinfectant for most pathogenic microorganisms—provided there is actual contact between the two. Bacteria and viruses tend to hide inside particles of suspended and colloidal matter, thereby, hindering the disinfection process. Thus, even if a chlorine residual is measured, a viable microbial population in the source water could exist. In addition, the effectiveness of chlorine disinfection is dependent on a number of variables, such as mixing, contact time, source water pH and temperature, and the resiliency of some pathogenic organisms. When evaluating a source water for substitution or reuse, the effectiveness of the disinfection (as measured by the total chlorine residual) should be corroborated with bacteriological analysis.

[*] DPD method—A method of measuring the chlorine residual in water. The residual may be determined by either titrating or comparing a developed color with color standards. DPD stands for N,N-diethyl-p-phenylenediamine.

WATER SUBSTITUTION AND REUSE GUIDELINES.

Based on microbial quality, there are three classes of source water—

- Ground water
- Surface water
- Treated wastewater

A. GROUND WATER. Because of its extremely low turbidity and bacterial contamination, ground water can be used directly for all non-potable water applications. Disinfection should not be required. The lone exception is "ground water under the direct influence of surface water." This federal designation refers to those waters that demonstrate significant microorganism contamination and closely correlate with nearby surface water conditions. For this classification, ground water would be treated as a surface water.

B. SURFACE WATER. Surface waters receive a certain amount of pollution from wastewater discharges and storm water runoff; however, this contamination is diluted in the receiving waters. Filtered water is higher quality surface water because most of the larger particles of contamination have been removed. Also, the ROWPU brine is generally considered better quality than the source water because of the prefiltering; however, the brine will have significantly higher concentrations of dissolved solids.

In early public health studies on the Ohio River, it was shown that there was a detectable health effect when bathing water approached 2,300 coliforms per 100 mL. However, it wasn't until 1986 that the U.S. EPA published the current ambient water quality criteria (Table 3) for bacteria in recreational waters. Based on a number of studies, the U.S. EPA felt that *E. coli* and enterococci were the two best indicators of gastrointestinal illness caused by the incidental ingestion of sewage contaminated water. These criteria eventually became federally enforced water quality standards in 2004.

Table 3. U.S. EPA Criteria* for Bathing in Recreational Fresh Water (measured as bacterial densities (colony forming units) per 100 mL)

Indicator	Geometric Mean Density^	Single Sample Maximum Allowable Density			
		Designated Bathing Beach	Moderate Full Body Contact Recreational	Lightly Used Full Body Contact	Infrequently Used Full Body Contact
Enterococi	33	61	78	107	151
E. coli	126	235	298	409	575

Notes:
* Based on an acceptable gastrointestinal illness rate of 8 per 1,000 swimmers.
^ Calculated with a minimum of five samples collected over a 30-day period.

There is a wide variety in the quality of surface waters. In the United States, wastewater and storm water discharges are regulated to ensure that surface waters are in compliance with their designated use and associated water quality standards. Conversely, in deployment situations, similar controls are not in effect, and surface waters could be heavily polluted. Because of this uncertainty, surface waters require disinfection before they can be used for unrestricted non-potable water applications such as showering and the like. Whereas, for industrial or restricted (limited contact) applications, such as dust suppression, surface water, can be used directly.

Table 4. Summary of Surface Water Use for Non-Potable Applications

Application	Action
Showering / Unrestricted Use	Disinfect and use
Industrial / Restricted Use	Use directly

c. Treated Wastewater. Treated wastewater has significant bacterial contamination and, therefore, poses a substantial health risk. To avoid any adverse consequences from inadvertent contact or accidental or intentional misuse of reclaimed wastewater, the U.S. EPA recommends that some level of disinfection be provided for all water reuse applications. The level of disinfection correlates with the level of human exposure. Both federal authorities and state regulators have developed a number of water reuse classifications with specific water quality guidelines and standards for various reuse applications.

Two of the categories address water reuse with unrestricted public exposure. One is “unrestricted urban reuse,” which mostly covers the irrigation of public access areas such as playgrounds, parks, and residences. The second is “unrestricted recreational reuse,” and it was developed for those recreational activities where public exposure is likely and could entail whole body contact. Both of these reuse categories require tertiary-treated wastewater, a relatively low turbidity (average limit of ≤2 NTU and not-to-exceed limit of 5 NTU), disinfection, and a low bacterial count (no detectable fecal coliform organisms/100 mL). This combination of disinfection and treatment is capable of producing water for reuse that is essentially free of bacterial and viral pathogens.

Two other categories address reuse applications where there is limited public exposure. One is “restricted urban reuse,” which is mostly urban irrigation where public access can be controlled, while the other is “restricted recreational reuse,” which regulates water impoundments where recreation is restricted to fishing, boating, and other non-contact activities. Both of these categories assume little or no human contact with the reclaimed water and, thus, allow for a lower quality standard—secondary treated wastewater, disinfection, and fecal coliform concentrations ≤200 counts/100 mL (median value). The basis for this standard is that most bacterial pathogens and viruses will be destroyed or reduced to low or insignificant levels in the water; disinfection of secondary treated effluent to this coliform level is readily achievable at minimal cost; and the significant health-related benefits associated with disinfection to lower, but not pathogen-free levels, are not obvious.

Another water reuse category is “industrial.” It encompasses not only the heavy industrial uses (such as, cooling water, process water, and boiler feed water) but also the miscellaneous urban uses (such as, sanitary sewer flushing, toilet flushing, street cleaning, dust control, soil compaction, concrete making, decorative fountains, commercial laundries, commercial car washes, equipment washing, and fire-protection systems). For these latter applications (also identified as urban non irrigation applications), the water reuse requirements are generally prescribed by the regulating authority on an individual basis, with degree of exposure to workers and the public as the primary determinant. For example, with minimized worker contact, the U.S. EPA suggests the following reuse guidelines for construction type activities (dust control, soil compaction, washing aggregate, and making concrete): secondary treatment, disinfection (≥ 1 mg/L chlorine residual), and median fecal coliform concentrations ≤ 200 counts/100 mL (with no single value > 800 counts/100 mL). If workers should come into contact with the reclaimed water on a more routine basis, then the level of disinfection would need to be increased.

For the Soldier in the field, the state and federal guidelines on wastewater reuse translate into two broad categories: (1) unrestricted use and (2) restricted/industrial use. Treated wastewater with low turbidity, high level of disinfection, and low bacterial count would be an excellent candidate for water reuse that involves skin contact; whereas, lesser quality water with lower level of disinfection and higher bacterial count can be used when human contact is minimized or avoided. Table 5 summarizes these categories.

TABLE 5. NON-POTABLE WATER REUSE WITH TREATED WASTEWATERS

Category	Wastewater Treatment	Turbidity (NTU)		*E. coli* (#/100 mL)	
		Median value	Single sample max	Median value	Single sample max
Unrestricted	Tertiary	≤2	≤5	none	≤10
Restricted/ Industrial	Secondary	≤5	≤10	≤150	≤600

What about treated wastewater that has a measured turbidity "somewhat greater" than 10? In deployment situations, this is probably commonplace. Can it be used for water reuse? This is a judgment call. If the treated wastewater can be successfully disinfected, then proceed with water reuse using precautions such as personal protective equipment (for example, rubber gloves, face shields, and coveralls) for workers and strict avoidance measures for Soldiers and the public. Wastewaters with turbidities "significantly greater" than 10 are not good candidates for water reuse. With highly turbid waters, the cost of disinfection becomes prohibitive, and there is increased uncertainty about the health protection provided by disinfection. Alternative source waters should be investigated.

Gray water is wastewater, and therefore, it falls under the general wastewater guidelines for water reuse. Conventional wastewater methods (biological) can be used to treat gray water. However, gray water without kitchen waste is generally considered a weak wastewater and can be treated using alternative filtering systems. Because of the segregation of wastewater in Force Provider encampments, gray water should be more readily available for reuse than the traditional combined wastewaters.

MILITARY GUIDANCE.

The Army's preference in the field is to use potable water for all of its needs; unfortunately, sometimes there is not a sufficient quantity of potable water available. In such situations, Technical Medical Bulletin (TB MED) 577 permits the use of alternatives.

TABLE 6. ACCEPTABLE USES FOR NON-POTABLE WATER*

Water Quality	Acceptable Activities
Disinfected Fresh Water	Centralized hygiene such as field showers Decontamination of personnel Retrograde cargo washing Heat casualty body cooling Graves registration personnel sanitation Well development
Fresh Water	Vehicle coolant Aircraft washing Pest control Field laundry Concrete construction Well drilling
Brackish and Seawater	Vehicle washing Electrical grounding Fire fighting CBRNE decontamination of materials

Note:
* Identified in TB MED 577

As indicated above, disinfected fresh water can be used for personnel decontamination, heat-casualty body cooling, and field showers pending the approval of the appropriate military public health authority. In the recent update to Department of the Army Pamphlet (DA Pam) 40-11, ROWPU brine was also elevated to the status of potential source water for non potable water showers.

Gray water reuse serves two functions: (1) it provides source water for non potable water reuse, and (2) reduces the disposal of a significant volume of wastewater. In Iraq, treated gray water has been used for dust suppression and certain construction activities. A number of Department of Defense guidelines support this reuse—

- TB Med 593 indicates that gray water may be treated and disinfected prior to reuse for dust control and other non potable industrial uses. The treated effluent will meet secondary treatment standards (BOD_5 and TSS ≤ 30 mg/L) and will be adequately disinfected (a detectable chlorine residual 30 minutes after chlorine addition).

- Multi National Corps-Iraq (MNC-I) Standing Operating Procedure (SOP) 06-04 suggests that an alternative use for recycled and treated laundry gray water is dust suppression.

- The Air Force published a dust control fact sheet for treated gray water. They recommend the following standards: BOD_5 ≤10 mg/L, Turbidity ≤ 2 NTU or TSS

≤ 5 mg/L, total or fecal coliforms = none detected (median of last 7 samples), and chlorine residual ≥ 1 mg/L after minimum contact time of 60 minutes.

However, the updated DA Pam 40-11 restricts gray water reuse alternatives; it states that shower and laundry wastewaters can only be recycled back to the generating activities.

The Army has issued medical standards for gray water reuse in non-potable water showers where the source water is treated laundry and shower wastewater. Because the source water comes into direct contact with the bather and there is some likelihood of shower water ingestion, the recycled water quality criteria (Table 7) is based on the Army's potable water consumption standard of 5 liters/day. To meet these criteria, the gray water would require tertiary wastewater treatment and disinfection.

Table 7. Water Quality Criteria[a] for Recycled Gray Water

Properties	Parameter	Proposed Criteria
Physical	Color Odor pH TDS Turbidity Chlorine residual[b]	50 units 3 5-9 2000 mg/L 1 NTU 2-5 mg/L after 30 minutes
Chemical	Arsenic Cyanide Lindane	0.3 mg/L 6 mg/L 0.6 mg/L
Biological	BOD_5 Coliform	10 0

Notes:
[a] Design criteria – not necessarily measured in the field.
[b] Alternative method of disinfection is acceptable.

Opportunities For Water Substitution And Reuse.

Extensive efforts are underway to implement water reclamation and reuse in agriculture, industry, residential communities, and commerce. However, for the Soldier in the field, water substitution and reuse opportunities are mostly limited to personal hygiene (such as, showers, laundry) and low-grade industrial applications.

a. Recycled Shower Water. Shower and laundry gray water from containerized systems, such as Force Provider, can be individually collected, treated, and reused for shower water. Currently, the Army is testing a Shower Water Reuse System (SWRS) that produces potable water quality. The treatment train includes a prefilter, micro filters, reverse osmosis, and carbon filtration. The SWRS is designed to treat 12,000 gallons a day of shower/laundry wastewater with a 75 percent recovery.

B. RECYCLED KITCHEN WATER. Gray water from field kitchen sanitation operations can be recycled back to the kitchen as sink and wash water. The Army has developed a small, portable ultrafiltration device that is capable of reducing the amount of gray water discharged by almost 90 percent.

C. RECYCLED LAUNDRY WATER. The Army has deployed two laundry systems with water reuse capabilities—the Containerized Batch Laundry (CBL) and the Laundry Advanced System (LADS). The CBL consists of commercial equipment capable of washing and drying 200 pounds of clothing per hour. It can recycle 50 percent of the water used in the laundering process. In contrast, the LADS unit can treat 400 pounds of laundry per hour. Because it has a built-in distillation system that heats the dirty water and captures and cools the steam, it can recycle approximately 97 percent of the water used in the laundering process.

D. IRRIGATION. Agriculture is the largest global water use. Water reuse can help increase local food production in arid regions and developing countries suffering from water shortfalls. The preferred source water for irrigation is treated sanitary wastewater because it contains the nutrients (such as, nitrogen, phosphorus, and organic matter) for growing crops and reducing fertilizer requirements. Unlike the indigenous population, the deployed military is not involved in agricultural activities. An exception might be small parcels of cultivated land for recreational use, stabilization, or general appearance. For recreational areas and the like where there is potential for human contact, federal guidance recommends secondary treatment followed by filtration (tertiary) and disinfection when the source water is primarily sanitary wastewater. The application of this reuse water should be monitored, and individuals should be restricted from the cultivated areas during irrigation and when the ground is saturated.

E. DUST SUPPRESSION. Water substitution and reuse can be employed for dust suppression on roads and helicopter landing areas. The applied water can be used alone as a temporary dust suppressant, or in combination with synthetic polymers for more efficient and permanent effect. Most of the synthetic polymers are non toxic and non hazardous. Dust suppression equipment normally includes mobile holding tanks and sprayers. To minimize potential health effects, spraying operations should be conducted to avoid contact with personnel.

FIGURE 1. SPRAYING OPERATIONS FOR DUST SUPPRESSION

F. VEHICLE AND EQUIPMENT WASHING. Washing is a regular part of equipment maintenance. It enhances the condition of the equipment and deters surface corrosion and deterioration. Vehicle and equipment washing are prime candidates for water reuse. It can be accomplished in two fashions—manual washing with a flexible hose, or a closed-loop wash system. With manual washing, there is a higher probability for dermal contact during washing and rinsing operations. This should suggest the use of higher quality source waters and disinfection. Conversely, with closed-loop wash systems, the wash water is collected, treated, and stored onsite for reuse. Less wastewater is produced for disposal, and less makeup water is required. Because these latter systems are self-contained and the operations tend to be automatic, there is a much lower probability for liquid contact with the operators or public.

G. INDUSTRIAL USES. There are a number of industrial applications where water substitution and reuse can be employed. Some typical activities are cooling, construction (such as, concrete mixing, dampening for soil compaction, and aggregate washing), pesticide and herbicide mixing, and fire protection.

CAUTION/WARNING. In any water substitution and reuse application, cross-connections must be avoided with the potable water system. Any equipment used to distribute non-potable water should be marked as such and not used for potable water without a thorough cleaning and disinfection. Much like wastewater, consideration must be given to the proper disposal of gray water and other contaminated source waters if they are not collected for reuse. Where water is being substituted or wastewater is being reused, training needs to be provided in the science, mechanics, and hazards of the practice.

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Appendix A

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APPENDIX B

GLOSSARY

BRINE (FROM ROWPU)
The rejected water from the reverse osmosis filter.

CHLORINE RESIDUAL
The chlorine present in the water after the chlorine demand has been met.

COLIFORM BACTERIA

TOTAL COLIFORMS: a measure of closely related, mostly harmless bacteria that live in soil, water, and the intestines of warm blooded animals.
FECAL COLIFORMS: indicator bacteria which occur naturally in the intestines and feces of warm blooded animals.
E. COLI – a member species of the fecal coliform group.

DISINFECTION
The inactivation of pathogenic organisms.

EFFLUENT
Liquid that flows out of a process.

FILTRATION

MEMBRANE FILTRATION: filtration technique based on a physical barrier (a membrane) with specific pore sizes that traps contaminants larger than the pore size on the top surface of the membrane. Contaminants smaller than the specified pore size may pass through the membrane or may be captured within the membrane by some other mechanism.
MICROFILTRATION: typical pore size of 0.1 micron.
ULTRAFILTRATION: typical pore size of .01 micron.
REVERSE OSMOSIS: typical pore size of 0.0001 micron.

FORCE PROVIDER
A modular base camp, capable of supporting 550 Soldiers with showers, kitchens, laundry, latrines, recreational services, and climate-controlled billeting.

GRAY WATER
Untreated household wastewater that does not come into contact with toilet waste.

NUTRIENT
Substance such as nitrogen or phosphorus that is assimilated by a living organism for growth and development.

PATHOGENIC MICROORGANISM
Any disease-producing microorganism.

POTABLE WATER
Water that is safe for drinking.

RECLAIMED WATER
Wastewater effluent that has been adequately and reliably treated so that it is suitable for beneficial use.

SOLIDS

SETTLEABLE SOLIDS: particles of matter that are heavy enough to settle out of water under quiescent conditions.

SUSPENDED SOLIDS: small particles of matter that contribute to turbidity and resist separation by gravity.

TURBIDITY
The cloudiness of water caused by the presence of fine suspended matter.

WASTEWATER TREATMENT

SECONDARY TREATMENT: Wastewater treatment step that follows primary treatment. Involves the removal of biodegradable, dissolved and colloidal organic matter using high-rate engineered aerobic biological treatment processes. Examples of secondary treatment include activated sludge, trickling filters, aerated lagoons, and oxidation ditches.

TERTIARY TREATMENT: wastewater treatment beyond secondary treatment that includes removal of nutrients and a high percentage of suspended solids, resulting in a higher quality effluent.

WATER REUSE
The use of treated wastewater for a beneficial application.