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EXPERIMENTAL STUDY OF THE CONSTITUENTS OF SPACE WASH WATER

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FOREWORD

This report presents experimental data, obtained under controlled conditions, which quantify the various constituents of human origin that may be expected in space wash water. The experiments were conducted with a simulated crew of two male and two female subjects. The data show that the expected wash water contaminants originating from human secretions are substantially lower than theoretical projections have indicated. The data presented are immediately useful and may have considerable impact on the trade-off comparisons among various unit processes and systems that are currently under consideration by NASA for recycling space wash water.

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SECTION 1. INTRODUCTION AND SUMMARY

Previous NASA studies have shown that future manned space missions will require relatively large quantities of wash water for personal hygiene and laundry purposes. The preferred approach to providing a continuous supply of high quality wash water throughout a long mission is to recycle the used or "grey" wash water in its own loop, separate from the potable water loop, using a nonphase-change water reclamation system.

The purpose of this study is to quantify the major constituents in typical "grey" water from shower and laundry operations. This involves the determination of the amounts of various materials that are removed from individuals by a daily shower, and the amounts that are removed and absorbed by clothing and later appear in "grey" laundry water. These data are needed by the designers, research scientists and development engineers who are working on the various unit processes and wash water reclamation systems for space application.

In a previous study (see Reference 1) a theoretical projection was developed of the types and amounts of various constituents that might be found in space wash water. This projection was made by identifying the major organic and inorganic species contained in sweat, sebaceous excretion, urine, fecal matter, saliva, tears and other body secretions that could reasonably be expected to appear in shower and laundry water. It was recognized that accurate predictions using this theoretical approach

were very difficult due to the large variations among people with respect to the composition and amount of body secretions produced. The variations are large from time to time, even for the same person. Some factors determining secretions are diet, environment, heredity, and physical, mental and emotional conditions. The ranges reported in this study (see Tables 1 and 2) show the wide differences possible between a 93.2 Kg (205 lb) male exercising during warm weather and a 57.7 Kg (127 lb) female in a cooler environment.

The current study was undertaken because of the lack of published data that could be used to verify or intelligently modify the theoretical model constructed in the previous study. The new experimental data obtained in this study are compared to the old theoretical model in Table 1.

It is clearly seen that the old model was very conservative, the experimental data being approximately 25 per cent of the theoretical values. Even if the new data were for an all-male crew, the values would still be only one third of the old model.

There was another unexpected finding, which is shown in Table 2. The females produced only about 55 per cent as much material as the males, as judged by shower data. (When the data are adjusted for differences in body weight, the females still produce only 75 per cent as much material as the males). Presumably these percentages would hold true for clothes also. Unfortunately that supposition cannot be verified because all of the clothes were laundered together. It would be an interest-

ing point to investigate in a future test.

Tables 1 and 2 show that approximately 45 per cent of the dissolved solids removed from the subjects are unidentified materials, probably organic in nature judging by the measured Total Organic Carbon levels. It was not within the scope of this study to identify these materials or to chemically characterize the suspended solids. It is felt, however, that such information would be beneficial and is needed to intelligently design a wash water reclamation system.

The concentrative properties of wash water (i.e. the physical properties of wash water concentrates) are also needed in order to determine the impact of feeding wash water concentrates to urine reclamation and waste management systems in which all of the water is ultimately extracted for reuse. The properties are needed over the full range of expected solute concentration, which is from raw wash water to complete dryness. The needed properties include: vapor pressure, heat of vaporization, heat of solution, osmotic pressure, specific heat, viscosity, surface tension, refractive index, specific conductivity and pH.

TABLE 1. COMPARISON BETWEEN ESTIMATED AND MEASURED CREW INPUTS TO WASH (SHOWER AND LAUNDRY) WATER (CLEANSING AGENTS EXCLUDED)

	Estimated (See Ref.1) mg/man-day	Measured This report 10-Day Avg. mg/man-day	Range* This report 1-Day Values mg/man-day
INSOLUBLE MATERIALS			
Desquamated Epithelium	3000		
Epithelium Cells and Protein	2460		
Hair	300		
Microorganisms	160		
TOTAL SUSPENDED SOLIDS	5920	851	322 - 1630
SOLUBLE MATERIALS			
Chloride	1564	197	15.4 - 503
Lactic Acid	1544	213	27.0 - 671
Sodium	1054	205	74.5 - 321
Urea (assumes all TKN is urea)	906	510	132 - 1146
Potassium	464	134	56 - 296
Calcium	13	8.3	0.16 - 25.5
Ammonia	0.3	8.6	0 - 46.1
Magnesium	0.2	6.5	0.25 - 15.7
Iron	0	0.27	0 - 1.47
Copper	0	0.426	0.09 - 1.34
Other	455	1032	238 - 1810
TOTAL DISSOLVED SOLIDS	6000	2315	543 - 4837
TOTAL SOLIDS	11,920	3166	865 - 6467

*Indicates potential differences between 93.2 Kg (205 lb) Male and 57.7 Kg (127 lb) Female

TABLE 2. COMPARISON BETWEEN MALE AND FEMALE INPUTS TO SHOWER WATER
(CLEANSING AGENTS EXCLUDED)

	MALE (10-Day Avg) mg/man-day	FEMALE (10-Day Avg) mg/man-day	MALE-FEMALE RANGE* (5-Day Avg.) mg/man-day	MALE-FEMALE RANGE* (1-Day Values) mg/man-day
INSOLUBLE MATERIALS				
TOTAL SUSPENDED SOLIDS	906	402	254 - 954	149 - 1393
SOLUBLE MATERIALS				
Chloride	144	49	16 - 287	14 - 287
Lactic Acid	88	35	13 - 171	7.4 - 302
Sodium	144	103	98 - 131	4.2 - 177
Urea (assumes all TKN is urea)	333	182	90 - 461	19 - 658
Potassium	96	45	21 - 114	16 - 166
Calcium	4.4	2.4	0.9 - 7.5	0.16 - 14.7
Ammonia	2.8	0.8	0 - 7.3	0 - 18.6
Magnesium	1.1	0.9	0.7 - 1.5	0.25 - 2.6
Iron	0.27	0	0 - 0.6	0 - 0.93
Copper	0.26	0.18	0.11 - 0.30	0.09 - 0.45
Other	578	367	406 - 564	327 - 848
TOTAL DISSOLVED SOLIDS	1362	785	646 - 1745	388 - 2475
TOTAL SOLIDS	2268	1188	900 - 2699	537 - 3868

*Indicates potential differences between 93.2 Kg (205 lb) Male and 57.7 Kg (127 lb) Female

SECTION 2. TECHNICAL APPROACH

The primary objective of this study was to obtain experimental data to check the previously developed theoretical model for space wash water and to modify the model as the data might indicate.

To obtain realistic data, wash water must be generated in a way that approximates the real thing as closely as possible. Ideally, one would like actual wash water from a space mission. The next best thing would be wash water from a manned chamber test having a simulated space environment with the proper atmosphere, diet, work/rest/exercise regimen, and stress situation. Since wash water was not available from a space mission or a manned chamber run, it had to be generated on site. This was done by using four test subjects who exercised and showered under controlled laboratory conditions. The subjects wore long sleeved undergarments on a 24-hour a day basis to collect most of their body sweat and sebum.

In order to obtain realistic data for future missions, two of the subjects were male and two were female. All four subjects participated in two separate 5-Day tests. Each subject's shower water was analyzed separately on a daily basis. Two sets of undergarments and socks were provided each subject. These were worn on alternate days. The soiled undergarments were laundered together once a day. Clean undergarments, laundered the previous day, were donned after the daily shower. Towels

were washed at the end of each 5-Day test period.

All clothing was preconditioned prior to the two 5-Day test periods by several washings in tap water followed by several more washings in distilled water. The shower and washing machine were also thoroughly rinsed with distilled water prior to the test runs, and baseline data were obtained before and after the manned tests. Distilled water was used throughout the test program except for the initial conditioning of the clothing.

The shower water from each subject and the laundry water were tested for the major soluble materials projected in the previous theoretical study (see Reference 1). In addition, the levels of two metals (iron and copper), which were present in the collection system, were measured. Determinations were also made for specific conductivity, total orgainc carbon, ammonia, total Kjeldahl nitrogen, foaming and total aerobic microorganisms. To obtain data on the particle size distribution of the insoluble material, all water was passed through a series of graded filters and subjected to gravimetric analysis. The analytical procedures were performed according to the methods listed in Table 3. In general, the methods used were those specified in Standard Methods, 13th Edition (see Reference 2) except when modified procedures were necessitated by interferences.

TABLE 3. CHEMICAL AND PHYSICAL ANALYSIS TECHNIQUES

PARAMETER	METHOD
Suspended Solids	Millipore Technical Brochure ADM 30
pH	Electrometric, SM 144
Specific Conductivity	Wheatstone Bridge, SM 154
Color	Colorimetric, SM 118
Turbidity	Nephelometric, SM 163
Total Dissolved Solids	Gravimetric, SM 224E
Ammonia	Wet Chemical, EPA p. 134
Total Kjeldahl Nitrogen	Wet Chemical, SM 135
Chloride	Wet Chemical, SM 112A, SIGMA Tech Bulletin #830
Lactic Acid	SIGMA Tech Bulletin #826-UV
Sodium	Atomic Absorbtion Spectroscopy, SM 129A
Urea	Sigma Tech Bulletin #640
Potassium	Atomic Absorbtion Spectroscopy, SM 129A
Calcium	Atomic Absorbtion Spectroscopy, SM 129A
Magnesium	Atomic Absorbtion Spectroscopy, SM 129A
Iron	Atomic Absorbtion Spectroscopy, SM 129A
Copper	Atomic Absorbtion Spectroscopy, SM 129A
Total Organic Carbon	Infrared Combustion, SM138A

SM = Standard Methods, 13th Edition.
EPA = Environmental Protection Agency Methods, 1971
SIGMA = SIGMA Chemical Co., St. Louis, Missouri

SECTION 3. APPARATUS

The special equipment used to generate and collect wash water is shown schematically in Figure 1 and listed below.

ITEM	DESCRIPTION
1	Shower stall with gravity drain to collection bottle
2	Squeegee for removal of water from shower walls and floor
3	Shower stand
4	Steps for entering and leaving shower
5	Hand held adjustable shower head
6,7	One gallon polyethelene bottle
8	Portable compressed air tank with regulator
9	Glass lined water heater
10	Bottled distilled water
11	Soap container
12	Soap dispenser, 4 ml syringe
13	Portable 5 lb. capacity clothes washer and spin dryer
14,15	Polyethelene pail, 5 gallon, calibrated
16	Clothes dryer
17	Freezer
18	Undergarments (8 sets) and towels (4)

ITEM 18. UNDERGARMENTS - BREAKDOWN

TOPS, LONG SLEEVES					**WEIGHT, GRAMS**
2	Hanes	M	38-40	25% Polyester - 75% Cotton	239 each
2	Hanes	M	38-40	50% Polyester - 50% Cotton	260 each
2	Hanes	L	42-44	50% Polyester - 50% Cotton	279 each
1	Hanes	XL	46-48	50% Polyester - 50% Cotton	338 each
1	West	XL	46	50% Polyester - 50% Cotton	192 each
BOTTOMS, LONG					
4	Hanes	34-M-36		25% Polyester - 75% Cotton	230 each
2	Hanes	38-L-40		25% Polyester - 75% Cotton	254 each
2	HealthKnit	XXL	46-48	50% Polyester - 50% Cotton	260 each
SOCKS					
8 pair, Cotton					49 to 76 per pair
TOWELS					
4	Sears	Cotton			412 each

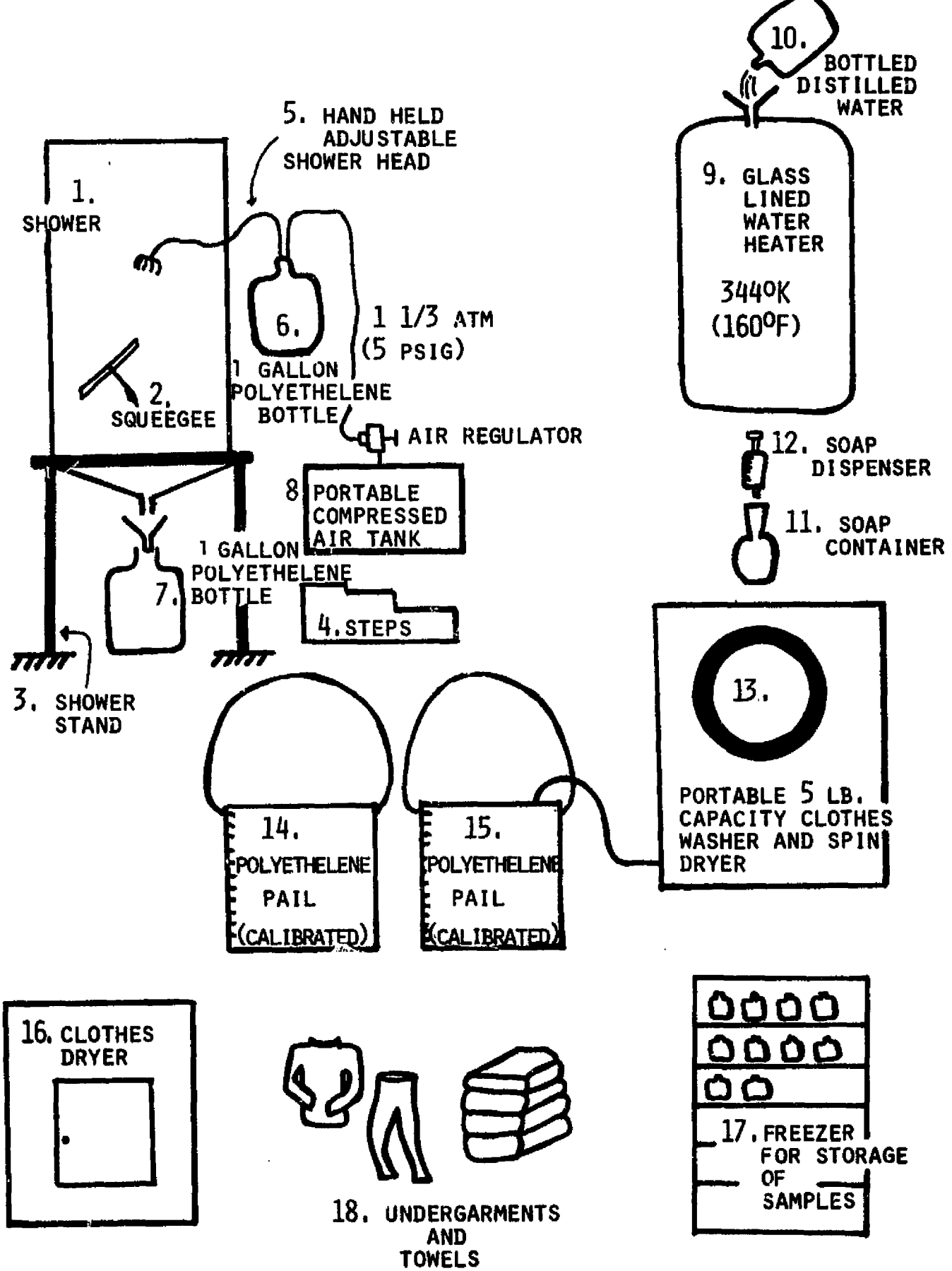

FIGURE 1. WASH WATER COLLECTION SYSTEM SCHEMATIC

SECTION 4. PROCEDURE

4.1 GENERATION OF WASH WATER

Wash water was generated by four subjects, 2 male and 2 female, with the equipment shown in Figure 1. The principal goal was to collect as much of the skin secretions produced by the subjects as possible. Attempts were made to minimize outside contamination by cautioning the subjects to refrain from all activities during the test period that might uncharacteristically contaminate the wash water. Because the subjects wore long underwear and socks around the clock, the only skin secretions not collected were those lost from the hands and face as a result of daily nonshower hygienic requirements. All shower water collected was analyzed on an individual basis. The laundry water was analyzed each day for the combined clothes of all four subjects. The time sensitive parameters (particle size and distribution, pH, specific conductivity, color, turbidity, foaming, total dissolved solids, ammonia and total Kjeldahl nitrogen) were analyzed on a real time basis. Aliquots of water were frozen for later analysis of chloride, urea, lactic acid, sodium, potassium, calcium, iron, copper and total organic carbon. The major test parameters and procedures are summarized in the following paragraphs.

A. Test Subjects

Four test subjects, 2 male and 2 female, participated in a regimen to generate wash water.

B. Clothing

Each subject wore a set of long, light underwear and socks to collect most of the body sweat and sebum. Two sets of clothing were issued to each subject. After the daily shower the used set was laundered and the clean set was worn for the next 24-hour period.

C. Test Duration

The underwear and socks were worn around the clock during two 5-day test periods. Each test commenced at 10 pm Sunday evening and ended with the last shower on Friday. A home shower was taken before the underwear was initially donned. Subjects did not shower at home for the duration of the test. The underwear was worn as the exercise outfit during the exercise period and was used to wipe off and collect all sweat generated during the exercise period before the shower was taken.

D. Exercise Regimen

The exercise regimen consisted of 1.6 Km (1 mi) of jogging. After the exercise period, body sweat was wiped off with the underwear before showering. Dirty underwear and socks were collected for laundering.

E. Shower

The shower water was bottled distilled water. It was taken from the water heater at 344^{0} K (160^{0}F) and diluted with a freshly opened bottle at room temperature to achieve a comfortable shower temperature while still maintaining essentially zero microorganisms in the shower supply. A nominal one gallon (3.79 liters) of water

was supplied for each shower and was entirely used. The water was dispensed at approximately 1 1/3 atm (5 psig) through a hand held adjustable shower head. The shower regimen was as follows:

1. Wet-down (Hair washing was optional)
2. Soap-up. In the first test series any amount of soap up to 4 ml (active ingredients = 0.612 g/ml) was used as desired. In the second series the soap was diluted to approximately half of the concentration value used in the first series in order to lower its viscosity and achieve improved dispensing characteristics. In the second series exactly 4 ml (active ingredients = 0.306 g/ml) of this diluted solution was used for each shower.
3. Rinse-off. The subjects used all of the remaining water in the 1 gallon supply to rinse off. This was generally somewhat more water than actually necessary for rinsing. At the end of the shower the subjects rubbed off as much water from themselves as they could with their hands and then used the squeegee to remove water from the sides and bottom of the shower stall into the drain.
4. Towel-down. The subjects dried themselves with the towels provided (each had his own towel) and then dressed in freshly laundered underwear and socks.

F. Shower Cleansing Agent

The cleansing agent was Sodium Dodecylbenzene Sulfonate

($C_{12}H_{25}$-C_6H_4-SO_3Na), molecular weight = 348. In the first test series an aqueous solution containing 60% active ingredients was used. In the second series the solution was diluted to 30% active ingredients.

G. Laundry

Underwear and socks were laundered after the daily exercise period so that a fresh change of clothing would be available to the test subjects the following day. The clothing of all four subjects was washed in one batch, and water from the wash and rinse cycles was pooled. Towels were washed at the end of the test week, also in one batch. New clothing and towels were laundered prior to the beginning of the test to stabilize them chemically. They were soaked in tap water for 24 hours followed by two wash/rinse cycles in distilled water. A measured amount of 344°K (160°F) laundry water was drawn from the water heater and transfered to the washer in five gallon plastic pails. The used water was collected in the same pails and measured. Each load of wash was subjected to one wash and one rinse cycle from which all water was pooled.

H. Laundry Cleansing Agent

The cleansing agent used for the laundry was also Sodium Dodecylbenzene Sulfonate ($C_{12}H_{25}$-C_6H_4-SO_3Na), molecular weight = 348. 2.48 grams of active ingredients were used for each washer load of clothes or towels in both series 1 and series 2 tests.

4.2 ANALYTICAL PROCEDURES

Standard analytical procedures as listed in Table 3 were used for the determinations. All procedures were satisfactory

except for the SIGMA tech method for urea and the Standard Method for chlorides.

The urea nitrogen values determined by this method were consistent with themselves, but high as compared to Total Kjeldahl Nitrogen values for both straight and spiked samples. Therefore, no urea data are presented in this report.

The chlorides in the first series of tests were found to be very inconsistent when measured by Standard Method's argentometric titration. The SIGMA method using the mercuric nitrate titration was used on those samples which had enough material remaining, and it is these data that are reported. All data in Series 2 were obtained using the SIGMA method.

SECTION 5. RESULTS

The results are divided into two parts. The first part contains concentration data that were measured directly. The second part contains total input figures that were calculated from the concentration data presented in the first part.

5.1 CONCENTRATION DATA

Concentration data for shower and laundry water were determined by direct measurement. Baseline data were also obtained so that the input from people could be calculated. The data are presented in tabular form in the following sequence:

- Shower Water, Series 1
  - Subject J
  - Subject D
  - Subject S
  - Subject B
  - Series 1 Averages
- Shower Water, Series 2
  - Subject J
  - Subject D
  - Subject S
  - Subject B
  - Series 2 Averages
- Shower Water, Series 1 and 2
- Shower Water, Baseline
- Soap Data
- Clothes Water Series 1
- Towel Water Series 1
- Clothes Water Series 2
- Towel Water Series 2

Clothes and Towel Water, Series 1 and 2 Averages
Clothes Baselines
Towel Baselines
Clothes Water Net Input From People Series 1 and 2
Towel Water Net Input From People Series 1 and 2

5.2 SUBJECT INPUT DATA

The input amount of each constituent on a per diem basis is presented in the following tables. The results were calculated from the concentration data in Section 5.1. The inputs resulting from the soap used and from the dissolution of clothing and other materials in the system were determined from baseline tests and are subtracted from the total inputs to obtain only those inputs that derived from the test subjects. The tables are presented in the following sequence:

Shower Baseline
Soap Baseline
Shower Water, Series 1
- Subject J
- Subject D
- Subject S
- Subject B
- Averages

Shower Water, Series 2
- Subject J
- Subject D
- Subject S
- Subject B
- Averages

Shower Water, Series 1 and 2
- Male Averages
- Female Averages
- Male and Female Averages

Total Input, Series 1 and 2 Averages
Clothes Water, Series 1 and 2
Towel Water, Series 1 and 2
Total Input From Subjects, Series 1
Total Input From Subjects, Series 2
Total Input From Subjects, Series 1 and 2 Averages

TABLE 4. CONCENTRATION DATA - SHOWER WATER: SERIES 1, SUBJECT J

Height: 1.73 m; Weight: 73.6 Kg; Sex: M

PARAMETER, UNITS*	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.60	3.60	3.58	3.65	3.53	3.59
SOAP USED, ml	2.0	2.0	2.0	2.0	2.0	2.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.22	1.22	1.22	1.22	1.22	1.22
pH	5.65	5.0	5.3	5.4	5.7	5.4
SPECIFIC CONDUCTIVITY μ mho/cm	230	364	291	235	251	274
COLOR, COLOR UNITS	90	45	75	65	LE	69
TURBIDITY, TURBIDITY UNITS	168	450	420	410	458	381
FOAMING, ml	LE	120	125	120	140	126
TOTAL KJELDAHL NITROGEN (TKN)	58.1	91.1	60.1	63.0	55.0	65.5
AMMONIA (NH_3)	6.01	5.71	1.00	.36	1.14	2.85
TOTAL ORGANIC CARBON (TOC)	268	343	151	317	363	288
TOTAL DISSOLVED SOLIDS (TDS)	688	666	775	726	930	757
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	8.6	11.9	8.75	7.6	LE	9.2
CHLORIDE (Cl^-)		36.7				36.7
SODIUM (Na)	51.9	61.9	59.0	52.5	50.6	55.2
POTASSIUM (K)	20.2	47.6	43.3	34.9	19.7	33.1
CALCIUM (Ca)	1.31	.73	.70	.82	.72	.86
MAGNESIUM (Mg)	1.14	.82	.68	.76	.73	.83
IRON (Fe)	.26	.33	.31	.42		.33
COPPER (Cu)	.069	.105	.069	-	-	.081
PARTICULATE MATTER:						
>30 μ	141	147	133	157	250	166
14 μ to 30 μ	51	42	41	52	40	45
5 μ to 14 μ	44	48	LE	46	57	49
1 μ to 5 μ	0	0	6.1	1.1	0	3.5
0.45 μ to 1 μ	9.4	9.2	LE	8.8	7.6	8.8
TOTAL PARTICLES	245	246	-	265	355	278
TOTAL AEROBIC PLATE COUNT 24-HOUR #/ml	14	25	86	100	280	101

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 5. CONCENTRATION DATA - SHOWER WATER: SERIES 1, SUBJECT D

Height: 1.83 m; Weight: 93.2 Kg; Sex: M

PARAMETER, UNITS*	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.46	3.47	3.45	3.48	3.44	3.46
SOAP USED, ml	1.0	2.0	2.0	2.2	3.2	2.1
SOAP USED, grams (ACTIVE INGREDIENTS)	0.61	1.22	1.22	1.35	1.96	1.29
pH	5.94	5.2	5.5	5.7	5.7	5.6
SPECIFIC CONDUCTIVITY μ mho/cm	305	423	348	340	370	357
COLOR, COLOR UNITS	35	75	65	45	LE	55
TURBIDITY, TURBIDITY UNITS	420	480	320	350	370	388
FOAMING, ml	LE	120	130	150	185	146
TOTAL KJELDAHL NITROGEN (TKN)	54.9	70.9	35.9	52.9	52.9	40.9
AMMONIA (NH_3)	2.73	4.13	1.15	.12	1.41	1.91
TOTAL ORGANIC CARBON (TOC)	293	363	373	431	412	374
TOTAL DISSOLVED SOLIDS (TDS)	LE	LE	770	880	1142	931
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	8.4	11.8	10.4	11.5	8.7	10.2
CHLORIDE (Cl^-)			83.2			83.2
SODIUM (Na)	55.7	81.5	68.3	72.1	63.2	68.2
POTASSIUM (K)	15.5	48.8	31.9	31.9	18.4	29.3
CALCIUM (Ca)	.48	.63	.51	.51	.50	.53
MAGNESIUM (Mg)	.51	.61	.66	.86	.67	.66
IRON (Fe)			.28	.20	.25	.24
COPPER (Cu)			.058	.055	.069	.061
PARTICULATE MATTER:						
>30 μ	134	224	126	164	279	185
14 μ to 30 μ	18	54	LE	LE	13	28
5 μ to 14 μ	6	58	25	23	24	27
1 μ to 5 μ	2.6	5.8		2.0	2.6	3.3
0.45 μ to 1 μ	9.2	11.2	LE	6.0	6.1	8.1
TOTAL PARTICLES	170	353	-	-	325	251
TOTAL AEROBIC PLATE COUNT 24-HOUR #/ml	8	1400	86	370	570	487

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 6. CONCENTRATION DATA - SHOWER WATER: SERIES 1, SUBJECT S

Height: 1.55 m; Weight: 57.7 Kg; Sex: F

PARAMETER, UNITS*	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.65	3.69	3.64	3.68	3.51	3.75
SOAP USED, ml	3.0	2.8	2.0	2.0	1.2	2.2
SOAP USED, grams (ACTIVE INGREDIENTS)	1.84	1.71	1.22	1.22	.73	1.35
pH	6.19	6.3	6.2	6.1	6.0	6.2
SPECIFIC CONDUCTIVITY μ mho/cm	210	215	138	196	84	168
COLOR, COLOR UNITS	35	15	25	25	LE	25
TURBIDITY, TURBIDITY UNITS	82	88	160	40	45	83
FOAMING, ml	LE	175	133	170	135	153
TOTAL KJELDAHL NITROGEN (TKN)	31.2	33.9	22.0	LE	25.9	28.3
AMMONIA (NH_3)	1.70	.85	LE	1.21	1.11	1.22
TOTAL ORGANIC CARBON (TOC)	366	322	317	265	304	315
TOTAL DISSOLVED SOLIDS (TDS)	842	792	309	531	671	629
LACTIC ACID (CH_3·CHOH·CO_2H)	3.6	4.1	4.9	5.7	2.6	4.2
CHLORIDE (Cl^-)	18.4		26.9			22.7
SODIUM (Na)	59.3	67.3	59.6	62.3	30.4	55.8
POTASSIUM (K)	9.5	11.2	15.6	17.3	5.0	11.7
CALCIUM (Ca)	.51	.62	.68	.26	.60	.53
MAGNESIUM (Mg)	.60	.51	.73	.66	.57	.61
IRON (Fe)	.17		.17	.09	.14	.14
COPPER (Cu)	.053		.103	.040	.045	.060
PARTICULATE MATTER:						
>30 μ	307	75	LE	67	148	149
14 μ to 30 μ	15.9	9.2	3.6	7.9	25.9	12.5
5 μ to 14 μ	7.9	5.1	10.4	10.0	44.4	15.6
1 μ to 5 μ			1.4	.8	0	.7
0.45 μ to 1 μ	4.9	LE	3.0	6.5	3.4	3.6
TOTAL PARTICLES				92	222	181
TOTAL AEROBIC PLATE COUNT 24-HOUR #/ml	3	29	420	80	120	130

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 7. CONCENTRATION DATA - SHOWER WATER: SERIES 1, SUBJECT B

Height: 1.70 m; Weight: 59.1 Kg; Sex: F

PARAMETER, UNITS*	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.68	3.70	3.68	3.69	3.67	3.68
SOAP USED, ml	2.4	1.0	2.2	2.2	4.0	2.36
SOAP USED, grams (ACTIVE INGREDIENTS)	1.47	.61	1.35	1.35	2.45	1.44
pH	5.35	5.4	5.1	5.3	5.4	5.3
SPECIFIC CONDUCTIVITY μ mho/cm	245	210	212	173	225	213
COLOR, COLOR UNITS	25	15	25	15	LE	20
TURBIDITY, TURBIDITY UNITS	48	64	150	40	110	82
FOAMING, ml	LE	165	155	170	240	183
TOTAL KJELDAHL NITROGEN (TKN)	42.9	34.1	41.0	LE	31.9	37.5
AMMONIA (NH_3)	.81	1.70	LE	.73	1.45	1.17
TOTAL ORGANIC CARBON (TOC)	256	275	255	255	402	289
TOTAL DISSOLVED SOLIDS (TDS)	754	674	298	594	1040	672
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	8.4	7.6	8.4	6.0	5.7	7.0
CHLORIDE (Cl^-)	15.8	17.6	20.1	26.3		20.0
SODIUM (Na)	56.7	50.6	58.7	74.1	63.6	60.7
POTASSIUM (K)	19.9	21.0	22.7	13.1	16.7	18.7
CALCIUM (Ca)	.39	.40	.56	.31	.82	.50
MAGNESIUM (Mg)	.65	.52	.73	.49	.89	.66
IRON (Fe)	.079	.089	.147	.058	.208	.116
COPPER (Cu)	.037	.040	.084	.053	.090	.061
PARTICULATE MATTER:						
>30 μ	356	10	24.2	43.9	159	119
14 μ to 30 μ	10.3	4.3	10.1	LE	9.5	8.6
5 μ to 14 μ	6.0	3.0	7.1	4.6	4.1	5.0
1 μ to 5 μ	.8	0				.4
0.45 μ to 1 μ	3.0	3.8	.8	1.9	1.9	2.3
TOTAL PARTICLES	376	21				135
TOTAL AEROBIC PLATE COUNT 24-HOUR #/ml	4	1	1	4	3	2.6

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 8. CONCENTRATION DATA - SHOWER WATER: SERIES 1, AVERAGES

PARAMETER, UNITS*	MALE	FEMALE	MALE AND FEMALE
WATER COLLECTED, LITERS	3.53	3.72	3.63
SOAP USED, ml	2.05	2.28	2.17
SOAP USED, grams (ACTIVE INGREDIENTS)	1.25	1.40	1.33
pH	5.5	5.8	5.6
SPECIFIC CONDUCTIVITY μ mho/cm	316	191	254
COLOR, COLOR UNITS	62	24	43
TURBIDITY, TURBIDITY UNITS	385	83	234
FOAMING, ml	136	168	152
TOTAL KJELDAHL NITROGEN (TKN)	53.2	32.9	43.1
AMMONIA (NH_3)	2.38	1.20	1.79
TOTAL ORGANIC CARBON (TOC)	331	218	275
TOTAL DISSOLVED SOLIDS (TDS)	844	651	748
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	9.7	5.6	7.7
CHLORIDE (Cl^-)	60.0	21.4	40.7
SODIUM (Na)	61.7	58.3	60.0
POTASSIUM (K)	31.2	15.2	23.2
CALCIUM (Ca)	.70	.52	.61
MAGNESIUM (Mg)	.75	.64	.70
IRON (Fe)	.29	.13	.21
COPPER(Cu)	.071	.061	.066
PARTICULATE MATTER: >30 μ	176	134	155
14 μ to 30 μ	37	10.6	23.8
5 μ to 14 μ	38	10.3	24.2
1 μ to 5 μ	3.4	.6	2.0
0.45 μ to 1 μ	8.5	3.0	5.8
TOTAL PARTICLES	265	158	212
TOTAL AEROBIC PLATE COUNT 24 - HOUR #/ml	294	66	180

*Units in mg/l except as noted

TABLE 9. CONCENTRATION DATA - SHOWER WATER: SERIES 2, SUBJECT J
Height: 1.73 m; Weight: 73.6 Kg; Sex: M

PARAMETER, UNITS *	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.59	3.62	3.60	3.57	3.57	3.59
SOAP USED, ml	4.0	4.0	4.0	4.0	4.0	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.22	1.22	1.22	1.22	1.22	1.22
pH	6.57	6.43	6.36	6.20	5.96	6.30
SPECIFIC CONDUCTIVITY μ mho/cm	218	220	240	226	245	230
COLOR, COLOR UNITS	55	55	45	35	45	47
TURBIDITY, TURBIDITY UNITS	460	580	510	375	450	475
FOAMING, ml	110	118	118	115	120	116
TOTAL KJELDAHL NITROGEN (TKN)	46.2	41.4	36.9	39.5	32.5	39.3
AMMONIA (NH_3)	.33	.05	1.32	.28	0	.40
TOTAL ORGANIC CARBON (TOC)	285	265	290	290	255	277
TOTAL DISSOLVED SOLIDS (TDS)	797	547	772	490	655	652
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	25	22	43	35	42	33.4
CHLORIDE (Cl^-)	20.9	19.1	26.9	24.9	31.1	24.6
SODIUM (Na)	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
POTASSIUM (K)	29.6	24.2	16.1	23.0	24.3	23.4
CALCIUM (Ca)	2.11	4.70	1.49	1.47	1.37	2.23
MAGNESIUM (Mg)	.95	.80	.61	.47	.72	.71
IRON (Fe)	.24	L.E.	.17	.20	.14	.19
COPPER (Cu)	.08	L.E.	.09	.08	.10	.088
PARTICULATE MATTER:						
>30 μ	180	185	166	143	145	164
8 μ to 30 μ	106	80	89	95	77	89
3 μ to 8 μ	1.7	1.9	2.2	1.7	.3	1.6
1.2 μ to 3 μ	.2	.2	.6	.2	.2	.3
0.45 μ to 1.2 μ	3.6	1.7	1.7	2.8	2.5	2.5
TOTAL PARTICLES	292	269	260	243	225	258
TOTAL AEROBIC PLATE COUNT 48-HOUR #/ml	2,300	9,500	14,000	15,000	2,460	8,652

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 10. CONCENTRATION DATA - SHOWER WATER: SERIES 2, SUBJECT D
Height: 1,83 m; Weight: 93.2 Kg; Sex: M

PARAMETER, UNITS *	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.62	3.60	3.60	3.54	3.56	3.58
SOAP USED, ml	4.0	4.0	4.0	4.0	4.0	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.22	1.22	1.22	1.22	1.22	1.22
pH	5.89	6.14	5.81	5.50	5.20	5.71
SPECIFIC CONDUCTIVITY μ mho/cm	355	248	263	247	239	270
COLOR, COLOR UNITS	70	45	45	35	35	46
TURBIDITY, TURBIDITY UNITS	510	380	400	250	330	374
FOAMING, ml	102	130	145	130	120	125
TOTAL KJELDAHL NITROGEN (TKN)	70.4	50.8	47.2	49.1	38.2	51.1
AMMONIA (NH_3)	0	.07	.52	0	0	.12
TOTAL ORGANIC CARBON (TOC)	300	270	260	260	295	277
TOTAL DISSOLVED SOLIDS (TDS)	1055	536	861	754	787	799
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	L.E.	34	34	85	41	48.5
CHLORIDE (Cl^-)	25.1	23.9	21.9	14.1	12.9	19.6
SODIUM (Na)	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
POTASSIUM (K)	28.6	22.4	25.1	27.3	32.8	27.2
CALCIUM (Ca)	4.35	1.69	1.49	2.23	2.00	2.35
MAGNESIUM (Mg)	1.24	.78	.64	.52	.57	.75
IRON (Fe)	.23	.11	.16	.26	.17	.19
COPPER (Cu)	.13	.06	.06	.10	.09	.088
PARTICULATE MATTER:						
>30 μ	317	197	L.E.	145	157	204
8 μ to 30 μ	77	66	61	62	51	63
3 μ to 8 μ	1.4	6.1	1.7	.8	1.1	2.2
1.2 μ to 3 μ	.6	.2	.2	.2	.2	.3
0.45 μ to 1.2 μ	3.9	1.1	2.8	.2	2.5	2.1
TOTAL PARTICLES	400	270	L.E.	208	212	272
TOTAL AEROBIC PLATE COUNT 48-HOUR #/ml	470	1700	3370	3300	700	1908

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 11. CONCENTRATION DATA - SHOWER WATER: SERIES 2, SUBJECT S
Height: 1.55 m; Weight: 57.7 Kg; Sex: F

PARAMETER, UNITS *	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.70	3.66	3.69	3.70	3.70	3.69
SOAP USED, ml	4.0	4.0	4.0	4.0	4.0	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.22	1.22	1.22	1.22	1.22	1.22
pH	6.69	6.47	6.28	5.97	6.00	6.28
SPECIFIC CONDUCTIVITY μ mho/cm	115	119	143	140	103	124
COLOR, COLOR UNITS	55	25	25	15	15	27
TURBIDITY, TURBIDITY UNITS	180	60	150	56	67	103
FOAMING, ml	130	160	175	165	165	159
TOTAL KJELDAHL NITROGEN (TKN)	7.8	21.3	21.7	16.5	16.5	16.8
AMMONIA (NH_3)	.35	0	.17	.23	0	.15
TOTAL ORGANIC CARBON (TOC)	200	225	275	290	215	241
TOTAL DISSOLVED SOLIDS (TDS)	627	500	702	486	465	556
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	L.E.	9	7	6.5	8	7.6
CHLORIDE (Cl^-)	4.3	4.1	4.3	5.1	5.7	4.7
SODIUM (Na)	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
POTASSIUM (K)	7.6	6.8	5.7	7.3	7.9	7.1
CALCIUM (Ca)	1.88	.89	1.18	1.19	1.26	1.28
MAGNESIUM (Mg)	1.13	.76	.68	.40	.34	.66
IRON (Fe)	.12	.05	.12	.12	.10	.10
COPPER (Cu)	.03	.04	.04	.03	.04	.036
PARTICULATE MATTER:						
>30 μ	57.0	52.7	78.9	32.4	42.7	52.7
8 μ to 30 μ	28.6	.3	60.7	20.3	18.9	25.8
3 μ to 8 μ	.2	.2	1.6	1.9	.2	.8
1.2 μ to 3 μ	.2	.2	.2	.2	.8	.3
0.45 μ to 1.2 μ	.5	2.7	.2	1.6	.2	1.0
TOTAL PARTICLES	86.5	56.1	142	56.4	62.8	80.7
TOTAL AEROBIC PLATE COUNT 48-HOUR #/ml	7000	6000	3300	134	1680	3623

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 12. CONCENTRATION DATA - SHOWER WATER: SERIES 2, SUBJECT B
Height: 1.70 m; Weight: 59.1 Kg; Sex: F

PARAMETER, UNITS *	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	3.65	3.60	3.60	3.56	3.70	3.62
SOAP USED, ml	4.0	4.0	4.0	4.0	4.0	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.22	1.22	1.22	1.22	1.22	1.22
pH	5.96	5.86	5.50	5.25	5.38	5.59
SPECIFIC CONDUCTIVITY μ mho/cm	190	168	154	175	146	167
COLOR, COLOR UNITS	25	25	15	15	15	19
TURBIDITY, TURBIDITY UNITS	96	110	90	57	52	81
FOAMING, ml	175	185	165	150	L.E.	169
TOTAL KJELDAHL NITROGEN (TKN)	40.5	35.6	26.7	34.0	22.2	31.8
AMMONIA (NH_3)	.76	0	.23	0	0	.20
TOTAL ORGANIC CARBON (TOC)	220	200	230	230	225	221
TOTAL DISSOLVED SOLIDS (TDS)	666	661	658	598	559	628
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	27	23	17.5	L.E.	L.E.	22.5
CHLORIDE (Cl^-)	8.5	7.8	6.4	7.6	4.6	7.0
SODIUM (Na)	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
POTASSIUM (K)	16.5	18.1	15.3	19.0	15.3	16.8
CALCIUM (Ca)	1.48	1.40	1.25	1.25	1.19	1.31
MAGNESIUM (Mg)	1.07	.83	.69	.46	.39	.69
IRON (Fe)	.11	.08	.06	.09	.12	.092
COPPER (Cu)	.04	.04	.03	.04	.12	.054
PARTICULATE MATTER:						
>30 μ	83.8	52.8	58.3	69.7	39.7	60.9
8 μ to 30 μ	11.2	30.8	8.1	13.8	10.3	14.8
3 μ to 8 μ	.8	.2	3.6	.6	.2	1.1
1.2 μ to 3 μ	.2	.2	2.5	.2	.2	.7
0.45 μ to 1.2 μ	1.1	.3	1.7	.2	1.1	.9
TOTAL PARTICLES	97.1	84.3	74.2	84.5	51.5	78.4
TOTAL AEROBIC PLATE COUNT 48-HOUR #/ml	140	410	77	170	15	162

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 13. CONCENTRATION DATA - SHOWER WATER. SERIES 2, AVERAGES

PARAMETER, UNITS*	MALE	FEMALE	MALE AND FEMALE
WATER COLLECTED, LITERS	3.59	3.67	3.62
SOAP USED, ml	4.0	4.0	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.22	1.22	1.22
pH	6.01	5.94	5.97
SPECIFIC CONDUCTIVITY μ mho/cm	250	146	198
COLOR, COLOR UNITS	47	23	35
TURBIDITY, TURBIDITY UNITS	425	92	258
FOAMING, ml	121	162	141
TOTAL KJELDAHL NITROGEN (TKN)	45.2	24.3	34.8
AMMONIA (NH_3)	.26	.18	.22
TOTAL ORGANIC CARBON (TOC)	277	231	254
TOTAL DISSOLVED SOLIDS (TDS)	723	592	659
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	41.0	15.1	28
CHLORIDE (Cl^-)	22.1	5.9	14.0
SODIUM (Na)	L.E.	L.E.	L.E.
POTASSIUM (K)	25.3	12.0	18.6
CALCIUM (Ca)	2.29	1.30	1.79
MAGNESIUM (Mg)	.73	.68	.70
IRON (Fe)	.19	.096	.14
COPPER (Cu)	.088	.045	.067
PARTICULATE MATTER:			
>30μ	184	56.8	120
8μ to 30μ	76	20.3	48.2
3μ to 8μ	1.9	1.0	1.4
1.2μ to 3μ	.3	.5	.4
0.45μ to 1.2μ	2.3	1.0	1.6
TOTAL PARTICLES	265	71.8	168
TOTAL AEROBIC PLATE COUNT 48 - HOUR #/ml	5280	1893	3586

*Units in mg/l except as noted

TABLE 14. CONCENTRATION DATA - SHOWER WATER: SERIES 1 AND 2, AVERAGES

PARAMETER,UNITS*	MALE		FEMALE		AVG. 1	AVG. 2	AVG. 1&2
	SERIES 1	SERIES 2	SERIES 1	SERIES 2			
WATER COLLECTED, LITERS	3.53	3.59	3.72	3.67	3.63	3.62	3.63
SOAP USED, ml	2.05	4.0	2.28	4.0	2.17	4.0	
SOAP USED, grams (ACTIVE INGREDIENTS)	1.255	1.224	1.395	1.224	1.328	1.224	1.276
pH	5.5	6.01	5.8	5.94	5.6	5.97	5.8
SPECIFIC CONDUCTIVITY μ mho/cm	316	250	191	146	254	198	226
COLOR, COLOR UNITS	62	47	24	23	43	35	39
TURBIDITY, TURBIDITY UNITS	385	425	83	92	234	258	246
FOAMING, ml	36	121	68	162	52	141	97
TOTAL KJELDAHL NITROGEN (TKN)	53.2	45.2	32.9	24.3	43.1	34.8	39.0
AMMONIA (NH_3)	2.38	.26	1.20	.18	1.79	.22	1.01
TOTAL ORGANIC CARBON (TOC)	331	227	218	231	275	254	265
TOTAL DISSOLVED SOLIDS (TDS)	844	723	651	592	748	659	704
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	9.7	41.0	5.6	15.1	7.7	28	17.9
CHLORIDE (Cl^-)	60.0	22.1	21.4	5.9	40.7	14.0	27.4
SODIUM (Na)	61.7	L.E.	58.3	L.E	60.0	L.E.	60.0
POTASSIUM (K)	31.2	25.3	15.2	12.0	23.2	18.6	20.9
CALCIUM (Ca)	.70	2.29	.52	1.30	.61	1.79	1.2
MAGNESIUM (Mg)	.75	.73	.64	.68	.70	.70	.70
IRON (Fe)	.29	.19	.13	.096	.21	.14	.18
COPPER (Cu)	.071	.088	.061	.045	.066	.067	.067
PARTICULATE MATTER:							
> 30μ	176	184	134	56.8	155	120	138
TOTAL PARTICLES	265	265	158	71.8	212	168	190
TOTAL AEROBIC PLATE COUNT 24 - HOUR #/ml	294		66		180		180
48 - HOUR #/ml		5280		1893		3586	3586

*Units in mg/l except as noted

TABLE 15. CONCENTRATION DATA - SHOWER WATER - BASELINES

PARAMETER, UNITS*	BEFORE SERIES 1	BEFORE SERIES 2	AFTER SERIES 2
WATER COLLECTED, LITERS	3.75	3.70	3.72
SOAP USED, ml	4.0	2.0	2.0
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	1.224	1.224
pH	6.87	6.83	6.20
SPECIFIC CONDUCTIVITY μ mho/cm	180	86	92
COLOR, COLOR UNITS	5	L.E.	0
TURBIDITY, TURBIDITY UNITS	14	1	0
FOAMING, ml	170	210	280
TOTAL KJELDAHL NITROGEN (TKN)	6.3	0	9.75
AMMONIA (NH_3)	2.1	0	.21
TOTAL ORGANIC CARBON (TOC)	276	220	210
TOTAL DISSOLVED SOLIDS (TDS)	696	384	366
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	.75	L.E.	.5
CHLORIDE (Cl^-)	0	.7	0
SODIUM (Na)	56	L.E.	L.E.
POTASSIUM (K)	2.1	1.51	.22
CALCIUM (Ca)	.14	L.E.	.36
MAGNESIUM (Mg)	.49	.63	.14
IRON (Fe)	.05	.21	.20
COPPER (Cu)	0	L.E.	.01
PARTICULATE MATTER:			
> 30 μ		5.9	8.7
8 μ to 30μ		L.E.	2.1
3 μ to 8 μ		0	.5
1.2 μ to 3 μ		0	.8
0.45 μ to 1.2 μ		0	0
TOTAL PARTICLES		L.E.	12.1

*Units in mg/l except as noted

TABLE 16. CONCENTRATION DATA - SOAP

PARAMETER, UNITS*	SOAP[1] 1	SOAP[1] 2	SOAP[1] 3	AVG. SOAP	THEORETICAL[2] SOAP
WATER COLLECTED, LITERS	3.78	3.78	3.78	3.78	3.78
SOAP USED, ml	2.0	2.0	2.0	2.0	2.0
SOAP USED, grams (ACTIVE INGREDIENTS)	1.224	1.224	1.224	1.224	1.224
pH	6.0	6.06		6.03	
SPECIFIC CONDUCTIVITY μ mho/cm	53	78		65.5	
COLOR, COLOR UNITS	0	L.E.		0	
TURBIDITY, TURBIDITY UNITS	L.E.	0		0	
FOAMING, ml	185	240		213	
TOTAL KJELDAHL NITROGEN (TKN)	L.E.	.03		.03	
AMMONIA (NH_3)	-	0		0	
TOTAL ORGANIC CARBON (TOC)	167	190		179	201
TOTAL DISSOLVED SOLIDS (TDS)	L.E.	370	318	344	323
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	.66	.53		.59	
CHLORIDE (Cl^-)	L.E.	0		0	
SODIUM (Na)	25	L.E.	23.5	24.3	21.4
POTASSIUM (K)	.03	L.E.	.00619	.018	
CALCIUM (Ca)	.12	L.E.	.1212	.12	
MAGNESIUM (Mg)	0	L.E.	.0279	.03	
IRON (Fe)	0	L.E.	<.0032	0	
COPPER (Cu)	0	L.E.	<.0021	0	

*Units in mg/l except as noted

1. Soap in distilled water, measured values
2. Soap in distilled water, calculated values based on manufacturers data.

TABLE 17. CONCENTRATION DATA - CLOTHES WATER: SERIES 1

PARAMETER, UNITS*	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	47	47	47	47	47	47
SOAP USED, ml	4.0	4.0	4.0	4.0	4.0	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448	2.448	2.448	2.448	2.448
pH	6.53	6.2	5.8	6.0	6.0	6.1
SPECIFIC CONDUCTIVITY μ mho/cm	110	117	120	110	84	108
COLOR, COLOR UNITS	15	15	25	15	L.E.	18
TURBIDITY, TURBIDITY UNITS	56.5	80	150	59	45	76
FOAMING, ml	L.E.	120	155	135	135	129
TOTAL KJELDAHL NITROGEN (TKN)	22	17	19	12	11	16.2
AMMONIA (NH_3)	2.55	1.34	.78	.89	1.25	1.36
TOTAL ORGANIC CARBON (TOC)	76	75	86	73	88	79.6
TOTAL DISSOLVED SOLIDS (TDS)	225	182	72.5	149	223	170
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	3.9	4.4	6.4	4.3	2.0	4.2
CHLORIDE (Cl^-)	10.5	L.E.	19.2	16.6	10.5	14.2
SODIUM (Na)	17.6	15.8	22.1	18.2	16.2	18.0
POTASSIUM (K)	8.00	7.20	11.5	6.06	4.58	7.47
CALCIUM (Ca)	0.280	0.306	0.54	0.246	0.219	0.318
MAGNESIUM (Mg)	1.31	1.56	1.50	1.05	0.739	1.232
IRON (Fe)	0.174	0.104	0.171	0.0916	0.101	0.128
COPPER (Cu)	0.0263	0.0290	0.0922	0.0158	0.0290	0.0385
PARTICULATE MATTER:						
>30 μ	202	L.E.	L.E.	24	101	109
14 μ to 30 μ	9	L.E.	12	10.5	10.8	10.6
5 μ to 14 μ	4.5	0.5	4.5	7.0	4.8	4.3
1 μ to 5 μ	1.5	L.E.	1.5	1.0	0	1.0
0.45 μ to 1 μ	22.5	6.5	5.0	6.0	4.4	8.9
TOTAL PARTICLES	239.5	L.E.	L.E.	48.5	121	133.8
TOTAL AEROBIC PLATE COUNT 24-HOUR #/ml						

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 18. CONCENTRATION DATA - TOWELS: SERIES 1

PARAMETER, UNITS*	DATA
WATER COLLECTED, LITERS	47
SOAP USED, ml	4.0
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448
pH	7.1
SPECIFIC CONDUCTIVITY μ mho/cm	49
COLOR, COLOR UNITS	L.E.
TURBIDITY, TURBIDITY UNITS	90
FOAMING, ml	160
TOTAL KJELDAHL NITROGEN (TKN)	5.0
AMMONIA (NH_3)	.24
TOTAL ORGANIC CARBON (TOC)	69
TOTAL DISSOLVED SOLIDS (TDS)	173
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	1.9
CHLORIDE (Cl^-)	6.1
SODIUM (Na)	15.5
POTASSIUM (K)	3.79
CALCIUM (Ca)	0.384
MAGNESIUM (Mg)	0.909
IRON (Fe)	0.1619
COPPER (Cu)	0.0421
PARTICULATE MATTER:	
>14μ	19.8**
5μ to 14μ	1
1μ to 5μ	0
0.45μ to 1μ	1.5
TOTAL PARTICLES	22.5

*Units in mg/l except as noted
**No 30μ filter

TABLE 19. CONCENTRATION DATA - CLOTHES: SERIES 2

PARAMETER, UNITS *	TEST DAY 1	2	3	4	5	AVE.
WATER COLLECTED, LITERS	47	47	47	47	47	47
SOAP USED, ml	8.0	8.0	8.0	8.0	8.0	8.0
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448	2.448	2.448	2.448	2.448
pH	6.84	6.60	6.38	6.08	6.00	6.38
SPECIFIC CONDUCTIVITY μ mho/cm	78	84	89	85	97	87
COLOR, COLOR UNITS	25	25	25	20	L.E.	24
TURBIDITY, TURBIDITY UNITS	80	40	105	70	68	73
FOAMING, ml	130	130	135	140	130	133
TOTAL KJELDAHL NITROGEN (TKN)	8.3	9.7	11.2	9.7	7.4	9.3
AMMONIA (NH_3)	L.E.	.27	.44	.15	0	0.22
TOTAL ORGANIC CARBON (TOC)	100	L.E.	L.E.	110	85	98
TOTAL DISSOLVED SOLIDS (TDS)	205	76	266	152	185	177
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	31	16	28	18	14	21.4
CHLORIDE (Cl^-)	L.E.	1.8	8.6	2.8	8.1	5.3
SODIUM (Na)	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
POTASSIUM (K)	4.29	4.75	5.06	4.73	4.37	4.64
CALCIUM (Ca)	1.60	1.54	1.64	1.72	1.74	1.65
MAGNESIUM (Mg)	2.06	1.65	1.76	1.31	1.37	1.63
IRON (Fe)	0.12	0.03	0.09	0.11	0.12	0.094
COPPER (Cu)	0.03	0.01	0.05	L.E.	0.05	0.035
PARTICULATE MATTER:						
>30 μ	20.0	5.8	L.E.	10.2	8.6	11.2
8 μ to 30 μ	25.9	L.E.	27.2	27.6	38.9	29.9
3 μ to 8 μ	0	1.3	0.4	0	L.E.	0.4
1.2 μ to 3 μ	0	0.4	0	0	0.6	0.20
0.45 μ to 1.2 μ	1.4	0	0.4	4.0	1.6	1.5
TOTAL PARTICLES	47.3	L.E.	L.E.	41.8	L.E.	43.2
TOTAL AEROBIC PLATE COUNT 48-HOUR #/ml						

*UNITS IN mg/l EXCEPT AS NOTED

TABLE 20. CONCENTRATION DATA - TOWELS: SERIES 2

PARAMETER, UNITS*	DATA
WATER COLLECTED, LITERS	47
SOAP USED, ml	8.0
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448
pH	6.73
SPECIFIC CONDUCTIVITY μ mho/cm	39
COLOR, COLOR UNITS	10
TURBIDITY, TURBIDITY UNITS	70
FOAMING, ml	140
TOTAL KJELDAHL NITROGEN (TKN)	3.3
AMMONIA (NH_3)	0
TOTAL ORGANIC CARBON (TOC)	44
TOTAL DISSOLVED SOLIDS (TDS)	144
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	6
CHLORIDE (Cl^-)	0.18
SODIUM (Na)	L.E.
POTASSIUM (K)	1.49
CALCIUM (Ca)	1.33
MAGNESIUM (Mg)	1.21
IRON (Fe)	0.02
COPPER (Cu)	0
PARTICULATE MATTER: > 30 μ	10.8
8 μ to 30 μ	13.2
3 μ to 8 μ	L.E.
1.2 μ to 3 μ	0
0.45 μ to 1.2 μ	0
TOTAL PARTICLES	24.0

*Units in mg/l except as noted

TABLE 21. CONCENTRATION DATA - CLOTHES AND TOWEL WATER: SERIES 1 AND 2

PARAMETERS, UNITS*	CLOTHES			TOWELS		
	SERIES 1	SERIES 2	AVG.	SERIES 1	SERIES 2	AVG.
WATER COLLECTED, LITERS	47	47	47	47	47	47
SOAP USED, ml	4.0	8.0		4.0	8.0	
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448	2.448	2.448	2.448	2.448
pH	6.1	6.38	6.24	7.1	6.73	6.92
SPECIFIC CONDUCTIVITY μ mho/cm	108	87	98	49	39	44
COLOR, COLOR UNITS	18	24	21	L.E.	10	10
TURBIDITY, TURBIDITY UNITS	76	73	75	90	70	80
FOAMING, ml	129	133	131	160	140	150
TOTAL KJELDAHL NITROGEN (TKN)	16.2	9.3	12.8	5.0	3.3	4.2
AMMONIA (NH_3)	1.36	0.22	0.79	.24	0	0.12
TOTAL ORGANIC CARBON (TOC)	79.6	98	88.8	69	44	56.5
TOTAL DISSOLVED SOLIDS (TDS)	170	177	174	173	144	159
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	4.2	21.4	12.8	1.9	6	1.3
CHLORIDE (Cl^-)	14.2	5.3	9.8	6.1	0.18	3.1
SODIUM (Na)	18.0	L.E.	18.0	15.5	L.E.	15.5
POTASSIUM (K)	7.47	4.64	6.1	3.79	1.49	2.6
CALCIUM (Ca)	0.318	1.65	0.74	0.384	1.33	0.86
MAGNESIUM (Mg)	1.232	1.63	1.43	0.909	1.21	1.06
IRON (Fe)	0.128	0.094	0.111	0.162	0.02	0.091
COPPER (Cu)	0.0385	0.035	0.0368	0.0421	0	0.0211
TOTAL PARTICLES	133.8	43.2	88.5	L.E.	24.0	24.0

*Units in mg/l except as noted

TABLE 22. CONCENTRATION DATA - CLOTHES BASELINES

PARAMETER, UNITS*	BEFORE SERIES 1	BEFORE SERIES 2	AFTER SERIES 2	AVG.
WATER COLLECTED, LITERS	47	47	47	47
SOAP USED, ml	4.0	8.0	8.0	
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448	2.448	2.448
pH	6.98	7.21	6.32	6.84
SPECIFIC CONDUCTIVITY μ mho/cm	24	33	21	26
COLOR, COLOR UNITS	15	L.E.	10	13
TURBIDITY, TURBIDITY UNITS	28	29	37	31
FOAMING, ml	140	160	125	142
TOTAL KJELDAHL NITROGEN (TKN)	8	0.006	2.4	3.5
AMMONIA (NH_3)	0.61	0	0.04	.22
TOTAL ORGANIC CARBON (TOC)	39	90	95	75
TOTAL DISSOLVED SOLIDS (TDS)	66.7	93.7	91	84
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	0.4	1	0.5	0.63
CHLORIDE (Cl^-)	4.9	<.17	<.17	1.7
SODIUM (Na)	10.2	L.E.	L.E.	10.2
POTASSIUM (K)	1.37	0.83	0.55	0.92
CALCIUM (Ca)	0.133	1.79	0.68	0.87
MAGNESIUM (Mg)	0.456	1.98	0.52	0.99
IRON (Fe)	0.0275	0.38	0.05	0.15
COPPER (Cu)	0.0158	0.02	0.03	0.022
PARTICULATE MATTER:				
> 30 μ		8.8	10.4	9.6
8 μ to 30 μ		14.0	19.2	16.6
3 μ to 8 μ		2.0	0	1.0
1.2 μ to 3 μ		0	0	0
0.45 μ to 1.2 μ		0.8	0	0.4
TOTAL PARTICLES		25.6	29.6	27.6

*Units in mg/l except as noted

TABLE 23. CONCENTRATION DATA - TOWEL BASELINES

PARAMETER, UNITS*	BEFORE SERIES 1	BEFORE SERIES 2	AFTER SERIES 2	AVG.
WATER COLLECTED, LITERS	47	47	47	47
SOAP USED, ml	4.0	8.0	8.0	
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448	2.448	2.448
pH	8.11	7.30	6.62	7.34
SPECIFIC CONDUCTIVITY μ mho/cm	30	30	21	27
COLOR, COLOR UNITS	8	L.E.	28	18
TURBIDITY, TURBIDITY UNITS	14	17	56	29
FOAMING, ml	152	160	140	151
TOTAL KJELDAHL NITROGEN (TKN)	0.6	0.36	0	0.32
AMMONIA (NH_3)	0.19	0.44	0	0.21
TOTAL ORGANIC CARBON (TOC)	39	34	31	35
TOTAL DISSOLVED SOLIDS (TDS)	82	90.4	61	78
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	0.2	L.E.	0.5	0.35
CHLORIDE (Cl^-)	4.1	<.17	<.17	1.5
SODIUM (Na)	13.6	L.E.	L.E.	13.6
POTASSIUM (K)	2.41	1.11	0.32	1.28
CALCIUM (Ca)	0.217	2.08	1.01	1.10
MAGNESIUM (Mg)	0.680	1.67	0.63	0.99
IRON (Fe)	0.0458	0.08	0.02	0.049
COPPER (Cu)	0	0.04	0.01	0.0167
PARTICULATE MATTER:				
> 30 μ		3.6	15.2	9.4
8 μ to 30 μ		7.2	17.2	12.2
3 μ to 8 μ		0	0.8	0.4
1.2 μ to 3 μ		0	0.8	0.4
0.45 μ to 1.2 μ		0	0	0
TOTAL PARTICLES		10.9	34.0	22.4

*Units in mg/l except as noted

TABLE 24. CONCENTRATION DATA - CLOTHES WATER
(NET INPUT FROM PEOPLE)

PARAMETER, UNITS*	SERIES 1			SERIES 2		
	5-DAY AVG.	BASE-LINE	NET INPUT FROM PEOPLE	5-DAY AVG.	BASE-LINE	NET INPUT FROM PEOPLE
WATER COLLECTED, LITERS	47	47		47	47	
SOAP USED, ml	4.0	4.0		8.0	3.0	
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448		2.448	2.448	
pH	6.1	6.84		6.38	6.84	
SPECIFIC CONDUCTIVITY μ mho/cm	108	26	82	87	26	61
COLOR, COLOR UNITS	18	13	5	24	13	11
TURBIDITY, TURBIDITY UNITS	76	31	45	73	31	42
FOAMING, ml	129	142	-13	133	142	-9
TOTAL KJELDAHL NITROGEN (TKN)	16.2	3.5	12.7	9.3	3.5	5.8
AMMONIA (NH_3)	1.36	.22	1.14	0.22	.22	0
TOTAL ORGANIC CARBON (TOC)	79.6	75	4.6	98	75	23
TOTAL DISSOLVED SOLIDS (TDS)	170	84	86	177	84	93
LACTIC ACID ($CH_3 \cdot CHOH \cdot CO_2H$)	4.2	0.63	3.57	21.4	0.63	20.8
CHLORIDE (Cl^-)	14.2	1.7	12.5	5.3	1.7	3.6
SODIUM (Na)	18.0	10.2	7.8	L.E.	10.2	L.E.
POTASSIUM (K)	7.47	0.92	6.55	4.64	0.92	3.72
CALCIUM (Ca)	0.318	0.87	0	1.65	0.87	0.78
MAGNESIUM (Mg)	1.232	0.99	0.242	1.63	0.99	0.64
IRON (Fe)	0.128	0.15	0	0.094	0.15	0
COPPER (Cu)	0.0385	0.022	0.0165	0.035	0.022	0.013
PARTICULATE MATTER: >30 μ				11.2	9.6	1.6
8 μ to 30 μ				29.9	16.6	13.3
3 μ to 8 μ				0.4	1.0	0
1.2 μ to 3 μ				0.20	0	0.2
0.45 μ to 1.2 μ				1.5	0.4	1.1
TOTAL PARTICLES				43.2	27.6	16.2

*Units in mg/l except as noted

TABLE 25. CONCENTRATION DATA - TOWEL WATER
(NET INPUT FROM PEOPLE)

PARAMETER, UNITS*	SERIES 1			SERIES 2		
	5-DAY AVG.	BASE-LINE	NET INPUT FROM PEOPLE	5-DAY AVG.	BASE-LINE	NET INPUT FROM PEOPLE
WATER COLLECTED, LITERS	47	47		47	47	
SOAP USED, ml	4.0	4.0		8.0	8.0	
SOAP USED, grams (ACTIVE INGREDIENTS)	2.448	2.448		2.448	2.448	
pH	7.1	7.34		6.73	7.34	
SPECIFIC CONDUCTIVITY μ mho/cm	49	27	22	39	27	12
COLOR, COLOR UNITS	L.E.	18	-	10	18	-8
TURBIDITY, TURBIDITY UNITS	90	29	61	70	29	41
FOAMING, ml	160	151	9	140	151	-11
TOTAL KJELDAHL NITROGEN (TKN)	5.0	0.32	4.68	3.3	0.32	2.98
AMMONIA (NH_3)	.24	0.21	.03	0	0.21	0
TOTAL ORGANIC CARBON (TOC)	69	35	34	44	35	9
TOTAL DISSOLVED SOLIDS (TDS)	173	78	95	144	78	66
LACTIC ACID (CH_3-CHOH-CO_2H)	1.9	0.35	1.55	6	0.35	5.7
CHLORIDE (Cl^-)	6.1	1.5	4.6	0.18	1.5	0
SODIUM (Na)	15.5	13.6	1.9	L.E.	13.6	L.E.
POTASSIUM (K)	3.79	1.28	2.51	1.49	1.28	0.21
CALCIUM (Ca)	0.384	1.10	0	1.33	1.10	0.23
MAGNESIUM (Mg)	0.909	0.99	0	1.21	0.99	0.22
IRON (Fe)	.1619	0.049	0.113	0.02	0.049	0
COPPER (Cu)	.0421	0.0167	0.0254	0	0.0167	0
PARTICULATE MATTER: >30 μ				10.8	9.4	1.4
8 μ to 30 μ				13.2	12.2	1.0
3 μ to 8 μ				0	0.4	0
1.2 μ to 3 μ				0	0.4	0
0.45 μ to 1.2 μ				0	0	0
TOTAL PARTICLES				24.0	22.4	2.4

*Units in mg/l except as noted

TABLE 26. INPUT DATA - SHOWER BASELINE

PARAMETER mg per man-day	BEFORE SERIES 1	BEFORE SERIES 2	AFTER SERIES 2	AVG.
TKN	234	0	36.2	19.9
TOC	0	137	104	80
TDS	0	22	0	7
NH_3	7.9	0	.78	2.9
LACTIC ACID	0	L.E.	0	0
Cl^-	0	2.6	0	.9
Na	26.2	0	0	8.7
K	7.8	5.5	.75	4.7
Ca	0	L.E.	.89	.45
Mg	1.62	2.22	.41	1.42
Fe	.19	.78	.74	.57
Cu	0	L.E.	.037	.019

TABLE 27. INPUT DATA - SOAP BASELINE

PARAMETER mg per man-day	2 ml SOAP
TKN	.1
TOC	677
TDS	1399
NH_3	0
LACTIC ACID	2.2
Cl^-	0
Na	91.9
K	.07
Ca	.45
Mg	.11
Fe	0
Cu	0

TABLE 28. INPUT DATA - SHOWER WATER: SERIES 1, SUBJECT J

PARAMETER mg per man-day	SHOWER INPUT	SOAP INPUT	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	19.9	.1	20	235	215
TOC	80	677	757	1034	277
TDS	7	1399	1406	2718	1312
NH_3	2.9	0	2.9	10.2	7.3
LACTIC ACID	0	2.2	2.2	33.0	30.8
Cl^-	.9	0	.9	131.8	130.9
Na	8.7	91.9	100.6	198.2	97.6
K	4.7	.07	4.77	118.8	114.0
Ca	.45	.45	.90	3.09	2.19
Mg	1.42	.11	1.53	2.98	1.45
Fe	.57	0	.57	1.18	.61
Cu	.019	0	.019	.291	.272

TABLE 29. INPUT DATA - SHOWER WATER: SERIES 1, SUBJECT D

PARAMETER mg per man-day	SHOWER INPUT	SOAP INPUT	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	19.9	.105	20	141.5	121.5
TOC	80	711	791	1294	503
TDS	7	1469	1476	3221	1745
NH_3	2.9	0	2.9	6.6	3.7
LACTIC ACID	0	2.3	2.3	35.3	33.0
Cl^-	0.9	0	0.9	287.9	287.0
Na	8.7	96.5	105.2	236.0	130.8
K	4.7	.07	4.77	101.4	96.6
Ca	.45	.47	0.92	1.83	0.91
Mg	1.42	.12	1.54	2.28	.74
Fe	0.57	0	0.57	0.83	.26
Cu	0.019	0	0.019	0.211	.192

TABLE 30. INPUT DATA - SHOWER WATER: SERIES 1, SUBJECT S

PARAMETER mg per man-day	SHOWER INPUT	SOAP INPUT	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	19.9	.11	20	106	86
TOC	80	745	825	1181	356
TDS	7	1539	1546	2359	813
NH_3	2.9	0	2.9	4.6	1.7
LACTIC ACID	0	2.4	2.4	15.8	13.4
Cl^-	0.9	0	.9	85.1	84.2
Na	8.7	101.1	109.8	209.3	99.5
K	4.7	.08	4.78	43.9	39.1
Ca	0.45	.50	0.95	1.99	1.04
Mg	1.42	.12	1.54	2.29	.75
Fe	0.57	0	.57	.53	0
Cu	0.019	0	.019	.225	.206

TABLE 31. INPUT DATA - SHOWER WATER: SERIES 1, SUBJECT B

PARAMETER mg per man-day	SHOWER INPUT	SOAP INPUT	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	19.9	.12	20	138	118
TOC	80	799	879	1063	184
TDS	7	1651	1658	2473	815
NH_3	2.9	0	2.9	4.3	1.4
LACTIC ACID	0	2.6	2.6	25.8	23.2
Cl^-	0.9	0	.9	73.6	72.7
Na	8.7	108.4	117.1	223.4	106.3
K	4.7	0.08	4.78	68.8	64.0
Ca	0.45	0.53	0.98	1.84	.86
Mg	1.42	0.13	1.55	2.43	.88
Fe	0.57	0	.57	.43	0
Cu	0.019	0	.019	.224	.205

TABLE 32. INPUT DATA - SHOWER WATER: SERIES 1, AVERAGES

PARAMETER, mg per man-day	MALE			FEMALE			MALE AND FEMALE AVG.
	J	D	AVG.	S	B	AVG.	
TKN	215	122	169	86	118	102	135
TOC	277	503	390	356	184	270	330
TDS	1312	1745	1529	813	815	814	1171
NH_3	7.3	3.7	5.5	1.7	1.4	1.6	3.6
LACTIC ACID	30.8	33.0	31.9	13.4	23.2	18.3	25.1
Cl^-	130.9	287.0	209.0	84.2	72.7	78.5	143.7
Na	97.6	130.8	114.2	99.5	106.3	102.9	108.6
K	114.0	96.6	105.3	39.1	64.0	51.6	78.5
Ca	2.19	0.91	1.55	1.04	0.86	0.95	1.25
Mg	1.45	0.74	1.10	0.75	0.88	0.82	0.96
Fe	0.61	0.26	0.44	0	0	0	0.22
Cu	0.272	0.192	0.232	0.225	0.205	0.215	0.224
PARTICULATES: >30 μ	571	616	594	533	412	473	534
14 μ to 30 μ	162	97	130	16	32	24	77
5 μ to 14 μ	176	93	137	59	18	39	88
1 μ to 5 μ	13	11	12	3	1	2	7
0.45 μ to 1 μ	32	28	30	14	8	11	21
TOTAL PARTICLES	954	845	903	625	471	549	727

TABLET 33. INPUT DATA - SHOWER WATER: SERIES 2, SUBJECT J

PARAMETER, mg per man-day	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	20	141	121
TOC	757	994	237
TDS	1406	2341	935
NH_3	2.9	1.4	0
LACTIC ACID	2.2	119.9	117.7
Cl^-	.9	88.3	87.4
Na	109.1	L.E.	L.E.
K	4.77	84.0	79.2
Ca	.90	8.01	7.11
Mg	1.53	2.55	1.02
Fe	.57	.68	.11
Cu	.019	.316	.297
PARTICULATES: >30 μ	27	589	562
8 μ to 30 μ	8	320	312
3 μ to 8 μ	.9	5.7	4.8
1.2 μ to 3 μ	1.5	1.1	0
0.45 μ to 1.2 μ	0	9.0	9.0
TOTAL PARTICLES	37.4	924.8	888

TABLE 34. INPUT DATA - SHOWER WATER: SERIES 2, SUBJECT D

PARAMETER, mg per man-day	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	20	183	162
TOC	757	992	235
TDS	1406	2860	1454
NH_3	2.9	.43	0
LACTIC ACID	2.2	173.6	171.4
Cl^-	.9	70.2	69.3
Na	109.1	L.E.	L.E.
K	4.77	97.4	92.6
Ca	.90	8.41	7.51
Mg	1.53	2.69	1.16
Fe	.57	.68	.11
Cu	.019	.315	.296
PARTICULATES: >30μ	27	730	703
8μ to 30μ	8	226	218
3μ to 8μ	.9	7.9	7.0
1.2μ to 3μ	1.5	1.1	0
0.45μ to 1.2μ	0	7.5	7.5
TOTAL PARTICLES	37.4	972.5	936

TABLE 35. INPUT DATA - SHOWER WATER: SERIES 2, SUBJECT S

PARAMETER, mg per man-day	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	20	62	42
TOC	757	889	132
TDS	1406	2052	646
NH_3	2.9	.55	0
LACTIC ACID	2.2	28.0	25.8
Cl^-	0.9	17.3	16.4
Na	109.1	L.E.	L.E.
K	4.77	26.2	21.4
Ca	0.90	4.72	3.82
Mg	1.53	2.44	0.91
Fe	0.57	0.37	0
Cu	0.019	0.133	0.114
PARTICULATES: >30 μ	27	194	167
8 μ to 30 μ	8	95	87
3 μ to 8 μ	.9	3.0	2.1
1.2 μ to 3 μ	1.5	1.1	0
0.45 μ to 1.2 μ	0	3.7	3.7
TOTAL PARTICLES	37.4	296.8	260

TABLE 36. INPUT DATA - SHOWER WATER: SERIES 2, SUBJECT B

PARAMETER, mg per man-day	SHOWER PLUS SOAP INPUT	TOTAL INPUT	PERSON INPUT
TKN	20	115	95
TOC	757	800	43
TDS	1406	2273	867
NH_3	2.9	.72	0
LACTIC ACID	2.2	81.5	79.3
Cl^-	0.9	25.3	24.4
Na	109.1	L.E.	L.E.
K	4.77	60.8	56.0
Ca	0.90	4.74	3.84
Mg	1.53	2.50	0.97
Fe	0.57	0.33	0
Cu	0.019	0.195	0.176
PARTICULATES: >30μ	27	220	193
8μ to 30μ	8	54	45
3μ to 8μ	.9	4.0	3.1
1.2μ to 3μ	1.5	2.5	1.0
0.45μ to 1.2μ	0	3.3	3.3
TOTAL PARTICLES	37.4	283.8	245

TABLE 37. INPUT DATA - SHOWER WATER: SERIES 2, AVERAGES

PARAMETER, mg per man-day	MALE			FEMALE			MALE AND FEMALE AVG.
	J	D	AVG.	S	B	AVG.	
TKN	121	162	142	42	95	69	105
TOC	237	235	236	132	43	88	162
TDS	935	1454	1195	646	867	757	976
NH_3	0	0	0	0	0	0	0
LACTIC ACID	117.7	171.4	144.6	25.8	79.3	52.6	98.6
Cl^-	87.4	69.3	78.4	16.4	24.4	20.4	49.4
Na	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
K	79.2	92.6	85.9	21.4	56.0	38.7	62.3
Ca	7.11	7.51	7.31	3.82	3.84	3.83	5.57
Mg	1.02	1.16	1.09	0.91	0.97	.94	1.02
Fe	.11	.11	.11	0	0	0	.06
Cu	0.297	0.296	.297	0.114	0.176	.145	.221
PARTICULATES >30μ	562	703	633	167	193	180	406
8μ to 30μ	312	218	265	87	45	66	166
3μ to 8μ	4.8	7.0	5.9	2.1	3.1	2.6	4.3
1.2μ to 3μ	0	0	0	0	1.0	.5	.3
0.45μ to 1.2μ	9.0	7.5	8.3	3.7	3.3	3.5	5.9
TOTAL PARTICLES	888	936	912	260	254	253	583

TABLE 38. INPUT DATA - SHOWER WATER: SERIES 1 AND 2, MALE AVERAGES

PARAMETER, mg per man-day	SUBJECT J Series 1	Series 2	Avg.	SUBJECT D Series 1	Series 2	Avg.	MALE AVG.
TKN	215	121	168	122	162	142	155
TOC	277	237	257	503	235	369	313
TDS	1312	935	1124	1745	1454	1600	1362
NH_3	7.3	0	3.7	3.7	0	1.9	2.8
LACTIC ACID	30.8	117.7	74.3	33.0	171.4	102.2	88.2
Cl^-	130.9	87.4	109.2	287.0	69.3	178.2	143.7
Na	97.6	L.E.	97.6	130.8	L.E.	130.8	114.2
K	114.0	79.2	96.6	96.6	92.6	94.6	95.6
Ca	2.19	7.11	4.65	0.91	7.51	4.21	4.43
Mg	1.45	1.02	1.24	0.74	1.16	0.95	1.09
Fe	0.61	0.11	0.36	0.26	0.11	0.19	0.27
Cu	0.272	0.297	0.285	0.192	0.296	0.244	0.264
PARTICULATES >30 μ	571	562	567	616	703	660	613
TOTAL PARTICLES	954	888	921	845	936	891	906

TABLE 39. INPUT DATA - SHOWER WATER: SERIES 1 AND 2, FEMALE AVERAGES

PARAMETER, mg per man-day	SUBJECT S Series 1	Series 2	Avg.	SUBJECT B Series 1	Series 2	Avg.	FEMALE AVG.
TKN	86	42	64	118	95	107	85
TOC	356	132	244	184	43	114	179
TDS	813	646	730	815	867	841	785
NH_3	1.7	0	.9	1.4	0	.7	.8
LACTIC ACID	13.4	25.8	19.6	23.2	79.3	51.3	35.4
Cl^-	84.2	16.4	50.3	72.7	24.4	48.6	49.4
Na	99.5	L.E.	99.5	106.3	L.E.	106.3	102.9
K	39.1	21.4	30.3	64.0	56.0	60.0	45.1
Ca	1.04	3.82	2.43	0.86	3.84	2.35	2.39
Mg	0.75	0.91	.83	0.88	0.97	.93	.88
Fe	0	0	0	0	0	0	0
Cu	0.225	0.114	0.170	0.205	0.176	0.191	0.180
PARTICULATES >30 μ	533	167	350	412	193	303	326
TOTAL PARTICLES	625	260	443	471	254	363	403

TABLE 40. INPUT DATA - SHOWER WATER: SERIES 1 AND 2, MALE AND FEMALE AVERAGES

PARAMETER, mg per man-day	MALE AVG.	FEMALE AVG.	MALE AND FEMALE AVG.
TKN	155	85	120
TOC	313	179	246
TDS	1362	785	1074
NH_3	2.8	.8	1.8
LACTIC ACID	88.2	35.4	61.8
Cl^-	143.7	49.4	96.6
Na	114.2	102.9	108.6
K	95.6	45.1	70.4
Ca	4.43	2.39	3.41
Mg	1.09	.88	.99
Fe	0.27	0	.14
Cu	0.264	0.180	.222
PARTICULATES: >30μ	613	326	470
TOTAL PARTICLES	906	403	655

TABLE 41. INPUT DATA - CLOTHES WATER: SERIES 1 AND 2

PARAMETER mg per man-day	SERIES 1	SERIES 2	AVG.
TKN	149	68	109
TOC	54.1	270	162
TDS	1011	1093	1052
NH_3	13.4	0	6.7
LACTIC ACID	41.9	244	143
Cl^-	146.9	42.3	94.6
Na	91.7	L.E.	91.7
K	77.0	43.7	60.4
Ca	0	9.17	4.6
Mg	2.84	7.52	5.18
Fe	0	0	0
Cu	0.194	0.153	0.174
PARTICULATES: >30μ		18.8	18.8
8μ to 30μ		156.3	156.3
3μ to 8μ		0	0
1.2μ to 3μ		2.4	2.4
0.45μ to 1.2μ		12.9	12.9
TOTAL PARTICLES		190.4	190.4

TABLE 42. INPUT DATA - TOWEL WATER: SERIES 1 AND 2

PARAMETER mg per man-day	SERIES 1	SERIES 2	AVG.
TKN	11	7	9
TOC	79.9	21	50.5
TDS	223	155	189
NH_3	0.1	0	0.05
LACTIC ACID	3.6	13.4	8.5
Cl^-	10.8	0	5.4
Na	4.5	L.E.	4.5
K	5.9	0.5	3.2
Ca	0	0.54	0.27
Mg	0	0.52	0.26
Fe	0.26	0	0.13
Cu	0.0597	0	0.030
PARTICULATES: >30 µ		3.3	3.3
8 µ to 30 µ		2.4	2.4
3 µ to 8 µ		0	0
1.2 µ to 3 µ		0	0
0.45 µ to 1.2 µ		0	0
TOTAL PARTICLES		5.7	5.7

TABLE 43. INPUT DATA - TOTAL INPUT FROM SUBJECTS: SERIES 1

PARAMETER, mg per man-day	CLOTHES	TOWELS	SHOWER	TOTAL
TKN	149	11	135	295
TOC	54.1	79.9	330	464
TDS	1011	223	1171	2405
NH_3	13.4	0.1	3.6	17.1
LACTIC ACID	41.9	3.6	25.1	70.6
Cl^-	146.9	10.8	143.7	301
Na	91.7	4.5	108.6	205
K	77.0	5.9	78.5	161
Ca	0	0	1.25	1.25
Mg	2.84	0	0.96	3.8
Fe	0	0.26	0.22	0.48
Cu	0.194	0.0597	0.224	0.478
PARTICULATES >30 μ			534	
14 μ to 30 μ			77	
5 μ to 14 μ			88	
1 μ to [illegible]			7	
0.45 μ to 1 μ			21	
TOTAL PARTICLES			727	

TABLE 44. INPUT DATA - TOTAL INPUT FROM SUBJECTS: SERIES 2

PARAMETER, mg per man-day	CLOTHES	TOWELS	SHOWER	TOTAL
TKN	68	7	105	180
TOC	270	21	162	453
TDS	1093	155	976	2224
NH_3	0	0	0	0
LACTIC ACID	244	13.4	98.6	356
Cl^-	42.3	0	49.4	92
Na	L.E.	L.E.	L.E.	L.E.
K	43.7	0.5	62.3	107
Ca	9.17	0.54	5.56	15.3
Mg	7.52	0.52	1.02	9.1
Fe	0	0	.06	.06
Cu	0.153	0	0.221	0.374
PARTICULATES				
>30μ	18.8	3.3	406	428
8μ to 30μ	156.3	2.4	166	325
3μ to 8μ	0	0	4.3	4.3
1.2μ to 3μ	2.4	0	.3	2.7
0.45μ to 1.2μ	12.9	0	5.9	18.8
TOTAL PARTICLES	190.4	5.7	583	779

TABLE 45. INPUT DATA - TOTAL INPUT FROM SUBJECTS: SERIES 1 AND 2 AVERAGES

PARAMETER, mg per man-day	SERIES 1	SERIES 2	AVG.
TKN	295	180	238
TOC	464	453	459
TDS	2405	2224	2315
NH_3	17.1	0	8.6
LACTIC ACID	70.6	356	213
Cl^-	301	92	197
Na	205	L.E.	205
K	161	107	134
Ca	1.25	15.3	8.3
Mg	3.8	9.1	6.5
Fe	0.48	0.06	0.27
Cu	0.478	0.374	0.426
PARTICULATES: > 30		428	492*
14 to 30		325	
5 to 14		4.3	
1 to 5		2.7	
0.45 to 1		18.8	
TOTAL PARTICLES		779	851*

* Average of Series 1 and 2 Shower Inputs plus Series 2 Clothes and Towels Inputs

SECTION 6. DISCUSSION OF RESULTS

The contaminant inputs to wash water from people were found to be substantially lower than previous theoretical projections had indicated (see Table 1). The previous theoretical projections were for an all male crew. They are four times higher than the data developed in this study for a male-female crew, and three times higher than the male data. This indicates that the basic assumptions used in the theoretical study were very conservative. The new lower value data will tend to make wash water reclamation systems that have relatively high expendables, such as multifiltration, look more favorable than they have to date when compared to low expendable systems like reverse osmosis.

Significant differences were observed between male and female data. The first and most obvious is that the females averaged to produce only about 55 per cent as much material as the males. When adjusted for body weight they still produced only 75 per cent of the male total. These comparisons are shown in Table 46 which has both actual and normalized values. It is interesting, and perhaps significant, that the weight adjusted values of the males differ by only 4% and those of the females by only ½%. These values, of course, are for the averaged total inputs. There are somewhat more variations among the two major catagories that comprise the total input, namely total suspended solids and total dissolved solids. A comparison of these parameters is shown in Table 47 for

both the first and second series of tests. The apparent correlation in the normalized data indicate that the inputs from a space crew may be predicted closely for an actual mission given the expected body weight ranges. However, one would like to have more test days involving many more test subjects and longer exercise periods to confirm these correlations.

Another interesting observation is that all of the iron input came from the males and none from the females. This finding apparently supports the often stated contention that women tend to have less iron in their systems than men. While discussing iron, it should be pointed out that the input values for iron and magnesium are subject to argument because the baseline values for these metals are large in comparison to the observed values. It is felt, however, that the metals really are human inputs although the amounts reported may be in doubt.

It should be noted that the reason for considerably lower aerobic plate counts in the Series 1 tests is that the plates were cultured for only 24 hours as opposed to 48 hours in Series 2. The plate count data are summarized in Table 48. The very low results for Subject B indicate she is one of those individuals that apparently have bacteriocidal or bacteriostatic skin.

There are several differences between Series 1 and Series 2 data that are thought to be a result of climate. Series 1 tests were run during a week of fairly hot weather with day time temperatures from 29-32°C (85-90°F). During Series 2 tests,

18-21°C (65-70°F) weather prevailed. This probably accounts for the higher nitrogen, chloride and potassium levels in Series 1 water. These are all constituents of perspiration. The high ammonia in Series 1 would indicate that some of the urea in the perspiration was being decomposed by skin bacteria.

Lactic acid is produced by muscular exercise and its greater presence in Series 2 would indicate greater physical activity. Possibly the subjects were more active due to the cooler weather. In any event, they all thought they worked out a little longer and harder in their Series 2 exercise regimen.

The broad ranges over which the data may vary are shown in Tables 1 and 2. The total inputs shown in Table 1 were obtained by adding the laundry inputs to the shower inputs. The laundry inputs (from clothes and towels) are the average inputs of four individuals. This is because all soiled clothing was combined and washed together. The total range would probably be considerably greater if the laundry inputs reflected maximum and minimum individual inputs rather than the averages. The shower inputs, which were added to the laundry inputs to obtain the total input figures shown in Table 1, do reflect the individual extremes. These extremes are best shown in Table 2, which contains the shower water results. A range is given for 5-Day Average figures as well as 1-Day spot values. These ranges reflect the wide differences possible between a 93.2 Kg (205 lb) male exercising during warm weather and a 57.7 (127 lb) female in a cooler environment.

It is clearly seen in Tables 1 and 2 that approximately 45 per cent of the dissolved materials in wash water are unidentified. The observed Total Organic Carbon levels indicate that most of the unidentified materials are probably organic in nature. An attempt should be made to identify at least the major components of this unidentified fraction.

TABLE 46. COMPARISON OF MALE AND FEMALE TOTAL SHOWER INPUTS

	Subject	Weight Kg	Height m	Total Input g/man-day	Specific Total Input (g/Kg)/man-day	Average Specific Total Input (g/Kg)/man-day
Male	J	73.6	1.73	2045	27.8	27.3
	D	93.2	1.83	2491	26.7	
Female	S	57.7	1.55	1173	20.3	20.4
	B	59.1	1.70	1204	20.4	
			- Normalized Values -			
Male	J	.79	.95	.82	1.00	1.00
	D	1.00	1.00	1.00	.96	
Female	S	.62	.85	.47	.73	.74
	B	.63	.93	.48	.73	

TABLE 47. BREAKDOWN COMPARISON OF MALE AND FEMALE SHOWER INPUTS

Subject	Total Dissolved Solids Input		Total Suspended Solids Input		Total Solids Input	
	Series 1	Series 2	Series 1	Series 2	Series 1	Series 2
			(g/man-day)			
J	1312	935	954	888	2266	1823
D	1745	1454	845	936	2590	2390
S	813	646	625	260	1438	906
B	815	867	471	254	1286	1121
			((g/Kg)/man-day)			
J	17.8	12.7	13.0	12.1	30.8	24.8
D	18.7	15.6	9.07	10.0	27.8	25.6
S	14.1	11.2	10.8	4.51	24.9	15.7
B	13.8	14.7	7.97	4.30	21.8	19.0
			(Normalized)			
J	.95	.81	1.00	1.00	1.00	.97
D	1.00	1.00	.70	.83	.90	1.00
S	.75	.72	.83	.37	.81	.61
B	.74	.94	.61	.36	.71	.74

TABLE 48. SUMMARY OF TOTAL AEROBIC PLATE COUNT DATA

Subject	Series 1 5-Day Average 24-Hour Count #/ml	Series 2 5-Day Average 48-Hour Count #/ml
J	101	8652
D	487	1908
S	130	3623
B	2.6	162

SECTION 7. CONCLUSIONS AND RECOMMENDATIONS

This report provides the first data, obtained under controlled conditions, that are suitable for use by the scientists, engineers and designers who are working on wash water reclamationtion systems for space application. The data show that the contaminant inputs from people are substantially lower than previous theoretical projections have indicated. Also, the contaminant input from females was found to be significantly lower than the input from males even when adjusted for differences in body weight. The data presented are immediately useful and may have considerable impact on the trade-off comparisons among various unit processes and systems.

This study did not answer all questions regarding the nature of space wash water. It is recommended that the following items be investigated in furture tests.

1. The data reported here derive from only four subjects and ten days of testing. Although there is a good correlation amoung the averages, more testing involving many more test subjects and longer exercise periods should be accomplished in order to obtain statistically reliable data.
2. Test data show that an appreciable percentage of dissolved solids cannot be accounted for by the analyses performed. Additional work should be accomplished to characterize and identify these materials.
3. Shower data show considerable differences between the

levels of materials contributed by males and females. It was not possible to see similar differences in laundry water because all of the clothes were washed together. Tests should be conducted to separately define male and female laundry water.

4. The largest constituent in used shower water is the soap. Shower data should be obtained without the use of soap to eliminate its masking effects.
5. Further work is needed to define a method to measure urea in shower and laundry water.
6. It is anticipated that projected wash water recycle systems will produce a concentrate or brine that will probably be fed to a urine recovery system. Therefore the concentrative properties of wash water should be determined to help define its impact on urine recovery systems.

REFERENCES

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