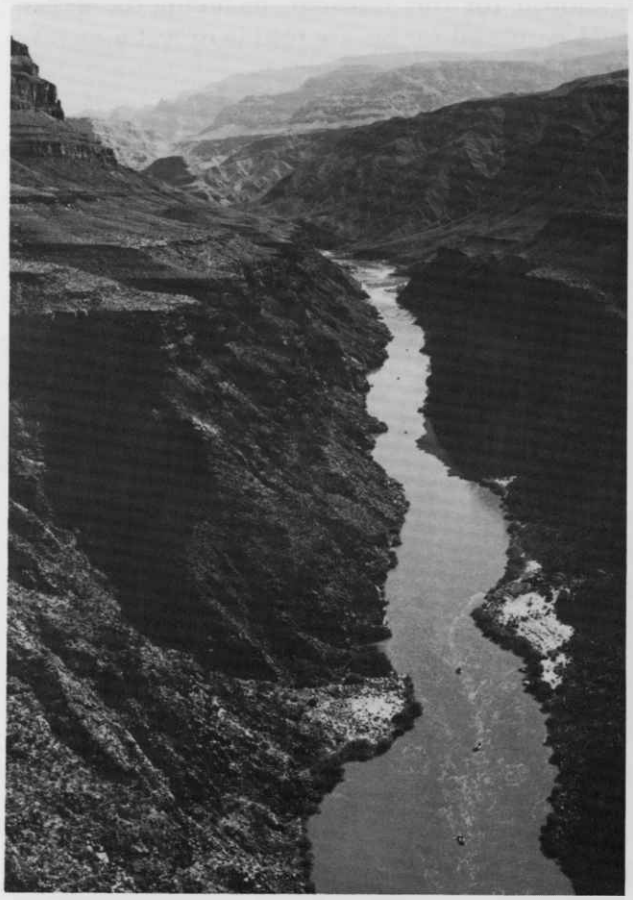

White-water Researchers Check Bacteria in the Grand Canyon

Using river rafts equipped as mobile laboratories is the best way to test water quality in the Colorado River of the Grand Canyon. The sharply increased number of boat trips through the canyon since the 1960s is the main reason that testing the water there has become important.

Based on two years of testing, UA School of Renewable Natural Resources researchers have made recommendations for safer use of river water by boaters. Boaters should treat water from the river and its tributaries before drinking it. Drinking straight from the river has been common in past seasons. Boaters also should avoid stirring up bottom sediments. The sediments contain much more bacterial contamination than does the surface water. Stirring up sediments, especially in side-stream pools, can raise the fecal bacteria count in water above the standard maximum for body-contact water use.

The UA researchers have explained these recommendations to boatmen from 22 licensed commercial outfitters during National Park Service training sessions for the boatmen.

By Dr. Brock Tunnicliff and Dr. Stan Brickler, School of Renewable Natural Resources, and Guy Webster, Agricultural Communications

Photograph: Recreational rafts navigate a stretch of the Colorado River in the lower half of the Grand Canyon. (Photo by Peter Kresan.)

The techniques developed for this research, including the design of laboratory rafts, should be useful for on-site testing of water quality in other white-water recreational rivers.

The popularity of river-running has boomed nationally in the past 15 years, but the Colorado River in the Grand Canyon is premier among more than 44 stretches of recreational rivers in the West. By controlling the flow of the Colorado, the Glen Canyon Dam has lengthened the canyon rafting season. Before the dam was built in the mid-1960s, the season lasted a few spring weeks of most years; now it runs from April through September. Until the dam was constructed the largest number of people to travel on the Colorado through the Grand Canyon in one year was 372. By 1972, the annual number had swelled to 16,432. A quota system held river traffic below 15,000 people a year from 1974 to 1980.

The Colorado River meanders 225 miles through the narrow corridor of the Grand Canyon, cutting through rock one and one-half billion years old and merging with more than 30 tributaries. River runners have traditionally used the Colorado and tributaries as sources of drinking and cooking water, for swimming and bathing, and, at times, disposal of some refuse. Since 1978, the National Park Service has required river runners to carry out human sewage rather than bury it.

During the 1972 and 1979 float-trip seasons, outbreaks of severe diarrhea struck river runners in the Grand Canyon. The Center for Disease Control from Atlanta, Georgia investigated the outbreaks. A disease-causing bacteria that affects the gastro-intestinal tract, *Shigella sonnei*, was isolated from some of the people who were sick. Possibly,

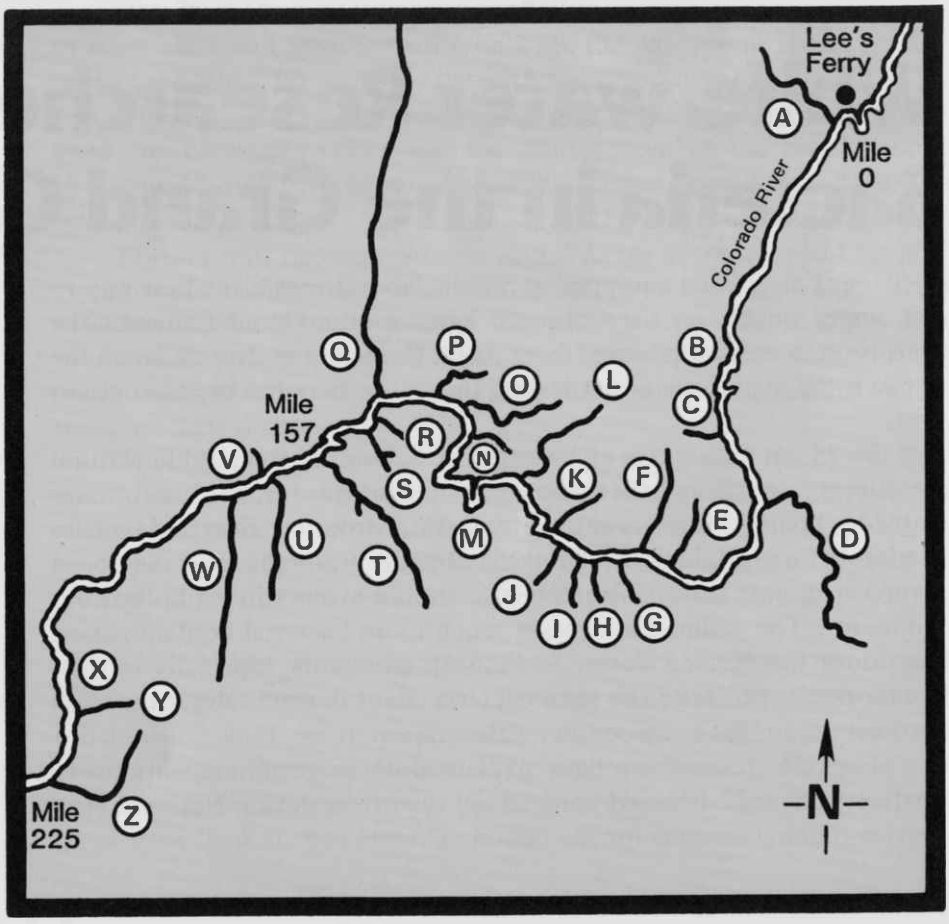

Figure 1 Legend

Paria River	A
Vasey's Spring	B
Nankoweep Creek	C
Little Colorado River	D
Clear Creek	E
Bright Angel Creek	F
Garden Creek	G
Monument Creek	H
Hermit Creek	I
Boucher Creek	J
Crystal Creek	K
Shinumo Creek	L
Elves Chasm	M
Stone Creek	N
Tapeats Creek	O
Deer Creek	P
Kanab Creek	Q
Olo Creek	R
Matkatamiba Creek	S
Havasu Creek	T
National Creek	U
Fern Glen	V
Mohawk Creek	W
Pumpkin Spring	X
Three Springs	Y
Diamond Creek	Z

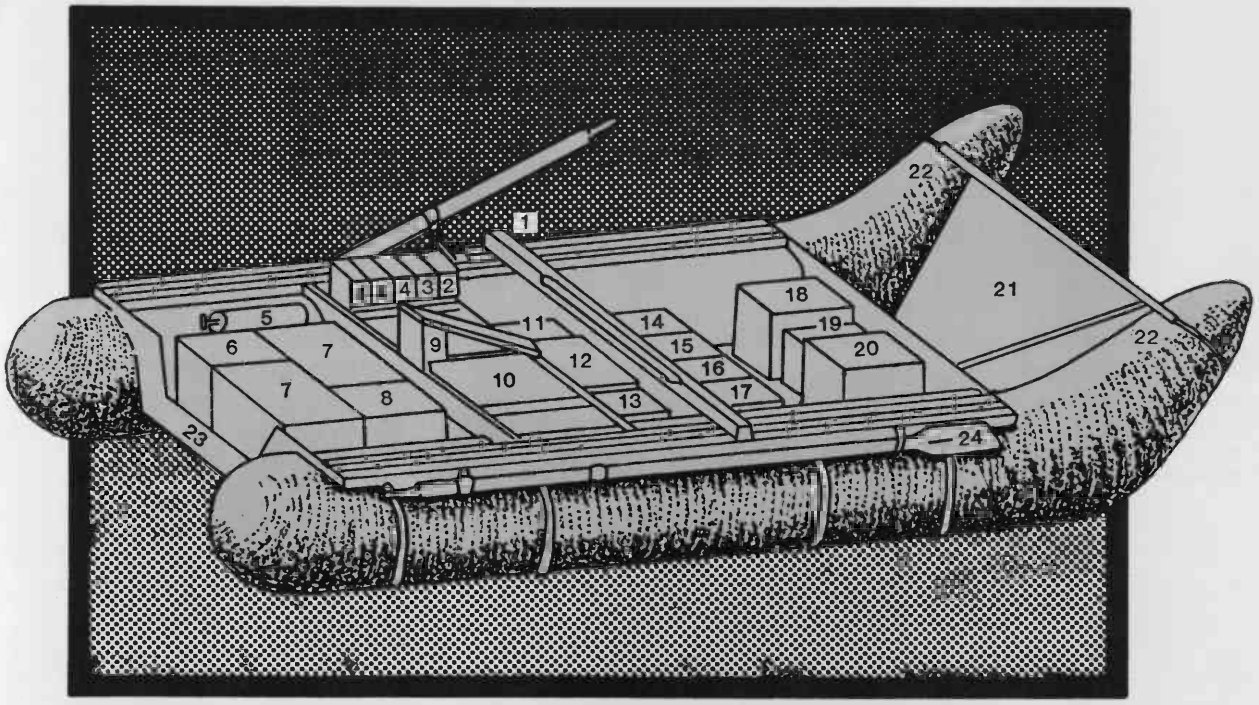

Figure 2
Research Raft with Exposed Inventory

1. Kick Board
2. Sample Gear
3. Library
4. Personal Gear
5. Boat Pump
6. MPN 35°C Incubator & Battery
7. MF Incubator Battery & Lab Supplies
8. UV Sterilization Box
9. Seat
10. Ice Chest: 210 lbs. of Ice, Food, & Samples
11. Chem Lab
12. Stove Propane Tank
13. Lab Filtration
14. Tool Kit
15. First Aid
16. Toilet
17. Stove
18. Kitchen
19. Food
20. Generator
21. Splash Shield
22. Inflatable Neoprene Rubber Pontoon
23. Aluminum Frame
24. Spare Oar

the river or a tributary was a source or carrier of this pathogen, but this has not been confirmed.

Intestinal disease organisms excreted in feces of humans, wildlife or domestic animals can become potential sources of infection, and water contaminated with fecal organisms can spread diseases. Bacteria that come from digestive tracts of humans or other warm-blooded animals are often found in the water and sediments of natural aquatic environments, but most are not disease-causing types.

Before this research project, testing samples of Grand Canyon water for bacterial content had always required carrying the samples from the canyon to a laboratory elsewhere. The quality of the water can change during the carrying time. For access to the Colorado River for collecting samples, foot trails are too long and scarce, and helicopters are too costly.

For this project, methods were developed that allow testing of water with portable laboratory equipment that can be packed onto a river raft. On six 225-mile trips through the Grand Canyon in 1978 and two in 1979, a total of 712 water samples from the Colorado River and 26 side streams were collected and tested (See Figure 1). Based on results of those tests, the National Park Service has contracted with the UA School of Renewable Natural Resources to monitor water quality in the canyon for five years. The research rafts will set out from Lee's Ferry this July as part of the monitoring project's second season.

Two research rafts, with 14-foot aluminum frames and 22-foot inflated pontoons, were built for the original project and are still in use An ice chest that can hold 210 pounds of ice was custom built for preserving water samples and the nutrient solutions used for tests. In addition to the scientific equipment, the rafts carry supplies for the eight-person team's 14 day trip. The five core members of the 1978-79 research crew were qualified as licensed river boatmen.

Photograph: Research team leaders Brock Tunnicliff (left) and Stan Brickler set up equipment to test water samples aboard one of the rafts.

The water tests conducted in 1978 and 1979 included analysis of chemical and physical qualities of samples, but the primary measurements were of the concentrations of two classes of bacteria: fecal coliform (FC) and fecal streptococcus (FS). These both enter the environment from fecal matter. They do not cause diseases themselves, but their concentrations are good indicators of the probability of disease-causing microorganisms also being present. The ratio of FC to FS concentrations also indicates whether the source of contamination is from human wastes, which are higher in FC, or animal droppings, with are higher in FS.

Federal and state standards for recreational waters are based on FC concentration. For full-body contact, such as swimming, water with more than 200 FC bacteria per 100 milliliters (3.3 fluid ounces) does not pass the standards.

The tests showed that the Colorado and its tributaries in the Grand Canyon have high-quality water for recreational use. Average FC counts from the river were 2.1 and 2.4 per 100 milliliters in 1978 and 1979. From the tributaries, average FC counts were 3.6 and 8.0. Diamond Creek and Elves Chasm had the highest averages, 18.8 and 12.9, still well within the 200 FC standard. Only two of the 497 river samples and seven of the 215 tributary samples exceeded that standard.

In neither the Colorado nor any of the tributaries, however, was surface water pure enough for drinking without treatment. The best drinking-water supply is surface water from the Colorado treated with eight to 10 drops of liquid chlorine bleach per gallon, or properly treated with a commercial treatment product such as iodine granules.

The quality of the surface water in some areas can be considerably degraded by stirring up bottom sediments from either the Colorado or the tributaries. Concentrations of FC bacteria in bottom sediments are much higher than in surface water (See Figure 3). Recreational activities, particularly water play in confined tributary pools, can bring river runners in direct contact with concentrated suspensions of sediment in the water. This represents an important water-quality hazard.

Ratios of FC and FS concentrations suggest that the predominant source of fecal contamination in the river and tributaries is from non-human sources. Such contamination should not be discounted as unimportant; some microorganisms that cause diseases in humans also occur in the digestive tracts of a variety of wildlife and livestock species.

The National Park Service is considering changes in its rules for river runners. One set of proposals that was scheduled to go into effect this season has been shelved. Former quotas for the number of people on the river at one time have been loosened. Use levels may be up by 30 to 40 percent. The continued monitoring of water quality will be important in keeping management actions consistent with safe and enjoyable use of the Grand Canyon.

Microbiologist Finn Sinclair, a member of the research team, steers through a quiet stretch of the canyon. (Photo by Stan Brickler.)

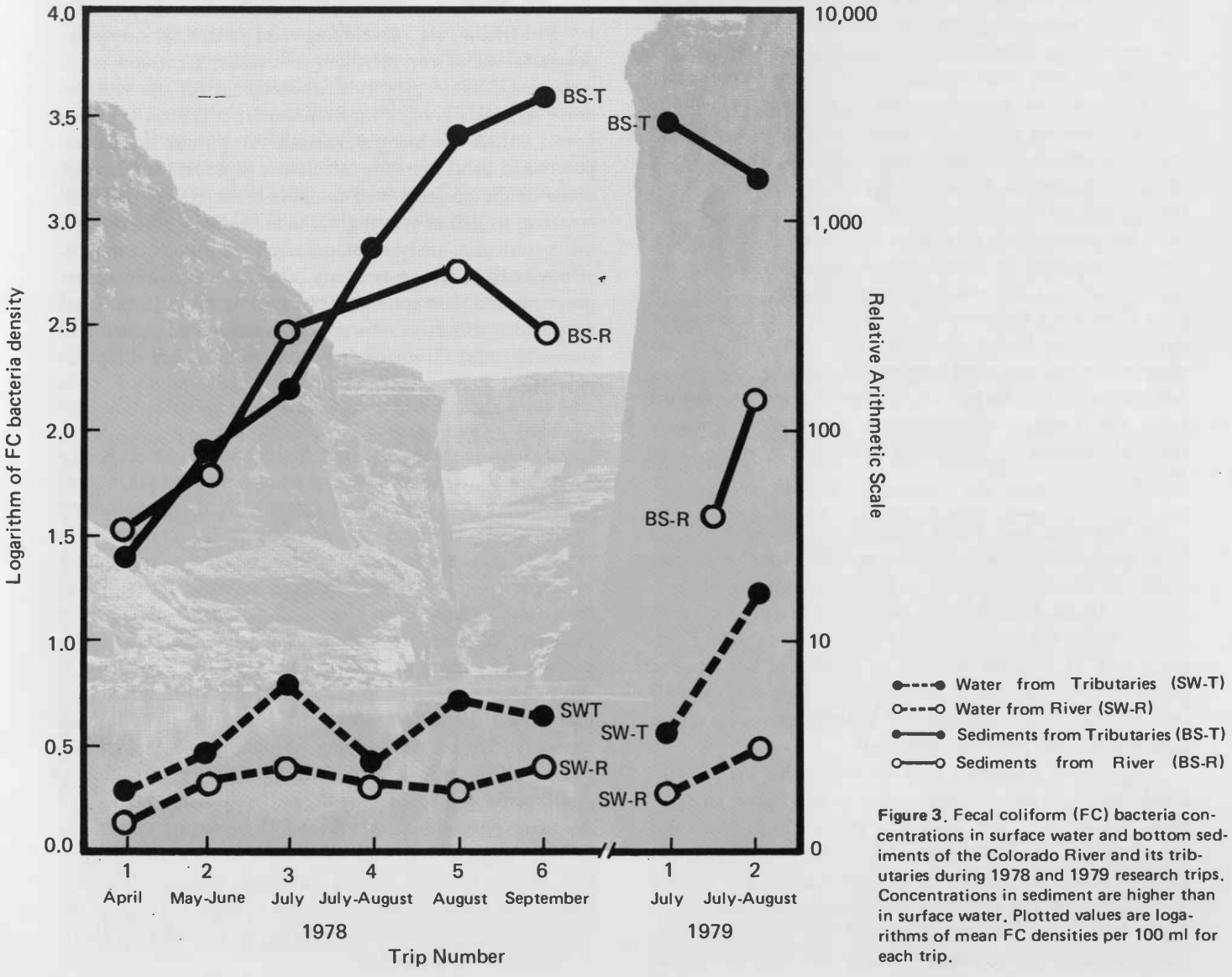

Figure 3. Fecal coliform (FC) bacteria concentrations in surface water and bottom sediments of the Colorado River and its tributaries during 1978 and 1979 research trips. Concentrations in sediment are higher than in surface water. Plotted values are logarithms of mean FC densities per 100 ml for each trip.