Project Background or Rationale

International Space Station (ISS) crew members must conserve as much water as possible because each crew member is allocated only about two liters of water per day. Reclaimed spacecraft water (humidity condensate and urine distillate) was recognized as an efficient, innovative, and safe source for potable water for the ISS. The ability to recover water on ISS has allowed for habitation of six crew members and made the ISS less dependent on ground resupply.

In early phases of the ISS, astronauts relied on a Russian Mir system, in which atmospheric humidity condensate was collected and processed into potable water by a condensate water processor. NASA's water recovery system (WRS), launched to ISS in 2008, goes one step further: it recovers urine in addition to humidity. The system can recover about 85 percent of the water in urine. In order to accomplish this treatment goal, the process necessitated careful engineering and enhanced water quality monitoring and assessment.

The WRS uses physical and chemical processes to remove contaminants from wastewater (Figure 1). The produced water is tested by onboard sensors; unacceptable water is cycled back through the water processor assembly. The reliability and safety of the system was demonstrated using a 90-day “checkout” on-orbit, during which no crew consumption of the reclaimed water was allowed. Monitoring during that timeframe showed that inflight chemical and microbial characteristics were similar to those observed in pre-flight system design and testing (Straub and Schulz, 2010). U.S. crews have obtained approximately 75-100 percent of their potable water from this source, and have been able to store excess water for contingencies. Processing downtimes have been limited, and the WRS has proven reliable and efficient.

Microbial growth has been observed, but primarily only during periods of stagnancy. No pathogenic organisms have been detected and monitoring for non-pathogenic levels of microorganisms have been generally consistent with ground-based potable water systems in terms of concentrations and types of microorganisms. In addition to potable uses, other ISS systems (such as oxygen generation) successfully utilize reclaimed water.

Capacity and Treatment Technology

Under optimized conditions, the WRS will process approximately 7 liters of condensate daily, along with a similar volume of urine distillate. Approximately 12 liters of potable water per day are reclaimed for potable purposes. As shown in Figure 1, recovered crew urine is distilled in the urine processor assembly.
(UPA), and fed to the water processor assembly (WPA) along with humidity condensate/wastewater; these elements together constitute the U.S. water recovery system (WRS), as shown in Figure 2. Reclaimed water is used by the crew as a potable source, and is fed to the oxygen generation assembly (OGA) as a source of electrolytic oxygen that is returned to the spacecraft cabin.

**Project Funding and Management Practices**

The ISS had substantial investments in the implementation of the WRS. Costs for launching water are approximately $10,000/lb ($50,000/liter) because of the relatively large weight of water necessary to support six crew members on ISS (~25 lbs/day or 11.3 kg/day), which makes a strong rationale for use of reclaimed water. Recycling water also serves to reduce crew dependency of resupply. Management was also interested in proving technologies such as WRS that represented skills/resources needed for more remote spaceflight missions.

**Institutional and Cultural Considerations**

Given the unique setting and end users, there were not significant objections to implementation of WRS on ISS. However, there were indeed stigmas regarding the reclaimed water use (especially in regard to urine recycling). Those stigmas were overcome through openness and effective communication with stakeholders. “Taste tests” and other forums were used to encourage acceptance among crew and decision-makers.

**Successes and Lessons Learned**

WRS has operated successfully since 2008, and serves as a model for implementation of complex and innovative hardware in a remote environment. Lessons learned have included the value of proper planning, the need for continued monitoring, and the challenges/strengths of multi-disciplinary collaboration.

**References**
