

Recycled Water Storage for Famous Golf Courses

Since May 2006, seven of California's famous golf courses on the spectacular Monterey Peninsula—including Cypress Point and US PGA Tour venues Pebble Beach, Spyglass Hill, and Poppy Hills—have been supplied recycled water from the newly commissioned Forest Lake Reservoir. Forest Lake Reservoir was originally constructed in 1887 and had operated as an unlined reservoir until the early 1990s.

The rehabilitation project was commissioned by the Pebble Beach Community Services District (PBCSD), in line with new operating permit requirements of the California Department of Water Resources Division of Safety of Dams (DSOD). In December 1998, PBCSD purchased the Forest Lake Reservoir from California-American Water Company pursuant to a quid-pro-quo agreement. The reservoir was to be rehabilitated and new improvements constructed to meet DSOD requirements.

On March 16, 2005, the PBCSD awarded an almost \$11-million contract to Anderson Pacific Engineering Construction, Inc. for construction of the improvements. Construction started in late March 2005; construction management was provided by E2 Consulting Engineers. The project was financed entirely by the sale proceeds of a portion of Pebble Beach Company's water entitlements obtained in return for financially guaranteeing the first phase of the reclamation project. Water entitlements are offered to the residential users within Pebble Beach.

Reservoir improvements included

installation of a liner and leak detection system on the interior reservoir surface, reconstruction of an exterior section of the north embankment, construction of new concrete intake/outlet structure, and installation of new pipelines for connection between the new reservoir and algae removal treatment facility and the existing distribution system and overflow line. The new treatment facility includes three microstrainers to remove algae, two pumps with the peak demand capacity to pump 4.5 mgd to the distribution system, instrumentation controls integrated with the existing supervisory control and data acqui-

rine injection and pH adjustment, and miscellaneous mechanical and electrical equipment in the chemical building. Instrumentation subcontractor Tesco Controls (www.tescocontrols.com) installed programming for the instrumentation controls located at the chemical and maintenance department buildings and calibrated a number of measuring devices required for automatic control of the treatment facility.

Recycled water from the reservoir is available for the distribution system through manual operation of the treatment facilities. The reservoir is filled with recycled water to the permitted

storage capacity of 325 acre-feet or 105 MG. No water has been observed to date from the leak detection system below the liner. Water stored in the reservoir initially had a green tint indicating the presence of algae, which was confirmed by high chlorophyll and pH concentrations measured in water sample testing. Poor water clarity in the reservoir was confirmed by a Secchi disc measurement of less than 18 in. Subsequently, water in the reservoir became clearer with a Secchi

disc measurement of approximately 6 ft and the green tint was replaced with a light brown tint. Water samples were collected weekly and chlorophyll and pH concentrations also dropped significantly.

Professor Alex Horne, Professor Emeritus, Ecological Engineering, University of California at Berkeley, and an expert limnologist, participated in the design of algae control measures including the mixer and air flow bubbler systems. Professor Horne visited the project and indicated all reservoirs expe-



Installation of a high-performance five-ply liner material nears completion at Forest Lake Reservoir in Pebble Beach, Monterey Peninsula, California.

sition system, and chemical process equipment for adjusting pH levels and disinfection of recycled water prior to entering the distribution system. The existing outlet of the overflow line was to be extended 200 ft and an energy dissipation structure was to be constructed at Sawmill Gulch Creek below Colton Road.

Anderson Pacific made good progress on construction of the reservoir components. The contractor performed initial testing of the microstrainers, plant feed pumps, chemical feed systems for chlo-

rience considerable fluctuations in algal growth levels initially. He believes the initial green color was a large concentration of small green algae. He collected water samples for microscopic examination, observed a species of rotifer that eat or graze on algae was abundant, and the rotifers were healthy with full green guts. Algal growth occurs in the upper layer of the reservoir exposed to sunlight. Algae control measures were designed to keep the reservoir water moving and keep the algae from settling in the upper layer. Professor Horne recommended adding a species of crustacean zooplankton that graze at a rate about 100 times greater than rotifers to help keep the reservoir balanced naturally. While the application of chemicals like copper sulfate or chlorine is an effective method of killing algae, the algae grazers are also killed and the natural balance of the reservoir goes back to square one.

In April 2006, four security cameras mounted on two new poles were installed near the outlet structure and on the chemical building. Signals will be transmitted wirelessly from the remote locations to the chemical building. A fiber optic line was also installed from remote locations to the chemical building.

The reservoir's long-service liner consists of DuPont Performance Elastomers (www.dupontelastomers.com) Hypalon® chlorosulfonated polyethylene. The high-performance liner material, consisting of three layers of Hypalon and two layers of woven fabric scrim, meets stringent leakproofing, soil stabilizing, and environmental demands and is expected to have a service life of at least 25 years. It was manufactured by Burke Industries (www.burkeindustries.com), then prefabricated into panels totaling nearly one million sq ft by Layfield Plastics Inc. (www.layfieldgroup.com), and installed on site by Layfield Environmental Systems Corporation (www.layfieldgroup.com).

Stability Concerns

"The DSOD was concerned that if water saturated the reservoir embankments, the stability of the embankments could be affected in an earthquake. Hypalon was used for a similar reservoir

rehabilitation project in the Los Angeles area. The new liner and leak detection system is designed to keep any stored water from entering the embankments," says Mike Niccum, district engineer at PBCSD.

The reservoir is filled with recycled water during winter months when there is excess production at the Carmel Area Wastewater District's treatment plant. Stored recycled water is used during summer months when the irrigation demands exceed the production, thereby further reducing the use of potable water. It is a key part of the recycled water distribution system that provides irrigation water to the seven top golf courses in the area as well as several additional recreation areas in the Del Monte Forest.

Onsite Installation

Jon Feenstra, project manager of Layfield Environmental Systems, and the site supervisor responsible for onsite field installation, describes his company's involvement in the Forest Lake Reservoir project.

"Layfield Plastics Inc., part of the Layfield Group, fabricated the roll stock of Hypalon, supplied by Burke Industries, into approximately 175 larger panels, the largest being 34 ft wide by 200 ft long, for field installation. This is where the Layfield Environmental Systems team took over, installing the panels over the graded and re-excavated site, using a hot wedge welding system and cross-seaming with adhesive patches of Hypalon."

Flexible geomembrane liners and covers for raw and potable water storage, produced from DuPont Performance Elastomers Hypalon, fulfill the latest demands of municipal reservoir engineers, and meet or exceed regulations such as ANSI/NSF Standard 61, and the American Water Works Association (AWWA) standard D 130-96. These lin-



Workers roll out one of the 175 liner panels.

ers resist ultraviolet radiation, ozone, and water treatment chemicals. The material has a low thermal expansion coefficient and remains stable yet flexible at high and low temperatures. Repeated freezing and thawing cycles do not cause mechanical damage, and its elasticity allows liners to accommodate limited earth movement. On-site seaming with chemical fusion or hot-air welding produces a strong seam and is simple, fast, and cost-effective. These liners and covers also offer an economically attractive alternative to concrete, steel, and other rigid construction materials. The flexible option offers low initial capital cost, low maintenance and operating cost, and also reduced chlorine costs through prevention of chlorine depletion.

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High-performance 65 mil five-ply liner is leakproof, stabilizes the soil, and has an expected service life of at least 25 years.