

Design of Moorings for Complex Fish Passage Project

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ABSTRACT

Westmar Consultants designed a mooring system for a large floating fish passage facility subject to 18.5 m water level fluctuations in the forebay of a deep-water reservoir in northwest Washington State, using OrcaFlex software developed for offshore oil rigs. The design included extensive numerical modeling to accommodate the large water level fluctuations and high wind and current loads on the floating structures and nets. This system replaced the original, which was installed during dam construction in 1959. The paper will describe this environmental project that uses state-of-the-art mooring design technology to enable salmon migration past dams and other river obstructions that do not otherwise allow for fish passage.

KEY WORDS: Moorings; fish passage; guide nets; dams; salmon migration.

INTRODUCTION

This paper describes the need for and the design and implementation of a system for improving salmon migration on the Baker River. Baker Lake's high water level variations, the close proximity of the structure to the dam, and the need to restrict the movement of the system under 1 in 50 year windstorm and flood flow conditions adds a high level of complexity to the design of the mooring system. For these reasons, the mooring system design utilized OrcaFlex, a state-of-the-art computer program from the offshore oil industry, and the mooring lines were manufactured from high-strength synthetic materials (Dyneema®) with low elasticity, combined with standard chains, anchors and winches.

Historical Perspective of Fish Capture at Upper Baker Dam

The Baker River Hydroelectric project is located near the town of Concrete in northwest Washington and is owned by Puget Sound Energy (PSE). The site location is shown in Fig. 1. The project consists of two dams: Upper Baker Dam and Lower Baker Dam. Upper Baker Dam, shown in Fig. 2, was completed in 1959 and consists of a 1,200 ft (366 m) long by 312 ft (95 m) high, straight-axis, concrete-block gravity dam with a powerhouse containing two Francis turbines that have a combined generating capacity of 90.7 megawatts (MW) at a flow rate of 5,050 cubic feet per second (cfs) (143 m³/s). The 9 mile (14.5 km) long reservoir behind Upper Baker Dam is referred to as Baker Lake, with depths to approximately 285 ft (87 m) and an annual pool level fluctuation of about 50 ft (15 m).

Lower Baker Dam, completed in 1925, consists of a 550 ft (168 m) long by 285 ft (87 m) high gravity arch dam with a powerhouse containing a single Francis turbine rated at 79.3 MW with a flow of 4,200 cfs (119 m³/s). Lake Shannon, the 7 mile (11.3 km) long reservoir behind Lower Baker Dam, has depths to approximately 270 ft (82 m) and an annual pool level fluctuation of about 49 ft (15 m).

Since the construction of Upper Baker Dam in 1959, fish passage has been an important feature. As part of the overall original project construction, a barrier dam and a fish trap facility were constructed downstream of Lower Baker Dam. The purpose of the two facilities is to collect upstream migrating adult salmon and steelhead. The collected fish are transported by vehicle to a point above both Upper Baker Dam and Lower Baker Dam and released to allow spawning.