Case 27

To Use or Not to Use?

Beaufort Sea Production Company (BSPC) operates a medium-sized oil field on Alaska's north coast. The field is still producing at its maximum rate, 325,000 barrels of oil per day (BOPD). However, to sustain this rate the company started a waterflood of the reservoir two years ago. Now a capacity bottleneck in the water disposal process is threatening to curtail production.

In waterflooding, salt water from the Beaufort Sea is treated to remove debris, impurities, and oxygen (to minimize corrosion problems). It is then pressurized to 2800 psig for injection into the reservoir, where it serves two purposes. First, it sweeps the oil toward nearby production wells, which increases oil recovery from the swept area. Second, it maintains the reservoir pressure for all wells by replacing the oil that is removed.

The injected water also becomes part of the fluids that are brought up through the production wells. Over time the wells steadily produce more and more water, which must be re-injected. They are now making 200,000 barrels of water per day (BWPD), and they can dispose of up to 380,000. Over the next three to four years, they expect the produced water rate to increase to around 600,000 BWPD before leveling out.

This produced water does replace an equal volume of seawater as the injection fluid. But due to the incompatibility of the seawater and the produced water (mixing causes immediate precipitation of calcium carbonate scale), different pump modules must be used. More pump modules must be added.

The lead time on new facilities is about 2 years, so alternatives to increase the disposal capacity of the produced-water system must be evaluated now. If the capacity is added too late, then oil production rates must be reduced to match the existing capacity. The economic penalties of deferred production are heavy. In fact, if the production is deferred too long, some of it may still be unrecovered when it becomes uneconomic to produce the field.

Fred, the lead project design engineer, has identified two primary options for the expansion. The first and lowest capital cost option is to complete construction of a module started three years earlier as part of the initial water flood facilities. The company had already spent $12.5 million on this module, when a new water flood plan reduced the area to be flooded. This made the third module unnecessary, construction was immediately stopped, and the module was mothballed. The pump and aero derivative gas turbine had already been purchased and the module partially constructed.

Since then, the mothballed module has been stored at the construction site. The design engineers estimate that it would cost an additional $22.5 million to complete, modify, and install it. Modifications include another produced-water tank and booster pumps to supply the water at the proper pressure for the suction of the high-pressure pump.

Management at BSPC sees this as a chance to salvage a useless module. The pump more than meets the requirements, since it has a design rate of 400,000 BWPD at 3375 psig. At the required pressure (2800 psig), it can pump up to 480,000 BWPD.

If not used for this, the module's only value is for spare parts for the two installed units. The book value of these spares (essentially only the pump and turbine, since the module is unusable) is $4.4 million. An extra $1.9 million is required for this option for replacement of the gas generator spare.

The second alternative is to add more pumps similar to BSPC's two largest produced-water disposal pumps. There are eight total. Each pump in the largest pair uses a 4600 horsepower (hp) industrial-type gas turbine to pump up to 85,000 BWPD. Three of these pumps would be needed. Fred's estimate for total costs is $30.1 million.

Fred realized that he needed some operation and maintenance (O&M) costs. Since he has had very little operating experience, he asked some engineers with the BSPC production facility to help. He was a bit surprised with their response. Operations had experienced many problems with the two 400,000 BWPD waterflood modules, especially during the first year. Correcting several manufacture-related problems had helped, but the pumps still did not run as smoothly as planned. Luckily, short interruptions of the injection of "new" seawater have minimal impact on the production of oil.

The production engineers were concerned with using such a large machine where shutdowns impact production greatly and quickly. Initial calculations of "residence times" indicated that there would be less than an hour to respond to an unexpected loss of the pump. With such a short response time, they would have to immediately shut-in a large number of production wells (80 to 90, if it were running at full capacity). They felt very strongly that they would operate the pump at a reduced capacity, probably less than 340,000 BWPD. Even at this reduced capacity, a number of the smaller pumps would be shut down.

On the positive side, they noted that the excess capacity could be useful should they have to shut down one of their smaller pumps for maintenance. In fact, it could actually serve as an on-line spare.

Since the two 85,000 BWPD pumps had only been installed for six months, little O&M data were available. They did know that when these pumps shut down unexpectedly, the operators only needed to cut back the wells with the highest water production rates. No wells had to be completely shut-in.

The addition of three more small pumps would give them eleven pumps with no full spares. With that many pumps, the chances of one or more being down was substantial. They estimated that the more numerous "minor" cutbacks in production would about equal the shut-in production from a loss of the bigger pump. There is only a negligible difference between the quantities of "deferred" oil for the two options.

To give Fred some numbers for his analysis, the production engineers roughly estimated the O&M costs of each machine. They estimated that the operators spend about half an hour each day conducting routine checks on the large waterflood machines. They figured the smaller disposal pumps take only about 20 minutes per day per machine. They also informed Fred that, when estimating their engineering projects, they generally use $150/hour for operator man-hours, which includes all associated overhead and burden. In addition, they have been given guidelines that indicate that an 8% discount rate should be used for any economic analysis.

Based on the last year, they estimate that routine maintenance on the large pump system will be about $65,000 per year. This includes normal preventive maintenance. Because of their smaller size, they figure that the preventive maintenance on an 85,000 BWPD pump will only cost about $25,000 per year.

Periodic major overhauls are required. In the large aero derivative turbines (used for the 400,000 BWPD modules) the manufacturer recommends replacing the gas generator every three years at a cost of $250,000. The industrial-type turbines have a longer overhaul interval, six years, with an expected cost of $75,000 per overhaul.

Major overhauls are needed for the pumps every five years. The large pump overhaul costs $80,000 and a small pump $30,000, exclusive of routine and preventive maintenance. The control systems need revamping every 10 years. Again, the large system is more expensive at $50,000. The smaller systems would each cost about $20,000.

With so much horsepower involved, fuel costs matter. BSPC pays $0.75 per thousand standard cubic foot (10^3 SCF) for their fuel, which has a heating value of 900 BTU/SCF. The aero derivative turbine at 8100 BTU/hp-hour is much more fuel-efficient than the industrial-type engines planned for the small pumps (9250 BTU/hp-hour). The small pumps would require the full 4600-hp rating of their turbines to put out 85,000 BWPD. Based on the pump curves for the existing water flood modules, the large pump would require 18,650 hp to pump 340,000 BWPD.

Another concern of the production engineers was freeze protection when the large pump is shut down. Depending on duration and the time of the year, displacement of oil with methanol might be required. (Below-freezing weather occurs nine months of the year). In addition, the frequent shutdown of equipment tends to increase repair costs for the wellhead chokes.

Freeze protection and extra maintenance costs due to shutdowns of the large pumps would be on the order of $350,000 per year. Since past experience has indicated that wells would not be shut-in when a smaller pump is lost, no freeze protection costs were estimated. Freeze protection costs for the water injectors themselves were not included. The original seawater pumps can maintain sufficient flow to each injector to keep the lines from freezing.

Fred must put all of this information together and make a recommendation to the company management. Should he recommend use of the existing module?

Option

Even though the value of the uncompleted waterflood module has been declining over time, BSPC has not yet been able to take a tax deduction for it. BSPC cannot depreciate the module until it enters service, and the company cannot simply expense it until it has actually begun to dismantle it.

Furthermore, if the module is not utilized for the produced water disposal, all investment tax credits originally taken must be "given back" to the government. This applies to any booked costs not officially transferred to operations. It excludes costs such as the book value of the spare parts that must be depreciated along with other capital equipment when they are placed in service.

The expenditure patterns expected for the two options are as shown in Table 27-1.

Table 27-1 Spending Patterns

	Prior Years	Year 1	Year 2
Large pumps	12.5	12.5	11.9[1]
Small pumps	4.2[2]	15.1	15.0

[1] Includes cost of replacement gas generator.
[2] Book value of spare parts transferred to operations warehouse. The pumps are assumed to be placed in service in year 3. The company pays a combined state and federal income tax of 48%.