To: John Brodie September 10, 2009

From: Walter Kuit

Subject: Faro Treatment Plant Operation

This is to provide a summary review of the treatment plant based on information that you and others have provided since about early spring of this year. As you know, I have not personally inspected the plant and, therefore, any comments I provide will be qualified. However, I have been closely involved with about 20 treatment plants over more than 35 years and have a reasonable understanding of the water treatment challenges faced at Faro. My local experience includes the design and start-up of the Vangorda treatment plant and site assessments for various purposes.

<u>Current Operation and Plant Capacity</u>

About 5,000 gpm of Faro pit water by itself or combined with IP water are treated in former mill facilities which essentially consist of two parallel banks of flotation cells for the lime chemistry task and a two thickeners in series (90 and 75 feet diameter, respectively) which provide clarification. The core plant equipment is accompanied by reagent systems for the preparation and delivery of lime slurry and flocculant solution.

My understanding is that the flotation cells provide about 20 minutes of retention time at typical input flows. Each bank appears to have its own pH feedback instrumentation loop for lime addition control and contains 6 agitators but not all are routinely used. The thickeners have not been modified to optimize clarification performance and their rakes are normally only operated during periods of sludge withdrawal. This is remarkable in my experience and speaks to the fact that sludge volume production in the plant is very small. Data from one settling test available to me indicated that the volume of sludge was only about 5% of the volume of water treated and the final density was about 5% solids. This density is very high relative to that expected for typical hydroxide sludges from low zinc concentration waters. This suggests that there is a large proportion of carbonates in the sludge solids which originate from carbonate/bicarbonate in feed water.

Assuming a treatment rate of 5,000 gpm, the unit hydraulic loadings in the primary and secondary clarifiers are about 0.8 gpm/ft2 and 1.1 gpm/ft2, respectively. These are very high in relation to a long standing rule of thumb which suggests a nominal design value of about 0.5 gpm/ft2 to provide good clarification efficiency. However, the overall clarification performance in the plant, particularly in the primary unit, is quite good as I understand that Water Licence limits on zinc are met as a rule. While the intent of the second clarifier is to provide polishing capacity, its efficiency is very limited as it yields only marginal improvements in final total zinc concentrations.

Assuming that current treatment rates will prevail in the future, I believe that there is no fundamental limitation on the ability of the existing plant to handle significantly higher contaminant loadings. There is more than ample capacity in the flotation cells system to handle increased "chemistry" burdens and the experience of myself and others suggests that clarification performance will generally improve with higher sludge solids production. This view is supported by limited data from the Faro plant that indicated a significantly improved performance with a higher strength blend of Faro pit and IP water than from Faro pit water alone.

High Density Sludge(HDS) Process

I am aware that there has been considerable interest in the possibility of a HDS plant to replace the existing treatment facility. I have long been an active promoter of the HDS process for general treatment application in circumstances where sludge disposal issues are a primary consideration. An HDS plant at Faro should generate sludge of about 25% solids in comparison to the current 5% solids which will result in greatly reduced volumes. However, current sludge volumes are already low and I understand that there are no serious problems associated with the present disposal method.

Solids in a HDS process generally settle much faster but this advantage can be off set by much higher solids loadings in clarifier feeds due to recycle. A minor disadvantage with the HDS process is that lime consumption will be slightly higher than current experience. This is due to the incorporation of some lime particles in the densified sludge solids.

It may be possible to convert the existing plant to operate with a HDS process but this would entail major changes in operating strategy such as continuous clarifier rake operation. As well, significantly increased underflow sludge pumping capacity may be necessary to ensure adequate recycle.

Potential Plant Improvements

The following should be considered as measures to upgrade the performance of the existing plant. They are provided in a general order of decreasing priority.

1. Convert the Clarifiers to Parallel Operation

    Achieving a split in flow proportional to each clarifier's surface area will greatly reduce the hydraulic loading and result in improved clarification performance over that from the current series arrangement. This will be a much more productive application of the second unit.

2. Review pH Control Set Points and Flocculant Addition Locations

    These are basically no cost measures that could lead to improvements in final effluent quality. The point about pH control is that the optimum values(ie those to achieve the lowest dissolved zinc concentrations) will almost certainly be different for different water mixture feeds. Generally, the optimum control point in a pH range of about 9 to 10.5 will be inversely proportional to feed water strength.

    Concerning flocculant addition, significant improvements can sometimes be made with simple adjustments to addition methods and locations. On this and pH control, some experimentation may be necessary but it may yield good returns.

3. Install "Fitch type" Feedwells in the Clarifiers

    These consist of significantly larger diameter and deeper feedwells with a feed piping arrangement that entails the splitting of the feed to opposite sides and elevations of the feedwell. The objective with these is to eliminate currents within the clarifiers themselves. At Kimberley, this conversion was made in a 120 foot diameter unit with a resultant average improvement in final TSS levels from 10 to about 4 mg/L. The cost for the installation was about $60,000.

4. Install "Thixo posts" on Clarifier Rakes

    These are simple angle iron posts from the rakes superstructure to the actual rakes that allows the elevation of the former from the sludge bed. This may result in the elimination of the solids "stirring" action that has been apparently observed in the plant. The design of the rakes and drive systems would have to be reviewed to determine if this conversion is feasible.