KEY POINT: The permitting process for deep well injection can be very complex due to environmental and geologic concerns.

SUMMARY OF ISSUES

- **Desal concentrate is considered an “industrial waste” under the Clean Water Act.** As a result, it must be injected via a Class I well per EPA Underground Injection Control (UIC) regulations. This regulatory framework restricts the number of compliant well sites and requires more conservative well construction, which can increase the cost associated with this method of concentrate management.

  Class I wells require 1) the injection zone to be at a greater depth than the USDW zone (underground sources of drinking water defined as water of less than 10,000 mg/L), 2) all casing down to the injection zone to be concrete lined, and 3) the use of a tubing and packer arrangement for injection and monitoring. The tubing and packer involves the injection tubing surrounded by a casing with the annular space between them filled with a monitoring fluid that is tested for changes in conductivity as an indication of leakage from the tubing. The special Class I requirements make Class I wells more expensive than wells in other classes.

  Texas has investigated the possibility of injecting concentrate via Class II (oil and gas wells) and Class V wells (well used for some non-hazardous waters, non-industrial waters). Class II and Class V wells do not have the above mentioned Class I requirements. As of 2009, in Texas, concentrate can be injected into Class II wells for the purpose of enhanced oil recovery and into Class V wells if the concentrate is 1) of lower salinity than the reservoir salinity and 2) meets primary water quality standards.

- **Deep well injection is not permitted in every state,** but those that do allow it, including California, Florida, Texas and New Mexico, require permits, monitoring wells, and completions in deep contained aquifers. To date, deep well injection for municipal concentrate management has been seldom used outside of Florida (where approximately one quarter of the desal facilities utilize this method of concentrate management), which has some of the best-suited geology (Mickley 2006).

- **The primary environmental concern associated with deep-well injection is potential concentrate leakage from** the injection well and/or the underground aquifer. If the injection well is not properly constructed and if the aquifer is not adequately separated
from other aquifers (including water supply aquifers) in the area, these aquifers may be contaminated by the injected concentrated pollutants (Xu et al. 2009).

- **Historically, some deep injection wells used for injection of hazardous wastes caused several large-magnitude earthquakes** (5 or greater on the Richter scale) and several thousand smaller ones in areas that are structurally stressed, including the Rocky Mountains in Colorado (NRC 2008 from Evans 1966 and Hsieh and Bredehoeft 1981) and the Rangely oil field in Colorado (NRC 2008 from De la Cruz and Raleigh, 1972). However, high injection pressures were used in these situations. Concentrate injection in artesian aquifer systems (which are typical of most formations used for deep-well injection), can cause increases in fluid pressure and vertical expansion of the aquifer framework, which may be expressed as a rise in land surface. Injection pressures used for concentrate injection are at pressures well below fracture pressures. Increase in fluid pressure can also trigger earthquakes in certain geologic environments (NRC 2008).

- **Relative to other concentrate management options, deep well injection requires a significant amount of data gathering and analysis prior to determination of technical feasibility.** This includes analysis available hydrogeological data, drilling of test wells, and testing of the wells.

### STRATEGIES

- From an environmental perspective, deep well injection is more acceptable if the salinity of the water in the formation matches or exceeds that of the concentrate, such that the quality of the confined aquifer is not degraded.

- To prevent adverse impacts to surrounding aquifers, the volume, location, and solute composition of any potentially displaced aquifer fluids and how they might influence the water quality of surrounding aquifers or surface waters must be well understood. This involves quantifying all flow boundaries and simulating groundwater flow dynamics using appropriate three-dimensional numerical transport and flow models.

- Modeling of concentrate and aquifer blending is helpful to indicate the possibility of precipitation of salts in the reservoir. A recent injection site (El Paso) is equipped with the capability of acid and antiscalant injection at the wellhead as a potential tool to use in the event of problematic precipitation.

- If the target formation is deep or in an area that has experienced tectonic activity in the relatively recent geologic past, the geologic conditions of proposed injection sites should be evaluated for potential increases in fluid pressure and vertical expansion.
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BENEFITS & COSTS

Benefits

› Given appropriate geologic conditions, deep well injection generally has the lowest environmental impact of all concentrate disposal options.

› Economies of scale make this disposal option more affordable for accommodating larger volume concentrates

› Over the long term the high capital investment may be partially offset by relatively low operating costs.

Costs

› The process of determining the feasibility of deep well injection, designing and constructing a Class I injection well, can be very expensive.

› Regulatory restrictions limit the number of compliant well sites and require more conservative well construction, which increases the costs associated with this method of concentrate management.

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KEY UNCERTAINTIES

Deep well injection is limited to site-specific conditions of confined aquifers with sufficient storage capacity and good soil transmissivity (Mickley 2006). According to Xu et. al. 2009, the permit for deep well injection is becoming more stringent because of the potential of leakage from the wells.

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