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Use of Produced Water in Recirculating Cooling Systems at Power Generating Facilities

Deliverable Number 9
Scaled and/or Demonstration Projects

Kent Zammit, EPRI Project Manager
3412 Hillview Ave.
Palo Alto, CA 94304-1395

Prepared by
Michael N. DiFilippo, Principal Investigator

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Abstract

The purpose of this study is to evaluate produced water as a supplemental source of water for the San Juan Generating Station (SJGS). This study incorporates elements that identify produced water volume and quality, infrastructure to deliver it to SJGS, treatment requirements to use it at the plant, delivery and treatment economics, etc.

SJGS, which is operated by Public Service of New Mexico (PNM) is located about 15 miles northwest of Farmington, New Mexico. It has four units with a total generating capacity of about 1,800 MW. The plant uses 22,400 acre-feet of water per year from the San Juan River with most of its demand resulting from cooling tower make-up. The plant is a zero liquid discharge facility and, as such, is well practiced in efficient water use and reuse.

For the past few years, New Mexico has been suffering from a severe drought. Climate researchers are predicting the return of very dry weather over the next 30 to 40 years. Concern over the drought has spurred interest in evaluating the use of otherwise unusable saline waters.

This deliverable describes possible test configurations for produced water demonstration projects at SJGS. The ability to host demonstration projects would enable the testing and advancement of promising produced water treatment technologies. Testing is described for two scenarios:

- Scenario 1 – PNM builds a produced water treatment system at SJGS and incorporates planned and future demonstration projects into the design of the system.
- Scenario 2 – PNM forestalls or decides not to install a produced water treatment system and would either conduct limited testing at SJGS (produced water would have to be delivered by tanker trucked) or at a salt water disposal facility (SWD).

Each scenario would accommodate demonstration projects differently and these differences are discussed in this deliverable.

PNM will host a demonstration test of water-conserving cooling technology – Wet Surface Air Cooling (WSAC) using cooling tower blowdown from the existing SJGS Unit 3 tower – during the summer months of 2005. If successful, there may be follow-on testing using produced water. WSAC is discussed in this deliverable.

Recall that Deliverable 4, Emerging Technology Testing, describes the pilot testing conducted at a salt water disposal facility (SWD) by the CeraMem Corporation. This filtration technology could be a candidate for future demonstration testing and is also discussed in this deliverable.

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Executive Summary

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This deliverable describes possible test configurations for produced water demonstration projects at SJGS. The demonstration projects would enable the testing and advancement of promising produced water treatment technologies. Testing is described for two scenarios.

In Scenario 1, PNM would build a produced water treatment system at SJGS where pilot testing would be conducted side-by-side with a produced water treatment system at SJGS. An advantage of this scenario is that multiple demonstration projects could be tested simultaneously. Process stream(s) could be taken from different points in the produced water treatment process as feed for the demonstration project, e.g. raw produced water, precipitation clarifier effluent, media filter effluent, etc. This scenario is ideal for demonstration tests, because the infrastructure would be in place to receive and process produced water at SJGS.

In Scenario 2, PNM would forestall or decide not to install a produced water treatment system and would either conduct testing at SJGS or at a SWD. In Scenario 2a, produced water would have to transported to SJGS by tanker truck. It may be possible to install temporary feedwater and wastewater lines for a pilot test unit from the coal mine that supplies fuel to SJGS. Product water would not be usable at SJGS unless it was desalinated in the demonstration process. If product water is not usable, it would have to be sent back to the SWD it came from (or the coal mine). Also, special provisions would have to be made to contain process spills and leaks.

In Scenario 2b, produced water would be treated at a SWD and no special provisions would be needed for produced water transport. The product water may be usable at an SWD, e.g. if the demonstration process is filtration, the water could be injected for disposal (with produced water via deep well injection) without further treatment. If product water was not usable, it would be sent upstream for re-treatment (de-oiling and filtration) or to the SWD waste tank.

Unless there is a compelling reason to test produced water demonstration technologies at SJGS, it would be easier to test them at a SWD, where there is infrastructure to readily supply and dispose of produced water.

PNM will host a demonstration test of WSAC water-conserving cooling technology operating on SJGS Unit 3 cooling tower blowdown during the summer months of 2005. If successful, there may be follow-on testing using produced water. WSAC technology is a good example of a testing that must be located at a site that has a significant thermal load, i.e. SJGS with a large cooling system.

Ceramic filter pilot testing will be conducted at McGrath SWD[1] (salt water disposal facility) during July 2005 by the CeraMem Corporation (and is described in detail in Deliverable 4). Ceramic filtration is an example of technology that is easily tested at an SWD. This filtration technology could also be a candidate for future demonstration testing.

[1] McGrath SWD is owned and operated by Burlington Resources, a major oil and gas producer in New Mexico.

9.1 Introduction

This deliverable describes possible test configurations for produced water demonstration projects at San Juan Generating Station (SJGS). Public Service of New Mexico (PNM) is the majority owner of SJGS and is responsible for plant operations. The ability to host demonstration projects would enable the testing and advancement of promising produced water treatment technologies. Testing is described for two scenarios:

- Scenario 1 – PNM builds a produced water treatment system at SJGS and incorporates planned and future demonstration projects into the design of the system.
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Recall that Deliverable 4, Emerging Technology Testing, describes the pilot testing conducted at McGrath SWD[1] by the CeraMem Corporation. This filtration technology could be a candidate for future demonstration testing and is also discussed later in this deliverable.

9.2 Produced Water Testing Scenarios

A wide array of demonstration projects could be implemented if a produced water treatment plant were built at SJGS. Test unit feed, product and wastewater streams could easily be incorporated into the design of the produced water treatment plant. For example, a filtration technology could be tested by inserting it parallel to the filters in the produced water treatment plant. Product water from the test filters could be used downstream as make-up to the weak-acid softeners and wastewater could be sent upstream to the precipitation clarifier.[2]

On the other hand, if a produced water treatment plant was not built, testing could still be conducted at SJGS, but it would be limited. Produced water would have to be transported to the plant by tanker truck. Pilot testing streams (feedwater, product water and wastewater), depending on quality (e.g. TDS), would likely have to be taken back to the producer for deep-well disposal. If the treated water quality[3] was acceptable, it could

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[1] McGrath SWD is owned and operated by Burlington Resources. Refer to Deliverable 1, Produced Water Assessment.
[2] Refer to Deliverable 3, Treatment & Disposal Analysis, for a description of the recommended produced water treatment process.
[3] Refer to Deliverable 3 for an analysis of SJGS water quality requirements.

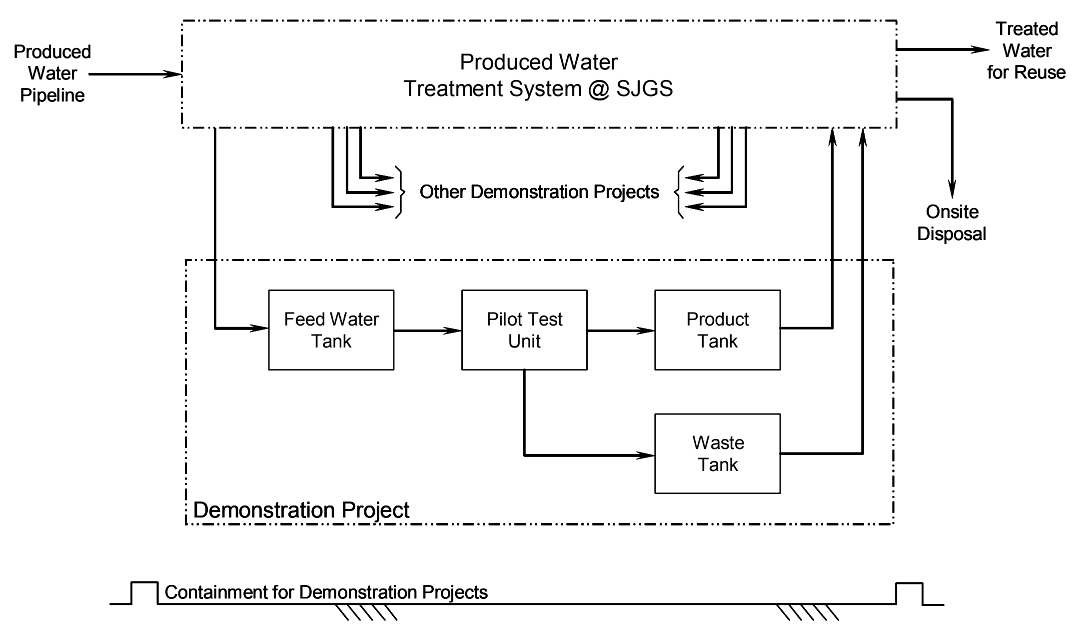
be used at the plant, e.g. for cooling water make-up.[4] The special-handling requirements for demonstration projects in this scenario would simply limit the number of possible tests.

Depending on the demonstration project, it might be more cost effective to conduct the testing at an SWD, because all process streams could be easily supplied, handled and injected into a well for disposal.

9.2.1 Scenario 1 – Incorporate Pilot Testing into a Produced Water Treatment System at SJGS

In this scenario, pilot testing would be conducted side-by-side with a produced water treatment system at SJGS. Refer to Figure 9.1 for a schematic of this concept. One or more demonstration projects could be tested in this scenario. Process stream(s) would be taken from different points in the produced water treatment process as feed for the demonstration project., e.g. raw produced water, precipitation clarifier effluent, media filter effluent, etc. Demonstration projects would be installed physically close to the produced water treatment system and would have to be fully contained to capture process leaks and/or losses. The demonstration project would provide temporary storage for feedwater, product water and wastewater as well as pumps (not shown in Figure 9.1) to transfer process streams.

Figure 9.1



Scenario 1 – Process Schematic for SJGS Testing
Produced Water Project

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[4] Recently passed legislation in New Mexico allows the "disposal" of produced water at electric power plants. Refer to Deliverable 1, Produced Water Assessment.

This scenario is ideal for demonstration tests, because the infrastructure would be in place to receive and process produced water at SJGS (including a pipeline that would deliver produced water to SJGS). Also, onsite infrastructure could likely accommodate a number of demonstration projects – all operating in parallel.

9.2.2 Scenario 2 – Stand-Alone Pilot Testing at SJGS or an SWD

In this scenario, a produced water treatment plant would not be built at SJGS and pilot testing would be conducted at either SJGS or an SWD as stand-alone tests, Scenarios 2a and 2b, respectively. Refer to Figures 9.2 and 9.3 for process schematics.

Scenario 2a – Testing at SJGS

In this scenario, produced water would be transported to SJGS by tanker truck and delivered to a temporary feedwater tank. Trucking would be required because there would be no produced water pipeline in place. As a point of reference, a 10-gpm pilot plant would require three deliveries (5,000-gallon tanker trucks) of produced water per day to operate. The demonstration unit would be placed in an area where spills could be easily controlled by means of a temporary containment system. An earthen dyke would be constructed around the demonstration unit and a synthetic membrane liner would be set in place to contain spills and leaks.[5]

Treated water and wastewater would be collected in temporary product and waste tanks. Product water would be unusable[6] at SJGS (unless it was desalinated), because regional produced water has high levels of TDS and chloride. If product water is not usable, it would be sent to the waste tank. All wastewater from testing would have to be transported by truck to the SWD it came from.

It may be possible to install temporary feedwater and wastewater lines for a pilot test unit from the coal mine that supplies fuel to SJGS. Each pipeline would have to have transfers tanks and pumps at each end for feedwater (mine water to SJGS) and wastewater (unusable water returned to the mine). The coal mine, which is operated by BHP Billiton, generates water similar to coal bed methane (CBM) produced water.[7] In planning a demonstration test at SJGS, the cost of trucking produced water to SJGS would have to be evaluated against the cost of supplying it with a temporary pipeline.

Scenario 2b – Testing at an SWD

In this scenario, produced water would be treated at a SWD, therefore transport by tanker truck would not be required. Produced water from SWD storage would be delivered to a temporary feedwater tank. The demonstration unit would be placed in an area where spills could be easily controlled by means of the SWD containment system.[8] Treated water and wastewater would be collected in temporary product and waste tanks.

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[5] SJGS has strict liquid discharge limits. Any variations to discharge volume or chemistry or accidental releases of process water must be reported.
[6] Refer to Deliverable 3 for an analysis of SJGS water quality requirements.
[7] This water was evaluated as a possible supplementary of produced water in Deliverable 3, Treatment & Disposal Analysis.
[8] Depending on the SWD, a separate containment area may have to be constructed to contain spills and leaks.

Figure 9.2

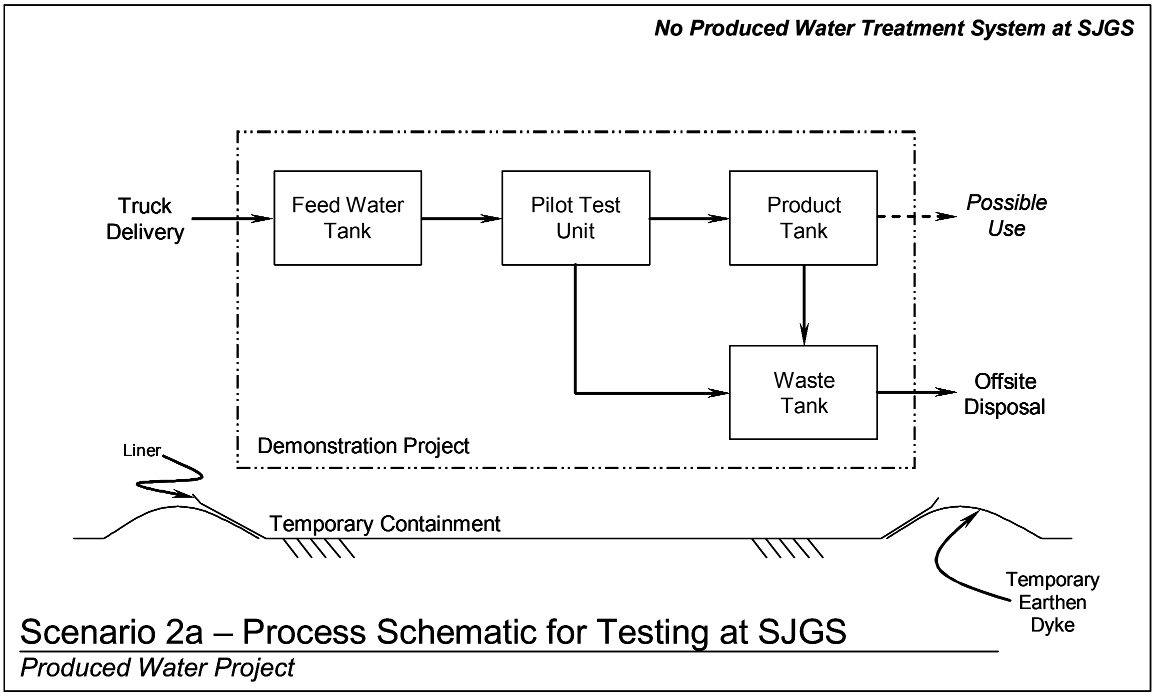
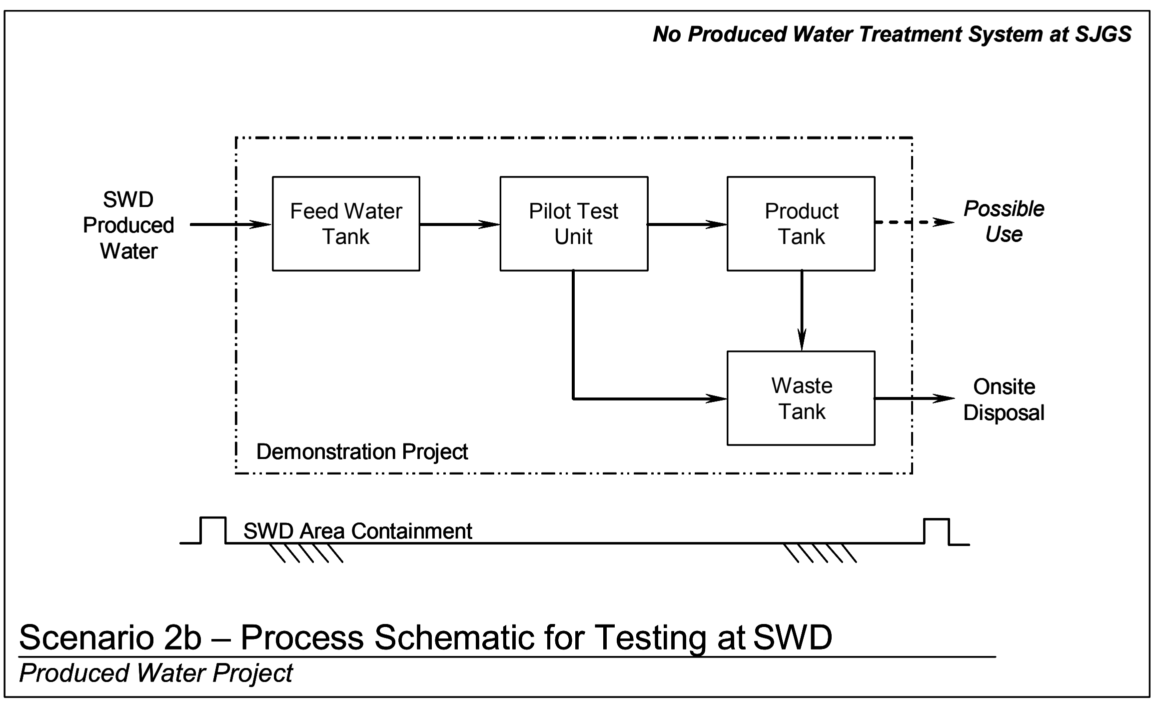


Figure 9.3



The product water may be usable at an SWD, e.g. if the demonstration process is filtration, the water could be injected for disposal (with produced water via deep well injection) without further treatment. If product water was not usable, it could be sent upstream for re-treatment (de-oiling and filtration) or to the SWD waste tank.

Unless there is a compelling reason to test produced water demonstration technologies at SJGS, it would be easier to test them at an SWD, where there is infrastructure to readily supply and dispose of produced water. On the other hand, WSAC water-conserving technology (discussed next) is a good example of a testing program that must be located at a site that has a significant thermal load, i.e. SJGS with a large cooling system.

Examples follow of Scenarios 2a and 2b, i.e. pilot tests planned for SJGS and SWD.

9.3 WSAC Testing at SJGS

PNM will host a demonstration test of WSAC cooling technology during the summer of 2005 at SJGS. A WSAC test unit will cool a 650-gpm slipstream of Unit 3 circulating water[9] and will use Unit 3 blowdown as the WSAC cooling medium. WSAC is a demonstrated cooling technology, however, because of its unique water circuit, it is being tested at SJGS as a water-conservation device. Generally, the testing will determine if WSAC technology can use cooling tower blowdown as a cooling medium instead of freshwater. If successful, there could be follow-up testing using produced water as the cooling medium.

Water to be cooled (Unit 3 circulating water) enters the WSAC and passes through a heat exchanger (inside the tubes). Refer to Figure 9.4 for a schematic of the pilot unit. Circulating plant water is cooled by way of deluge spraying of cooling water on the outside of the exchanger tubes. Cooling air flows over the tubes in the same direction as the deluge water. Ambient air is drawn through the heat exchanger bundles and around to the fans where it exhausts. WSAC cooling (deluge) water is collected in the WSAC basin and circulated back to the nozzles to be sprayed again. <u>WSAC cooling water and Unit 3 circulating water do not mix in this process</u>. Cooling occurs as a small fraction of WSAC cooling water evaporates (into the air stream) while deluging the tubes. As water evaporates, Unit 3 blowdown (same as Unit 3 circulating water) is fed to the WSAC to compensate for the losses. WSAC blowdown will be closely monitored to control the build-up of mineral scales.[10]

Chemistry is one of the primary concerns of using degraded waters (like produced water), i.e. it is usually saline with high levels of scale-forming constituents. The unique characteristic of WSAC is that it allows scale to form, but because the cooling water deluges heat transfer surfaces, scale stays in suspension. Scale typically settles in the WSAC basin and does deposit on heat transfer surfaces. Testing goals are:

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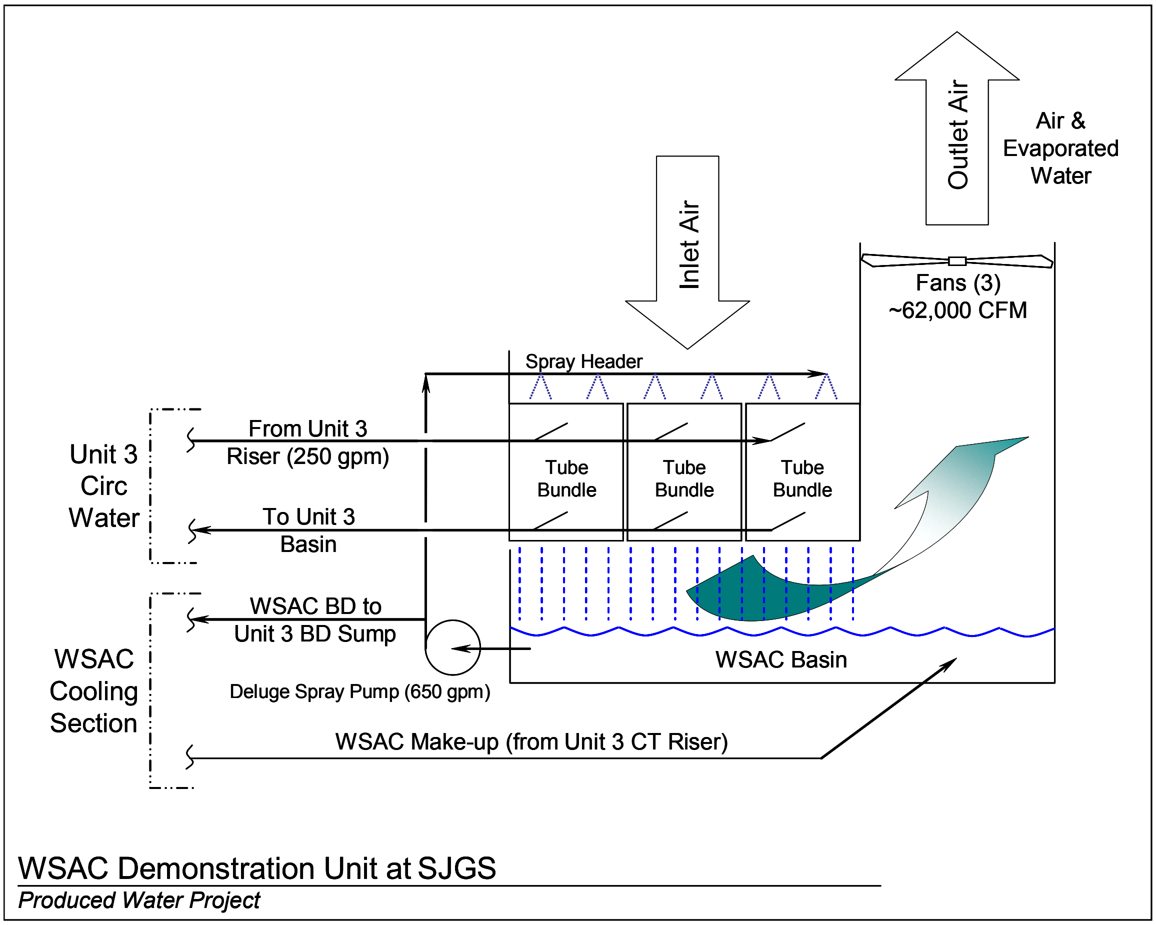
[9] Circulating water is the primary means of cooling for the plant. It is used to condense steam in the power generation cycle.

[10] Scale is comprised of hard mineral deposits that form as water is heated and evaporated. It inhibits heat transfer, so power plants are constantly trying to control scale formation.

- Determine the cycles of concentration[11] the WSAC can manage before it scales.
- Determine the type of control required to operate at high cycles of concentration, i.e. pH, scale inhibitors, scale dispersants, etc. (typical cooling system control parameters).
- Determine the degree to which SJGS cooling tower blowdown be concentrated, i.e. what level of water conservation can be achieved at SJGS using WSAC.
- Determine compatible metallurgy for effective corrosion control.

This testing will provide valuable data on power plant water use and reuse, especially as it relates to the possible use of produced water for cooling. Results of the testing will be reported separately from this project.

Figure 9.4



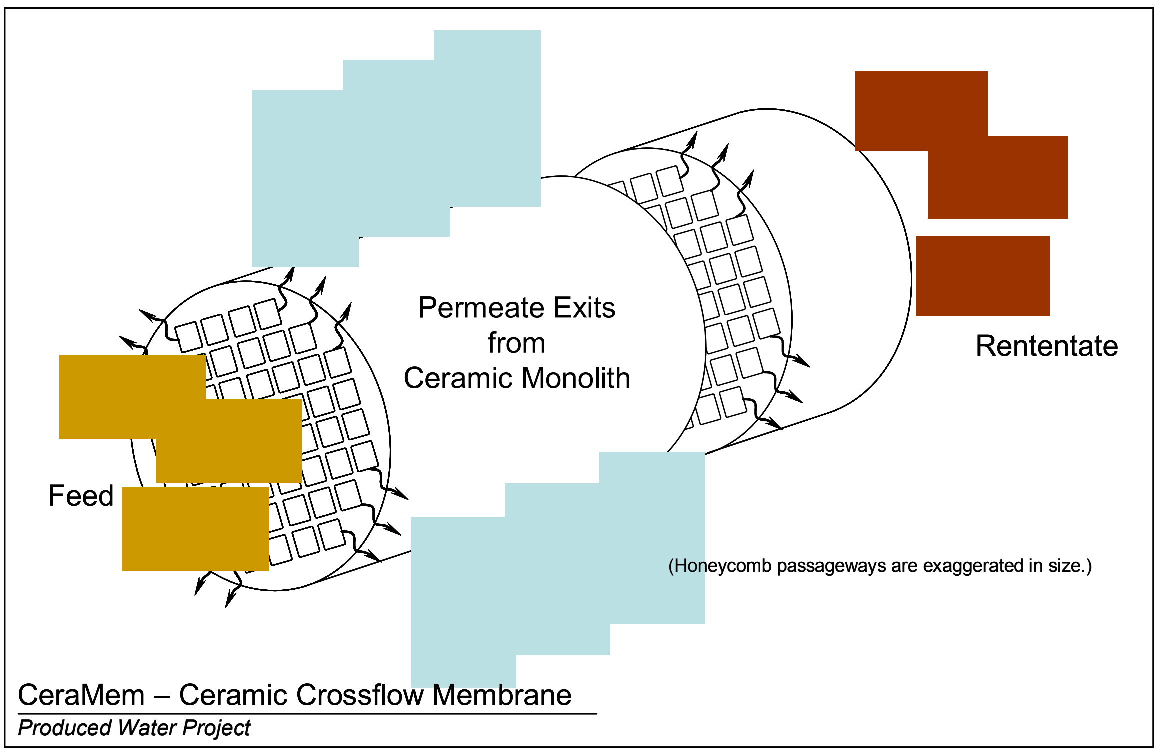
[11] Cycles of concentration is a measure of water utilization in a cooling system. For example, if a cooling tower is operating at five cycles of concentration, it has concentrated the feedwater by a factor of five times. Naturally occurring salts in water concentrate because heat is exchanged in a cooling tower by evaporating water. At higher cycles of concentration, water use (make-up) is reduced, i.e. less wastewater (blowdown) is generated.

9.4 Ceramem Testing at McGrath SWD

Bench-scale testing will be conducted during the summer of 2005 by CeraMem Corporation at the McGrath SWD to evaluate ceramic membrane filtration. McGrath is an ideal location to test this type of equipment (as well as other technologies), because it receives produced water from a range of sources, and thus water quality varies dramatically. Membrane filters could significantly reduce the level of oil, oil emulsions and particulate matter in produced water. A benefit of this technology is that ceramic membranes could last for a significant period of time, thereby reducing the operating cost of pretreatment. As such, it could be a valuable pretreatment process for reverse osmosis.

Crossflow ceramic filters are cylindrical in shape and are comprised of an array of passageways resembling a honeycomb. Refer to Figure 9.5. Water that is filtered (permeate) flows through the ceramic membrane. Impurities and a fraction of the feedwater stay behind (rententate) to exit the passageways for disposal (or further treatment). This process configuration allows for long periods of continuous operation between membrane cleanings.

Figure 9.5



Water at McGrath SWD is initially stored in receiving tanks and then passed through an oil-water separator to remove grit and floatable oil. The pretreated water is placed in intermediate storage and then passed through two levels of filtration, i.e. deep-bed sand filters followed by 5-micron cartridge filters. The water is then ready for deep well injection.

It was decided that the CeraMem test equipment should treat effluent from the sand filters at McGrath SWD, because ceramic membranes would eliminate the need for cartridge (final) filtration for reverse osmosis in a produced water treatment system. Additionally, ceramic membranes could augment the removal of oil in the effluent of the media filters. It may also be possible to use this technology at SWDs, since cartridge filter replacement is one of the largest costs of treating produced water for disposal.

Since the pilot test unit is quite small, product and wastewater will be sent to the waste sump at McGrath. McGrath has provided a small building for the purpose of bench[12] testing promising technologies. The building is designed to contain minor process leaks and spills.

Results of the testing are found in Deliverable 4, Emerging Technology Testing.

9.5 Summary

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[12] Bench-scale testing is usually small in scale and involves the first step in proof-of-concept testing for a technology.

Unless there is a compelling reason to test produced water demonstration technologies at SJGS, it would be easier to test them at a SWD, where there is infrastructure to readily supply and dispose of produced water. WSAC water-conserving technology is a good example of a testing program that must be located at a site that has a significant thermal load, i.e. SJGS with a large cooling system.

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