SGW-61673
Revision 0

TREATMENT OF MODUTANK WATER AT 200 WEST PUMP AND TREAT

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
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Terms

DO	dissolved oxygen
ETF	Effluent Treatment Facility
FBR	fluidized bed reactor
FY	fiscal year
NCO	nuclear chemical operator
ORP	oxidation-reduction potential
P&T	pump and treat
TDS	total dissolved solids
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSS	total suspended solids

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1 Purpose

The purpose of this document is to evaluate the 200 West Pump and Treat (200 West P&T) for treatment of Modular Storage Unit (hereinafter referred to as Modutank) water to remove constituents known to cause injection well fouling and to augment the natural evaporation process. Fouling of 200 West P&T injection wells requires regular well maintenance. Well fouling is detrimental to the overall plant throughput. Multiple improvements to operations, plant design, and well development techniques have been implemented to limit well fouling. For example, recently the phosphorus-based antiscalant at the 200 West P&T was replaced with a "green" alternative that resulted in a 90% reduction of phosphorous in the treated effluent. Phosphorus is a known stimulant to biological growth.

This document evaluates a proposed method to reduce additional constituents known to cause injection well fouling. Specifically, a more effective way to manage well development water that involves the use of existing modular storage units and filtration to greatly reduce well fouling constituents into the 200 West P&T is proposed.

This document provides recommendations for successful processing of Modutank water at the 200 West P&T to remove well foulants and to augment evaporation.

The Modutanks consist of two aboveground modular containment units designed to store around 3,785,400 L/min (1,000,000 gal) (Modutank 2) and 4,807,458 L/min (1,270,000 gal) (Modutank 3) of purgewater for treatment via solar evaporation. Purgewater is defined as water extracted or otherwise derived from the ground in connection with well development, well remediation and construction, well sampling, well decommissioning, well maintenance, aquifer testing, and decontamination water (DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*). The storage units are located in the 600 Area, near the Effluent Treatment Facility (ETF).

Historically, the Modutanks have accepted purgewater from well construction and development activities. This purgewater often contains solids with the groundwater, mostly silts and sands associated with well development. In addition, well redevelopment water also contains chemicals used to clean and recondition the wells (e.g., sulfuric acid or hydrogen peroxide) along with the well foulants that are being removed (i.e., biosolids, manganese, aluminum, iron, and calcium). On several occasions biological solids (biosolids) were trucked to the Modutanks for disposal when the 200 West P&T could not process its biosolids. Since this time the water in the Modutanks has been from well development and well redevelopment activities. It is notable that the solids are mounded at one end of the Modutank, the end that receives the deliveries. The accumulated solids are typically covered with water to prevent dust formation and wind dispersion.

An initial feedstream analysis was performed to assess the capability of the 200 West P&T to treat Modutank water (SGW-61287, *Impact of Modutank Water on the 200 West Pump and Treat*). The guidelines used to evaluate adding Modutank water to the feed stream are outlined in SGW-59872, *Feed Acceptance Criteria for 200W Pump and Treat*. The feedstream analysis found that manganese was a key contaminant that could cause increased fouling of injection wells if present at the 95th percentile concentration (5,050 µg/L). The feedstream analysis recommended additional sampling including filtered samples and to restrict flow from the Modutanks to below 189 L/min (50 gal/min) unless sampling indicated otherwise. This evaluation carries this recommendation further to provide recommendations to remove known well foulants such as manganese to avoid recycling them back to the plant.

2 Water Quality

Modutanks 2 and 3 have been sampled annually since 2013. The contaminant concentrations fluctuate as the Modutanks accept purgewater of varying quality and then allow constituents to concentrate by evaporation. The feed stream analysis (SGW-61287, *Impact of Modutank Water on the 200 West Pump and Treat*) recommended additional samples to augment and update the historical data.

Table 1 summarizes the data from annual sampling events from March 2013 through March 2017. A comparison of the average to the 95th percentile values provides perspective on the degree of variation observed over this time. Note that the average uranium and technetium-99 concentrations are below the cleanup levels and do not require treatment. However, the 95th percentile uranium concentration is greater than the cleanup level of 30 µg/L and would require treatment. This variation causes uncertainty in the chemical quality of the water in the Modutanks. Risk from this uncertainty is addressed in Chapter 3.

Table 1. Key Contaminant Concentrations from Yearly Sampling Events from 2013 Through 2017

Constituent	Units	Average Concentration	95th Percentile Concentration
Nitrate	mg/L	0.43	0.81
Uranium	µg/L	8.63	42.7
Technetium-99	pCi/L	38.2	61.1
Iodine-129	pCi/L	0.98	1.87
Tritium	pCi/L	2254	3223
Hexavalent chromium	N/A	N/A	N/A
Chromium (total)	µg/L	5.58	10.9
Carbon tetrachloride	µg/L	0.19	0.30
Trichloroethylene	µg/L	0.27	0.30
Cyanide	N/A	N/A	N/A
Chloroform	µg/L	0.17	0.30
pH	unitless	9.45	10.1
ORP	RmV	338	350
Sulfate	mg/L	248	439
TDS	mg/L	985	1223
Hardness	mg/L	347	524
TSS	mg/L	50.8	70
DO	mg/L	13.6	15.9
Alkalinity	mg/L	198	425

DO = dissolved oxygen
N/A = not available
ORP = oxidation-reduction potential
TDS = total dissolved solids
TSS = total suspended solids

The pH and oxidation-reduction potential (ORP) were found to be greater than expected. In the four annual sampling events between 2013 and 2017, average pH was 9.45 and the average ORP was 338 RmV. The author postulates that the known algal growth observed in the Modutanks is responsible for the high pH and ORP. Like all plants, algae remove CO2 from and produce O2 to the water column as a consequence of photosynthesis. Removing CO2 causes the pH to increase. This is a well-documented phenomenon in natural water bodies and algal treatment systems. The addition of oxygen to the water helps maintain a high ORP.

The high pH and ORP create a chemical environment conducive to the removal of many of the metals responsible for well fouling, such as manganese. Manganese in particular has been observed in the injection system piping and in the wells (SGW-61398, *Nature of Injection Well Foulant and Recommendations to Limit Injection Well Fouling at 200 West Pump & Treat*). Figure 1 shows that manganese in the plant effluent began to increase in the summer of 2015 to values well above 1,000 μg/L. In contrast manganese is added to the treatment process as one of the micronutrients at doses of 50 to 70 μg/L. The authors theorize that excess manganese, not used for biological processes, exits the 200 West P&T and collects in the wells and filter pack. When the wells are cleaned, the manganese is pulled out of the well in the purgewater. The first 11,356 to 15,142 L (3,000 to 4,000 gal) of this water is taken to the Modutanks. After that 22,712 to 37,854 L (6,000 to 10,000 gal) of purgewater are taken back to the 200 West P&T for treatment. Any manganese remaining in the purgewater was recycled back to the 200 West P&T where it passed through to the effluent to be recycled to the wells. Over time as well redevelopment methods improved and more manganese was removed from the wells, manganese concentrations continued to build, resulting in a high value of over 10,000 μg/L of manganese in the plant effluent.

The data in Figure 1 show that near the beginning of 2017 manganese concentrations decreased to between 50 and 80 μg/L. It was in this timeframe that all purgewater was returned to the Modutanks. No purgewater was brought to the 200 West P&T facility, halting the recycling and build up of manganese.

Figure 2 shows that at high pH and high ORP (pE), insoluble forms of manganese (MnO_2 and Mn(O)OH) will precipitate or be captured by the filters. Similar relationships for the other metals of concern were reviewed; iron is primarily in the form of $Fe(OH)_3$. Zinc precipitates as ZnO at pHs greater than about 8. Copper precipitates as copper oxide (CuO) at pHs greater than 8.

In October 2017, additional samples were taken to evaluate the effectiveness of filtration for removing nuisance metals from Modutank water. The metals concentrations were analyzed before and after filtration with either a 1.0 µm or 5.0 µm filter (Figure 3). Samples were filtered in the field on collection. Typical field measurements as well as total dissolved solids and total suspended solids were also collected.

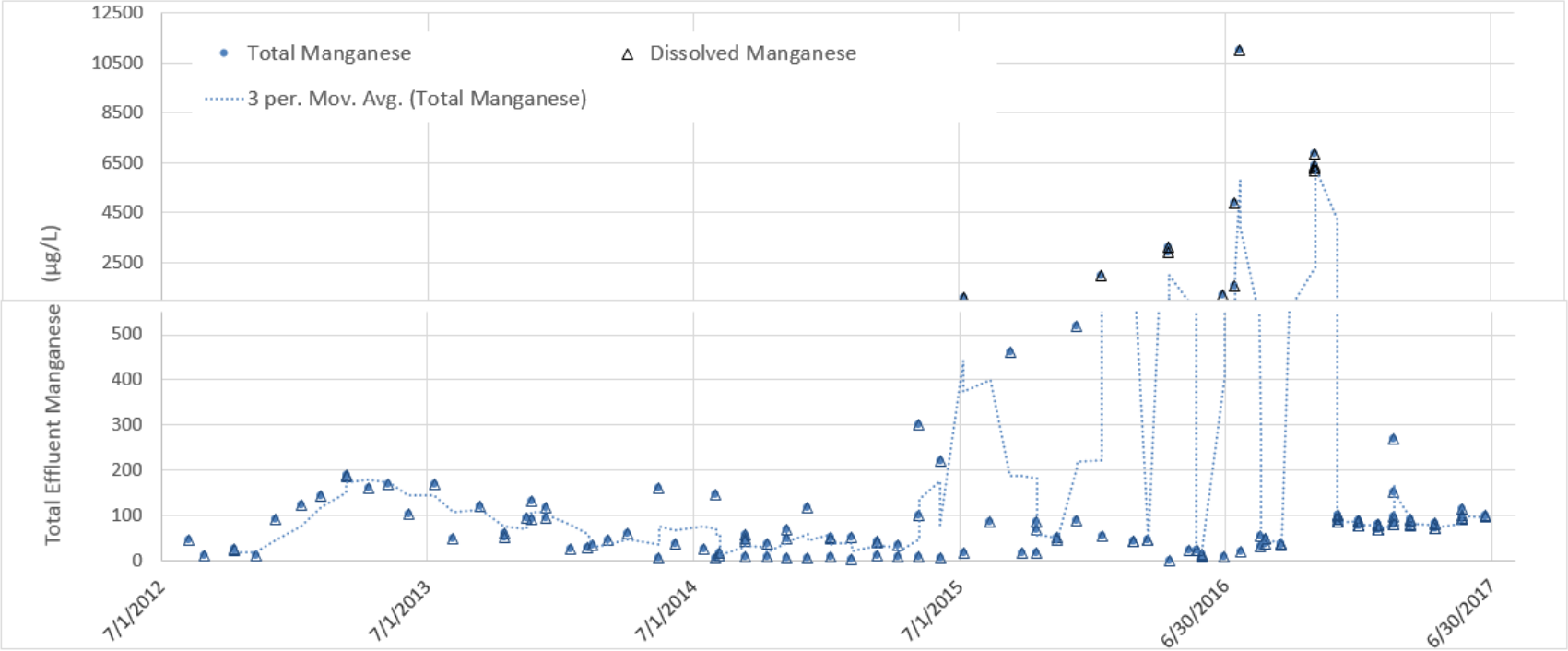
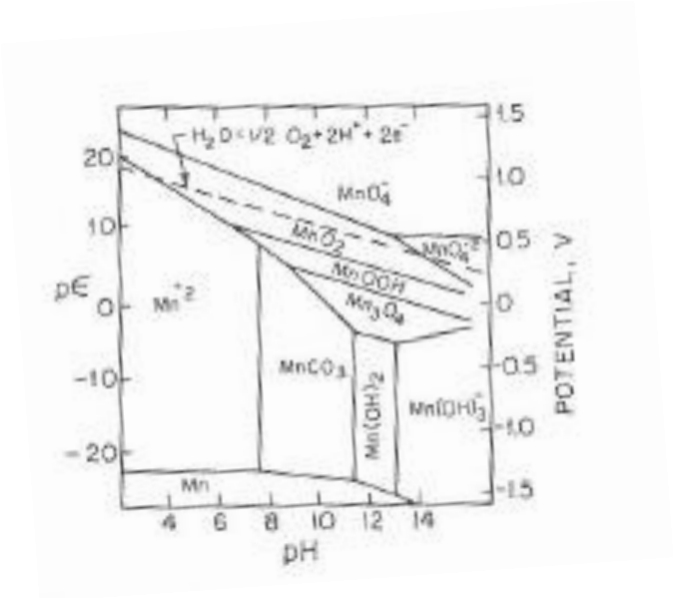


Figure 1. Manganese in Treated Plant Effluent from the 200 West P&T



Source: Figure 10-6 in Stumm and Morgan, *Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters*.

Figure 2. Stability Diagram for Manganese

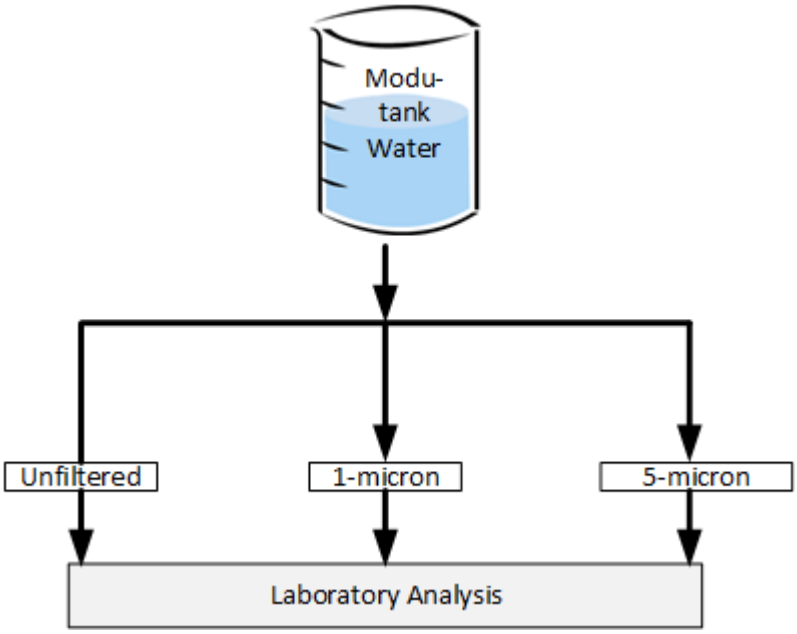


Figure 3. Method Used to Collect Samples of Modutank Water to Simulate Filtration by 1 µm and 5 µm Filters

Table 2 compares the 95th percentile concentrations from the yearly sampling events to the filtered samples taken in October 2017. With the exception of copper, the preliminary sampling results support the results predicted by the chemical stability equations. In addition, the results indicate that a 5.0 µm filter is sufficient to remove most of the manganese and iron, and, to a lesser extent, zinc.

Table 2. 95th Percentile Metal Concentrations Collected from March 2013 Through May 2017 Compared to Filtered Samples Collected in October 2017

		Yearly Sampling	October 2017 Sampling Event*		
Constituent	**Units**	**95th Percentile Concentration**	**Unfiltered**	**5.0 µm Filtered**	**1.0 µm Filtered**
Iron	µg/L	823	456	53	30
Manganese	µg/L	5050	73.7	6.94	2.47
Zinc	µg/L	536	8.9	3.3	3.3
Copper	µg/L	43	32.2	27.4	33.4
Molybdenum	µg/L	76	N/A	N/A	N/A
Nickel	µg/L	20	17.1	14.1	12.6
Aluminum	µg/L	284	<1	<1	<1
Selenium	µg/L	2.2	N/A	N/A	N/A

*Reporting highest measurement from Modutanks 2 and 3.
N/A = not applicable

Copper was present at about 30 µg/L in both filtered and unfiltered samples. Copper sulfate is added to the Modutanks at the request of the ETF for algae control. At the time of sampling ETF was treating the Modutank water with about 2 mg/L copper sulfate pentahydrate (about 500 µg/L as elemental copper). At the pH of the water (about 9.5) copper is expected to be less than 1 µg/L. The author theorizes that the copper had not had enough time to completely transform to an insoluble form.

The low concentration of metals involved in well fouling in the filtered Modutank water strongly suggests that the Modutanks can be used as part of the overall strategy to control well fouling. The purgewater can be trucked to the Modutanks and stored. Once or twice a year the Modutank water can be filtered with 5 µm filters and transferred to the 200 West P&T.

Table 3 summarizes the typical influent concentration without Modutank water and when blending Modutank water at 170 L/min (45 gal/min). Comparing this with the criteria in the feedstream acceptance document for the 200 West P&T (Tables 2 and 3 of SGW-59872), none of the constituents exceed the recommended blended influent concentration.

Table 3. Influent Concentration for Key Constituents when Treating Modutank Water

Constituent	Units	Concentrations			Waste Acceptance Criteria (SGW-59872)
		Equalization Tank[a]	Modutank[b]	Blended Influent (Modutank Flow = 45 gal/min; Other Flows = 2,000 gal/min)	
Nitrate as N	mg/L	23.5	0.8	23.0	40
Carbon tetrachloride	µg/L	440	<0.3	430	675
Technetium-99	pCi/L	100	34.4	99	14,700
Chromium	µg/L	21.0	2.7	21	47
Trichloroethylene	µg/L	3.60	<0.3	4	4
Uranium	µg/L	1.0	2.8	1.0	570
Manganese	µg/L	1.0	6.9	1.1	No impact expected
Iron	µg/L	30.0	53.0	31	No impact expected
Zinc	µg/L	3.3	3.3	3.3	No impact expected
Copper	µg/L	<0.3	28.3	0.9	No impact expected
Molybdenum	µg/L	3.8	25.5	4.3	No impact expected
Aluminum	µg/L	<19.3	<19.3	<19.3	No impact expected
Sulfate	mg/L	56.0	186.0	59	60
pH	unitless	7.50	8.50	7.5	7.0 to 7.8

Reference: SGW-59872, *Feed Acceptance Criteria for 200W Pump and Treat.*

a. From equalization tank sample on October 16, 2017.

b. From March 13, 2017 (total) or October 5, 2017 sampling of Modutank water (field filtered through 5 µm filter).

3 Risks

Several risk elements are associated with the treatment of Modutank water. These risks are documented and addressed in the following sections.

3.1 No Action

One risk of no action is that the Modutanks could reach maximum capacity and there would be no place for purgewater to be treated. As a result activities associated with new well development and existing well redevelopment would cease. Production at the 200 West P&T would be compromised.

Another risk is that all purgewater is recycled directly back to the 200 West P&T causing the recycled compounds to increase in concentration and cause more rapid fouling of the wells. At some point production would be compromised.

The risk of no action is so great that this alternative is not considered further.

3.2 Treatment at the Effluent Treatment Facility

The ETF has been unable to reliably treat Modutank water; therefore, the key risk is that the Modutanks will become full, raising the production risk described in Section 3.1. The ETF is not equipped to remove solids and the water must be filtered before delivery. There have been instances where the water has been filtered as specified before being loaded into a tanker truck, but more solids formed, likely by biological activity, in the tanker truck. Then, when the water was treated, it clogged the filters at ETF, which caused suspension of further delivery. Treatment has also been interrupted by work stoppages unrelated to the 200 West P&T. Engineering staff at ETF have expressed concern with continued treatment of Modutank water. Although this water can be treated at the ETF, it is not reliable and takes ongoing management interaction and staff coordination to resume. Given the importance of the Modutanks to 200 West P&T operation, the authors do not recommend treatment at ETF at this time.

3.3 Treatment at the 200 West Pump and Treat

Modutank water has the potential to either upset the 200 West P&T treatment process or to exacerbate injection well fouling. The water chemistry in the Modutanks is uncertain because of the multiple sources of varying water quality that are placed in the Modutanks. In addition, evaporation concentrates the dissolved constituents. Finally, the sediments create a relatively isolated environment with the potential for water chemistry that is quite different than the bulk water. This interstitial water likely has lower ORP and different species of metals that are soluble are in higher concentration than the bulk water.

The uncertainty in water chemistry poses some specific risks, including the following:

- If contaminants are in high enough concentrations they may not meet the new feed stream requirements listed in SGW-59872.
- Increased sulfate concentrations could cause upset to the ion exchange and possibly to the biological treatment processes. Sulfate competes with uranium for sites on the resin. Sulfate can be used as an electron acceptor by the bacteria in the fluidized bed reactors (FBRs) once the nitrate is depleted. When this happens hydrogen sulfide will be formed and sulfides have been shown to chemically fix micronutrients making them unavailable to the bacteria.
- Manganese, iron, and aluminum could be released in high concentrations and increase the potential for fouling in the injection well system.

The Modutank water has both bacteria and algae growing. Bacteria and algae in the Modutank may not be compatible with the treatment conditions at the 200 West P&T.

4 Risk Mitigation/Treatment

Table 4 lists the risks identified in the previous chapter along with the proposed mitigation methods. These mitigation efforts provide a key benefit to the 200 West P&T that should not be underestimated. Many of the compounds that pose risk to well fouling are being recycled and concentrated in the injection wells and related piping and tanks. Manganese is a good example. Manganese is added as a micronutrient. Excess manganese passed through the plant where it is concentrated in biofilms throughout the injection well system. The biofilm sloughs off and accumulates in the injection wells until the well is taken out of service for redevelopment. The well redevelopment process yields water that is suspected to have high concentrations of manganese. Some of this water is sent to the Modutanks, but much of the redevelopment water is sent back to the 200 West P&T where it repeats its journey at higher concentrations. Using the risk mitigation methods that follow will not only reduce risk to the 200 West P&T, but will also remove manganese as well as aluminum, iron, and some zinc.

Table 4. Risk Elements Associated with Treating Modutank Water and Recommended Mitigation Steps

Specific Risk Element	Mitigation
Uncertain water chemistry going forward	Sample Modutanks 3 to 6 weeks before pumping. Recent samples will confirm if any constituents are present at concentrations that exceed treatment thresholds.
Introduction of unexpected contaminants from water in interstitial space	Water will be processed from near the surface away from the sediment buildup. The pumping campaign (estimated to be 757,080 [200,000 gal]) is expected to last less than 1 week, and sediments will not be disturbed during this time.
Copper and sulfates	Copper and sulfates will be measured prior to delivery to 200 West P&T and will be blended at a rate to avoid exceeding about 60 mg/L in the influent. If copper sulfate is added for treatment purposes (discussed later in this document) then a mass balance will be performed to determine the expected increase in concentration and blending ratio will be adjusted. This is a conservative approach as much of the copper can be expected to precipitate.
Uranium	Uranium will be measured prior to delivery to 200 West P&T and if present at concentrations >30 µg/L the water will be treated by uranium ion-exchange resin.
Iron and manganese	The water will be filtered through a 5 µm filter. If testing indicates manganese is in dissolved form, the water will be chlorinated to oxidize manganese to a particulate state.
Aluminum	The water will be filtered through a 5 µm filter. Testing has shown aluminum to be removed by filtration.
Algae and bacteria	Water will be filtered. Testing has shown algae to be removed by filtration (see Figures 4 through 6 in this document)

5 Water Processing Requirements

The following water processing requirements were developed both from the mitigation efforts discussed in the previous chapter and previous documentation regarding Modutank water. DOE/RL-2009-31, *Investigation Derived Waste Purgewater Management Engineering Evaluation/Cost Analysis*, evaluates six removal action alternatives for the management of purgewater. Action alternative 2 is described as transporting purgewater to a groundwater operable unit P&T facility. This approach requires the P&T system to provide a step for separation of solids (e.g., filtration) followed by necessary treatment for constituents of concern in the purgewater. For treatment at the 200 West P&T, the filtration would be performed at a filter skid near the Modutanks before the water is pumped or trucked to the facility. The Modutank feedstream analysis (SGW-61287) concluded that the 200 West P&T is capable of treating the Modutank water to the P&T effluent standards.

The main concerns for treatment of Modutank water at the 200 West P&T result from the introduction of iron, manganese, aluminum, copper sulfate, algae, and bacteria that could exacerbate well fouling or upset the treatment process. Sample results (described in Table 2) show that the metals of concern can be effectively removed with 5.0 µm filters. The data presented earlier in Table 3 showed that when filtered Modutank water is blended with typical well water, the chemistry of the blended influent is within acceptable limits and can be treated by the 200 West P&T facility.

Filtration will also remove algae and bacteria. A pilot study reported that around 50% of the algae population could be removed with a 5.0 µm filter using cross-flow filtration (Wilson, 2012, “Cross Flow Filtration for Mixed-Culture Algae Harvesting for Municipal Wastewater Lagoons”). The bacteria component would also be reduced, but may not be an issue due to blending and because the mass of

bacteria in the FBRs is much greater than the contribution from Modutanks. The type of biology in the FBR is also controlled by creating the proper environment to sustain denitrifying bacteria, and bacteria introduced from other sources will not persist.

Removal of algae and bacteria by filtration was tested by collecting three samples of Modutank water on December 6, 2017, from Modutank 3 for visual inspection under the microscope. The samples were collected from 0.6 m (2 ft) below the water surface.

The three samples were as follows:

1. Raw water – no filtration
2. Water filtered through 5 µm filter
3. Water filtered through 1 µm filter

The water sampled from Modutank 3 was visually more turbid and had more algae than was observed in Modutank 2. The algae stuck to the bottom of the plastic Nalgene™ bottles used for sample collection.

Figure 4 shows the typical field for the raw water. The water was full of algal and bacterial cells. Based on a typical total suspended solids concentration of 50.8 mg/L, a volume of 757,080 L (200,000 gal), and 70% of the solids being biomass, less than 30 kg of biomass would be transferred to the 200 West P&T. This is in comparison to around 240 kg of biomass present in each FBR (PNNL-23679, *Characterization of Biofilm in 200W Fluidized Bed Reactors*).

Figures 5 and 6 show the same water after filtration with 5 µm and 1 µm filters, respectively.

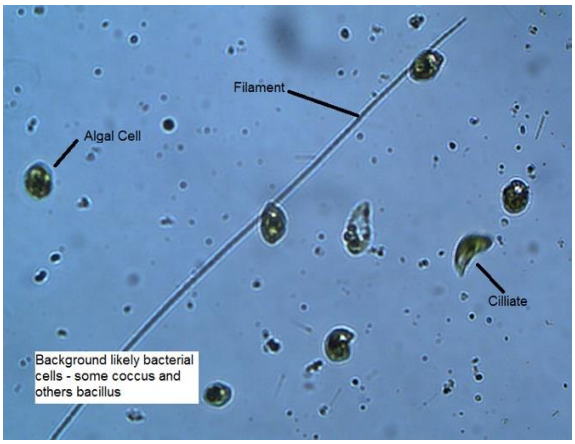


Figure 4. Modutank Water Collected on December 6, 2017, Not Filtered

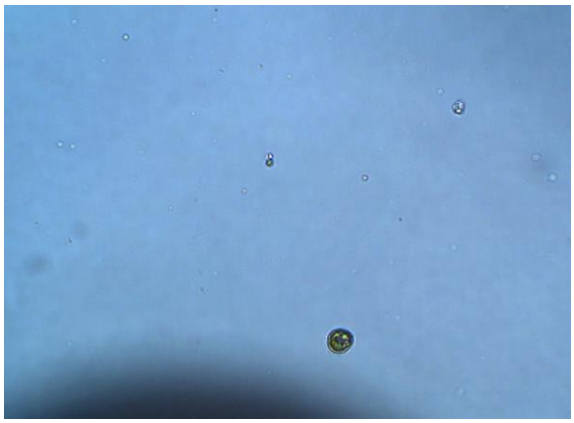


Figure 5. Modutank Water Collected on December 6, 2017, 5 µm Filter

™ Nalgene is a trademark of Thermo Fisher Scientific.

Figure 6. Modutank Water Collected on December 6, 2017, 1 µm Filter

These figures show two important points:

- Filtration will reduce the biomass to levels that are negligible.
- The 5 µm is sufficient to remove the bulk of the biomass. The additional filtration to 1 µm provides very little benefit.

These observations are consistent with the results obtained from evaluating the impact of filtration on metal concentrations.

In the fall of 2017 Modutank water was taken to ETF for disposal because losses to evaporation were not sufficient and the Modutanks began to fill. After algae clogged their filters ETF requested that copper sulfate be applied at a dose of 2 mg/L. However, algae provide beneficial treatment of the water by raising the pH and possibly tying up metals. Several investigators have observed the removal of metals by algae (Filip et al., 1979, "Residual Heavy Metal Removal by Algae Intermittent Sand Filtration System"; Costa and Leite, 1990, "Cadmium and Zinc Biosorption by *Chlorella homophaera*"; Chu and Hashim, 2004, "Quantitative Analysis of Copper Biosorption by the Microalgae *Chlorella vulgaris*"; Volesky, 1992, "Removal of Heavy Metals by Biosorption"; Worku and Sahu, 2012, "Reduction of Heavy Metal and Hardness by Algae"). These observations have led to the development of engineered systems that use algae for treatment (Zimmo et al., 2002, "Process Performance Assessment of Algae-Based and Duckweed-Based Wastewater Treatment Systems"; Kumar and Goyal, 2010, "Waste Water Treatment and Metal (Pb^{+2}, Zn^{+2}) Removal by Microalgal Based Stabilization Pond System"; Wilson, 2012). The author proposes using the beneficial effects of algae for aiding in the control of nuisance metals that contribute to well fouling.

Copper sulfate adds both copper and sulfate to the water. Copper is a micronutrient that can support biological growth and foul wells. Sulfate can interfere with treatment at the 200 West P&T. Copper sulfate addition should be curtailed or limited to promote the beneficial impacts of algae and to avoid increasing the copper and sulfate content of the Modutank water.

There are times when algae contribute to the rapid fouling of filters. Sodium hypochlorite can be used in place of copper sulfate for algae control. In addition, chlorine will help control iron, manganese, and bacteria. Sodium hypochlorite is used at the 200 West P&T to clean the membrane from biological fouling and is known to the 200 West P&T staff. Hypochlorite will act as an oxidizer in the Modutank water to fully oxidize the manganese to a solid form, which will aid in capturing manganese by the filters. A residual of at least 15 mg/L of chlorine will also kill algae and bacterial growth. The initial plan would be to set up two totes at opposite ends of the Modutank and allow the chlorine to mix and react over a

period of days. When the residual is less than 40 mg/L chlorine, then the water could be treated at the 200 West P&T as long as flow is less than 5% of total plant flow.

In summary, the authors recommend sampling Modutank water and analyzing both filtered (5 µm) and unfiltered samples prior to treatment. If there is excel algae or more than 20 µg/L manganese or 100 µg/L iron, adding chlorine will aid in iron and manganese oxidation and reduce the algal load on the filters. In addition, precautions will be taken to avoid disturbing the sediments while withdrawing Modutank water for treatment at the 200 West P&T. The water will be withdrawn from the opposite end where sediments have collected. An adequate amount of time between sediment removal and water withdrawal will be incorporated in the operating procedures.

6 Regulatory Requirements

To treat Modutank water at the 200 West P&T, several U.S. Department of Energy- and U.S. Environmental Protection Agency-approved *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* documents must be modified. Below is a summary of the documents affected and proposed changes:

- DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*: No changes are needed. Several locations in the document acknowledge that purgewater can be sent to P&T facilities.
  - Section 1: "Hanford purge-water can either be returned to the environment in accordance with Section 10 of this Strategy, collected for management at the modular storage unit(s), or transported to another appropriate Hanford facility (e.g., the 200 Area ETF or pump and treat operations)."
  - Section 6.2: "All extracted groundwater, including purge-water and free liquids separated from sediments and/or other materials generated during well drilling, well construction and well development, will be discharged to the ground surface in accordance with Section 10 of this Strategy, collected for management at the modular storage unit(s), or transported to another appropriate unit (e.g., the 200 Area ETF or pump and treat facilities). Transportation of the groundwater by truck, the storage of nonempty trucks during off-hours, and collection of the groundwater at the modular storage unit is governed by DOE/RL-2009-39, *Action Memorandum for the Non-Time-Critical Removal Action for Investigation Derived Waste Purgewater Management*, as amended), and DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*, as amended)."
- DOE/RL-2009-39, *Investigation-Derived Waste Purgewater Management Action Memorandum*: No changes needed. The selected alternative includes a decision to pursue other alternatives for long-term purgewater management, including those from the engineering evaluation (DOE/RL-2009-31). Alternative 2 is to send the purgewater to a P&T for treatment.
  - Section 9: "Although Alternative 3 was selected because it was the most effective alternative in the short-term, other alternatives for long-term purge-water management will continue to be pursued. "
- DOE/RL-2009-80, Rev. 0, *Investigation Derived Waste Purgewater Management Work Plan*: A change is needed in Section 4.2.7 that adds the 200 West P&T to the list of facilities to which purgewater can be shipped. This change will be made with the Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) change notice process.

- DOE/RL-2008-78, Rev. 0, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan:* No changes needed at this time. It is undergoing a major revision and the authors recommend the changes be made to this document as it progresses through its current revision.

- DOE/RL-2009-124, Rev. 5, *200 West Pump and Treat Operations and Maintenance Plan:*

  – This document currently allows shipment of purgewater from certain operable units directly to the 200 West P&T.

    Appendix B, Section B4.4.1, states: "Purge-water generated from investigation and remediation activities within the 200-ZP-1, 200-UP-1, 200-DV-1, 200-BP-5, and 200-PW-1 OUs will be managed in accordance with DOE/RL-2011-41 and DOE/RL-2009-80. For wells already connected to the 200 West P&T, purge-water may be taken to the 200 West P&T for treatment." And "For wells not already connected to the 200 West P&T, purge-water associated with installation, development, testing, monitoring, sampling, and maintenance, as well as any water decanted from saturated drill cuttings, is generally collected in a purge-water truck at the time of generation and transported to the purge-water modular storage units (MSUs) or the ETF, provided ETF waste acceptance criteria can be met. The 200 West P&T may also be used for purge-water disposition after its use is approved in DOE/RL-2009-80."

  – The authors recommend three changes to this document and plan to incorporate these into a Tri-Party Agreement (Ecology et al., 1989) change notice.

    - Add "and water from Modular Storage Unit" everywhere in the document that the other feed streams are listed (e.g., Environmental Restoration Disposal Facility leachate) and use the 200 West P&T feed stream acceptance criteria analysis (SGW-61287) when the other feed stream analyses are used. This includes all of the appendices.

    - Add a paragraph to Executive Summary and the Introduction (1.0) with the following wording:

      "Treatment and disposal of purge-water is described in the Hanford Site Strategy for Investigation Derived Waste (DOE/RL-2011-41) and Investigation-Derived Waste Purge-water Management Action Memorandum (DOE/RL-2009-39) at the Modular Storage Units, ETF, and Pump & Treat facilities. The Investigation Derived Waste Purge-water Management Work Plan (DOE/RL-2009-80) permits Modular Storage Unit vs. truck tank water to be shipped to ETF and the 200 West Pump and Treat for treatment and disposal. Acceptability of the Modular Storage Tank water at the 200 West Pump and Treat is described in the Impact of Modutank Water on the 200 West Pump and Treat (SGW-61287)."

    - Add the following to Appendix D, Section D3.5:

      "Sampling of the water from the Modular Storage Units will be performed prior to each transfer campaign from each Modular Storage Unit."

7 Treatment Option Cost Analysis

Several scenarios for treating water at the Modutanks were considered. The different scenarios are based on different means to convey the water to the 200 West P&T. The assumptions are provided in a list format. The costs for treatment at ETF were not included because of the uncertainties and risks previously described in this document. The cost of adding a new modular tank was included for completeness.

7.1 Modutank Estimate Assumptions

1. 1,514,160 L/yr (400,000 gal/yr) to be pumped from Modutanks.
2. Two campaigns per year, 757,080 L (200,000 gal) per campaign.
3. Four estimates, two for trucking and two for piping.
4. Assume manganese treatment with hypochlorite is required (assumption will be tested).
5. Assume 13,249 L (3,500 gal) per filter at $400 per filter. This is based on current experience and is conservative. If copper sulfate or chlorine are used for algae filter clogging will be less problematic and longer filters runs can be expected.
6. Currently the pump rate is 132 L/min (35 gal/min) but is assumed to be 170 L/min (45 gal/min) for the estimate based on use of either copper sulfate or chlorine to control algae and manganese. Currently algae is a significant foulant to the filters.
7. Use existing filter skid with pumps on skid.
8. Rent generator and compressor for air diaphragm pumps.
9. Assume the filter skid is tended while in operation to release air pockets and check for leaks.
10. Adding sodium hypochlorite for algae and manganese control is not considered treatment under the *Resource Conservation and Recovery Act of 1976* (this has been confirmed by the Soil and Groundwater Environmental Compliance Officer).

7.1.1 Trucking (1 Truck)

1. Use existing filter skid and pumps
2. One purgewater truck is dedicated
3. 9,464 L (2,500 gal) per truck
4. At 170 L/min (45 gal/min) a truck is filled in 1 hour
5. Labor needed 1 Truck: 1 supervisor, 2 nuclear chemical operators (NCOs) tending filter skid, 1 NCO tending gate, 1 teamster, and 1 pipefitter 10 hr/day
6. Assume dedicated labor not needed at 200 West
7. Assume two trips per day with one truck (based on ETF experience)
8. 1,514,160 L/18,927 L (400,000 gal/5,000 gal) per day = 80 days total; 40 in spring and 40 in fall
9. Assume 15 miles roundtrip x 80 trips = 1,200 miles per campaign, 2,400 miles total
10. Truck offloads to z-line trench at 200 West

11. Filter skid maintenance and repair is covered in existing budget
12. *Potentially need to purchase purge water truck – not in estimate*

7.1.2 Trucking (2 Trucks)

Same as above except for the following:

1. Two purgewater trucks dedicated
2. Labor needed 2 Trucks: 1 supervisor, 2 NCOs tending filter skid, 1 NCO tending gate, 2 teamsters, and 1 pipefitter 12 hr/day
3. Assume 4 trips per day
4. 1,514,160 L/37,854 L (400,000 gal/10,000 gal) per day = 40 days total; 20 in spring and 20 in fall
5. *Potentially need to purchase purge water trucks – not in estimate*

7.1.3 Piping

1. Assume piping is from Modutank to BP-5 (Y-32) tank
2. Labor needed: 1/2 supervisor, 2 NCOs (2 at filter and 0 at gate), 1 pipefitter, and 0 teamster 10 hr/day (based on ETF experience)
3. Pumping occurs only while staffed to tend the pumps and filters and watch for leaks
4. 6 hours pump time per 10-hour shift; 4 hours mob/demob and change filters
5. 170 L/min (45 gal/min) pump rate for 6 hr/day = 61,323 L/day (16,200 gal/day) (Note: ETF is 132 L/min [35 gal/min]) on average but if reduced algae would go faster.)
6. 1,514,160 L/per year/61,323 L/day (400,000 gal per year/16,200 gal/day) = 25 days plus 4 days mob/demob = 29 days for 2 campaigns
7. Shared connection with line from YE-27 and connect/disconnect each campaign
8. 3 in. single-wall high-density polyethylene
9. Assume use existing strap on flowmeter to measure flow
10. Assume shared the connection with a line from C-farms and connect and disconnect each time pumping occurs
11. Assume 2 butterfly valves are purchased to isolate line when connecting and disconnecting and one actuated shut-off valve tied to existing level indicator on tank
12. Interposing relays and Hoffman Box for tying the level indicator to the motor-actuated valve
13. One supervisor for 3 days, 2 electricians 2 days to install line to actuator, and 2 pipefitters 3 days to install valving
14. Labor for bonding crew (pipe) = 12 days @ 3 full-time equivalent

7.1.4 Piping and New Pumps

Same assumptions as piping with the following exceptions:

1. New pump station is electric and requires less attention: 1/2 supervisor, 1 NCO, 1 pipefitter
2. Labor for pump station installation = 2 carpenters for 2 days, 2 pipefitters for 2 days, 1 supervisor
3. Two new pumps with adjustable frequency drives
4. Need 170 L/min (45 gal/min) at 80 to 690 kPa (100 lb/in^2)

7.2 Installing Additional Modutank

The cost estimate for construction of Modutank 3 was done in August 2009. The total cost for construction in fiscal year (FY) 2009 dollars was estimated at $703,784.40 (CHPRC-0900500) and will be used for this evaluation. The yearly operations and maintenance cost of $213,000 per tank is based on a cost analysis for FY 2006, FY 2007, and FY 2008 included in DOE/RL-2009-31.

The estimated costs for various alternatives are provided in Table 5. This table is based on the assumptions presented previously, which may be inaccurate. For example, the trucking alternatives assume that tanker trucks are available and new ones do not need to be purchased.

Table 5. Estimated Cost for Modutank Treatment Alternative

Treatment Alternative	One-Time Cost	Additional Yearly Cost	Total Cost First Year
Modutank trucking (1 truck)	N/A	$540,552	$540,552
Modutank trucking (2 trucks)	N/A	$399,672	$399,672
Modutank piping	$264,040	$170,568	$434,608
Piping and new pumps	$284,809	$141,288	$426,097
Add another Modutank	$703,784	$213,000	$916,784

N/A = not applicable

Based on the costs in Table 5, adding another Modutank as a means of expanding treatment of purgewater is not recommended. The additional tank will eventually be filled, and CH2M HILL Plateau Remediation Company will again be in the same position of trying to find alternative treatment to reduce Modutank levels. All other alternatives are viable and are not mutually exclusive. For example, the water can be trucked initially while a pipeline is under further consideration or construction.

8 Recommendations

Based on careful consideration of the information provided, the authors recommend the following:

- Update the regulatory documentation to include the treatment of Modutank water at the 200 West P&T.
- Use the Modutanks as a means of removing nuisance metals from purgewater.
- Send purgewater to the Modutanks whenever practical. It is expected that evaporation will be insufficient to avoid the Modutanks from filling to capacity.

- Transfer the excess water to the 200 West P&T for processing approximately twice a year. It is estimated that approximately 757, 080 L (200,000 gal) will need to be taken during each campaign for a total of approximately 1,514,160 L (400,000 gal) annually.
- Allow algal growth in the Modutanks to maintain the current chemical conditions because these conditions are conducive to the treatment of the nuisance metals
- Prepare a procedure for treating Modutank water that includes the following steps essential for risk mitigation:

  1. Sample Modutank water prior to pumping campaign:

     a. Samples include total and 5.0 µm filtered water

     b. Analyze for the following constituents:

        i. Metals by 6020: including the metals listed in Table 2 and chromium and uranium
        ii. Chlorophyll a
        iii. Anions by 9056: including chloride, nitrate, and sulfate
        iv. Volatile organic analysis: including carbon tetrachloride, trichloroethylene, and chloroform
        v. Cyanide: free, amenable, and total
        vi. Hexavalent chromium
        vii. Alkalinity
        viii. Iodine-129
        ix. Technetium-99
        x. Tritium
        xi. Total dissolved solids
        xii. Total suspended solids
        xiii. Field samples: pH, electrical conductivity, ORP, temperature, turbidity, dissolved oxygen

  2. Treat approximately 757, 080 L (200,000 gal) twice per year, in the spring and fall. Evaporation is not as effective in the winter so pumping events before and after should help manage Modutank levels.

  3. Sample the water to be transferred from Modutanks 3 to 6 weeks before planned transfer to evaluate concentration of key contaminants identified in this document. Provide both unfiltered and filtered (5 µm) samples to the laboratory.

  4. Plan on blending Modutank water at no more than about 5% of process flow. Use measured values of contaminants from sampling program to refine the blend ratio. Avoid sulfate concentrations greater than about 60 mg/L in the plant influent.

  5. Use measured values of uranium to determine whether to introduce this water to the ion-exchange system or to the biological treatment system at 200 West P&T. The uranium concentration should be less than 30 µg/L for treatment in the biological treatment system.

  6. Prepare for chlorine addition at Modutanks pending evaluation of laboratory results.

7. Test these recommendations with a pilot test (Appendix A).
8. Perform limited sampling of purgewater from well development for the following constituents to confirm that it is a source of well foulants:
    a. pH
    b. Conductivity
    c. Calcium
    d. Iron
    e. Manganese
    f. Aluminum
    g. Cobalt
    h. Molybdenum
    i. Copper

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Appendix A

Pilot Test Approach

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A1 Pilot Test Approach

This appendix describes a pilot test to check the proposed plan to treat Modutank water at the 200 West Pump and Treat (P&T). The pilot will replicate treatment at Modutanks as closely as possible.
The proposed treatment includes the following key steps:

1. Pump water from the Modutanks through a filter skid with 25 or 5 µm filters. Transfer the filtered water to a 10,000 gal skid tank (existing). Sample both the unfiltered and filtered water for the following analytes:
   - Metals by 6020: including iron, manganese, zinc, copper, molybdenum, nickel, aluminum, selenium, chromium, and uranium
   - Anions by 9056: including chloride, nitrate, and sulfate
   - Volatile organic analysis: including carbon tetrachloride, trichloroethylene, and chloroform
   - Cyanide: free, amenable, and total
   - Hexavalent chromium
   - Chlorophyll-a
   - Alkalinity
   - Iodine-129
   - Technetium-99
   - Tritium
   - Total dissolved solids
   - Total suspended solids
   - Field samples: pH, electrical conductivity, oxidation-reduction potential, temperature, turbidity, dissolved oxygen
2. Pump the water to the plant at a rate of approximately 40 gal/min. The following locations at the 200 West P&T will be sampled:
   - Recycle tank
   - Fluidized bed reactor effluent
   - Membrane bioreactor effluent
   - Effluent tank

   These locations will be sampled at three times as follows:
   1. Before pumping starts
   2. During the pumping
   3. After pumping is complete

The sampling will be timed to account for travel time to the plant to ensure the Modutank water has reached the sample site. For example, at a flow of 2,350 gal/min water takes about 4 hours to reach the effluent tank from the recycle tank. Sampling the effluent tank shortly after the start of pumping would not provide insight to the impact of Modutank water.

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