CITY OF OKANOGAN

OKANOGAN COUNTY, WASHINGTON

ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY

G&O #17065
FEBRUARY 2018

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY

PURPOSE

The purpose of this Arsenic Treatment Facility Sludge Disposal Feasibility Study (Study) is to investigate various alternatives for the City to dispose of the solid waste generated at its arsenic treatment facility. This Study is intended to meet the project report requirements of WAC 246-290-110 to allow the City to construct improvements to the arsenic treatment facility based upon the recommendations identified herein and to seek funding for the project, if applicable.

INTRODUCTION

The City of Okanogan has operated an arsenic treatment facility since 2008. The facility was constructed as an EPA demonstration project, and is one of the first of its kind in eastern Washington. The treatment facility operates based upon the affinity that arsenic has for iron when the arsenic is in its oxidized As(V) state, as opposed to As(III), and the process is frequently referred to as an oxidation/filtration process. The oxidation/filtration process includes chemical addition of $FeCl_3$ to provide a sufficient source of iron in the water for arsenic to adhere to, chemical addition of NaOCl to oxidize the As(III) to As(V), and filtration media to remove the resulting Fe_2O_3-As complex.

Backwash cleaning cycles are required on a frequent basis to remove the Fe_2O_3-As complex from the filters. The Okanogan facility includes a concrete above-grade tank for storage of the backwash produced from these cycles. The backwash is a suspension comprised of potable water from the City's distribution system and a significant loading of the Fe_2O_3-As complex. The backwash storage tank provides a quiescent environment which results in the complex settling out of suspension, thereby allowing the remaining backwash water to be pumped through the filters again and reclaimed for potable use in the City's distribution system.

Over time, a sludge accumulates in the backwash storage tank that must be disposed of. When the arsenic treatment facility was first constructed, the operational concept was for the sludge to be washed into the domestic sewer system through a floor drain in the tank after four backwash cycles were completed. This resulted in an arsenic-rich wastewater flow entering the domestic wastewater treatment facility (WWTF), whereby the arsenic was ultimately removed in the digested sludge in the aerobic digesters after sedimentation in the primary clarifier and secondary clarifiers. The digested biosolids are dried in sludge drying beds at the WWTF site. This processing sequence resulted in elevated concentrations of arsenic in the dried biosolids, which prevented the City from land-applying them, instead requiring that the City dispose of the biosolids at the landfill.

Biosolids are required to be applied to the land for the purposes of improving soil characteristics to enhance the growth of vegetation consistent with protecting human health and the environment. Per WAC 173-308-005(1), the biosolids from a WWTF are treated "to meet certain quality standards that allow it to be applied to the land for beneficial use". As further defined in WAC 173-308-160(1), the arsenic concentration in treated biosolids must be less than 75 mg/kg to be categorized as biosolids and qualify for land application. Table 1 summarizes the results of Okanogan WWTF biosolids arsenic testing for the period 2008-2013. Arsenic concentrations were not consistently above the allowable limit during this time, but the City was concerned about the feasibility of continuing to operate in that matter.

TABLE 1

Historical Okanogan WWTF Biosolids Arsenic Concentration (1)

Year	Arsenic Concentration (mg/kg)
2008	<10
2009	61
2010	84
2011	31
2012	36
2013	91

(1) WAC 173-308-160(1) limit is 75 mg/kg

To address this problem, the City modified its arsenic sludge removal approach in the spring of 2014. Rather than wash the sludge into the domestic sewer system, the City began to haul the sludge to the wastewater treatment facility in a truck. Excess water is evaporated in the sludge drying beds, but the arsenic sludge is no longer comingled with WWTF biosolids, and therefore the biosolids can be land applied, complying with beneficial use requirements. The arsenic sludge is still disposed of at the landfill. However, dedicating sludge drying bed area and volume to the arsenic sludge has decreased the available capacity of the sludge drying beds, and has caused problems for the City's biosolids management operations. Therefore, the City commissioned this study to determine the best approach for storing and dewatering arsenic sludge in the future.

BACKWASH OPERATIONS

The arsenic treatment facility controls operate based upon time and level control in the backwash tank. During typical operation, the facility will operate for up to 8 hours, after which it will shut down for a backwash cycle to occur. A backwash cycle produces 6,000 gallons of backwash, which is stored in the 23,500-gallon backwash reclaim tank (20' diameter x 10' height). Once the well is called again, the arsenic treatment facility will

receive flow again. After a backwash cycle completes, the reclaimed water pump will operate for up to 2.5 hours to pump flow from the backwash tank through the arsenic treatment plant at an average rate of 60 gpm. This pump cycle will occur the next time that Well No. 4 is called. However, if the well call lasts for less than 1.7 hours, less than 6,000 gallons of backwash may potentially be returned.

During periods where the reclaimed water pump does not return 6,000 gallons, backwash will accumulate in the backwash tank. However, the backwash return pump has a greater capacity than required to return 6,000 gallons within the allotted 2.5 hour time period, and theoretically can reclaim over 9,000 gallons of backwash. The City has indicated that on a periodic basis, a series of backwash accumulation events, i.e. periods where less than 6,000 gallons of backwash are reclaimed, will result in the backwash tank filling. The backwash controls do not allow the treatment plant to operate with a full backwash tank until the tank is completely emptied. If backwash accumulation is not the cause for the backwash tank to be emptied, the City pumps the tank empty after 35 backwash cycles.

If it is possible for the City to modify the arsenic treatment plant and Well No. 4 controls, it would be in the City's best interest to allow the backwash return pump to operate in a manner that allows it to complete its 2.5-hour cycle, even if Well No. 4 would not otherwise operate. These changes may require modifying the reservoir operating setpoints to avoid overfilling reservoirs. This changes would benefit the City, as backwash accumulation in the backwash storage tank is a consistent, ongoing operations problem.

ARSENIC SLUDGE PRODUCTION

For the period April 2014 through October 2016, the City disposed of approximately 6,100 pounds of arsenic sludge at the Okanogan County Central Landfill. For the same period, the City treated approximately 107,284,500 gallons of water. Therefore, it is assumed that the arsenic treatment process will require 1 pound of arsenic sludge to be landfilled for every 17,530 gallons of water treated.

The arsenic treatment facility only treats water produced by Well No. 4, which is not the City's primary water source. Therefore, arsenic sludge is mostly produced during the summer when water demand is highest and all of the City's water sources are operated. Arsenic sludge production is likely to increase in the future as the City grows, and for planning purposes it is assumed that sludge production will increase with projected water demand. However, the increase will not be proportional, as the percentage of annual water production increases for Well No. 4 as total production for the year increases. Table 2 summarizes this historical relationship.

TABLE 2

Well No. 4 Annual Production

Year	Total Water Produced (gal)	Well No. 4 Annual Water Produced (gal)	Well No. 4 Percentage of Total Production
2012	222,626,000	76,308,000	34.3%
2013	208,481,000	71,868,000	34.5%
2014	169,170,000	32,280,000	19.1%
2015	205,031,000	54,996,000	26.8%
2016	183,773,000	37,392,000	20.3%

Figure 1 shows the data summarized in Table 2. The best fit relationship that can be approximated for this data set is as follows:

$$\text{Well No. 4 Production} = (1.92E6)e^{(1.64E-8)(Total\ Production)}$$

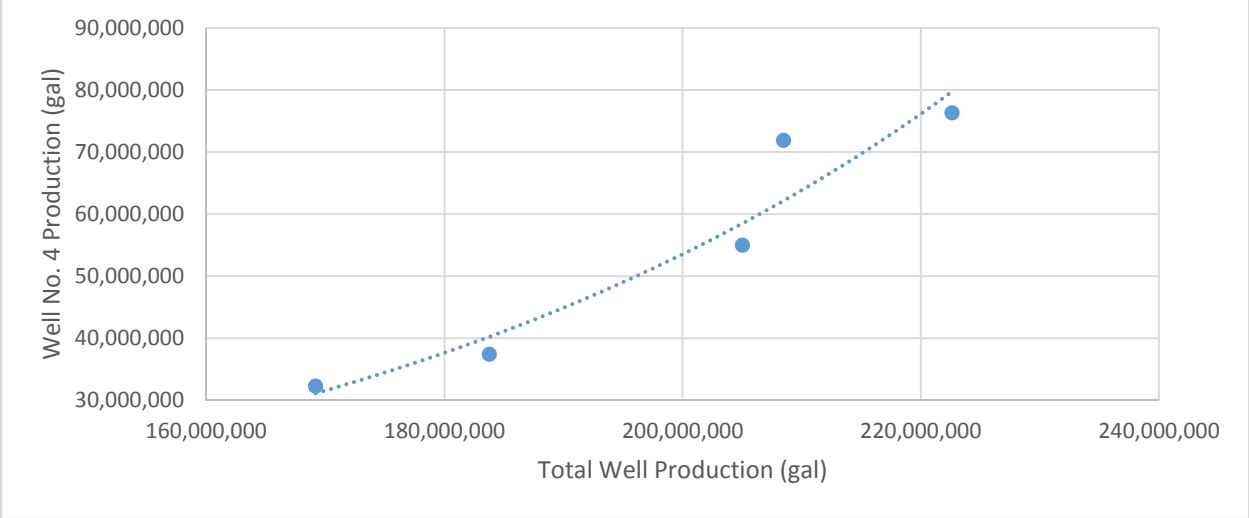


FIGURE 1

Well No. 4 Annual Production

To project future arsenic sludge production, water demand projections have been used from Table 2-10 of the 2016 Water System Plan, and this best fit relationship has been applied to estimate the corresponding Well No. 4 production. Table 3 summarizes the projected arsenic sludge production for a 20-year planning period ending in 2038.

TABLE 3

Projected Arsenic Sludge Production

Year	Service Area Population[(1)]	Projected Annual Production gal/yr [(2)]	Projected Well No. 4 Production gal/yr [(3)]	Well No. 4 Percentage of Total Production[(4)]	Projected Arsenic Sludge Production lb/yr [(5)]
2018	2,776	207,714,200	57,907,000	27.9%	3,300
2023	2,832	211,904,400	62,026,200	29.3%	3,540
2028	2,889	216,169,400	66,520,000	30.8%	3,790
2033	2,947	220,509,300	71,427,100	32.4%	4,070
2038	3,006	224,924,000	76,790,300	34.1%	4,380

(1) Population for 2018 from Water System Plan. Growth at 0.4 percent per year, per Water System Plan.
(2) Production is 205 gal/yr/person per Average Daily Demand identified in Water System Plan.
(3) Well No. 4 Production = $(1.92E6)e^{(1.64E-8)(Total\ Production)}$
(4) Well No. 4 Percentage of Total Production = Well No. 4 Production / Annual Production.
(5) Arsenic Sludge Production = Well No. 4 Production ÷ 17,530 gal/lb.

ARSENIC SLUDGE MANAGEMENT ALTERNATIVES

Alternative 0 – Do Nothing Alternative

This alternative consists of not completing a capital project, and instead continuing to manage arsenic sludge with existing facilities. If the City were to select this alternative, there would be two primary impacts to the City. The first impact would be the ongoing impact to staff time. The existing method of removing sludge from the backwash storage tank requires two staff, pumping sludge into a truck with a portable pump at a slow rate, transporting the sludge to the wastewater treatment facility site, and then emptying the sludge into a drying bed. This process requires in excess of 8 man-hours in many cases, and is repeated whenever sludge accumulates in the tank.

The second impact would be the loss of biosolids storage space at the WWTF. At this time, there is insufficient space in the existing WWTF sludge drying beds to allow arsenic sludge to be stored and dried without affecting biosolids management. During portions of the year, all of the sludge drying bed volume is required for the WWTF biosolids, and therefore the arsenic sludge must be hauled to the landfill to empty the drying beds for biosolids storage and dewatering. When solids are removed from the bed, City staff sweep/shovel solids into garbage bags by hand, and the bags are lifted into a dump truck for removal and disposal.

While the current seasonal approach has worked for the City to date, population growth will result in more biosolids being produced, more arsenic sludge being produced, and less time allowed for storage of arsenic sludge in the drying beds before the space is

required for biosolids storage. As a result, there will come a point at which there will be insufficient space or drying time available for arsenic sludge.

Alternative 1: Sludge Drying Beds - Pumped

This alternative consists of constructing sludge drying beds at the arsenic treatment facility. The drain piping for the backwash tank discharges below grade, and therefore a positive displacement pump would be required to fill drying beds located at existing grade.

The City's goal should be to minimize the volume of potable water that is wasted to the collection system. Therefore, it is not recommended that the City drain the tank completely at any time, except for maintenance, repairs, or other activities that require the tank to be completely out of service. Instead, the reclaimed water pumps should be used to reclaim water whenever feasible, thereby avoiding the impact on the wastewater treatment facility associated with treating potable water and the expense of discharging potable water to sewer instead of selling it to a consumer. For this reason, it is recommended that the sludge drying beds be constructed to contain a single backwash cycle, plus a factor of safety. If the backwash tank were to be completely filled, the tank could be partially drained to the drying bed, thereby providing sufficient space in the tank for a backwash cycle to be completed when the control system calls for a cycle to occur. Subsequently, the reclaimed water pumps would operate as designed, and the backwash tank could be further emptied by reclaiming the backwash, rather than draining it to the collection system.

This alternative includes a paved, sloped drying bed to allow the solids to drain freely with a trench drain on the downhill end of the bed. Therefore, the majority of the drying would occur by gravity, rather than evaporation. The drain would be lined with sand or gravel to filter the water entering the drain, thereby retaining solids and allowing the liquid component to flow through. Per discussions with City staff, the backwash stratifies significantly as it settles in the tank, and the staff can visually determine whether the backwash exiting the backwash tank contains the concentrated Fe_2O_3-As complex or not, due to the deep red color of backwash containing solids. The sludge drying bed could be reduced in size by providing a valve that allows the operators to divert flow to the drain manhole instead of the sludge drying bed once the flow becomes clear. A backwash sample taken in December 2017 indicated that the clear, settled backwash has an arsenic concentration of approximately 11 ppb.

The positive displacement pump installed with this alternative would be located in a vault adjacent to the backwash storage tank. The vault would also contain valving to allow the pump to be bypassed and allow flow to be diverted to the existing collection system manhole. The electrical for this pump would be fed from one of the spare receptacles in the arsenic treatment building panelboard. A local on/off switch and disconnect would be mounted at the vault.

Assuming that a backwash cycle is initiated for every 8 hours of well operation (550 gpm, constant speed), a backwash occurs for every 264,000 gallons (550 gpm * 60 min/hr * 8 hr) of production. Further assuming 1 pound of sludge for every 17,530 gallons of well production, each backwash cycle produces approximately 15 pounds of sludge (264,000 gallons ÷ 17,530 gal/lb). It is assumed that the sludge could drain to a concentration of 5 percent solids between backwash tank pumping events, which would allow the sludge to drain to a volume of 5 ft^3
(15 lb ÷ 0.05 ÷ 62.4 lb/ft^3).

The City has determined that if possible, the drying beds should be located inside the fenced area northwest of the backwash storage tank. As shown in Figure 2, there is approximately 450 ft^2 of area available for a sludge drying bed on site. Assuming that the beds are 1.5 ft deep, the beds would have a volume of 5,000 gallons. Due to the rapid draining of the beds and the assumption that only half of a 6,000 gallon backwash would be stored in the drying bed, this is sufficient volume to allow the City to periodically remove solids from the bed. Minor site grading and installation of a larger gate would also be necessary to allow a small piece of equipment to be driven into the bed to assist in solids removal, if desired. This study does not include rolling stock or ancillary equipment costs associated with the bagging and removal of dried solids from the site, as the City does not currently load its arsenic sludge with mechanical equipment.

The frequency with which the City would be required to empty the solids from the bed would depend on how often the backwash tank required pumping. During periods where the arsenic plant backwashed 2-3 times per day, backwash would be discharged to the sludge drying beds approximately once every 2 weeks. Under those conditions, a 5,000 gallon drying bed could accommodate 3,000 gallons of concentrated backwash while storing the solids from approximately 55 backwash cycles, each containing 5 ft^3 of sludge. Therefore, during peak Well No. 4 use, the sludge drying beds would be capable of storing approximately 1 month of sludge before some or all of the sludge was bagged by City staff and removed from the site.

This alternative does not address the need for City staff to be on site during the removal of sludge from the backwash storage tank. The single withdrawal point in the tank results in pockets of sludge being removed above the withdrawal pipe, but continuous agitation of the sludge is required to remove sludge that has settled along the perimeter of the tank. Other communities with similar facilities have constructed modifications to their backwash tank influent piping to attempt to distribute solids throughout the tank and mix "rat holes" formed by point withdrawal of sludge from the tank. It is recommended that the City construct similar modifications to reduce the formation of "rat holes" during sludge withdrawal, although it is likely that some manual sludge agitation will still be required to adequately remove all of the sludge accumulated in the tank. These modifications consist of the influent piping being equipped with multiple arms and nozzles to induce mixing during backwash. The influent piping modifications are recommended for all alternatives.

Assuming that the liquid draining from the drying beds has a similar arsenic concentration as the clear backwash in the tank (11 ppb), approximately 250 mg of arsenic would drain to the wastewater treatment facility each time backwash was drained to the drying beds, as summarized below.

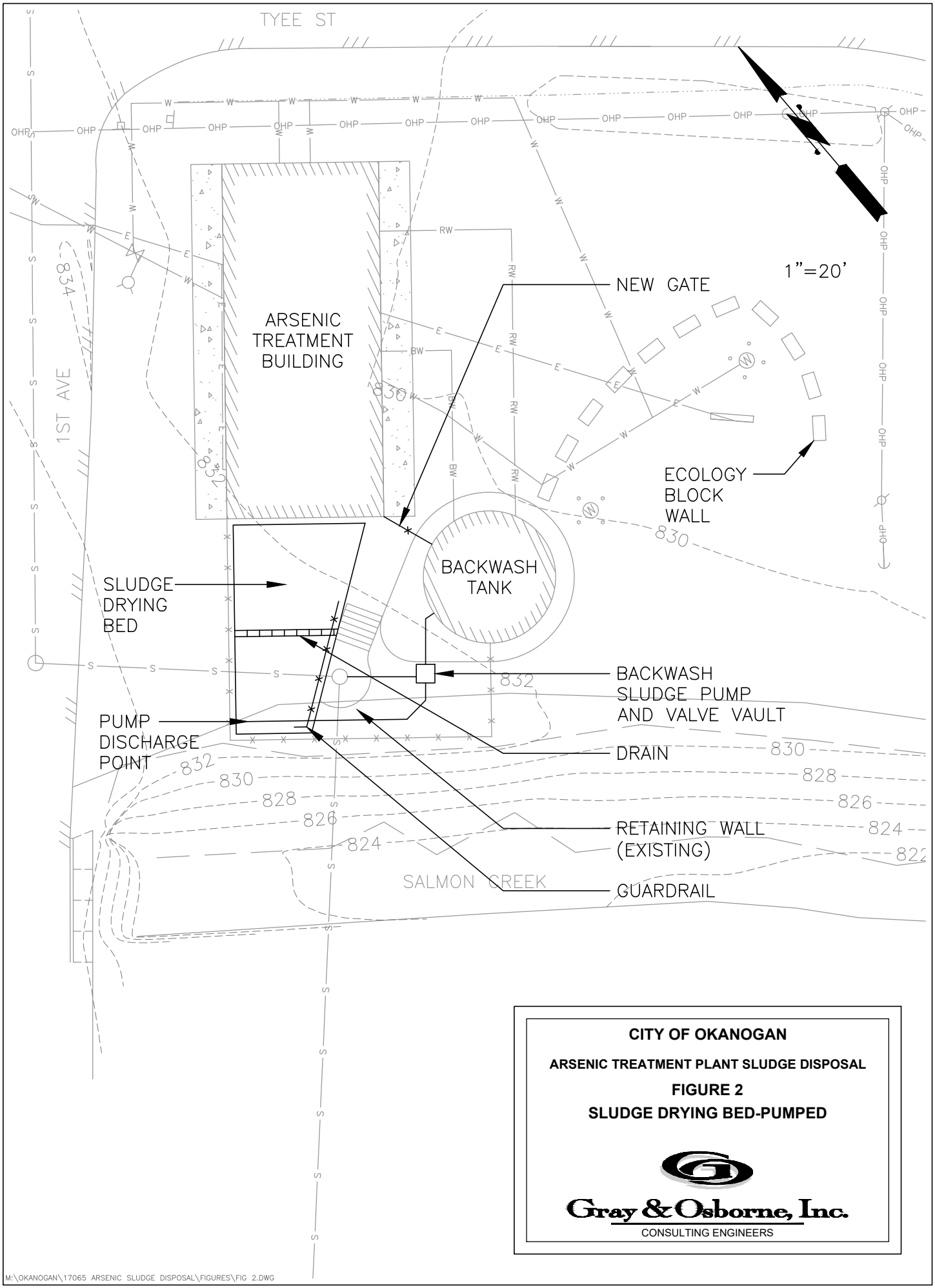
1 Backwash	= 6,000 gal = 802 ft^3
50% of Backwash Stored	= 3,000 gal = 401 ft^3
Dried Sludge Volume	= 5 ft^3
Drainage Volume	= 401 ft^3 - 5 ft^3 = 396 ft^3
Drained Solids	= (396 ft^3)(28.3 L/ft^3)(0.011 mg/L)
	= 125 mg
Clear Backwash Drained	= 3,000 gal = 401 ft^3
Drainage Volume	= 401 ft^3
Drained Solids	= (401 ft^3)(28.3 L/ft^3)(0.011 mg/L)
	= 125 mg
Arsenic to Sewer System	= 125 mg + 125 mg = 250 mg
	= 250 mg/6,000 gal of backwash
	= 0.042 mg/gal backwash

Backwash is emptied from the backwash tank once every 35 backwash cycles during normal operations. The resulting mass of arsenic entering the sewer system from normal operations is calculated below.

2038 Well No. 4 Production	= 76,790,300 gal
Total Backwash Cycles	= (76,790,300 gal) / (264,000 gal/backwash)
	= 291 cycles
Backwash Tank Empty Events	= 291 / 35 = 9 events
Backwash Drained to Drying Bed	= 6,000 gal * 9 events = 54,000 gal
Arsenic to Sewer System	= (0.042 mg/gal)(54,000 gal)
	= 2,268 mg

In addition to the arsenic that would enter the sewer system through typical backwash operations, as estimated above, it is assumed that a backwash volume of 6,000 gallons would be removed from the tank once every other week between March and October, or approximately 102,000 additional gallons. This would account for operating conditions that require the City to drain backwash from the tank due to accumulation or other process upsets. The arsenic loading to the sewer system from these operations would be equal to 4,284 mg (0.042 mg/gal)(102,000 gal).

Combining the routine backwash drained to the drying beds with the backwash that would be removed from the tank biweekly between March and October, the total arsenic loading transferred to the wastewater treatment plant through the sewer system in 2038 would be 6,552 mg. The City is projected to produce 4,380 lb (1,987 kg) of biosolids



CITY OF OKANOGAN

ARSENIC TREATMENT PLANT SLUDGE DISPOSAL

FIGURE 2

SLUDGE DRYING BED-PUMPED

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M:\OKANOGAN\17065 ARSENIC SLUDGE DISPOSAL\FIGURES\FIG 2.DWG

during that year, resulting in an arsenic loading in the biosolids of 3.3 mg/kg (6,552 mg ÷ 1,987 kg) as a result of drainage from the arsenic treatment facility. The existing operation contributes 0 mg/kg to the biosolids due to the complete removal of arsenic sludge from the sewer system; it is anticipated that this alternative would result in a modest increase in arsenic concentration for the City's biosolids. However, based upon the historical arsenic concentrations in the City's biosolids (Table 1), an increase of 3.3 mg/kg would not impact the City's ability to land apply biosolids in the future.

The estimated cost for this alternative is $184,000, including taxes and engineering (Appendix A). Design criteria for the new infrastructure are listed in Table 4.

TABLE 4

Design Criteria – Alternative 1

Sludge Pump	
Quantity	1
Type	Progressing Cavity
Capacity	30 gpm @ 10 ft TDH
Motor	1 hp
Control	Manual
Sludge Drying Bed	
Dimensions	30 ft x 15 ft (average) x 1.5 ft
Area	450 ft^2
Bed Construction	Asphalt Paved

Alternative 2: Drying Beds Gravity-Drained

This alternative is the same as Alternative 1, with the exception that the drying beds would be located below existing grade. The invert of the sewer line exiting the drain manhole is located approximately 14 feet below the drain line from the backwash tank, therefore it is feasible to gravity drain from the backwash tank into a sludge drying bed with a sidewall height of 1.5 feet, and still gravity drain the drying beds to the existing sewer. The walls along the north, west, and south sides of the bed would be approximately 5 feet deep to serve as retaining walls.

The benefit to constructing the sludge drying bed below the existing grade is the removal of a pump to fill the sludge drying bed. However, due to the minimal available area, it would be necessary to construct a retaining wall along the perimeter of the bed to obtain sufficient area without sloping the site downward to the bed. This change would also decrease the available drying bed area by approximately 2 feet in each direction to accommodate minor site grading and the construction of a retaining wall. This alternative is shown in Figure 3. The estimated cost for this alternative is $179,500, including taxes and engineering (Appendix A). Design criteria for the new sludge drying beds are listed in Table 5.

TABLE 5

Design Criteria – Alternative 2

Sludge Drying Bed	
Dimensions	28 ft x 13 ft (average) x 5 ft
Area	360 ft^2
Bed Construction	Asphalt Paved

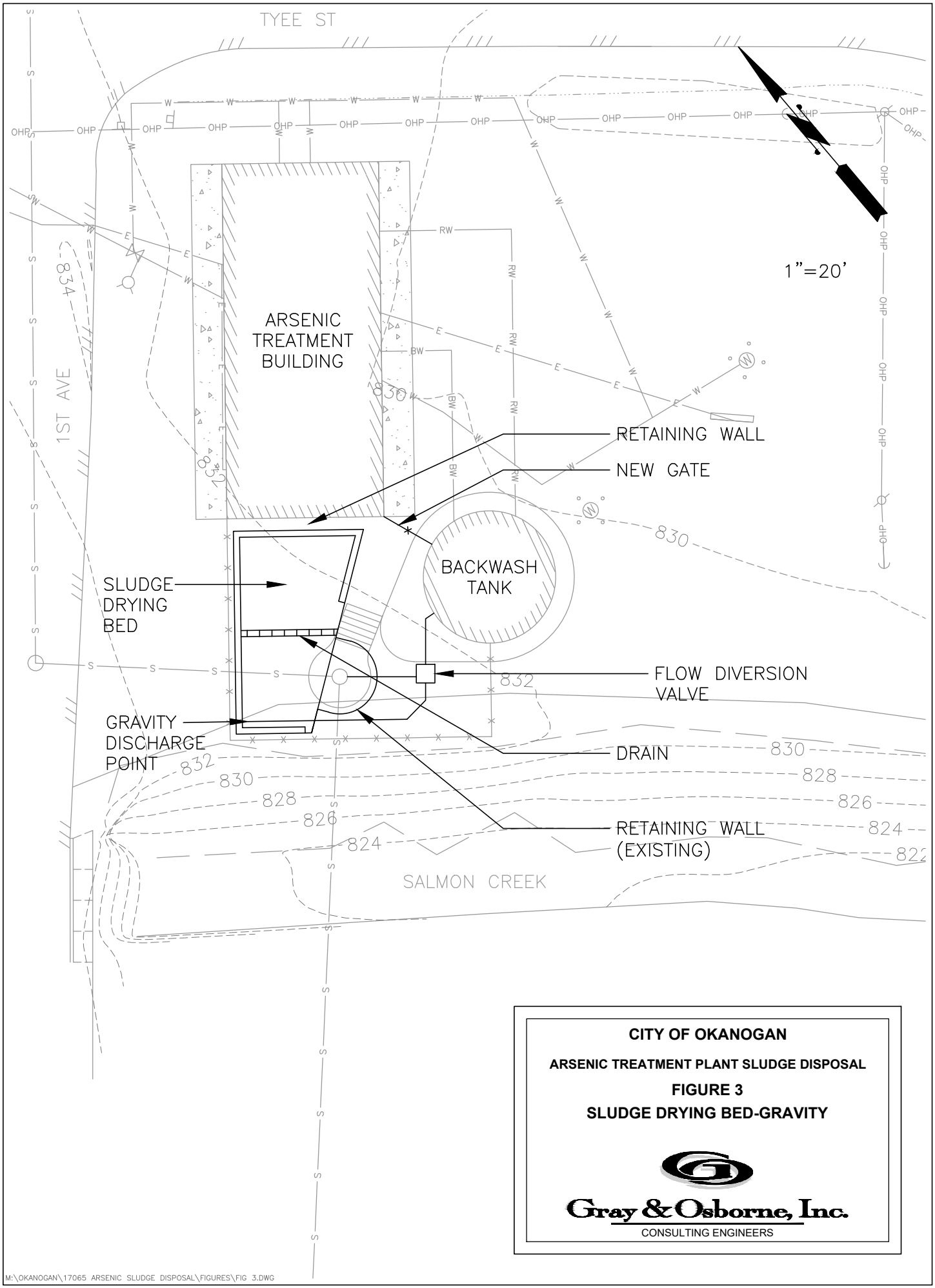
Alternative 3: Sludge Bagger – Pumped

This alternative consists of installing a packaged sludge bagger system. The system skid would include a stainless steel frame, distribution piping, and connection points for 6 woven, porous, synthetic bags that receive the backwash tank contents under pressure. The system control panel moderates flow to the bags, and a cyclic pumping control scheme allows the bags to fill and drain repeatedly, allowing for solids accumulation over time. Each bag has a 22.5 gallon nominal capacity. The nearby community of Electric City currently dewaters its arsenic sludge using this approach.

City staff have expressed reservations about this approach because it can be difficult to maintain a clean working environment. While filling under pressure, the sludge bags often display pinhole streams of water that exit the bag in random directions, and the spray pattern from these bags often results in the backwash staining the surrounding area, instead of all of the water dropping into the collection tray below the bags. This can be somewhat mitigated by surrounding the skid with a structure to shield the area, although cleanup may still be time-consuming. The system is often supplied with a polymer feed system in biosolids dewatering applications to assist in dewatering of the sludge. This would not be necessary for the City's installation, but can be included if the City's experience handling its arsenic sludge suggests that polymer addition would be valuable.

Once the bags are filled, they are typically laid on pallets or otherwise solar dried to further dry the bag contents prior to disposal. It appears that there is sufficient space available on the site for the City to store filled bags in this manner.

This alternative is shown in Figure 4. The estimated cost for this alternative is $240,900, including taxes and engineering (Appendix A). For planning purposes, a 4-sided pole structure with removable panels has been included to decrease the aesthetic problems that may be created by the system and to protect the system from the elements. However, this would not prevent freezing of the piping, and therefore the system would either need to be drained and removed from service during months with freezing weather, or the City would need to construct a more robust structure and provide heat to it. This would increase project cost considerably. Design criteria for this alternative are listed in Table 6.



CITY OF OKANOGAN

ARSENIC TREATMENT PLANT SLUDGE DISPOSAL

FIGURE 3

SLUDGE DRYING BED-GRAVITY

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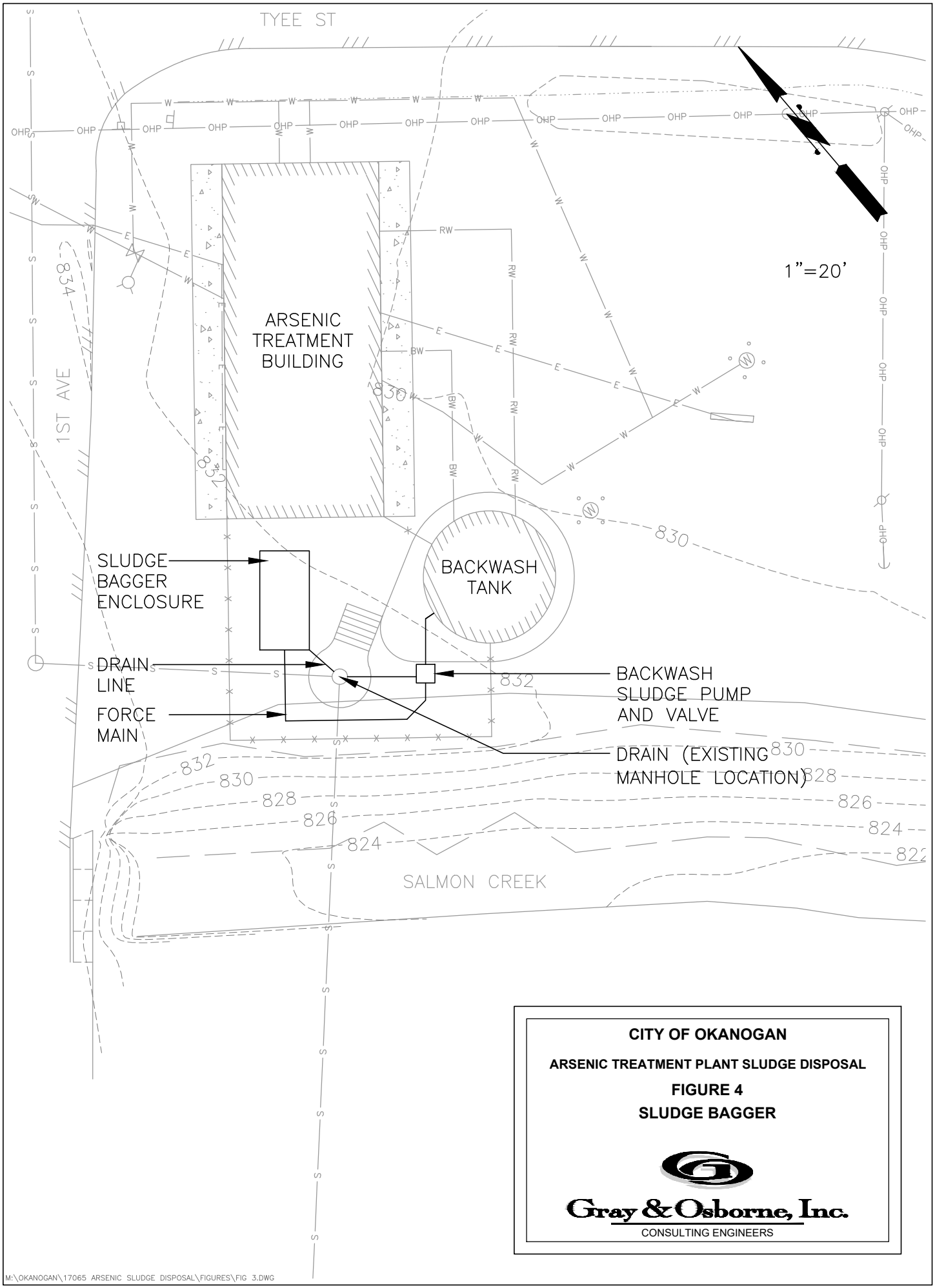
M:\OKANOGAN\17065 ARSENIC SLUDGE DISPOSAL\FIGURES\FIG 3.DWG



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ARSENIC TREATMENT PLANT SLUDGE DISPOSAL

FIGURE 4

SLUDGE BAGGER

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M:\OKANOGAN\17065 ARSENIC SLUDGE DISPOSAL\FIGURES\FIG 3.DWG

TABLE 6

Design Criteria – Alternative 3

Sludge Bagger	
Dimensions	10 ft x 2 ft x 6 ft
Number of Bags	6
Bag Capacity, Each	22.5 gallons
Dry Solids Loading Rate	20 lb/d
Sludge Pump	
Quantity	1
Type	Progressing Cavity
Capacity	30 gpm @ 10 ft TDH
Motor	1 hp
Control	Manual
Enclosure	
Dimensions	16 ft x 8 ft x 8 ft
Area	128 ft^2
Construction	Wooden Post, Steel Panel

Alternative 4: Sludge Drainage Bag – Pumped

This alternative is a similar to previous alternatives. Settled backwash would be pumped into a woven bag sized to fit the existing footprint available, which in this case would be a 14' bag with a 30' circumference. The bag would be placed in a concrete bed, and as it filled with solids, the excess water would percolate through the bag to a drain. It is assumed that the same drying bed area would be used as in Alternative 1. When filled, the manufacturer has indicated that the bags would be approximately 4 to 4.5 feet tall.

One advantage to using the bags would be a greater capture rate of arsenic. This is because the sludge is contained within the bag, and the initial discharge of sludge into the drying beds would not result in unfiltered backwash immediately flowing to the drain. As addressed previously, the drains would be lined with sand or gravel to filter the flow entering the drain, but there is still a possibility of solids entering the drain through this mechanism. When using the bags, the bag is a second filtration media that serves to reduce the concentration of arsenic entering the drying bed drain.

Once the bags are filled and then sufficiently drained, the City would be required to cut the bags open and re-load the solids into garbage bags or otherwise remove the solids from the drying bed. The bags can be disposed of at a landfill, although they are cumbersome due to size, and the City may wish to cut them into smaller pieces to assist in their removal and disposal.

Because the bags are essentially installed inside of sludge drying beds, it is feasible to select Alternative 1 or 2 and then connect bags to the fill line in the future to determine

whether the added value of containing solids as they dewater is preferable to the City or not. The cost of the bags is approximately $275 each for the required size, and the City would fill approximately 3 bags per year. Aside from this cost, there is not expected to be a significant difference between Alternative 1 and Alternative 4. The estimated cost for this alternative is $184,600, including taxes and engineering (Appendix A).

Design criteria for this alternative are listed in Table 7.

TABLE 7

Design Criteria – Alternative 4

Sludge Pump	
Quantity	1
Type	Progressing Cavity
Capacity	30 gpm @ 10 ft TDH
Motor	1 hp
Control	Manual
Sludge Drying Bed	
Dimensions	30 ft x 15 ft (average) x 1.5 ft
Area	450 ft^2
Bed Construction	Asphalt Paved
Sludge Drainage Bags	
Material	Woven Geotextile
Dimensions (empty)	14 ft x 15 ft x 1 ft
Dimensions (filled)	14 ft x 9 ft x 4 ft

Alternative 5: Sludge Drainage Bag Gravity-Drained

Similar to the description of Alternative 4 above, this alternative is identical to Alternative 2, with the exception of installing a large woven bag in the sludge drying bed to contain solids during dewatering. Because the filled bags are expected to have a filled height of approximately 4 feet, it would be necessary to construct the drying bed at a low enough elevation to allow the bag to fill completely below the invert elevation of the backwash tank drain line. The drying beds described for Alternative 2 would be approximately 5 feet deeper than existing grade, therefore the drying bed required for this alternative would be approximately 4 feet deeper, or 9 feet deep. The existing site constraints do not easily accommodate drying beds at this depth due to the space necessary to construct the required retaining walls, the setback required from the arsenic treatment building to avoid undermining its foundation, and the site grading necessary to provide an access road or otherwise allow for adequate vehicle access to the drying beds for sludge removal. For these reasons, this alternative will not be considered further.

Alternative 6: Sludge Drying Bed – WWTF Site

This alternative consists of constructing a new sludge drying bed at the WWTF site. Unlike the previous alternatives, this alternative would require the City to continue pumping solids out of the backwash tank and trucking them to the WWTF. This approach would be more labor-intensive than constructing facilities at the arsenic treatment plant site, but would result in no arsenic entering the biosolids. There appears to be sufficient space throughout the WWTF site for the City to identity a suitable location, and it would not be necessary to construct the bed to store a limited volume of sludge.

It is assumed that the new drying bed would be required to complete all of the drying for the year within a 4-month period from April to October. The average annual evaporation rate for the surrounding area is 37 in/yr[1] over this period, and the average annual precipitation rate for the area is 15 in/yr[2]. Assuming that the drying bed drains allows the solids to dry to 5 percent solids by gravity and the City's target solids concentration for sludge removal is 75 percent, the required drying bed size is calculated as follows:

Drying Bed Volume for 6,000 gal	= (6,000 gal)(1 ft^3/7.48 gal) / (1.5 ft) = 540 ft^2
Total Arsenic Sludge (5% Solids)	= 4,380 lb / 0.05 = 87,600 lb
Total Arsenic Sludge (75% Solids)	= 4,380 lb / 0.75 = 5,800 lb
Total Evaporation	= 87,600 lb – 5,800 lb = 81,800 lb = 1,300 ft^3
Drying Bed Area Storage	= (1,300 ft^3) / [(37 in – 15 in)(1 ft/12in)] = 710 ft^2
Total Drying Bed Area	= 710 ft^2 + 540 ft^2 = 1,250 ft^2

The estimated cost for this alternative is $162,900, including taxes and engineering (Appendix A).

Design criteria for this alternative are listed in Table 8.

[1] https://wrcc.dri.edu/htmlfiles/westevap.final.html

[2] https://www.usclimatedata.com/climate/omak/washington/united-states/uswa0320

TABLE 8

Design Criteria – Alternative 6

Sludge Drying Bed	
Dimensions	50 ft x 25 ft x 1.5 ft
Area	1,250 ft^2
Bed Construction	Asphalt Paved

ALTERNATIVE COMPARISON

To assist the City in comparing the various alternatives, a list of assumptions regarding O&M costs are presented below. Disposal costs are not included in this comparison, as it is assumed to be the same for all alternatives. Table 9 summarizes O&M costs for each option. Electricity costs are estimated at $0.10/kWh.

Alternative 1: Sludge Drying Beds – Pumped
- Bed-Filling Labor: 135 hr/yr @ $50/hr
- Bed-Cleaning Labor: 40 hr/yr @ $50/hr
- Sludge Pump: 1 hp @ 45 hr/yr

Alternative 2: Drying Beds Gravity-Drained
- Bed-Filling Labor: 80 hr/yr @ $50/hr
- Bed-Cleaning Labor: 60 hr/yr @ $50/hr

Alternative 3: Sludge Bagger – Pumped
- Bag-Filling Labor: 135 hr/yr @ $50/hr
- Bag-Change-Out Labor: 20 hr/yr @ $50/hr
- Solids Loading Labor: 40 hr/yr @ $50/hr
- Bags: $3/bag @ 48 bags/yr
- Sludge Pump: 1 hp @ 45 hr/yr

Alternative 4: Sludge Drainage Bag – Pumped
- Bed-Filling Labor: 135 hr/yr @ $50/hr
- Bed-Cleaning Labor: 30 hr/yr @ $50/hr
- Sludge Pump: 1 hp @ 45 hr/yr
- Bags: $275/bag @ 3 bags/yr

Alternative 6: Sludge Drying Bed – WWTF Site
- Bed-Filling Labor: 215 hr/yr @ $50/hr
- Bed-Cleaning Labor: 30 hr/yr @ $50/hr

TABLE 9

Alternative Analysis - Operation and Maintenance Costs

Option	Labor	Bags	Electricity	Total
1: Sludge Drying Beds - Pumped	$ 8,750	$ 0	$3	**$ 8,753**
2: Drying Beds Gravity-Drained	$ 7,000	$ 0	$0	**$ 7,000**
3: Sludge Bagger – Pumped	$ 9,750	$144	$3	**$ 9,753**
4: Sludge Drainage Bag – Pumped	$ 8,250	$825	$3	**$ 8,253**
6: Sludge Drying Bed – WWTF Site	$12,250	$ 0	$0	**$12,250**

Table 10 summarizes a 20-year present worth analysis of the six options analyzed above. An interest rate of 4 percent is used for the interest rate in the analysis.

TABLE 10

Alternative Analysis – Present Worth Costs

Option	Capital Cost	Annual O&M Cost	Present Worth
1: Sludge Drying Beds - Pumped	$184,600	$ 8,753	**$304,000**
2: Drying Beds Gravity-Drained	$179,500	$ 7,000	**$275,000**
3: Sludge Bagger – Pumped	$240,900	$ 9,753	**$373,000**
4: Sludge Drainage Bag – Pumped	$184,600	$ 8,253	**$297,000**
6: Sludge Drying Bed – WWTF Site	$162,900	$12,250	**$329,000**

As indicated in Table 10, the difference in present worth costs for the various alternatives is not significant enough to make a decision based entirely upon financial considerations. Therefore, a variety of other factors have been included in a matrix analysis to assist in determining the best alternative for the City. Table 11 shows the evaluation matrix. Each criterion in the matrix has been assigned an importance factor, from 1 to 5, to weight its value based upon discussions with City staff. Each alternative is then rated from one to ten for each criterion, with a higher score indicating a better rating. The importance factor is then multiplied by the rating for that criteria and summed for each alternative. The total score for each criterion is shown in parentheses.

TABLE 11

Alternative Decision Matrix

Criterion	Relative Importance Factor	Alternative Number				
		1	2	3	4	6
Relative Capital Cost	2	7 (14)	9 (18)	3 (6)	7 (14)	10 (20)
Relative O&M Cost	3	8 (24)	9 (27)	6 (18)	8 (24)	3 (9)
Aesthetics	2	5 (10)	5 (10)	7 (14)	8 (16)	10 (20)
Safety	5	6 (30)	6 (30)	9 (45)	8 (40)	5 (25)
Location	1	10 (10)	10 (10)	10 (10)	10 (10)	7 (7)
Score	**13**	**88**	**95**	**93**	**104**	**81**

RECOMMENDED ALTERNATIVE

As identified in Table 11, the highest rated alternative is Alternative 4, the construction of above-grade sludge drying beds at the arsenic treatment facility that utilize a woven geotextile dewatering bag to provide aesthetic shielding of the sludge and contain the dewatered solids. The advantage of utilizing the dewatering bags would be a more aesthetically-pleasing project site as the sludge is more contained, and the likelihood of a high capture rate of arsenic.

SAFETY CONSIDERATIONS

During discussions with City staff, it has become apparent that there are concerns for how to handle the arsenic treatment facility sludge in a safe manner. Copies of Material Safety Data Sheets (MSDS) for the chemicals that are expected to be present in the sludge are included in Appendix B. The majority of the sludge consists of Fe_2O_3, which is iron oxide, or rust. The presence of arsenic in the sludge is concerning, but the majority of the risk associated with arsenic is for inhalation or ingestion. There are additional risks of eye irritation and skin irritation.

The City may be able to minimize exposure risk by not allowing the drying solids to reach a dusty-dry composition prior to bagging. The appropriate balance between complete drying and landfill tipping fees will depend on City experience and a determination of what solids concentration renders the sludge too dry to handle without significant generation of dust.

APPENDIX A

COST ESTIMATES

CITY OF OKANOGAN
ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY
TOTAL ESTIMATED PROJECT COST
ALTERNATIVE 1: SLUDGE DRYING BED - PUMPED
(November 2017 ENR Construction Cost Index #11443)

NO.	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1.	Mobilization and Demobilization	1	LS	$10,000	$10,000
2.	Trench Excavation Safety Systems	1	LS	$10,000	$10,000
3.	Minor Changes	1	CALC	$10,000	$10,000
4.	Erosion/Water Pollution Control	1	LS	$1,000	$1,000
5.	SPCC Plan	1	LS	$1,000	$1,000
6.	Sludge Pump	1	EA	$5,000	$5,000
7.	Electrical and Controls	1	LS	$20,000	$20,000
8.	Backwash Tank Piping Modification	1	LS	$5,000	$5,000
9.	Valving	1	LS	$5,000	$5,000
10.	Vault	1	LS	$5,000	$5,000
11.	2" Force Main	30	LF	$20	$600
12.	Sludge Drying Beds	450	SF	$50	$22,500
13.	Guardrail	1	LS	$500	$500
14.	Site Grading	1	LS	$5,000	$5,000
15.	Fencing Modifications	1	LS	$1,000	$1,000
16.	Surface Restoration	1	LS	$5,000	$5,000
				Subtotal:	$106,600
				Washington State Sales Tax (8.2%):	$8,700
				Construction Subtotal:	$115,300
				Construction Contingency (25%):	$28,800
				Construction Total:	$144,100
				Design and Construction Engineering:	$40,000
				City Administrative Costs:	$500
				Total Estimated Project Cost:	$184,600

CITY OF OKANOGAN
ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY
TOTAL ESTIMATED PROJECT COST
ALTERNATIVE 2: SLUDGE DRYING BED - GRAVITY
(November 2017 ENR Construction Cost Index #11443)

NO.	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1.	Mobilization and Demobilization	1	LS	$9,000	$9,000
2.	Trench Excavation Safety Systems	1	LS	$10,000	$10,000
3.	Minor Changes	1	CALC	$10,000	$10,000
4.	Erosion/Water Pollution Control	1	LS	$1,000	$1,000
5.	SPCC Plan	1	LS	$1,000	$1,000
6.	Excavation	70	CY	$30	$2,100
7.	Retaining Wall	20	CY	$1,100	$22,000
8.	Backwash Tank Piping Modification	1	LS	$5,000	$5,000
9.	Valving	1	LS	$5,000	$5,000
10.	Vault	1	LS	$5,000	$5,000
11.	Sludge Drying Beds	360	SF	$50	$18,000
12.	Site Grading	1	LS	$5,000	$5,000
13.	Fencing Modifications	1	LS	$1,000	$1,000
14.	Surface Restoration	1	LS	$5,000	$5,000
				Subtotal:	$99,100
				Washington State Sales Tax (8.2%):	$8,100
				Construction Subtotal:	$107,200
				Construction Contingency (25%):	$26,800
				Construction Total:	$134,000
				Design and Construction Engineering:	$45,000
				City Administrative Costs:	$500
				Total Estimated Project Cost:	$179,500

CITY OF OKANOGAN
ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY
TOTAL ESTIMATED PROJECT COST
ALTERNATIVE 3: SLUDGE BAGGER
(November 2017 ENR Construction Cost Index #11443)

NO.	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1.	Mobilization and Demobilization	1	LS	$13,000	$13,000
2.	Trench Excavation Safety Systems	1	LS	$10,000	$10,000
3.	Minor Changes	1	CALC	$10,000	$10,000
4.	Erosion/Water Pollution Control	1	LS	$1,000	$1,000
5.	SPCC Plan	1	LS	$1,000	$1,000
6.	Sludge Pump	1	EA	$5,000	$5,000
7.	Electrical and Controls	1	LS	$25,000	$25,000
8.	Backwash Tank Piping Modification	1	LS	$5,000	$5,000
9.	Valving	1	LS	$5,000	$5,000
10.	2" Force Main	20	LF	$20	$400
11.	4" Drain Line	10	LF	$30	$300
12.	Sludge Bagger Skid	1	LS	$55,000	$55,000
13.	Pole Building	128	SF	$50	$6,400
14.	Surface Restoration	1	LS	$5,000	$5,000
				Subtotal:	$142,100
				Washington State Sales Tax (8.2%):	$11,700
				Construction Subtotal:	$153,800
				Construction Contingency (25%):	$38,500
				Construction Total:	$192,300
				Design and Construction Engineering:	$48,100
				City Administrative Costs:	$500
				Total Estimated Project Cost:	$240,900

CITY OF OKANOGAN
ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY
TOTAL ESTIMATED PROJECT COST
ALTERNATIVE 4: SLUDGE DRAINAGE BAG - PUMPED
(November 2017 ENR Construction Cost Index #11443)

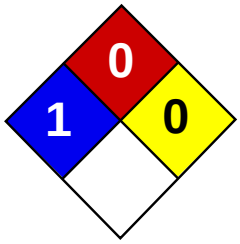
NO.	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1.	Mobilization and Demobilization	1	LS	$10,000	$10,000
2.	Trench Excavation Safety Systems	1	LS	$10,000	$10,000
3.	Minor Changes	1	CALC	$10,000	$10,000
4.	Erosion/Water Pollution Control	1	LS	$1,000	$1,000
5.	SPCC Plan	1	LS	$1,000	$1,000
6.	Sludge Pump	1	EA	$5,000	$5,000
7.	Electrical and Controls	1	LS	$20,000	$20,000
8.	Backwash Tank Piping Modification	1	LS	$5,000	$5,000
9.	Valving	1	LS	$5,000	$5,000
10.	Vault	1	LS	$5,000	$5,000
11.	2" Force Main	30	LF	$20	$600
12.	Sludge Drying Beds	450	SF	$50	$22,500
13.	Guardrail	1	LS	$500	$500
14.	Site Grading	1	LS	$5,000	$5,000
15.	Fencing Modifications	1	LS	$1,000	$1,000
16.	Surface Restoration	1	LS	$5,000	$5,000
				Subtotal:	$106,600
				Washington State Sales Tax (8.2%):	$8,700
				Construction Subtotal:	$115,300
				Construction Contingency (25%):	$28,800
				Construction Total:	$144,100
				Design and Construction Engineering:	$40,000
				City Administrative Costs:	$500
				Total Estimated Project Cost:	$184,600

CITY OF OKANOGAN
ARSENIC TREATMENT FACILITY SLUDGE DISPOSAL FEASIBILITY STUDY
TOTAL ESTIMATED PROJECT COST
ALTERNATIVE 6: WWTF DRYING BED
(November 2017 ENR Construction Cost Index #11443)

NO.	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1.	Mobilization and Demobilization	1	LS	$9,000	$9,000
2.	Trench Excavation Safety Systems	1	LS	$1,000	$1,000
3.	Minor Changes	1	CALC	$10,000	$10,000
4.	Erosion/Water Pollution Control	1	LS	$500	$500
5.	SPCC Plan	1	LS	$500	$500
6.	Backwash Tank Piping Modification	1	LS	$5,000	$5,000
7.	Excavation	50	CY	$30	$1,500
8.	Sludge Drying Beds	1,250	SF	$50	$62,500
9.	Site Piping	1	LS	$1,000	$1,000
10.	Site Grading	1	LS	$5,000	$5,000
				Subtotal:	$96,000
				Washington State Sales Tax (8.2%):	$7,900
				Construction Subtotal:	$103,900
				Construction Contingency (25%):	$26,000
				Construction Total:	$129,900
				Design and Construction Engineering:	$32,500
				City Administrative Costs:	$500
				Total Estimated Project Cost:	$162,900

APPENDIX B

MATERIAL SAFETY DATA



Material Safety Data Sheet
Sodium Hypochlorite, 5% MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium Hypochlorite, 5%

Catalog Codes: SLS1654

CAS#: Mixture.

RTECS: Not applicable.

TSCA: TSCA 8(b) inventory: Sodium hypochlorite; Sodium hydroxide; Water

CI#: Not applicable.

Synonym: Chlorine Bleach, Bleach, Soda Bleach, Chlorox; Sodium Hypochlorite, Solution, 5% Available Chlorine

Chemical Name: Hypochlorous acid, sodium salt, solution

Chemical Formula: Not applicable.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium hypochlorite	7681-52-9	4-7
Sodium hydroxide	1310-73-2	<1
Water	7732-18-5	>92

Toxicological Data on Ingredients: Sodium hypochlorite: ORAL (LD50): Acute: 5800 mg/kg [Mouse]. 8910 mg/kg [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, . Hazardous in case of skin contact (corrosive), of eye contact (corrosive). Slightly hazardous in case of inhalation (lung sensitizer). Non-corrosive for lungs. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Prolonged exposure may result in skin burns and ulcerations. Over-exposure by inhalation may cause respiratory irritation. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Sodium hypochlorite]. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. [Sodium hypochlorite]. Mutagenic for mammalian somatic cells. [Sodium hydroxide]. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to lungs, mucous membranes, skin, eyes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: combustible materials, metals, organic materials

Explosion Hazards in Presence of Various Substances:
Slightly explosive in presence of open flames and sparks. Non-explosive in presence of shocks.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards:
Releases chlorine when heated above 35 deg. C. The substance itself is non-combustible and does not burn. However, when heated to decomposition it emits corrosive and/or toxic fumes. May ignite combustibles. Fire risk in contact with organic materials. Contact with metals may evolve flammable hydrogen gas.

Special Remarks on Explosion Hazards:
Anydrous Sodium Hypochlorite is very explosive. Primary amines and calcium hypochlorite or sodium hypochlorite react to form normal chloroamines, which are explosive. Interaction of ethyleneimine with sodium (or other) hypochlorite gives the explosive N-chloro cmpd. Removal of formic acid from industrial waste streams with sodium hypochlorite soln becomes explosive at 55 deg C. Several explosions involving methanol and sodium hypochlorite were attributed to formation of methyl hypochlorite, especially in presence of acid or other esterification catalyst. Use of sodium hypochlorite soln to destroy acidified benzyl cyanide residues caused a violent explosion, thought to have been due to formation of nitrogen trichloride. (Sodium hypochlorite)

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

Large Spill:
Corrosive liquid. Oxidizing material. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Avoid contact with a combustible material (wood, paper, oil, clothing...). Keep substance damp using water spray. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep container dry. Keep away from heat. Keep away from sources of ignition. Keep away from combustible material.. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as reducing agents, combustible materials, organic materials, metals, acids.

Storage:
Keep container tightly closed. Keep container in a cool, well-ventilated area. Separate from acids, alkalies, reducing agents and combustibles. See NFPA 43A, Code for the Storage of Liquid and Solid Oxidizers. Air Sensitive Sensitive to light. Store in light-resistant containers.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
Sodium hypochlorite TWA: 1 CEIL: 1 (ppm as Cl2) STEL: 1 (ppm as Cl2) from ACGIH (TLV) [United States] Sodium hydroxide STEL: 2 (mg/m3) from ACGIH (TLV) [United States] TWA: 2 CEIL: 2 (mg/m3) from OSHA (PEL) [United States] CEIL: 2 (mg/m3) from NIOSH Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Characteristic. Chlorine-like (Slight.)

Taste: Not available.

Molecular Weight: Not applicable.

Color: Colorless to light greenish yellow

pH (1% soln/water): Neutral.

Boiling Point: Decomposition temperature: 40°C (104°F)

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: 1.07 - 1.093 (Water = 1)

Vapor Pressure: 2.3 kPa (@ 20°C)

Vapor Density: The highest known value is 0.62 (Air = 1) (Water).

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Easily soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials. light, air, heat

Incompatibility with various substances: Reactive with reducing agents, combustible materials, organic materials, metals, acids.

Corrosivity:
Extremely corrosive in presence of aluminum. Corrosive in presence of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Decomposed by carbon dioxide from air. Slowly decomposes on contact with air. Unstable in air unless mixed with sodium hydroxide. Incompatible with ammonium acetate, ammonium carbonate, ammonium nitrate, ammonium oxalate, and ammonium phosphate. Decompostion of sodium hypochlorite takes place within a few seconds with these salts. Also incompatible with primary amines, phenyl acetonitrile, ethyleneimine, methanol, acidified benzyl cyanide, formic acid, urea, nitro compounds, methylscellulose, celloluse, aziridine, ether, ammonia. Mixing this product with chemicals (e.g. ammonia, acids, detergents, etc.) or organic matter (e.g. urine, feces, etc.) will release chlorine gas. Chloramine gas may be evolved when ammonia and bleach are mixed. Decomposed by hot water. Sensitive to light. Exposure to light accelerates decompositon.

Special Remarks on Corrosivity:
Sodium Hypochlorite is extremely corrosive to brass, and moderately corrosive to bronze. There is no corrosivity information for copper.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact. Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 5800 mg/kg [Mouse]. (Sodium hypochlorite).

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Sodium hypochlorite]. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. [Sodium hypochlorite]. Mutagenic for mammalian somatic cells. [Sodium hydroxide]. Contains material which may cause damage to the following organs: lungs, mucous membranes, skin, eyes.

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (irritant), of ingestion, . Hazardous in case of skin contact (corrosive), of eye contact (corrosive). Slightly hazardous in case of inhalation (lung sensitizer, lung corrosive).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: May affect genetic material (mutagenic) (Sodium hypochlorite)

Special Remarks on other Toxic Effects on Humans:
Potential Health Effects: Can cause severe irritation and possible burns to skin and eyes. Eye contact may also cause corneal and conjunctival edema, conjunctival hemorrhages. Contact with skin may also cause vesicular eruptions and eczematoid dermatitis which becomes evident upon re-exposure. Prolonged or repeated eye contact may cause conjunctivitis. Ingestion can cause burns to the digestive tract. Symptoms may include: 1. pain and inflammation of the mouth, pharynx, esophagus, and stomach, 2. erosion of the mucous membranes (chiefly of the stomach), nausea, vomiting, choking, coughing, hemorrhage, 3. circulatory collapse with cold and clammy skin (due to methemoglobinemia), cyanosis, and shallow respirations, 4. confusion, delirium, coma, 5. edema of the pharynx, glottis, larynx with stridor and obstruction, 6. perforation of the esophagus, or stomach, with mediastinitis or peritonitis. Inhalation causes slight to severe respiratory tract irritation and delayed pulmonary edema. Prolonged or repeated inhalation may cause allergic respiratory reaction (asthma).

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Dilute with water and flush to sewer of local ordinances allow, otherwise, whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Hypochlorite solution UNNA: 1791 PG: III

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Illinois toxic substances disclosure to employee act: Sodium hydroxide Illinois chemical safety act: Sodium hydroxide New York release reporting list: Sodium hydroxide Rhode Island RTK hazardous substances: Sodium hydroxide Pennsylvania RTK: Sodium hypochlorite; Sodium hydroxide Florida: Sodium hypochlorite Minnesota: Sodium hypochlorite; Sodium hydroxide Massachusetts RTK: Sodium hypochlorite; Sodium hydroxide New Jersey: Sodium hypochlorite; Sodium hydroxide Louisiana spill reporting: Sodium hydroxide TSCA 8(b) inventory: Sodium hypochlorite; Sodium hydroxide; Water CERCLA: Hazardous substances.: Sodium hypochlorite: 100 lbs. (45.36 kg); Sodium hydroxide: 1000 lbs. (453.6 kg);

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): CLASS E: Corrosive liquid.

DSCL (EEC):
R8- Contact with combustible material may cause fire. R31- Contact with acids liberates toxic gas. R36/38- Irritating to eyes and skin. S28- After contact with skin, wash immediately with plenty of water. S36/37/39- Wear suitable protective clothing, gloves and eye/face protection. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 0

Personal Protection:

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 06:32 PM

Last Updated: 05/21/2013 12:00 PM

Material Safety Data Sheet
IRON(III) OXIDE, 99.999%, -100 MESH

Section 1 - Chemical Product and Company Identification

MSDS Name:	IRON(III) OXIDE, 99.999%, -100 MESH
Catalog Numbers:	19326-0000, 19326-0100, 19326-0500
Synonyms:	Ferric Oxide Red
Company Identification:	Acros Organics BVBA Janssen Pharmaceuticalaan 3a 2440 Geel, Belgium
Company Identification: (USA)	Acros Organics One Reagent Lane Fair Lawn, NJ 07410
For information in the US, call:	800-ACROS-01
For information in Europe, call:	+32 14 57 52 11
Emergency Number, Europe:	+32 14 57 52 99
Emergency Number US:	201-796-7100
CHEMTREC Phone Number, US:	800-424-9300
CHEMTREC Phone Number, Europe:	703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name:	%	EINECS#
1309-37-1	IRON(III) OXIDE, 99.999%, -100 MESH	99.999%	215-168-2

Hazard Symbols:	None listed
Risk Phrases:	None listed

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Not available

Potential Health Effects

Eye:	Dust may cause mechanical irritation.
Skin:	Dust may cause mechanical irritation.
Ingestion:	No information found.
Inhalation:	Dust is irritating to the respiratory tract. Inhalation of fumes may cause metal fume fever, which is characterized by flu-like symptoms with metallic taste, fever, chills, cough, weakness, chest pain, muscle pain and increased white blood cell count.

Chronic: Chronic inhalation may cause effects similar to those of acute inhalation.

Section 4 - First Aid Measures

Eyes:	Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.
Skin:	Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists.
Ingestion:	If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get medical aid immediately.
Inhalation:	Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.
Notes to Physician:	

Section 5 - Fire Fighting Measures

General Information:	As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear.
Extinguishing Media:	Substance is noncombustible; use agent most appropriate to extinguish surrounding fire.

Section 6 - Accidental Release Measures

General Information:	Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks:	Vacuum or sweep up material and place into a suitable disposal container. Wear a self contained breathing apparatus and appropriate personal protection. (See Exposure Controls, Personal Protection section). Avoid generating dusty conditions.

Section 7 - Handling and Storage

Handling:	Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Minimize dust generation and accumulation. Keep container tightly closed. Do not get on skin or in eyes. Do not ingest or inhale.
Storage:	Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls:

Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.

Exposure Limits

CAS# 1309-37-1:

United Kingdom, WEL - TWA: 5 mg/m3 TWA (fume, as Fe); 10 mg/m3

TWA (total inhalable, listed as rouge); 4 mg United Kingdom, WEL - STEL: 10 mg/m3 STEL (fume, as Fe); 30 mg/m3 STEL (total inhalable, listed as rouge); 1

United States OSHA: 10 mg/m3 TWA

Belgium - TWA: 2 ppm VLE (fume, as Fe); 5 mg/m3 VLE (fume, as Fe)

France - VME: 5 mg/m3 VME (as Fe)

Germany: 6 mg/m3 TWA (respirable fraction)

Malaysia: 2 ppm TWA (dust and fume, particulate matter containing no asbestos and <1% crys

Netherlands: 10 mg/m3 MAC (as Fe2O3)

Russia: 4 mg/m3 TWA (aerosol)

Spain: 5 mg/m3 VLA-ED (dust and fume, as Fe)

Personal Protective Equipment

Eyes:	Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin:	Wear appropriate protective gloves to prevent skin exposure.
Clothing:	Wear appropriate protective clothing to prevent skin exposure.
Respirators:	Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 - Physical and Chemical Properties

Physical State:	Powder
Color:	rust
Odor:	Not available
pH:	Not available
Vapor Pressure:	1 mm Hg @ 20C
Viscosity:	Not available
Boiling Point:	Not available
Freezing/Melting Point:	1538 deg C (2,800.40°F)
Autoignition Temperature:	Not available
Flash Point:	Not available
Explosion Limits: Lower:	Not available
Explosion Limits: Upper:	Not available
Decomposition Temperature:	Not available

Solubility in water: insoluble

Specific Gravity/Density: 5.2400g/cm3

Molecular Formula: Fe2O3

Molecular Weight: 159.69

Section 10 - Stability and Reactivity

Chemical Stability:	Stable at room temperature in closed containers under normal storage and handling conditions.
Conditions to Avoid:	Incompatible materials, dust generation.
Incompatibilities with Other Materials	Aluminum, carbon dioxide, ethylene oxide, hydrazine, calcium hypochlorite, bromine pentafluoride, cesium carbide.
Hazardous Decomposition Products	None.
Hazardous Polymerization	Has not been reported.

Section 11 - Toxicological Information

RTECS#:	CAS# 1309-37-1: NO7400000 NO7420000 NO7480000
LD50/LC50:	RTECS: Not available.
Carcinogenicity:	IRON(III) OXIDE, 99.999%, -100 MESH - IARC: Group 3 (not classifiable)
Other:	See actual entry in RTECS for complete information.

Section 12 - Ecological Information

Other: No information available.

Section 13 - Disposal Considerations

Dispose of in a manner consistent with federal, state, and local regulations.

Section 14 - Transport Information

	IATA	IMO	RID/ADR
Shipping Name:	Not available	Not available	Not available
Hazard Class:			
UN Number:			
Packing Group:			

Section 15 - Regulatory Information

European/International Regulations

European Labeling in Accordance with EC Directives

Hazard Symbols:Not available

Risk Phrases:

Safety Phrases:

S 24/25 Avoid contact with skin and eyes.

WGK (Water Danger/Protection)

CAS# 1309-37-1: 0

Canada

CAS# 1309-37-1 is listed on Canada's DSL List

</ TD>

US Federal

TSCA

CAS# 1309-37-1 is listed on the TSCA Inventory.

Section 16 - Other Information

MSDS Creation Date: 7/16/1996

Revision #0 Date Original.

Material Safety Data Sheet
Arsenic(V) oxide

MSDS# 02088

Section 1 - Chemical Product and Company Identification

MSDS Name:	Arsenic(V) oxide
Catalog Numbers:	AC192500000, AC192500250, AC366310000, AC366310050, AC366310250
Synonyms:	Arsenic pentoxide; Diarsenic pentaoxide; Arsenic acid anhydride; Arsenic anhydride.
Company Identification:	Acros Organics BVBA Janssen Pharmaceuticalaan 3a 2440 Geel, Belgium
Company Identification: (USA)	Acros Organics One Reagent Lane Fair Lawn, NJ 07410
For information in the US, call:	800-ACROS-01
For information in Europe, call:	+32 14 57 52 11
Emergency Number, Europe:	+32 14 57 52 99
Emergency Number US:	201-796-7100
CHEMTREC Phone Number, US:	800-424-9300
CHEMTREC Phone Number, Europe:	703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#:	1303-28-2
Chemical Name:	Arsenic(V) oxide
%:	>99.9
EINECS#:	215-116-9

Hazard Symbols: T N

Risk Phrases: 45 23/25 50/53

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Danger! May be fatal if swallowed. Harmful if inhaled. Cancer hazard. May cause fetal effects. Contains inorganic arsenic. May cause nervous system effects. Causes eye, skin, and respiratory tract irritation. Target Organs: Liver, lungs, nervous system, skin.

Potential Health Effects

Eye:	May cause eye irritation. May result in corneal injury.
Skin:	May cause skin irritation. May cause skin sensitization, an allergic reaction, which becomes evident upon re-exposure to this material.
Ingestion:	May cause liver damage. Can cause nervous system damage. Ingestion of arsenical compounds may cause burning of the lips, throat constriction, swallowing difficulties, severe abdominal pain, severe nausea, projectile vomiting, and profuse diarrhea. All soluble arsenic (As) compounds are considered to be poisonous to humans. Inorganic arsenic is more toxic than organic arsenic. Organic arsenic is excreted more rapidly than inorganic arsenic. Arsenic 5+ is excreted more rapidly than arsenic 3+. Arsenic inhibits enzymes required for cellular

respiration and also competes with phosphorus for incorporation into ATP, depleting cellular energy stores and leading to cell death.

Inhalation: Causes respiratory tract irritation. May cause effects similar to those described for ingestion. Inhalation of arsenic compounds may lead to irritation of the respiratory tract and to possible nasal perforation.

Chronic: Chronic ingestion is characterized by weakness, anorexia, gastrointestinal disturbances, impairment of cognitive function, peripheral neuropathy, and skin disorders. Chronic ingestion may cause fetal effects. Inorganic arsenic compounds may cause skin and lung cancers in humans.

Section 4 - First Aid Measures

Eyes: Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately.

Skin: Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists.

Ingestion: Call a poison control center. If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical aid.

Inhalation: Get medical aid immediately. Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.

Notes to Physician:

Section 5 - Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear.

Extinguishing Media: Use water spray to cool fire-exposed containers.

Autoignition Temperature: Not available

Flash Point: Not available

Explosion Limits: Lower: Not available

Explosion Limits: Upper: Not available

NFPA Rating: health: 3; flammability: 0; instability: 0;

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks: Vacuum or sweep up material and place into a suitable disposal container. Avoid generating dusty conditions. Provide ventilation.

Section 7 - Handling and Storage

Handling: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Do not get in eyes, on skin, or on clothing. Do not ingest or inhale. Use only with adequate ventilation or respiratory protection.

Storage: Poison room locked.

Section 8 - Exposure Controls, Personal Protection

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Arsenic(V) oxide	0.01 mg/m3 TWA (as As) (listed under Arsenic, inorganic compounds).	5 mg/m3 IDLH (as As) (listed under Arsenic, inorganic compounds).	10 æg/m3 TWA (as As) (listed under Arsenic, inorganic compounds).5 æg/m3 Action Level (as As); 10 æg/m3 TWA (as As, Cancer hazard - see 29 CFR 19 10.1018, except Arsine) (listed under

			|Arsenic,

OSHA Vacated PELs: Arsenic(V) oxide: None listed

Engineering Controls:

Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits. See 29CFR 1910.1018 for regulatory requirements pertaining to all occupational exposures to inorganic arsenic.

Exposure Limits

Personal Protective Equipment

Eyes: Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin: Wear appropriate protective gloves to prevent skin exposure.

Clothing: Wear appropriate protective clothing to prevent skin exposure.

Respirators: Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 - Physical and Chemical Properties

Physical State: Solid

Color: white

Odor: odorless

pH: acidic in soln

Vapor Pressure: Not available

Vapor Density: Not available

Evaporation Rate: Not available

Viscosity: Not available

Boiling Point: Not available

Freezing/Melting Point: 315 deg C (dec)

Decomposition Temperature:

Solubility in water: Soluble

Specific Gravity/Density:

Molecular Formula: As2O5

Molecular Weight: 229.84

Section 10 - Stability and Reactivity

Chemical Stability: Stable under normal temperatures and pressures.

Conditions to Avoid: Excess heat, moist air.

Incompatibilities with Other Materials: Acids, aluminum, halogens, zinc, rubidium carbide.

Hazardous Decomposition Products: Oxides of arsenic.

Hazardous Polymerization: Has not been reported.

Section 11 - Toxicological Information

RTECS#: CAS# 1303-28-2: CG2275000

LD50/LC50: RTECS:
CAS# 1303-28-2: Oral, mouse: LD50 = 55 mg/kg;
Oral, rat: LD50 = 8 mg/kg;
.

Carcinogenicity: Arsenic(V) oxide - California: carcinogen, initial date 2/27/87 (Arsenic, inorganic compounds). NTP: Known carcinogen (Arsenic, inorganic compounds). IARC: Group 1 carcinogen

Other: See actual entry in RTECS for complete information.

Section 12 - Ecological Information

Other: No information available.

Section 13 - Disposal Considerations

Dispose of in a manner consistent with federal, state, and local regulations.

Section 14 - Transport Information

US DOT
Shipping Name: Please contact Fisher Scientific for shipping information
Hazard Class:
UN Number:
Packing Group:
Canada TDG
Shipping Name: Not available
Hazard Class:
UN Number:
Packing Group:

USA RQ: CAS# 1303-28-2: 1 lb final RQ; 0.454 kg final RQ

Section 15 - Regulatory Information

European/International Regulations

European Labeling in Accordance with EC Directives

Hazard Symbols: T N

Risk Phrases:

R 45 May cause cancer.

R 23/25 Toxic by inhalation and if swallowed.

R 50/53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Safety Phrases:

S 53 Avoid exposure - obtain special instructions before use.

S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

S 60 This material and its container must be disposed of as hazardous waste.

S 61 Avoid release to the environment. Refer to special instructions/safety data sheets.

WGK (Water Danger/Protection)

CAS# 1303-28-2: 3

Canada

CAS# 1303-28-2 is listed on Canada's DSL List

Canadian WHMIS Classifications: D2A, D1A

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.

CAS# 1303-28-2 is listed on Canada's Ingredient Disclosure List

US Federal

TSCA

CAS# 1303-28-2 is listed on the TSCA Inventory.

Section 16 - Other Information

MSDS Creation Date: 9/02/1997

Revision #6 Date 7/20/2009

or any special, indirect, incidental, consequential, or exemplary damages howsoever arising, even if the company has been advised of the possibility of such damages.

Ferric Chloride Solution

Safety Data Sheet

according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

Date of issue: 12/12/2013 Revision date: 01/17/2017 Supersedes: 01/17/2017 Version: 1.1

SECTION 1: Identification

1.1. Identification

Product form : Mixtures

Product name : Ferric Chloride Solution

Product code : LC14380

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture : For laboratory and manufacturing use only.

Restrictions on use : Not for food, drug or household use

1.3. Details of the supplier of the safety data sheet

LabChem Inc
Jackson's Pointe Commerce Park Building 1000, 1010 Jackson's Pointe Court
Zelienople, PA 16063 - USA
T 412-826-5230 - F 724-473-0647
info@labchem.com - www.labchem.com

1.4. Emergency telephone number

Emergency number : CHEMTREC: 1-800-424-9300 or 011-703-527-3887

SECTION 2: Hazard(s) identification

2.1. Classification of the substance or mixture

GHS-US classification

Skin corrosion/irritation Category 1C	H314
Serious eye damage/eye irritation Category 1	H318
Hazardous to the aquatic environment - Acute Hazard Category 2	H401

Full text of H statements : see section 16

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :

GHS05

Signal word (GHS-US) : Danger

Hazard statements (GHS-US) : H314 - Causes severe skin burns and eye damage
H401 - Toxic to aquatic life

Precautionary statements (GHS-US) : P260 - Do not breathe mist, vapors, spray
P264 - Wash exposed skin thoroughly after handling
P273 - Avoid release to the environment
P280 - Wear protective gloves, eye protection
P301+P330+P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P303+P361+P353 - IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower
P305+P351+P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a poison center or doctor/physician
P363 - Wash contaminated clothing before reuse
P405 - Store locked up
P501 - Dispose of contents/container to comply with local, state and federal regulations
If inhaled: Remove person to fresh air and keep comfortable for breathing

2.3. Other hazards

Other hazards not contributing to the classification : None.

2.4. Unknown acute toxicity (GHS US)

Not applicable

SECTION 3: Composition/Information on ingredients

3.1. Substances

Not applicable

3.2. Mixtures

Name	Product identifier	%	GHS-US classification
Ferric Chloride, Hexahydrate	(CAS No) 10025-77-1	71	Acute Tox. 4 (Oral), H302 Skin Corr. 1C, H314 Eye Dam. 1, H318 Aquatic Acute 2, H401
Water	(CAS No) 7732-18-5	29	Not classified

Full text of hazard classes and H-statements : see section 16

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label where possible).

First-aid measures after inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center or doctor/physician.

First-aid measures after skin contact : Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower. Immediately call a poison center or doctor/physician.

First-aid measures after eye contact : Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center or doctor/physician.

First-aid measures after ingestion : Rinse mouth. Do NOT induce vomiting. Immediately call a poison center or doctor/physician.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/injuries : Causes severe skin burns and eye damage.

Symptoms/injuries after eye contact : Causes serious eye damage.

4.3. Indication of any immediate medical attention and special treatment needed

No additional information available

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Foam. Dry powder. Carbon dioxide. Water spray. Sand.

Unsuitable extinguishing media : Do not use a heavy water stream.

5.2. Special hazards arising from the substance or mixture

Reactivity : Thermal decomposition generates : Corrosive vapors.

5.3. Advice for firefighters

Firefighting instructions : Use water spray or fog for cooling exposed containers. Exercise caution when fighting any chemical fire. Prevent fire-fighting water from entering environment.

Protection during firefighting : Do not enter fire area without proper protective equipment, including respiratory protection.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Protective equipment : Safety glasses. Gloves. Protective clothing.

Emergency procedures : Evacuate unnecessary personnel.

6.1.2. For emergency responders

Protective equipment : Equip cleanup crew with proper protection.

Emergency procedures : Ventilate area.

6.2. Environmental precautions

Prevent entry to sewers and public waters. Notify authorities if liquid enters sewers or public waters. Avoid release to the environment.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Soak up spills with inert solids, such as clay or diatomaceous earth as soon as possible. Collect spillage. Store away from other materials.

6.4. Reference to other sections

See Heading 8. Exposure controls and personal protection.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Wash hands and other exposed areas with mild soap and water before eating, drinking or smoking and when leaving work. Provide good ventilation in process area to prevent formation of vapor. Do not breathe mist, vapors, spray.

Hygiene measures : Wash exposed skin thoroughly after handling. Wash contaminated clothing before reuse.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Comply with applicable regulations.

Storage conditions : Keep only in the original container in a cool, well ventilated place away from : incompatible materials. Keep container closed when not in use.

Incompatible products : Strong bases. metals.

Incompatible materials : Sources of ignition. Direct sunlight.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Ferric Chloride, Hexahydrate (10025-77-1)		
NIOSH	NIOSH REL (TWA) (mg/m³)	1 mg/m³

Water (7732-18-5)
Not applicable

8.2. Exposure controls

Appropriate engineering controls : Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure. Provide adequate general and local exhaust ventilation.

Personal protective equipment : Avoid all unnecessary exposure. Face shield. Gloves. Protective clothing. Safety glasses.

Hand protection : Wear protective gloves.

Eye protection : Chemical goggles or face shield.

Skin and body protection : Wear suitable protective clothing.

Respiratory protection : Wear appropriate mask.

Other information : Do not eat, drink or smoke during use.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state : Liquid

Color : amber

Odor : None.

Odor threshold : No data available

pH : No data available

Melting point : No data available

Freezing point : No data available

Boiling point : No data available

Flash point : No data available

Relative evaporation rate (butyl acetate=1) : No data available

Flammability (solid, gas) : Non flammable.

Vapor pressure : No data available

Relative vapor density at 20 °C : No data available

Relative density	:	No data available
Solubility	:	Soluble in water.
Log Pow	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	No data available
Explosion limits	:	No data available
Explosive properties	:	No data available
Oxidizing properties	:	No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

Thermal decomposition generates : Corrosive vapors.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Not established.

10.4. Conditions to avoid

Direct sunlight. Extremely high or low temperatures.

10.5. Incompatible materials

metals. Strong bases.

10.6. Hazardous decomposition products

Hydrogen chloride. iron oxide. Thermal decomposition generates : Corrosive vapors.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Likely routes of exposure	:	Skin and eye contact
Acute toxicity	:	Not classified

Ferric Chloride, Hexahydrate (10025-77-1)	
LD50 oral rat	1872 mg/kg (Rat)
ATE US (oral)	1872.000 mg/kg body weight

Water (7732-18-5)	
LD50 oral rat	≥ 90000 mg/kg
ATE US (oral)	90000.000 mg/kg body weight

Skin corrosion/irritation	:	Causes severe skin burns and eye damage.
Serious eye damage/irritation	:	Causes serious eye damage.
Respiratory or skin sensitization	:	Not classified
Germ cell mutagenicity	:	Not classified
Carcinogenicity	:	Not classified
Reproductive toxicity	:	Not classified
Specific target organ toxicity – single exposure	:	Not classified
Specific target organ toxicity – repeated exposure	:	Not classified
Aspiration hazard	:	Not classified
Potential Adverse human health effects and symptoms	:	Based on available data, the classification criteria are not met.

Symptoms/injuries after eye contact : Causes serious eye damage.

SECTION 12: Ecological information

12.1. Toxicity

Ecology - water : Harmful to aquatic life.

Ferric Chloride Solution	
LC50 fish 1	<

Ferric Chloride, Hexahydrate (10025-77-1)	
EC50 Daphnia 1	9.6 mg/l (EC50; 48 h; Daphnia magna)
LC50 fish 2	75.6 mg/l (LC50; 96 h; Gambusia affinis)

12.2. Persistence and degradability

Ferric Chloride Solution	
Persistence and degradability	Not established.

Ferric Chloride, Hexahydrate (10025-77-1)	
Persistence and degradability	Biodegradability: not applicable. Biodegradability in soil: not applicable. No test data on mobility of the substance available.
Biochemical oxygen demand (BOD)	Not applicable
Chemical oxygen demand (COD)	Not applicable
ThOD	Not applicable

Water (7732-18-5)	
Persistence and degradability	Not established.

12.3. Bioaccumulative potential

Ferric Chloride Solution	
Bioaccumulative potential	Not established.

Ferric Chloride, Hexahydrate (10025-77-1)	
BCF fish 1	<= 100 (BCF)
Bioaccumulative potential	No bioaccumulation data available.

Water (7732-18-5)	
Bioaccumulative potential	Not established.

12.4. Mobility in soil

No additional information available

12.5. Other adverse effects

Effect on the global warming : No known effects from this product.

GWPmix comment : No known effects from this product.

Other information : Avoid release to the environment.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste disposal recommendations : Dispose in a safe manner in accordance with local/national regulations. Dispose of contents/container to comply with local, state and federal regulations.

Ecology - waste materials : Avoid release to the environment.

SECTION 14: Transport information

Department of Transportation (DOT)

In accordance with DOT

Transport document description : UN2582 Ferric chloride, solution, 8, III

UN-No.(DOT) : UN2582

Proper Shipping Name (DOT) : Ferric chloride, solution

Transport hazard class(es) (DOT)	:	8 - Class 8 - Corrosive material 49 CFR 173.136
Packing group (DOT)	:	III - Minor Danger
Hazard labels (DOT)	:	8 - Corrosive

DOT Packaging Non Bulk (49 CFR 173.xxx)	:	203
DOT Packaging Bulk (49 CFR 173.xxx)	:	241
DOT Special Provisions (49 CFR 172.102)	:	B15 - Packaging must be protected with non-metallic linings impervious to the lading or have a suitable corrosion allowance. IB3 - Authorized IBCs: Metal (31A, 31B and 31N); Rigid plastics (31H1 and 31H2); Composite (31HZ1 and 31HA2, 31HB2, 31HN2, 31HD2 and 31HH2). Additional Requirement: Only liquids with a vapor pressure less than or equal to 110 kPa at 50 C (1.1 bar at 122 F), or 130 kPa at 55 C (1.3 bar at 131 F) are authorized, except for UN2672 (also see Special Provision IP8 in Table 2 for UN2672). T4 - 2.65 178.274(d)(2) Normal..... 178.275(d)(3) TP1 - The maximum degree of filling must not exceed the degree of filling determined by the following: Degree of filling = 97 / 1 + a (tr - tf) Where: tr is the maximum mean bulk temperature during transport, and tf is the temperature in degrees celsius of the liquid during filling.
DOT Packaging Exceptions (49 CFR 173.xxx)	:	154
DOT Quantity Limitations Passenger aircraft/rail (49 CFR 173.27)	:	5 L
DOT Quantity Limitations Cargo aircraft only (49 CFR 175.75)	:	60 L
DOT Vessel Stowage Location	:	A - The material may be stowed ‘‘on deck’’ or ‘‘under deck’’ on a cargo vessel and on a passenger vessel.
Other information	:	No supplementary information available.

SECTION 15: Regulatory information

15.1. US Federal regulations

Ferric Chloride Solution	
SARA Section 311/312 Hazard Classes	Immediate (acute) health hazard

All components of this product are listed, or excluded from listing, on the United States Environmental Protection Agency Toxic Substances Control Act (TSCA) inventory except for:

Ferric Chloride, Hexahydrate	CAS No 10025-77-1	71%

This product or mixture does not contain a toxic chemical or chemicals in excess of the applicable de minimis concentration as specified in 40 CFR §372.38(a) subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

Ferric Chloride, Hexahydrate (10025-77-1)	
SARA Section 311/312 Hazard Classes	Immediate (acute) health hazard

15.2. International regulations

CANADA

Ferric Chloride Solution	
WHMIS Classification	Class E - Corrosive Material

Ferric Chloride, Hexahydrate (10025-77-1)	
WHMIS Classification	Class E - Corrosive Material

Water (7732-18-5)	
WHMIS Classification	Uncontrolled product according to WHMIS classification criteria

EU-Regulations

No additional information available

National regulations
No additional information available

15.3. US State regulations

California Proposition 65 - This product does not contain any substances known to the state of California to cause cancer, developmental and/or reproductive harm

SECTION 16: Other information

Revision date : 01/17/2017

Other information : None.

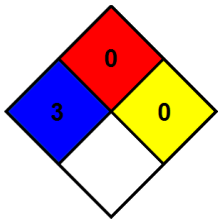
Full text of H-phrases: see section 16:

H302	Harmful if swallowed
H314	Causes severe skin burns and eye damage
H318	Causes serious eye damage
H401	Toxic to aquatic life

NFPA health hazard : 3 - Materials that, under emergency conditions, can cause serious or permanent injury.

NFPA fire hazard : 0 - Materials that will not burn under typical dire conditions, including intrinsically noncombustible materials such as concrete, stone, and sand.

NFPA reactivity : 0 - Material that in themselves are normally stable, even under fire conditions.



HMIS III Rating

Health : 3 Serious Hazard - Major injury likely unless prompt action is taken and medical treatment is given

Flammability : 0 Minimal Hazard - Materials that will not burn

Physical : 0 Minimal Hazard - Materials that are normally stable, even under fire conditions, and will NOT react with water, polymerize, decompose, condense, or self-react. Non-Explosives.

Personal protection : H

H - Splash goggles, Gloves, Synthetic apron, Vapor respirator

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