

Odorous Emissions Analysis for the Town of Windsor Eastside Road Storage Project

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This technical memorandum contains an analysis of the potential for odorous emissions from a planned recycled water storage facility for the Town of Windsor, CA. The storage facility is the subject of a Supplemental Environmental Impact Report (SEIR) currently being produced by CH2M HILL.

Project Background

The Town of Windsor (Town) uses recycled water to irrigate agricultural lands, recreational facilities, schools, and residential yards. Each year, approximately 650 million gallons (MG) of wastewater are provided tertiary treatment to produce the recycled water supply, and approximately 350 MG of the recycled water is reused in various applications. The remaining 300 MG is discharged to Mark West Creek.

Eastside Road Storage Project History

The Eastside Road Storage Project (the Project) is part of the approved *Water Reclamation Master Plan for Treatment, Storage and Disposal* (Master Plan) developed by the Town (Brelje & Race, 2001). With the growth in population anticipated and allowed under the Town's General Plan (Ogden, 1996), overall demand for water will increase beyond what the Town can provide with its existing potable water supply and recycled water systems. The Project would provide a new storage pond to augment the existing recycled water program.

Recycled water not discharged to Mark West Creek would be stored in a new location and used for seasonal irrigation. The function of the proposed storage pond is to balance inflow of the recycled water with outflows to irrigation and discharge. Therefore, recycled water that cannot be discharged in the spring or fall due to low flows in Mark West Creek can be stored and used for irrigation during the summer, when demand for recycled water is at its peak.

The Project site is located on a Town-owned 168-acre parcel southwest of Windsor near the intersection of Eastside Road and Trenton-Healdsburg Road. The parcel is bounded by Eastside Road to the west, Mark West Station Road to the south, agriculture and rural residential to the east, and open space to the north. The Sonoma County Water Agency's Ocean View Reservoir is just east of the parcel. The pond site (the Pond T location in the

Master Plan) is located in a central intermittent drainage of the parcel between east-west trending ridgelines of approximately 260 feet in elevation.

The proposed Project consists of a storage pond with a capacity of approximately 215 MG, an onsite pump station, and a pipeline to connect to the existing recycled water distribution system. The storage pond would be established by constructing an earthen dam at the western end of the drainage, near Eastside Road. The storage pond is the focus of this odor evaluation.

Nearest Potential Receptor

The preliminary design layout of the proposed storage pond is depicted on an aerial photograph in Figure 1. A close-up of the nearest potential odor receptor (the closest building that is continuously inhabited) is provided in Figure 2. A red line is shown highlighting the 210-ft contour of the proposed pond, which is the closest contour to the vertical elevation that corresponds to the design capacity pond depth of 209 feet.



FIGURE 1
Proposed Pond Location and Distance to Nearest Potential Receptor



FIGURE 2
Proposed Pond Location and Distance to Nearest Receptor (Closeup)

A receptor is defined in this analysis as a permanent dwelling or commercial building in which there is at least one inhabitant. At this elevation and location in space, the nearest receptor (a house, as shown in Figures 1 and 2) is approximately 250 feet away. Note that according to calculations, the distance of 250 feet is the *minimum* distance that the proposed pond could be from the nearest receptor. At times when the pond is not at capacity, the distance from the edge of the pond to the nearest receptor will be greater (for instance, when the pond is half full, the distance to the nearest receptor will be closer to 500 feet).

Town of Windsor Wastewater Treatment Plant Description

The potential for odorous emissions from the pond depends in part on the constituents contained in the recycled water to be stored in the pond. Although the proposed Project does not include any modifications to the Town of Windsor Wastewater Treatment Plant, the existing treatment processes were evaluated to understand what odor-generating constituents might be present. The Town of Windsor Water Reclamation Treatment Plant occupies a 74-acre site immediately west of the Northwest Pacific Railroad tracks in Windsor, California. The dry weather average flowrate is about 2 million gallons per day (mgd). The treatment plant provides tertiary treatment of all influent wastewater, with a large percentage of recycled water being provided directly to reuse. Following are the main components of the primary and secondary treatment system:

- The influent pump station lifts all collected raw sewage to the influent bypass valve station, which controls the flow of influent wastewater. Under normal conditions, all flow is directed to the headworks, but in high flow (wet weather) conditions, excess flow is directed to the high-flow storage ponds.
- The headworks removes debris and grit from the raw wastewater.

- The aeration basins provide secondary treatment via an extended aeration activated sludge process. Aerobic biological processes remove biochemical oxygen demand (BOD), and ammonia and anoxic biological processes remove nitrate.
- The secondary clarifiers remove the solids produced in the aeration basins and either recycle the solids back to the aeration basins or waste the solids to the sludge ponds. The clarified effluent is conveyed to the advanced wastewater treatment (AWT) system for tertiary treatment.

The AWT system provides tertiary treatment of the wastewater to acceptable standards for reuse. Following are the main components of the AWT system:

- Chemical addition facilities provide rapid mixing for alum and polymer, which are added to coagulate the impurities in the wastewater.
- Large suspensions of solid material, “flocs,” are formed in two-stage flocculation tanks, whose mixers provide low shear (slow) agitation and produce larger, heavier solid masses.
- Floc material is removed in circular, metal clarifiers, where the heavy solid matter settles to the bottom of the tanks and is removed by a skimmer.
- Five Dynasand filters and two Rotoco sand filters provide removal of fine solid particles, following clarification.
- The filtered water flows by gravity through two ultraviolet (UV) disinfection channels, where 10 UV banks and an on-line control system determine the appropriate dose of UV light to provide appropriate disinfection of the water.

Downstream of the UV disinfection channels, the recycled water is conveyed to the various water reuse recipients and storage areas. Following AWT treatment, the water is of sufficiently high quality for various forms of reuse.

No odor control is applied to any of the liquid-phase treatment processes at the plant. Odorous compounds found in the liquid-phase plant influent are expected to be removed over the course of the existing treatment processes.

Odor Emissions Analysis

Calculations made during the preliminary design indicate that at its 215 MG capacity, the pond will be approximately 75 feet deep at its deepest point and will occupy approximately 14 acres of land. A pond this size has the potential to emit odors based on its large contributing surface area, but odorous emissions are expected to be minimal due to the high level of treatment being provided prior to conveying the water to the pond. This section reviews potential types of odorous emissions for the proposed pond, based on the presence of odor-generating constituents in the recycled water. This section projects the chance that odorous compounds would be emitted by the storage pond in significant quantities during its use.

Sulfide Species

In wastewater treatment, odorous emissions from the liquid phase are most often associated with various compounds (inorganic and organic) that contain sulfide. Hydrogen sulfide (H₂S), which has a characteristic rotten egg odor, is the most common odorous compound emitted by wastewater treatment processes. Hydrogen sulfide is formed by the reduction of sulfates commonly found in domestic wastewater and is volatilized in various treatment processes. In addition to H₂S, several more complex organic reduced sulfur compounds are commonly emitted by wastewater treatment processes, including methyl mercaptan, dimethyl sulfide, and dimethyl disulfide.

Table 1 depicts a general accounting of expected amounts of hydrogen sulfide emissions at the types of domestic wastewater treatment process units used by the Town of Windsor. Unit processes are listed in order of where they appear in the overall treatment scheme. Hydrogen sulfide emissions data are not collected by the Town of Windsor; therefore, the expected emissions in Table 1 are based on an analysis of data from 108 comparable wastewater plants throughout North America (CH2M HILL, unpublished internal database). Hydrogen sulfide concentrations, in parts per million (ppm) or parts per billion (ppb), shown in the table are typical measured concentrations in the gas phase headspace above the water surface at that point in the treatment train (note that the human detection threshold for H₂S is about 0.5 ppb). Other odorous sulfide compounds typically measured at or within the listed process units are also listed in the table.

TABLE 1
General Summary of Typical Sulfide Odors Observed in Wastewater Treatment Processes

Unit Process	Typical H ₂ S Range	Other Expected Sulfide Compounds
Influent Pumping Wet Wells	1 to 50 ppm	Potential for organic reduced sulfur species
Headworks	1 to 50 ppm	Potential for organic reduced sulfur species
Aerated Grit Chambers	5 to 100 ppm	Potential for organic reduced sulfur species
Primary Clarifiers	5 to 65 ppm	Potential for organic reduced sulfur species
Aeration Basins	0 to 10 ppm	Potential for organic reduced sulfur odors such as methyl mercaptan
Trickling Filters	1 to 240 ppm	Strong potential for reduced sulfur organic odors such as methyl mercaptan
Secondary Clarifiers	0 to 10 ppm	Organic reduced sulfur species less than 5 ppm
Disinfection	Less than 0.1 ppm	Organic reduced sulfur species less than 0.1 ppm
Advanced Wastewater Treatment	Less than 0.5 ppb	Organic reduced sulfur species less than 0.5 ppb

Note:

The human detection threshold for hydrogen sulfide (H₂S) is approximately 0.5 parts per billion (ppb).
Source: CH2M HILL, unpublished case study data from 108 facilities throughout North America.

The table shows how over the course of a typical wastewater treatment process train the H₂S emissions progressively decrease, to the point where no H₂S emissions are expected in the water from an advanced wastewater treatment facility. More complex organic reduced

sulfur compounds are also found in varying amounts throughout the liquid-phase treatment train, and similar to the inorganic hydrogen sulfide, also are typically not found downstream of advanced wastewater treatment process units. This is because the processes that physically remove solid matter and biologically oxidize carbonaceous matter also serve to lower sulfide levels in the wastewater process train. In addition, high sulfide emissions at the head of the plant take sulfide out of the aqueous phase, thus less sulfide is available for volatilization further downstream.

The typical observation of reduced sulfide emissions in the downstream processes units of a wastewater treatment facility is expected to be the case at the Windsor Water Reclamation Plant. The tertiary treatment, additional coagulation, flocculation, clarification, and filtration processes, virtually assure that all sulfide emissions (inorganic and organic) will be zero in the recycled water to be sent to the new pond.

Ammonia and Amine Species

Another important group of compounds that can increase odorous emissions in domestic wastewater treatment facilities is organic and inorganic nitrogen-containing compounds. Ammonia (NH_3) is frequently measured in detectable quantities within wastewater treatment processes, especially in solids processing facilities and in processes where the pH is elevated (Water Environment Federation, 2004). The most common organic nitrogen-containing compounds in wastewater odorous emissions are methyl amine, dimethyl amine, indole, and skatole. Similar to ammonia, these compounds are also most frequently found in solids processing facilities.

Table 2 depicts a general accounting of expected amounts of ammonia emissions at the types of domestic wastewater treatment process units used by the Town of Windsor. The expected emissions in Table 2 are based on data from 108 comparable wastewater plants throughout North America (CH2M HILL, unpublished internal database). Note that ammonia and other expected nitrogen compounds are typically only present in the gas phase in detectable quantities for solids processing facilities. Ammonia emissions of less than 1 ppm and similar levels of odorous amines are projected to exist in the headspace above the pond surface. Because the limit of human detection is 17 ppm for ammonia and 4.7 ppm for methyl amine, no odor generation would be expected.

TABLE 2

General Summary of Typical Nitrogen-Based Odors Observed in Wastewater Treatment Processes

Unit Process	Typical NH_3 Range	Other Expected Nitrogen Compounds
Influent Pumping Wet Wells	0-1 ppm	Not in significant quantities
Headworks	0-1 ppm	Not in significant quantities
Aerated Grit Chambers	0-1 ppm	Not in significant quantities
Primary Clarifiers	0-1 ppm	Not in significant quantities
Aeration Basins	0-1 ppm	Low (<1 ppm) amounts of methyl amine may form
Secondary Clarifiers	0-1 ppm	Low (<1 ppm) amounts of methyl amine may form
Advanced Wastewater Treatment	0-1 ppm	Low (<1 ppm) amounts of methyl amine may form
Sludge Thickening	0-100 ppm	Significant quantities of amine compounds may form

TABLE 2

General Summary of Typical Nitrogen-Based Odors Observed in Wastewater Treatment Processes

Unit Process	Typical NH ₃ Range	Other Expected Nitrogen Compounds
Sludge Dewatering	0-100 ppm	Significant quantities of amine compounds may form

Notes:

The human detection threshold for ammonia (NH₃) is approximately 17 ppm.

The human detection threshold for methyl amine is approximately 4.7 ppm.

Source: CH2M HILL, unpublished case study data from 108 facilities throughout North America.

In the Town of Windsor's 2006 Chronic Toxicity Report (Town of Windsor, 2007), ammonia levels in the recycled water, which would be the water conveyed to the proposed storage pond, were reported for the period of January 2006. Table 3 provides the ammonia measurements, reported in mg/L as nitrogen (N) in the liquid samples.

TABLE 3

Ammonia Measurements for Town of Windsor Water Reclamation Plant Effluent, January 2006

Sampling Date	Ammonia Concentration (mg/L as N)
1/4/06	< 1.0
1/6/06	< 1.0
1/9/06	< 1.0
1/23/06	1.86
1/30/06	< 1.0

Source: Town of Windsor, 2007

As shown in the table, out of five samples, in only one sample were ammonia levels above the detection limit of 1.0 mg/L as N, with a measurement of 1.86 mg/L. This ammonia concentration in the liquid phase was converted to a projected gas-phase emission concentration, based on Henry's Law at equilibrium conditions. Henry's Law is the governing equation that estimates the volatilization of compounds from the liquid to gas phase.

Henry's Law coefficient (estimated to be 0.00072 for this application) is multiplied by the measured aqueous-phase concentration (modified for temperature and expected pH) to arrive at a corresponding gas-phase concentration of 0.0074 ppm ammonia. This is much lower than the human detection threshold of 17 ppm. Therefore, with other measurements being less than the detection limit of the ammonia concentration analysis, the Windsor testing is further evidence that ammonia odors will not be emitted in noticeable quantities by the proposed pond.

Volatile Organic Compounds

Certain volatile organic compounds (VOCs) found in wastewater are odorous when the compound volatilizes from the liquid to the gas phase. Emissions of VOCs in treated wastewater are typically a function of what VOCs are present in the influent. Domestic

sewage typically does not contain high VOC concentrations, though if industrial wastewater makes up a significant portion of the influent flow, VOC concentrations could be higher, making odorous emissions a concern.

The makeup of wastewater entering the Windsor water reclamation plant is mostly domestic, so VOCs are not expected in high concentrations. Table 4 depicts the concentrations of all VOCs measured in the plant effluent in the Town of Windsor 2006 Annual Monitoring Report. Compounds were measured in the liquid phase in micrograms per liter ($\mu\text{g/L}$). The three listed in the table were the only three VOCs detected amongst more than 60 VOCs tested.

TABLE 4
Volatile Organic Compound Measurements in Windsor Water Reclamation Plant Effluent, 2006

VOC	Measurement ($\mu\text{g/L}$)	Henry's Law Coefficient	Equilibrium Gas-Phase Concentration (ppm)
Bis(2-Ethylhexyl)phthalate	0.8	6.93E-06	3.99E-06
Chloroform	0.2	0.112	1.61E-02
Trichloroethane (TCE)	0.08	0.153	8.80E-03

Source: Town of Windsor, 2007

Each of the three measurements were marginally above the detection limits for measuring the compound by the analytical laboratory, and in several sampling events, these VOCs were not measured in quantities above the detection limit. Table 4 also presents calculations of an equilibrium gas-phase concentration for each VOC. This calculation, made using the Henry's Law coefficient and assumptions of typical temperature and pH, produces gaseous concentrations that are all orders of magnitude less than 1 ppm.

Table 5 presents a comparison of estimated gas-phase VOC concentrations above the pond water surface versus odor thresholds for those compounds. This comparison provides an indication of the lack of odors that would be expected at these low compound concentrations. Both chloroform and TCE are projected to be emitted at concentrations that are orders of magnitude below the human detection threshold. Bis(2-Ethylhexyl)phthalate is not odorous at any concentration.

TABLE 5
VOC Estimated Emissions in Windsor Recycled Water versus Odor Thresholds

VOC	Equilibrium Gas-Phase Concentration (ppm)	Equilibrium Gas-Phase Concentration (mg/m^3)	Odor Threshold (mg/m^3)
Bis(2-Ethylhexyl)phthalate	3.99E-06	5.54E-06	Not odorous
Chloroform	1.61E-02	2.24E-02	30
Trichloroethane (TCE)	8.80E-03	1.22E-02	2,100

Source: Town of Windsor, 2007

As indicated in Tables 4 and 5, the VOCs measured in the recycled water from the Windsor water reclamation plant (which will be the makeup water of the proposed storage pond) were in very low concentrations below human detection. This indicates that VOCs from recycled water in the pond are not expected to produce odors.

Conclusions

Table 6 presents conclusions regarding the impact of various potentially odorous constituents associated with the recycled water to be stored in the proposed pond. The “emission potential” refers to a projection of the likelihood that the odorous component will be present in large enough quantities in the pond emissions to generate odors.

TABLE 6
Odorous Component Potential for Emission and Impacting the Nearest Receptor

Odorous Component	Odor Potential
Hydrogen Sulfide	Negligible
Organic Reduced Sulfur Compounds	Negligible
Ammonia	Negligible
Amine Compounds	Negligible
Volatile Organic Compounds	Negligible

The following are support for the projections of emission potential in Table 6:

- Hydrogen sulfide and inorganic sulfide species will be removed from the wastewater over the course of the treatment scheme at the water reclamation facility. No inorganic aqueous sulfide species are expected in the recycled water, thus there is no potential for emissions as H₂S from the proposed pond.
- Complex organic reduced sulfide compounds will be removed from the wastewater over the course of the treatment scheme at the water reclamation facility. Therefore, there will not be sufficient sulfide content in the wastewater to form these compounds. Additionally, only minor organic loading is expected in the pond; the security fence and 15-foot access road provide a buffer that limits wind-blown vegetation from entering the pond. The pond will also be lined and will be periodically drained.
- Low ammonia levels were measured in one sample from the 2006 Annual Monitoring Report. Even in instances where measurable ammonia is present in the pond, the estimated corresponding emissions would be significantly lower than the ammonia human detection threshold of 17 ppm. All other samples from the 2006 report were below the detection limit.
- Amine compounds typically found in wastewater treatment are not projected to be present in the recycled water at levels in excess of the human detection threshold. These compounds are removed in upstream processes and emissions are associated more with in solids processing facilities.
- VOC concentrations in the recycled water laboratory testing were low and correspond to gaseous emissions that are much lower than the detection threshold. Therefore, negligible emissions of VOCs are expected from the proposed pond due to these low concentrations.

Therefore, it is projected that the proposed pond will have negligible odor impacts to the nearest receptor. Odorous emissions are projected to be lower overall than the human detection threshold for each compound because of the high level of treatment being provided at the water reclamation facility.

References

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