

REQUEST FOR PROPOSAL

RFP # 26-51

Testing of Odor-Reducing Chemical Treatment for Municipal Sludge

City of Ann Arbor
Public Services Area/Water Resource Recovery Facility



Due Date: November 18, 2026 by 2:00 p.m. (local time)

Issued By:

City of Ann Arbor
Procurement Unit
301 E. Huron Street
Ann Arbor, MI 48104

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SECTION I - GENERAL INFORMATION

A. OBJECTIVE

The City of Ann Arbor is seeking proposals from qualified chemical suppliers, laboratories, wastewater treatment specialists, and/or engineering firms to conduct Phase 1 laboratory-scale jar testing of primary and thickened waste activated sludge to identify and evaluate chemical treatment alternatives for reducing odor.

B. QUESTIONS AND CLARIFICATIONS / DESIGNATED CITY CONTACTS

All questions regarding this Request for Proposal (RFP) shall be submitted via e-mail. Questions will be accepted and answered in accordance with the terms and conditions of this RFP.

All questions shall be submitted on or before November 3, 2026 at 5:00 p.m. (local time), and should be addressed as follows:

Scope of Work/Proposal Content questions shall be e-mailed to **Anne Warrow, Senior Engineer – awarrow@a2gov.org**.

RFP Process and Compliance questions shall be e-mailed to **Colin Spencer, Buyer - CSpencer@a2gov.org**.

Should any prospective offeror be in doubt as to the true meaning of any portion of this RFP, or should the prospective offeror find any ambiguity, inconsistency, or omission therein, the prospective offeror shall make a written request for an official interpretation or correction by the due date for questions above.

All interpretations, corrections, or additions to this RFP will be made only as an official addendum that will be posted to a2gov.org and MITN.info and it shall be the prospective offeror's responsibility to ensure they have received all addenda before submitting a proposal. Any addendum issued by the City shall become part of the RFP, and must be incorporated in the proposal where applicable.

C. PRE-PROPOSAL MEETING

A pre-proposal meeting will be held:

WHEN: October 28, 2026 at 1:00 p.m.
WHERE: Ann Arbor Water Resource Recovery Facility, 2nd Floor Conference Room, 49 S. Dixboro Road, Ann Arbor, Michigan 48105

The meeting is not mandatory; however, it is highly recommended that interested offerors attend the meeting. The purpose of this meeting is to discuss the project with

prospective offerors and to answer any questions concerning RFP 26-51. Any questions and answers furnished in the pre-proposal meeting will not be official until verified in writing through an addendum.

D. PROPOSAL FORMAT

To be considered, each firm must submit a response to this RFP using the format provided in Section III. No other distribution of proposals is to be made by the prospective offeror. An official authorized to bind the offeror to its provisions must sign the proposal. Each proposal must remain valid for at least ninety days from the due date of this RFP.

Proposals should be prepared simply and economically providing a straightforward, concise description of the offeror's ability to meet the requirements of the RFP. No erasures are permitted. Mistakes may be crossed out and corrected and must be initialed in ink by the person signing the proposal.

E. SELECTION CRITERIA

Responses to this RFP will be evaluated using a point system as shown in Section III. A selection committee comprised of staff from the City will complete the evaluation.

The fee proposals will not be reviewed at the initial evaluation. After initial evaluation, the City will determine top proposals, and open only those fee proposals. The City will then determine which, if any, firms will be interviewed. During the interviews, the selected firms will be given the opportunity to discuss their proposal, qualifications, past experience, and their fee proposal in more detail. The City further reserves the right to interview the key personnel assigned by the selected offeror to this project. If the City chooses to interview any respondents, the interviews will be tentatively held the **week of November 30, 2026**. Offeror must be available on these dates.

All proposals submitted may be subject to clarifications and further negotiation. All agreements resulting from negotiations that differ from what is represented within the RFP or in the proposal response shall be documented and included as part of the final contract.

F. SEALED PROPOSAL SUBMISSION

All proposals are due and must be delivered to the City on or before, November 18, 2026 at 2:00 p.m. (local time). Proposals submitted late or via oral, telephonic, telegraphic, electronic mail or facsimile **will not** be considered or accepted.

Each respondent must submit in a sealed envelope

- **one (1) original proposal**
- **one (1) additional proposal copy**

- one (1) digital copy of the proposal preferably on a USB/flash drive as one file in PDF format

Each respondent should submit in a single separate sealed envelope marked **Fee Proposal**

- two (2) copies of the fee proposal

The fee proposal and all costs should be separate from the rest of the proposal.

Proposals submitted should be clearly marked: **“RFP No.26-51 – Testing of Odor-Reducing Chemical Treatment for Municipal Sludge”** and list the offeror’s name and address.

Proposals must be addressed and delivered to:
City of Ann Arbor
c/o Customer Service
301 East Huron Street
Ann Arbor, MI 48104

All proposals received on or before the due date will be publicly opened and recorded on the due date. No immediate decisions will be rendered.

Hand delivered bids may be dropped off in the Purchasing drop box located in the Ann Street (north) vestibule/entrance of City Hall which is open to the public Monday through Friday from 8am to 5pm (except holidays). The City will not be liable to any prospective offeror for any unforeseen circumstances, delivery, or postal delays. Postmarking on the due date will not substitute for receipt of the proposal. Offerors are responsible for submission of their proposal. Additional time will not be granted to a single prospective offeror. However, additional time may be granted to all prospective offerors at the discretion of the City.

A proposal may be disqualified if the following required forms are not included with the proposal:

- **Attachment C - City of Ann Arbor Non-Discrimination Declaration of Compliance**
- **Attachment D - City of Ann Arbor Living Wage Declaration of Compliance**
- **Attachment E - Vendor Conflict of Interest Disclosure Form of the RFP Document**

Proposals that fail to provide these forms listed above upon proposal opening may be deemed non-responsive and may not be considered for award.

Please provide the forms outlined above (Attachments C, D and E) within your narrative proposal, not within the separately sealed Fee Proposal envelope.

All proposed fees, cost or compensation for the services requested herein should be provided in the separately sealed Fee Proposal envelope only.

G. DISCLOSURES

Under the Freedom of Information Act (Public Act 442), the City is obligated to permit review of its files, if requested by others. All information in a proposal is subject to disclosure under this provision. This act also provides for a complete disclosure of contracts and attachments thereto.

H. TYPE OF CONTRACT

A sample of the Professional Services Agreement is included as Appendix A. Those who wish to submit a proposal to the City are required to review this sample agreement carefully. **The City will not entertain changes to its Professional Services Agreement.**

The City reserves the right to award the total proposal, to reject any or all proposals in whole or in part, and to waive any informality or technical defects if, in the City's sole judgment, the best interests of the City will be so served.

This RFP and the selected offeror's response thereto, shall constitute the basis of the scope of services in the contract by reference.

I. NONDISCRIMINATION

All offerors proposing to do business with the City shall satisfy the contract compliance administrative policy adopted by the City Administrator in accordance with the Section 9:158 of the Ann Arbor City Code. Breach of the obligation not to discriminate as outlined in Attachment C shall be a material breach of the contract. Contractors are required to post a copy of Ann Arbor's Non-Discrimination Ordinance attached at all work locations where its employees provide services under a contract with the City.

J. WAGE REQUIREMENTS

The Attachments provided herein outline the requirements for payment of prevailing wages or of a "living wage" to employees providing service to the City under this contract. The successful offeror must comply with all applicable requirements and provide documentary proof of compliance when requested.

K. CONFLICT OF INTEREST DISCLOSURE

The City of Ann Arbor Purchasing Policy requires that the consultant complete a Conflict of Interest Disclosure form. A contract may not be awarded to the selected offeror unless and until the Procurement Unit and the City Administrator have

reviewed the Disclosure form and determined that no conflict exists under applicable federal, state, or local law or administrative regulation. Not every relationship or situation disclosed on the Disclosure Form may be a disqualifying conflict. Depending on applicable law and regulations, some contracts may awarded on the recommendation of the City Administrator after full disclosure, where such action is allowed by law, if demonstrated competitive pricing exists and/or it is determined the award is in the best interest of the City. A copy of the Conflict of Interest Disclosure Form is attached.

L. COST LIABILITY

The City of Ann Arbor assumes no responsibility or liability for costs incurred by the offeror prior to the execution of a Professional Services Agreement. The liability of the City is limited to the terms and conditions outlined in the Agreement. By submitting a proposal, offeror agrees to bear all costs incurred or related to the preparation, submission, and selection process for the proposal.

M. DEBARMENT

Submission of a proposal in response to this RFP is certification that the Respondent is not currently debarred, suspended, proposed for debarment, and declared ineligible or voluntarily excluded from participation in this transaction by any State or Federal departments or agency. Submission is also agreement that the City will be notified of any changes in this status.

N. PROPOSAL PROTEST

All protests must be in writing and filed with the Purchasing Agent within 5 business days of any notices of intent, including, but not exclusively, divisions on pre-qualification of bidders, shortlisting of bidders, or a notice of intent to award a contract. Only bidders who responded to the solicitation may file a bid protest. The offeror must clearly state the reasons for the protest. If an offeror contacts a City Service Area/Unit and indicates a desire to protest an award, the Service Area/Unit shall refer the offeror to the Purchasing Manager. The Purchasing Manager will provide the offeror with the appropriate instructions for filing the protest. The protest shall be reviewed by the City Administrator or designee, whose decision shall be final.

Any inquiries or requests regarding this procurement should be only submitted in writing to the Designated City Contacts provided herein. Attempts by the offeror to initiate contact with anyone other than the Designated City Contacts provided herein that the offeror believes can influence the procurement decision, e.g., Elected Officials, City Administrator, Selection Committee Members, Appointed Committee Members, etc., may lead to immediate elimination from further consideration.

O. SCHEDULE

The proposals submitted should define an appropriate schedule in accordance with the requirements of the Proposed Work Plan in Section III.

The following is the schedule for this RFP process.

Activity/Event	Anticipated Date
Pre-Proposal Meeting	October 28, 2026, 1:00 p.m.
Written Question Deadline	November 3, 2026, 5:00 p.m.
Addenda Published (if needed)	Week of November 2, 2026
Proposal Due Date	Nov. 18, 2026, 2:00 p.m. (Local Time)
Tentative Interviews (if needed)	Week of November 30, 2026
Selection/Negotiations	November 2026
Expected City Council Authorizations	January 2027

The above schedule is for information purposes only and is subject to change at the City's discretion.

P. IRS FORM W-9

The selected offeror will be required to provide the City of Ann Arbor an IRS form W-9.

Q. RESERVATION OF RIGHTS

1. The City reserves the right in its sole and absolute discretion to accept or reject any or all proposals, or alternative proposals, in whole or in part, with or without cause.
2. The City reserves the right to waive, or not waive, informalities or irregularities in of any proposal if determined by the City to be in its best interest.
3. The City reserves the right to request additional information from any or all offerors.
4. The City reserves the right to reject any proposal that it determines to be unresponsive and deficient in any of the information requested within RFP.
5. The City reserves the right to determine whether the scope of the project will be entirely as described in the RFP, a portion of the scope, or a revised scope be implemented.
6. The City reserves the right to select one or more consultants to perform services.
7. The City reserves the right to retain all proposals submitted and to use any ideas in a proposal regardless of whether that proposal is selected. Submission of a proposal indicates acceptance by the firm of the conditions contained in this RFP, unless clearly and specifically noted in the proposal submitted.
8. The City reserves the right to disqualify proposals that fail to respond to any requirements outlined in the RFP, or failure to enclose copies of the required documents outlined within RFP.

R. ENVIRONMENTAL COMMITMENT

The City of Ann Arbor recognizes its responsibility to minimize negative impacts on human health and the environment while supporting a vibrant community and economy. The City further recognizes that the products and services the City buys have inherent environmental and economic impacts and that the City should make procurement decisions that embody, promote and encourage the City's commitment to the environment.

The City strongly encourages potential vendors to bring forward tested, emerging, innovative, and environmentally preferable products and services that are best suited to the City's environmental principles. This includes products and services such as those with lower greenhouse gas emissions, high recycled content, without toxic substances, those with high reusability or recyclability, those that reduce the consumption of virgin materials, and those with low energy intensity.

As part of its environmental commitment, the City reserves the right to award a contract to the most responsive and responsible bidder, which includes bids that bring forward products or services that help advance the City's environmental commitment. In addition, the City reserves the right to request that all vendors report their annual greenhouse gas emissions, energy consumption, miles traveled, or other relevant criteria in order to help the City more fully understand the environmental impact of its procurement decisions.

SECTION II - SCOPE OF SERVICES

The City of Ann Arbor is seeking proposals from qualified chemical suppliers, laboratories, wastewater treatment specialists, and/or engineering firms to conduct Phase 1 laboratory-scale jar testing of primary and thickened waste activated sludge to identify and evaluate chemical treatment alternatives for reducing odor.

The objective of this Phase 1 effort is to evaluate commercially available odor-control chemicals under controlled laboratory conditions and identify the most promising treatment alternatives for potential Phase 2 pilot-scale testing at the Ann Arbor WRRF.

Phase 1 is a data-driven selection of one or more odor-control chemical treatment alternatives suitable for controlled field demonstration in Phase 2.

The City's ultimate objective is to identify a treatment approach that can provide measurable and sustainable odor reduction while being operationally practical, safe, cost-effective, and compatible with existing municipal sludge treatment and disposal practices.

Successful completion of Phase 1 will provide the City with the data necessary to select one or more chemical treatment programs for field pilot testing.

The selected proposer should provide sufficient laboratory data to allow the City to understand the expected odor-control performance, required chemical dosage, operating considerations, preliminary treatment costs, and potential risks associated with each leading alternative.

Background

The City of Ann Arbor operates a municipal water resource recovery facility (WRRF) that generates and handles sludge through primary clarification, secondary treatment, thickening of waste activated sludge, dewatering with centrifuges, storage, and hauling to a landfill.

An odor study for the Ann Arbor Water Resource Recovery Facility (WRRF) area was performed in 2018 and 2019 by HDR, Michigan, Inc. (HDR) to address ongoing nuisance odor complaints from WRRF neighbors. The Area Odor Study Report, dated July 27, 2020, prepared by HDR can be found in Attachment A.

Odor associated with sludge handling, storage, processing, and/or transfer has been identified as an operational concern. The City is seeking a practical chemical treatment approach that can reduce odor while minimizing impacts on sludge handling, downstream treatment processes, worker safety, and overall operating costs.

The City intends to use a phased approach:

Phase 1: Laboratory jar testing and screening of odor-reducing chemical alternatives.

Phase 2: Pilot-scale field demonstration of selected chemical treatment(s), subject to successful Phase 1 results,

This RFP is specifically for Phase 1.

Objective

The primary objectives of the Phase 1 testing program are to:

- Characterize the odor-control performance of candidate chemical treatments on representative municipal sludge.
- Compare multiple chemical products or treatment chemistries under controlled laboratory conditions.
- Determine appropriate chemical dosages and contact times.
- Evaluate odor reduction relative to untreated sludge.
- Identify potential impacts of treatment on sludge characteristics and downstream handling.
- Develop preliminary chemical consumption and treatment-cost estimates.
- Evaluate the impact of
- Identify the most promising treatment alternatives for Phase 2 pilot testing.
- Establish recommended Phase 2 operating conditions, including dosage ranges, application points, and monitoring requirements.

Scope of Services

The selected Consultant/Contractor shall provide all labor, technical expertise, equipment, chemical products, laboratory supplies, testing, data analysis, and reporting necessary to complete the Phase 1 evaluation.

Task A: Sludge Sampling and Characterization

The proposer shall provide recommendations for obtaining representative sludge samples. The City anticipates providing sludge samples of primary sludge and thickened waste activated sludge from the sludge holding tanks. The proposer shall recommend appropriate sample collection, preservation, transportation, storage, and testing procedures. Baseline sludge characterization should include, as applicable:

- Total solids and volatile solids
- pH
- Temperature
- Moisture content
- Oxidation-reduction potential (ORP)
- Sulfide and/or dissolved sulfide
- Other odor-related parameters relevant to the proposed treatment
- Any additional parameters necessary to interpret treatment performance

The proposer shall identify any additional laboratory analyses considered necessary. The testing program shall consider whether chemical treatment adversely affects sludge characteristics or downstream operations.

Task B: Candidate Chemical Selection

Proposers shall identify the chemical products or treatment technologies they recommend evaluating. Candidate treatments may include, as appropriate:

- Oxidizing agents
- Precipitating or binding agents
- pH-adjustment products
- Odor-masking or neutralizing products
- Biological or enzymatic products
- Other commercially available chemical treatment technologies

Proposers shall provide technical information for each proposed product, including:

- Product name and manufacturer
- Active ingredients or treatment chemistry
- Recommended applications
- Typical dosage ranges
- Applicable pH and temperature ranges
- Safety considerations
- Storage and handling requirements
- Potential impacts on wastewater/sludge processes
- Relevant municipal wastewater references or case studies

The City reserves the right to provide additional products for testing or request modifications to the proposed test matrix.

Task C: Jar Testing

The proposer shall develop and execute a laboratory jar-testing program designed to compare untreated sludge with multiple chemical treatment alternatives and dosages.

The testing program should, at a minimum, evaluate:

- Untreated/control samples
- Multiple chemical treatment alternatives
- Multiple chemical dosages for each treatment
- Appropriate contact times
- Replicate samples where appropriate
- Odor reduction under representative conditions

The proposer shall explain the proposed test matrix and provide the rationale for the selected dosages and contact times.

Task D: Odor Measurement

Proposers shall identify the proposed method(s) for measuring odor reduction.

Depending on the proposed testing approach, measurements may include:

- Hydrogen sulfide
- Ammonia
- Volatile sulfur compounds
- Other odor-causing compounds
- Instrumental measurements
- Laboratory sensory evaluation

- Odor concentration or intensity measurements
- Other scientifically defensible odor indicators

The proposer shall clearly distinguish between odor-causing compound reduction and actual odor reduction, where applicable. Testing methodology, detection limits, sampling procedures, quality control procedures, and data interpretation shall be described in the proposal.

Task E: Phase 2 Pilot Recommendations

A key deliverable from Phase 1 shall be a recommendation for Phase 2 pilot testing.

The proposer shall identify:

- Recommended chemical(s)
- Recommended dosage range
- Recommended application location
- Recommended chemical feed method
- Estimated contact time
- Expected odor reduction
- Recommended monitoring parameters
- Recommended pilot duration
- Estimated chemical consumption
- Preliminary chemical cost per unit of sludge treated
- Required equipment and infrastructure
- Safety considerations
- Potential operational limitations
- Recommended criteria for determining Phase 2 success

The proposer should also identify any additional laboratory testing recommended before proceeding to field pilot testing. For promising treatment alternatives, the proposer shall conduct additional testing as necessary to identify an effective dosage range.

Deliverables

The selected Consultant/Contractor shall provide the following deliverables:

- Phase 1 Testing Plan
- Laboratory Test Results
- Phase 1 Final Report

Consultant's Proposal

In keeping with the objective and the required tasks as outlined in this Request for Proposal, the consultants submitting proposals shall discuss in detail the manner in which the consultant shall work with the City to fulfill the City's needs.

The outline at a minimum shall address:

- Identify key personnel proposed for project team and their roles, including relevant qualifications and experience.
- Communication and coordination.
- Compatibility with city's standards, goals, and objectives.

- Working relationship between consultant and City staff.
- Information which will assist the City to determine the consultant's capability of performing the work.
- Provide a proposed schedule from project kickoff & investigation through submission of the final report.

SECTION III - MINIMUM INFORMATION REQUIRED

PROPOSAL FORMAT

Offerors should organize Proposals into the following Sections:

- A. Professional Qualifications
- B. Past Involvement with Similar Projects
- C. Proposed Work Plan
- D. Fee Proposal (include in a separate sealed envelope clearly marked "Fee Proposal")
- E. Authorized Negotiator
- F. Attachments

The following describes the elements that should be included in each of the proposal sections and the weighted point system that will be used for evaluation of the proposals.

A. Professional Qualifications – 20 points

1. State the full name and address of your organization and, if applicable, the branch office or other subsidiary element that will perform, or assist in performing, the work hereunder. Indicate whether it operates as an individual, partnership, or corporation. If as a corporation, include whether it is licensed to operate in the State of Michigan.
2. Include the name of executive and professional personnel by skill and qualification that will be employed in the work. Show where these personnel will be physically located during the time they are engaged in the work. Indicate which of these individuals you consider key to the successful completion of the project. Identify only individuals who will do the work on this project by name and title. Resumes and qualifications are required for all proposed project personnel, including all subcontractors. Qualifications and capabilities of any subcontractors must also be included.
3. State history of the firm, in terms of length of existence, types of services provided, etc. Identify the technical details that make the firm uniquely qualified for this work.

B. Past involvement with Similar Projects – 30 points

The written proposal must include a list of specific experience in the project area and indicate proven ability in implementing similar projects for the firm **and** the individuals to be involved in the project. A complete list of client references must be provided for similar projects recently completed. The list shall include the firm/agency name, address, telephone number, project title, and contact person.

C. Proposed Work Plan – 30 points

Provide a detailed and comprehensive description of how the offeror intends to provide the services requested in this RFP. This description shall include, but not be limited to: how the project(s) will be managed and scheduled, how and when data and materials will be delivered to the City, communication and coordination, the working relationship between the offeror and City staff, and the company's general philosophy in regards to providing the requested services.

Offerors shall be evaluated on the clarity, thoroughness, and content of their responses to the above items.

D. Fee Proposal - 20 points

Fee schedules should be submitted in a separate, sealed, envelope as part of the proposal. Fee quotations are to include the names, title, hourly rates, overhead factors, and any other relevant details. The proposal should highlight key staff and positions that would likely be involved with projects. Offerors shall be capable of justifying the details of the fee proposal relative to personnel costs, overhead, how the overhead rate is derived, material and time.

E. Authorized Negotiator

Include the name, phone number, and e-mail address of persons(s) in your organization authorized to negotiate the agreement with the City

F. Attachments

Legal Status of Offeror, Conflict of Interest Form, Living Wage Compliance Form, and the Non-Discrimination Form should be returned with the proposal. These elements should be included as attachments to the proposal submission.

PROPOSAL EVALUATION

1. The selection committee will evaluate each proposal by the above-described criteria and point system (A through C) to select a short-list of firms for further consideration. The City reserves the right to reject any proposal that it determines to be unresponsive and deficient in any of the information requested for evaluation. A proposal with all the requested information does not guarantee the proposing firm to be a candidate for an interview. The committee may contact references to verify material submitted by the offerors.
2. The committee then will schedule interviews with the selected firms if necessary. The selected firms will be given the opportunity to discuss in more detail their qualifications, past experience, proposed work plan and fee proposal.

3. The interview must include the project team members expected to complete a majority of work on the project, but no more than six members total. The interview shall consist of a presentation of up to thirty minutes (or the length provided by the committee) by the offeror, including the person who will be the project manager on this contract, followed by approximately thirty minutes of questions and answers. Audiovisual aids may be used during the oral interviews. The committee may record the oral interviews.
4. The firms interviewed will then be re-evaluated by the above criteria (A through D), and adjustments to scoring will be made as appropriate. After evaluation of the proposals, further negotiation with the selected firm may be pursued leading to the award of a contract by City Council, if suitable proposals are received.

The City reserves the right to waive the interview process and evaluate the offerors based on their proposals and fee schedules alone and open fee schedules before or prior to interviews.

The City will determine whether the final scope of the project to be negotiated will be entirely as described in this RFP, a portion of the scope, or a revised scope.

Work to be done under this contract is generally described through the detailed specifications and must be completed fully in accordance with the contract documents.

Any proposal that does not conform fully to these instructions may be rejected.

PREPARATION OF PROPOSALS

Proposals should have no plastic bindings but will not be rejected as non-responsive for being bound. Staples or binder clips are acceptable. Proposals should be printed double sided on recycled paper. Proposals should not be more than 30 sheets (60 sides), not including required attachments and resumes.

Each person signing the proposal certifies that they are a person in the offeror's firm/organization responsible for the decisions regarding the fees being offered in the Proposal and has not and will not participate in any action contrary to the terms of this provision.

ADDENDA

If it becomes necessary to revise any part of the RFP, notice of the addendum will be posted to Michigan Inter-governmental Trade Network (MITN) www.mitn.info and/or the City of Ann Arbor web site www.A2gov.org for all parties to download.

Each offeror must acknowledge in its proposal all addenda it has received. The failure of an offeror to receive or acknowledge receipt of any addenda shall not relieve the offeror

of the responsibility for complying with the terms thereof. The City will not be bound by oral responses to inquiries or written responses other than official written addenda.

SECTION IV - ATTACHMENTS

Attachment A – The Area Odor Study Report, dated July 27, 2020, prepared by HDR

Attachment B - Legal Status of Offeror

Attachment C – Non-Discrimination Ordinance Declaration of Compliance Form

Attachment D – Living Wage Declaration of Compliance Form

Attachment E – Vendor Conflict of Interest Disclosure Form

Attachment F – Non-Discrimination Ordinance Poster

Attachment G – Living Wage Ordinance Poster

ATTACHMENT A
THE AREA ODOR STUDY REPORT, DATED JULY 27, 2020, PREPARED BY HDR



Area Odor Study Report

City of Ann Arbor WWTP Area Odor Study

Document # 10152084-0WW-M0007

Revision: 0

Ann Arbor, Michigan

July 27, 2020

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Appendices

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1 Executive Summary

This report provides an overview of the development and implementation of a work plan which investigated and identified odor sources onsite at the City of Ann Arbor's Wastewater Treatment Plant (WWTP) located at 49 Old Dixboro Rd., Ann Arbor, Michigan 48105 and offsite locations within a two-mile radius around the plant. One additional remote collection system odor source location within the City of Ann Arbor (City) was also evaluated. The work plan approach was developed due to complaints that City staff received from the community within the area boundary. The work plan entailed the following tasks:

- Subjective Odor Surveys;
- Air Sampling Investigation Work Planning;
- Spring Odor and Summer Odor Sampling;
- Seasonal Odor Sampling for Offsite Sources;
- Odor Dispersion Modeling;
- Odor Control Technology Evaluation

The overall objective of the study was to investigate and determine potential priority odor sources, both onsite and offsite, and their potential odor impacts to the surrounding community. In order to meet this objective, an understanding of the baseline odor impacts was established to characterize the existing odor sources. Subjective surveys were completed at the beginning of the project (February 2019) and in the spring of 2019. The surveys collected field visual and odor observations for all odor sources. The observations were used to develop a detailed air sampling plan for spring and summer testing at the WWTP, along with seasonal sampling in the surrounding sanitary sewer collection system. Odor emission rates for each source were then determined and used as a basis for odor impact dispersion modeling. Sensitive receptor locations were selected around the WWTP and incorporated into the model to determine how each source was impacted.

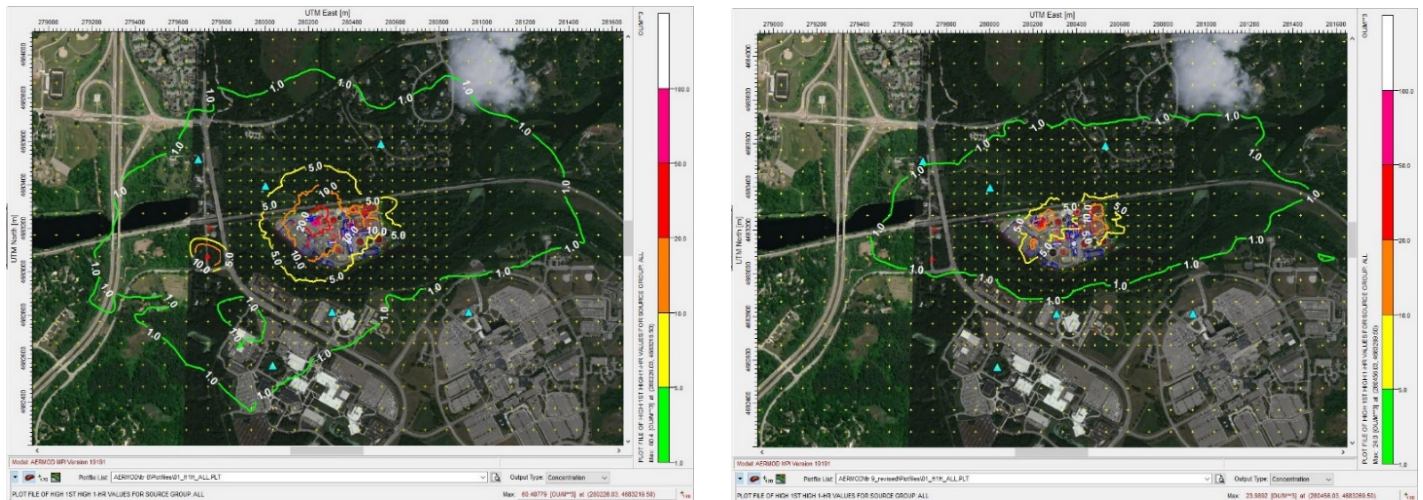
As a result of the dispersion modeling, it was found that the Raw Sewage Influent Lift Station, the Screenings and Grit (S&G) Building, and the Solids Handling Building (SHB) Truck Bay during winter biosolids loading were identified as priority sources onsite. Manholes located offsite on Old Dixboro Rd., at the Washtenaw Community College, and Nichols Arboretum were also identified as priority sources that should be addressed. These findings were presented by the City and HDR to community stakeholders in order to determine an odor detection threshold (DT) impact goal.

The stakeholders and the City selected a maximum 1-hour odor 5 DT impact goal at 100% compliance in terms of potential impact to the community. An odor control treatment technology evaluation was completed for each of these sources to determine a recommended approach to meet this goal.

As a result of the technology evaluation, one activated carbon adsorption system is recommended for the co-located Influent Lift Station and Screenings and Grit Building and one activated carbon adsorption system is recommended for the SHB Truck Bay. Manhole odor control inserts are recommended at the offsite manholes.

The benefit of implementing odor control at the Lift Station and Screenings and Grit Building is shown in Figure 1-1 odor isopleth plots.

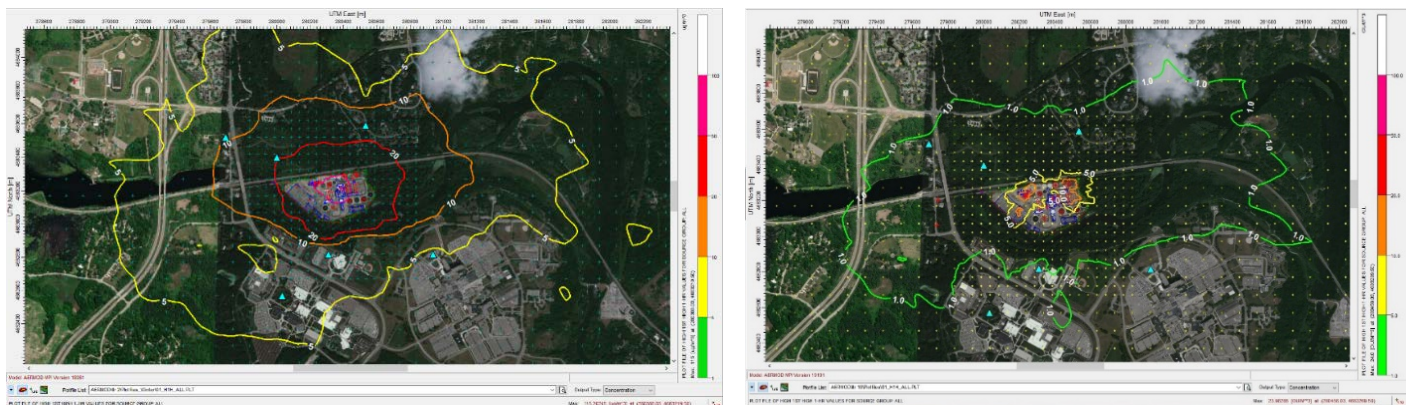
Figure 1-1. Current Baseline Impact with All Continuous Odor Sources (Left); Future Odor Impact After Recommended Carbon Odor Control Implementation (Right)



The dispersion modeling of a carbon odor control system at the Influent Lift Station and Screenings and Grit Building shows that a 5 DT impact goal would be met 100% of the time in terms of potential impact to the community odor receptors. The highest remaining potential impact locations are the Towsley neighborhood and the new retirement homes but the maximum 1-hour projected impact is well below the 5 DT goal 100% of the time (i.e. 100% compliance goal).

The benefit of implementing odor control for the SHB Truck Bay during winter biosolids loading is shown in Figure 1-2 isopleth plots below.

Figure 1-2. Current Conditions in the Truck Bay during Winter Biosolids Loading (Left); Future Odor Impact After Recommended Carbon Odor Control Implementation at Truck Bay (Right)



The dispersion modeling of a carbon odor control system at the truck bay during winter biosolids loading also shows that a 5 DT impact goal would be met 100% of the time in terms of potential impact to the community.

2 Purpose and Background

The purpose of this report is to provide an overview of the development and implementation of a work plan which investigated and identified odor sources within a two-mile radius area around the WWTP and one location within the City. The work plan approach was developed due to complaints that City staff received from the community within the area boundary.

The WWTP processes sanitary sewage received from the City's wastewater sewer collection system. The WWTP treats the sewage onsite with process systems that include a lift station, screenings and grit removal, a retention equalization basin, primary clarifiers, aeration basins, secondary clarifiers, tertiary filters, ultraviolet disinfection, and biosolids management systems. Existing odor control is limited to capturing and treating odors from various sources in the SHB and related biosolids processes and a small sewer vent scrubber on the incoming sewer line. The odorous air from the head space of the biosolids holding tanks is captured and sent to a wet ammonia scrubber followed by carbon adsorption units. Odorous air from a covered gravity thickener and two covered blend tanks and cake hoppers are also collected and treated.

Figure 2-1 provides a simplified process flow diagram of the plant. Figure 2-2 provides an aerial view of the WWTP. Figure 2-3 provides a map of the Ann Arbor odor complaint locations from 2016 to present.

Figure 2-1. Simplified Plant Process Flow Diagram for Ann Arbor WWTP

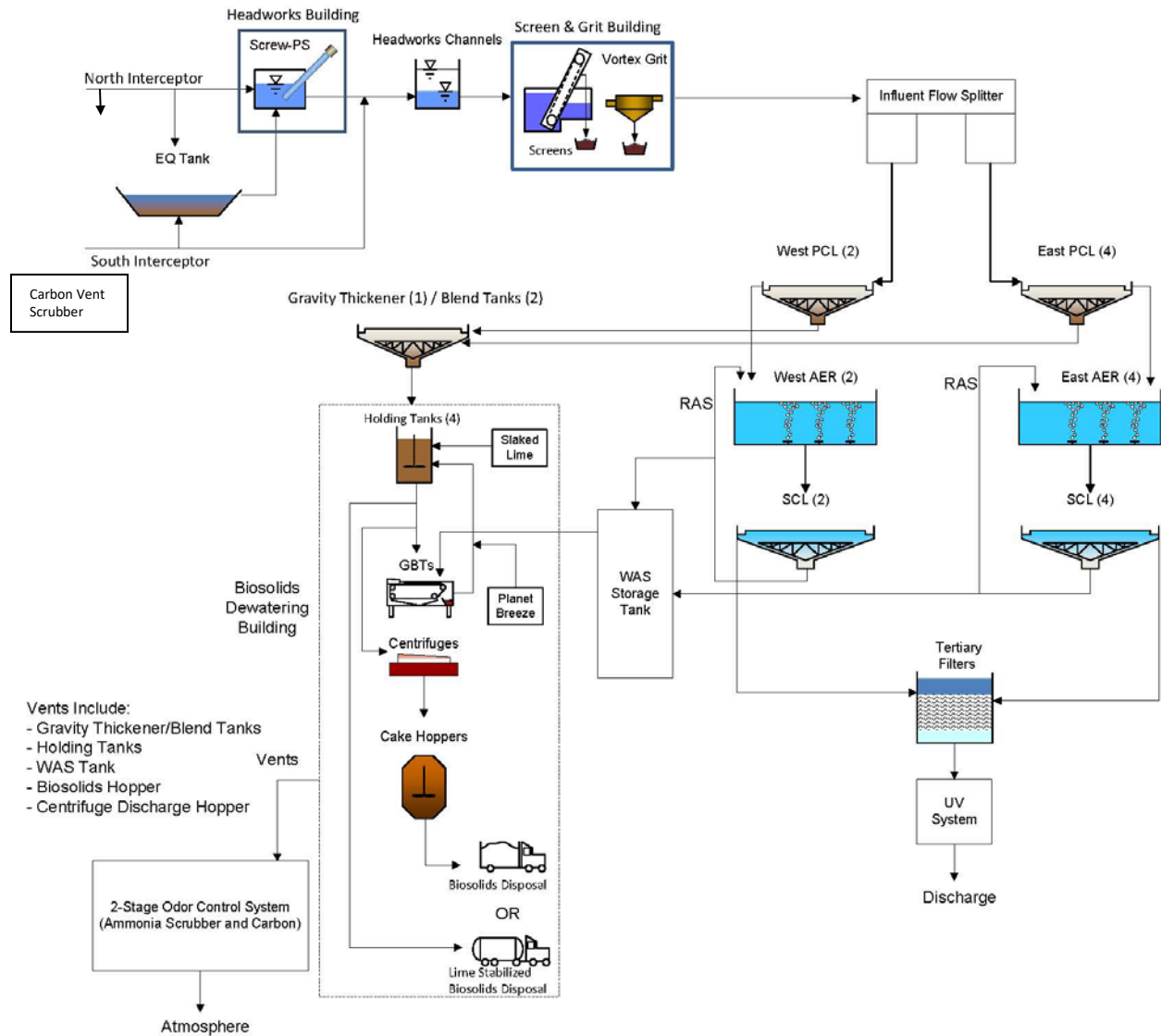
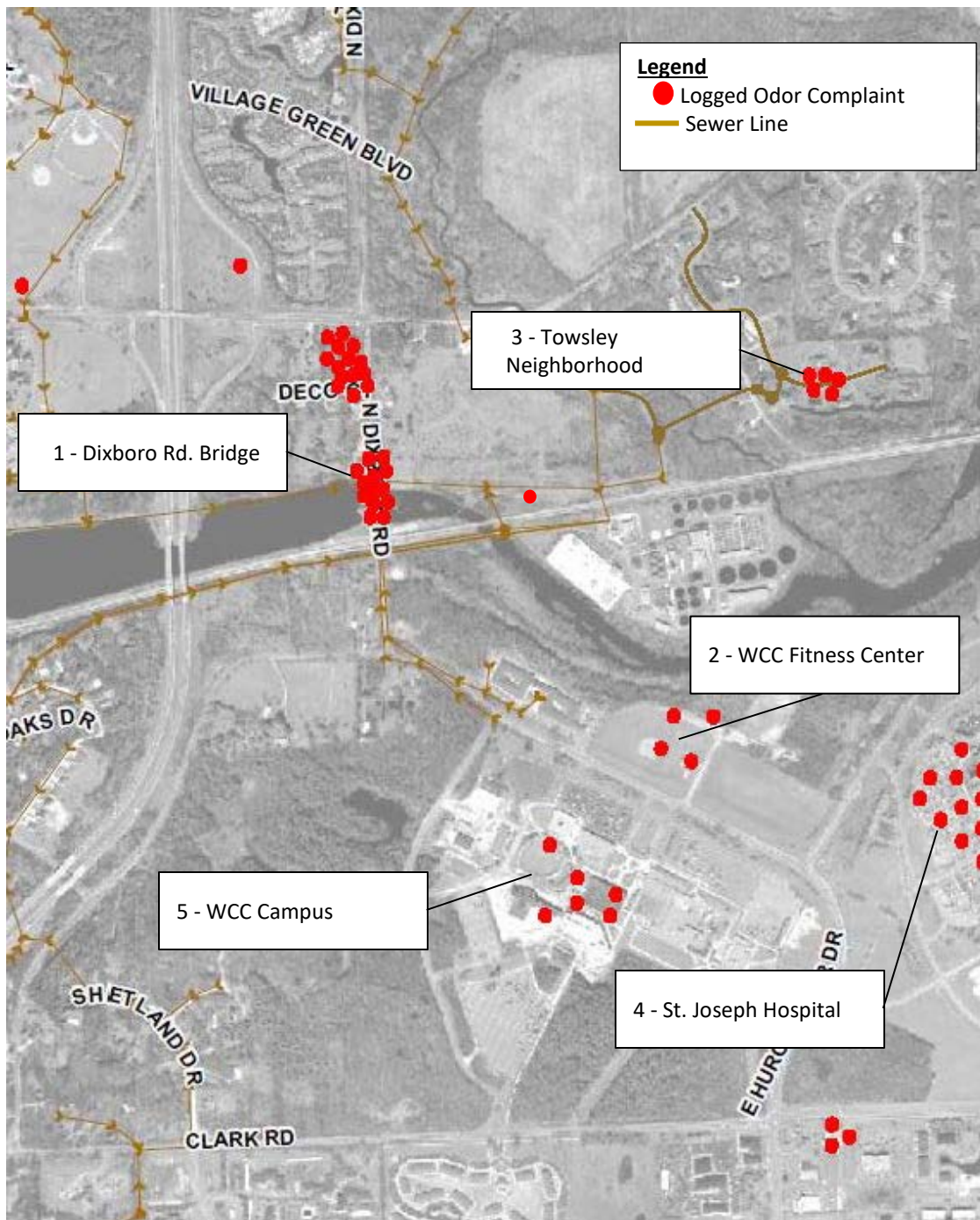


Figure 2-2. Plant Aerial View of Ann Arbor WWTP



Figure 2-3. Map of Ann Arbor Odor Complaint Locations from 2016 – present



Review of the complaints indicated they came from five areas:

1. The Dixboro Rd. Bridge area west by northwest of the plant.
2. The Washtenaw Community College (WCC) Fitness Center south of the plant.
3. The Towsley Neighborhood northeast of the plant.
4. The St. Joseph Hospital campus southeast of the plant.
5. The WCC campus south of the plant.

Subjective odor surveys were conducted at the plant and each of the five areas to collect field visual and odor observations. As a result of the subjective surveys, the initial potential onsite and offsite odor sources identified were:

- Raw Sewage Influent Lift Station
- Retention / Equalization Basin
- Screenings and Grit Building
- Grit Effluent Room
- Screenings and Grit Effluent Channels
- Flow Splitter Structures
- Primary clarifiers
- Aeration Basins
- Gravity Belt Thickener Room in Solids Handling Building
- Centrifuge Room in Solids Handling Building
- Upper Level of Cake Hoppers in Solids Handling Building
- Solids Handling Building Odor Control Systems (Ammonia and Carbon Filters)
- Cake Truck Bay in Solids Handling Building
- Secondary Clarifiers
- Tertiary Filters
- Influent Vent Carbon Filter offsite
- Influent Overflow Structure offsite
- Manhole on Old Dixboro Rd. offsite
- WCC Fitness Center Pump Station offsite
- Manhole at WCC entrance off East Huron River Dr. offsite
- Manhole at Nichols Arboretum Park entrance offsite

The objectives and results of the subjective surveys can be found in more detail in Section 3. This information was used to develop seasonal odor sampling plans used to characterize these potential odor sources.

This report provides a thorough review of the odor study work plan approach, subjective odor surveys conducted, spring and summer odor sampling testing results, and odor dispersion modeling results from different odor source locations both onsite and offsite.

Based on workshop discussions of the evaluation results, an odor impact criteria goal was set by community stakeholders and WWTP staff. The goal was then used to evaluate odor mitigation measures based on technical and economic analysis to help Ann Arbor create an odor mitigation action plan moving forward. This report summarizes that action plan and provides a basis for deciding any potential future actions to most effectively manage nuisance odors from onsite and offsite sources focusing on the potential high risk odor sources identified during the study.

3 Odor Source Characterization

In order to understand the impacts that odor may have in the area around the WWTP, the odors needed to be characterized from each source in order to determine its odor impact potential. The first step in characterizing the odor sources for the Ann Arbor WWTP was to perform two subjective surveys of the potential odor sources onsite and offsite. An air sampling investigation work plan was then developed by HDR in collaboration with the City to include all priority sources identified in the surveys. Spring and summer detailed air sampling testing was then completed to gather field and laboratory data to characterize odor sources. The following sections provide a summary of how the subjective surveys were conducted and how the air sampling plan was developed and performed.

3.1 Subjective Surveys

An initial odor source subjective site survey was completed by HDR and Bowker and Associates (team) on February 12 and 13, 2019, as well as a follow up spring survey during warmer weather on April 18, 2019. The survey performed by the team on February 12 focused on the WWTP itself while the February 13 survey began with observing a cake truck loading, followed by field tours of key collection system locations offsite. The team also performed an April survey which repeated the February survey during warmer spring conditions allowing a comparison of winter and spring conditions. This was important for determining which potential odor sources would be sampled in the spring and summer.

The detailed site survey reports are included as appendices to this report. The following section highlights field odor observations made by the team during the initial odor survey held February 12 and 13, 2019. A comparison of observations during the follow up survey in April 2019 was also performed.

Observations for each odor source were provided using the following subjective source rating scale:

- 0 = no detectable odors
- 1 = very faint odors
- 2 = faint odor
- 3 = moderate, possible nuisance odor
- 4 = strong, very unpleasant odor
- 5 = very strong, not fit to breathe

A subjective, offsite potential odor impact rating of low, medium, or high probability to create offsite impacts was assigned for each location. Although subjective in nature (opinion based on field observation), the following guidelines define the low, medium and high offsite impact ratings:

- A low rating means that based on subjective observations (opinion) that the combination of the perceived odor levels and the nature of the odor source was unlikely to cause offsite odor impacts.
- A medium rating indicates that the potential for noticeable offsite odor impact may exist and that field sampling and follow up evaluation should be considered.

- A high rating indicates significant perceived potential for offsite impact is high and that this source warrants further evaluation and sampling.

Table 3-1 provides a comparison of the onsite location observation results for the initial February and April 2019 surveys. Odor descriptors were also listed for each location. For instance descriptors such as, rotten egg like hydrogen sulfide (H₂S), musty, diaper, rancid, fishy, or urine were used. More information on the odor descriptors can be found in Appendix A.

Table 3-1. Comparison of Onsite Locations during Initial February 2019 Survey and April 2019 Survey Observations

Location	Source Rating February 2019	Offsite Impact Potential Rating February 2019	Source Rating April 2019	Offsite Impact Potential Rating April 2019
Flow Equalization Basin	1 - 2	Low	0 - 1	Low
Raw Sewage Lift Station	2 - 3	Medium	2	Low to Medium
Screening and Grit Building	3 - 4	Medium to High	3 - 4	Medium to High
Grit Teacup Effluent Discharge Room	2 - 3	Low	2 - 3	Low to Medium
Flow Splitter Structures (East and West)	3 - 4	Medium to High	3 - 4	Medium to High
Primary Clarifiers (East and West)	2 - 3	Medium to High	3	Medium to High
Aeration Basins (East and West)	1 - 2	Low to Medium	1 - 2	Low
Gravity Belt Thickener Room	2	Low to Medium	3	Medium
Centrifuge Dewatering Room	3 - 4	Medium	1 - 2	Low
Cake Hopper upper level	3 - 4	Medium	4	Medium
Cake Truck Bay	4 - 5	Medium to High	4 - 5	High
Secondary Clarifiers	0 - 1	Low	1	Low
Tertiary Filters	0 - 1	Low	0 - 2	Low

3.1.1 Key Observations

In addition to the above onsite subjective survey observations, the following offsite observations were made.

- The overflow structure at the entrance of the plant and the sewer manholes on the 78 inch interceptor along Old Dixboro Rd. leading into the WWTP, including the carbon vent scrubber, appeared to have very low level odor impacts localized at the structure. Positive pressurization and outgassing was present at these locations. H₂S and pressure monitoring were performed seasonally at the overflow and carbon vent during the course of this project.
- The Nichols Arboretum manhole was observed to have positive pressurization and was exhausting odorous air. This confirmed the need to monitor this location for both H₂S and pressure seasonally due to the elevated odor risk associated with the manhole location.
- The Towsley Neighborhood Pump Station was observed at the wet well. No odors were observed at this pump station. No additional monitoring was performed.

- The WCC Fitness Center Pump Station was observed. Odor potential was low but the station was monitored in the summer given its location in an active community parking lot and because odor complaints had been logged in this general location.
- The WCC Pump Station located in the green space on campus was observed. No odors were observed at this pump station. No additional monitoring was performed.
- The WCC sewer manhole at the northwest driveway off Huron River Dr. was observed. Odor potential was low but the manhole was monitored in the summer given its location near the campus where complaints had occurred.
- Walking inspection of manholes around the Saint Joseph Mercy Ann Arbor Hospital did not identify any noticeable odor source from the hospital collection system. No additional monitoring was performed.
- The manhole on the east side of Old Dixboro Rd. was observed and found to have positive pressurization and outgassing. The manhole was monitored for H₂S and pressure during the summer given its location near to the Dixboro Rd. bridge area where complaints had occurred.

The initial February site odor survey and follow up April survey resulted in the initial source sampling recommendations that were presented to the City in technical memorandum (TM) 10152084-0WW-M0001, Rev. 1. The TM can be found in Appendix A.

3.2 Spring Odor Sampling

Information gained from the February and April 2019 subjective survey effort was used to identify higher priority odor sources that warranted follow-on detailed emissions sampling and analysis. An air sampling work plan was developed to gather air quality data from different odor sources both onsite and offsite. The plan included air sampling for onsite and offsite locations, description of tests conducted, and frequency/duration of testing. The sampling plan can be found in document 10152084-0WW-M0003, Rev. 1 in Appendix B. Offsite sampling in the collection system consisted of installing H₂S Acrulog data loggers and pressure monitoring devices to collect data over a one week period during the spring, summer and fall seasons.

The overall air sampling plan provided the necessary information to address the City's and stakeholders concerns about seasonal odor impact changes. The subjective surveys and draft air sampling work plan were then presented to stakeholders in a community presentation to inform attendees of the City's approach for addressing their concerns and to gain input and acceptance from the stakeholder group and community.

3.2.1 Spring Sampling Methods

The sampling included evaluation of Odor Intensity as measured by Odor Panel Analysis to define the DT values following ASTM E-679. Individual odor causing compounds were also evaluated by Gas Chromatograph with Flame Photometric Detection (GC/FPD) following ASTM 5504. The analysis scans for 20 reduced sulfur odor causing compounds including a full range of organic based odor compounds:

- | | |
|--------------------|----------------------|
| • Hydrogen sulfide | • Thiophene |
| • Carbonyl sulfide | • Isobutyl mercaptan |
| • Methyl mercaptan | • Diethyl sulfide |
| • Ethyl mercaptan | • n-Butyl mercaptan |

- | | |
|---|--|
| <ul style="list-style-type: none"> • Dimethyl sulfide • Carbon disulfide • Isopropyl mercaptan • tert-Butyl mercaptan • n-Propyl mercaptan • Ethyl methyl sulfide | <ul style="list-style-type: none"> • Dimethyl disulfide • 3-Methylthiophene • Tetrahydrothiophene • 2,5-Dimethylthiophene • 2-Ethylthiophene • Diethyl disulfide |
|---|--|

Liquid phase sampling was included for measurement of influent wastewater dissolved sulfide and pH.

Field spring odor sampling was performed by the team on April 17, 2019. The plant operations were considered normal. A Jerome H₂S Analyzer, along with real-time scans for ammonia (NH₃) and amine based odorants with colorimetric tubes were used for field sampling. Additionally, Tedlar bag samples were collected for Odor Panel and GC/FPD analysis.

The primary purpose of the spring odor source sampling focused on specific areas within the plant where odor impacts may change during winter and summer months due to changes in biosolids dewatering and disposal approaches in the different seasons. The shift in disposal approaches occurs in early spring from winter landfill disposal of dewatered biosolids cake to summer land application of liquid biosolids.

H₂S and pressure monitors were installed at four locations onsite and offsite to obtain measurements from May 7 – 14, 2019. The purpose of this was to see if H₂S was present at the locations and to determine if pressurization occurs such that the odor “exhausts” to the atmosphere.

3.2.2 Spring Sampling Results

Table 3-2 summarizes the onsite spring sampling results from the Odor Panel Analysis and ASTM GC analysis, as well as field measurements for H₂S and ammonia related odors. Ammonia odors are listed with amines because the field colorimetric tubes cross measure these compounds. The ammonia and amine based odors during this sampling are very likely due to using polymer as part of the thickening and dewatering process. Field observations suggested a fishy odor in the processes where ammonia or amines were detected. This is often from the polymer.

It was suspected that data collected during the summer might show higher ammonia levels once lime slurry addition becomes part of seasonal biosolids processing when the liquid biosolids are hauled for land application. Sampling was also performed to evaluate this ammonia potential to see if it occurs or not.

Table 3-3 summarizes the offsite spring results from the H₂S Acrulogs and pressure monitoring.

Table 3-2. Spring Sampling Onsite Odor Source Data Summary

Source Location	Ann Arbor Odor DT	St. Croix Paper DT ¹	Odor Description	H ₂ S (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
SHB Truck Loading Bay (No truck loading)	19		sour, stale, plastic, swampy	0	ND	ND	0.04	0.13	0.10	Truck bay had not been used for 24 hours
SHB Truck Loading Bay (During active truck loading)	16,575	1,638	sewage, sulfur, garbage, manure, fecal, rotten sludge	3.40	0.80	0.60	ND	0.12	ND	Actively loading cake to truck in closed truck bay. Very odorous. H ₂ S levels approaching OSHA limits
Ammonia Scrubber Inlet (SHB)			NA						2 (NH ₃)	Only sampled odor NH ₃ in order to check performance
Ammonia Scrubber Outlet (SHB)			NA						ND (NH ₃)	Only sampled NH ₃ in order to check performance. Data suggests effective removal of low level NH ₃ odors
Carbon Units' Inlet (SHB)	11,730		feces, rotten sludge, sewage, dirty toilet, outhouse, fecal	0.96	0.25	0.26	0.35	0.03	ND	
Carbon Unit 1 Outlet (SHB)	82	202	sour, rotten manure, garbage, sewage, rotten sludge, mercaptan	ND	ND	0.12	ND	ND	ND	
Carbon Unit 2 Outlet (SHB)	45	202	sour, feces, manure, rotten vegetable garbage, rotten mercaptan, rotten spinach, dirty toilet, outhouse	ND	ND	0.07	0.05	ND	ND	
Centrifuge Room Exhaust (SHB)	19		sour, stale, vegetation, salty, plastic, burning plastic, smoky, burnt	ND	ND	ND	ND	ND	ND	
Upwind	10		sour, stale, plastic, burnt plastic, vegetation mushrooms, salty	ND	ND	ND	ND	ND	ND	
Downwind	17		sour, stale, plastic, vegetation, candle wax	ND	ND	ND	ND	ND	ND	

Note 1: St. Croix published a Water Environment Federation Paper “Odor Threshold Emission Factors for Common WWTP Processes” in April 2008. Data shown in this column is the average DT from samples that have been collected by St. Croix from WWTP plants across the U.S. and Canada.

Table 3-3. Spring Sampling Offsite Odor Source Data Summary

Offsite Sources	Gas Phase H ₂ S Concentration (average/peak)	Gas Phase Pressure (average/peak)
Plant Influent Carbon Vent Scrubber Raw Un-treated Air	0.05 ppm / 1 ppm	0.0445 in. H ₂ O / 0.141 in. H ₂ O
Plant Influent Overflow Structure	0.06 ppm / 3 ppm	0.0036 in. H ₂ O / 0.2 in. H ₂ O
Screenings and Grit Building (onsite)	0 ppm / 1 ppm	Did not collect pressure data as this room is vented at atmospheric pressure.
Arboretum Manhole	0.25 ppm / 15 ppm	-0.0077 in. H ₂ O / 0.058 in. H ₂ O

Note 1: PPM is used for gas phase concentrations; mg/L is used for liquid phase concentrations.
NA = Not Available. Testing was not performed.

A raw water sample was collected in the spring from the influent channel in the Screenings and Grit Building to determine dissolved sulfides (0 – 0.1 mg/L), pH (7.7) and temperature (60.8 F).

3.2.3 Key Observations from Spring Sampling

Key observations from the spring sampling include:

- Plant upwind and downwind impacts were only slightly different with downwind at 17 DT compared to upwind at 10 DT. While this may suggest a slight contribution to downwind fence line odors from the plant, the difference is minor.
- Cake truck bay odors were dramatically higher during the truck bay load out at 16,575 DT. This is higher than typically recorded at other plants and may be due to the cake being septic during sealed cake bin storage.
- The scrubber systems in the SHB were performing well providing over 99% odor DT reduction.
- The centrifuge room exhaust was low in odor in terms of DT and detectable reduced sulfur organic compounds with a DT of only 19.
- The influent carbon vent scrubber raw untreated air data showed that this sewer location was intermittently pressurized and that the H₂S levels were significant verifying the importance of the plant's carbon adsorption scrubber at this location.
- The Screenings and Grit Building odors were relatively low during the spring sampling with cooler wastewater temperatures.
- Wastewater dissolved sulfides were very low with slightly alkaline wastewater reinforcing the relatively low odor potential for the incoming winter wastewater.
- The remaining sewer source, remote manhole from the plant in the Arboretum, showed intermittent pressurization with slightly higher H₂S levels.

Further details on the spring sampling were presented to the City in TM 10152084-0WW-M0002, Rev. 0. The TM can be found in Appendix C.

3.3 Summer Odor Sampling

Summer field odor sampling was performed on July 31 and August 1, 2019. The same sampling methods and locations tested in the spring sampling were used for the summer sampling, but additional locations were tested in the summer. Summer testing was completed for two reasons:

1. Odor potential is highest in the warmest months of the year due to higher than average wastewater and ambient temperatures.
2. Liquid biosolids from the WWTP are land applied which is different from the spring where biosolids are dewatered into stored cake bins and landfilled.

3.3.1 Summer Sampling Methods

Similar to the spring sampling, detailed field sampling was completed during the summer sampling for H₂S using a Jerome H₂S Analyzer, along with real-time scans for NH₃ and amine based odorants where needed. Additionally, Tedlar bag samples were collected for Odor Panel and GC/FPD analysis.

Some of the odor samples were grab samples such as the process room, wall louvers or carbon filter exhausts. Others were taken using an EPA approved flux chamber in order to capture a controlled odor emission directly from the surface of process basins. Figure 3-1 shows a photo of a flux chamber used during aeration basin sampling. Flux chamber samples were only taken in the summer and included:

- Primary influent flow splitter channels
- Primary clarifier quiescent and weir zones
- Aeration basin un-aerated and aerated zones
- Secondary clarifier quiescent zone

Figure 3-1. Summer Sampling Using EPA Flux Chamber



H₂S monitors were installed in seven locations and pressure monitors were installed at six of these onsite and offsite locations to obtain summer data. The monitors collected one week of field data from July 30 to August 6, 2019. Measurements for parameters were taken every three minutes for the duration of the testing period. The locations included:

- The activated carbon vent filter on the inlet interceptor to the plant (H₂S and pressure)
- The overflow structure at WWTP entrance (H₂S and pressure) on influent 42" sewer
- The S&G building exhaust (H₂S only)
- Manhole #71-61488 on Old Dixboro Rd. near the plant entrance (H₂S and pressure)
- Arboretum manhole #71-69257 near the University of Michigan Hospital (H₂S and pressure)
- WCC Fitness Center Lift Station Wet Well (H₂S and pressure)
- WCC driveway manhole S-18b (H₂S and pressure)

The purpose of these monitors was again to see if H₂S was present at the location and to determine if pressurization occurs such that the odor “exhausts” to the atmosphere from key offsite manhole locations. An H₂S monitor was also installed at an exhaust fan in the plant’s S&G Building to evaluate how levels changed during the day and night and as compared to

the spring sampling data at this same location. Monitors were also installed in the field from November 15 to November 22, 2019 to collect fall data from the offsite locations monitored in the spring. Fall results were obtained for comparison purposes to spring and summer conditions.

3.3.2 Summer Sampling Results

Table 3-4 summarizes the sampling results from the Odor Panel Analysis and the GC/FPD analysis, as well as field measurements for H₂S and ammonia and amine related odors. Ammonia odors are listed with amines because the field colorimetric tubes cross measure these compounds. The spring ammonia and amine based odors were very likely due to polymer as part of the biosolids thickening and dewatering process. During summer, biosolids dewatering is not performed and centrifuge dewatering is not active. The data indicates lower odor levels in the summer related to dewatering and truck loadings than in the spring.

During summer, lime is mixed with the liquid biosolids as part of the stabilization process before it is hauled away for land application. This lime addition creates added potential for ammonia release due to pH shifts. Higher ammonia levels are observed from the raw biosolids odor sources but the plant's odor scrubber systems were effectively removing these ammonia and amine odors.

Table 3-5 provides a comparison summary of the offsite spring, summer and fall results from the H₂S Acrolugs and pressure monitoring

Table 3-4. Summer Sampling Onsite Odor Source Data Summary

Sampling Location	Ann Arbor Odor Panel DT	St. Croix Paper ¹	Odor Description	H ₂ S field number (ppm)	H ₂ S Lab (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Diethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
Retention / EQ Building	75		sour, sewage, sulfur, rotten vegetables, garbage, sour milk, earthy, dirt	0.006	ND	ND	ND	ND	ND	ND	NA	Sample taken during Retention / EQ Basin filling period at a roof hatch.
Raw Sewage Influent Lift Station	8313	3158	H ₂ S, rotten sewage, sulfur, rotten eggs, garbage	16.5	5.1	0.175	ND	ND	0.147	ND	NA	Sample taken midday August 1, 2019. The area was noticeably odorous in the immediate area around the lift station and inlet to the screenings building.
Screen and Grit Building Exhaust Fan	211	719	H ₂ S, rotten sewage, sulfur, rotten eggs	0.27	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Sampled from inside the room near screens at 11:18AM August 1, 2019. Acrulog H ₂ S data ranged from 0 to 5 ppm this week at this location with an average of 1 ppm. The Acrulog average was slightly higher than during the field grab sample event.
Grit Tank (Scum) Room	298	682	rotten sewage, sulfur, sulfides, rotten eggs,H ₂ S, rotten garbage	0.13	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Sampled from inside the room near tankage.
Flow Splitter Structure Primary Influent – West	1451	2552	sour, rotten eggs, garbage, sewage, sulfur, H ₂ S	1.9	ND	ND	ND	ND	ND	ND	0.1 (NH ₃) 0.2 (Amine)	Sampled with flux chamber in the West Flow Splitter Structure on July 31 at 1:53 pm. Odorous in the field. Turbulence noted from aeration and weirs. Smell of odor was observed above open grating covered channels from the Screen and Grit Building leading into the West Flow Splitter Structure and as well as open grating leading into the East Flow Splitter Structure.
Primary Clarifier Quiescent Zone – East Plant	163	947	skunk, mercaptan, rotten garbage, sludge, feces	0.029	ND	ND	ND	ND	ND	ND	0.1 (NH ₃) 0.2 (Amine)	Sampled midday July 31, 2019.
Primary Clarifier Weir Zone – East Plant	1507	2322	sour, sewage, sulfur, H ₂ S, rotten garbage, rotten eggs, sludge, feces	1	ND	ND	ND	ND	ND	ND	ND (NH ₃) 0.1 (Amine)	Sampled midday July 31, 2019. Weir turbulence and bubble transport were present.
Anoxic/Anaerobic Zone of Aeration Basin – East Plant	21	134	sour, H ₂ S, sewage, rotten sludge, garbage, vegetables, skunk, mercaptan, vomit	0.045	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Aerated Zone 1 Near Front of Aeration Basin – East Plant	21	134	sour, H ₂ S, sewage, rotten sludge, garbage, vegetables, skunk, mercaptan	0.014	0.0138	ND	ND	0.044	ND	ND	ND (NH ₃) ND (Amine)	
Aerated Zone 3 Near end of Aeration Basin – East Plant	11	134	sulfur, H ₂ S, gassy, swampy, earthy, cleaning products, plastic	0.0097	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Secondary Clarifier Quiescent Zone – East Plant	11	96	sour, sewage, gassy, sulfur, rotten, plastic, cleaning products	0.001	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	The quiescent zone was the only area sampled as the weirs were covered.
Gravity Belt Thickener Room Exhaust (SHB)	11	868	sour, sewage, sulfur, wet cardboard, earthy, chlorine, new vinyl	0.005	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Centrifuge Room Exhaust (SHB)	11	1105	sour, light sewage, rubber, plastic, cleaning chemicals	0.001	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Note that centrifuge dewatering was offline as summer liquid biosolids disposal was active and dewatered biosolids cake was not being made.

Sampling Location	Ann Arbor Odor Panel DT	St. Croix Pape ^{r1}	Odor Description	H ₂ S field number (ppm)	H ₂ S Lab (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Diethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
Cake Hopper Level Exhaust Air (SHB)	12		sour, rotten eggs, garbage, vegetables, sewage, old urine, chlorine, earthy, dirt, plastic	0.01	ND	ND	ND	ND	ND	ND	1.5 (NH ₃) ND (Amine)	
Centrifuge (Lower) Room Conveyor Floor Exhaust Fan (SHB)	8		sulfur, sewage, plastic, cleaning chemicals, chlorine, new vinyl	0.006	ND	ND	ND	ND	ND	ND	ND (NH ₃) 0.2 (Amine)	Note that centrifuge dewatering was offline as summer liquid biosolids disposal was active and dewatered biosolids cake was not being made.
SHB Truck Loading Bay (During active truck loading)	11	1638	sour, sulfur, sewage, garbage, urine, outhouse, feces, fishy, plastic	0.0017	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Truck was being loaded during sample collection.
Tertiary Filter Room Exhaust	10		sour, H ₂ S, rotten, sewage, plastic, rubber	0	ND	ND	ND	ND	ND	ND	NA	
Inlet of Carbon Filters (common in SHB)	620		sewage, sulfur, sludge, rotten vegetables, garbage, outhouse, earthy, dirt	0.15	ND	ND	ND	ND	ND	ND	1.3 (NH ₃) ND (Amine)	
Outlet of Carbon Filters (SHB)	69 to 75	202	sulfur, sewage, rotten vegetables, garbage	0.05 to 0.055	ND	ND	0.1 to 0.11	ND	0.117 to 0.136	ND	1.5 to 2 (NH ₃) 2 to 4 (Amine)	Two samples were collected; one from Carbon Filter Stack #2 and one from Carbon Filter Stack #3.
Overflow Splitter Structure Headspace at plant entrance	250		rotten sewage, cabbage, garbage, feces, manure, outhouse, sulfur, urine	0.002	ND	ND	ND	ND	ND	ND	NA	
Ammonia Scrubber Inlet (SHB)	No odor lab test			NA	ND	ND	ND	ND	ND	ND	20 (NH ₃) >20 (Amine)	
Ammonia Scrubber Outlet (SHB)	No odor lab test			NA	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Upwind	19		sour, sulfur, vegetation, wet grass, plastic, exhaust	0	ND	ND	ND	ND	ND	ND	NA	NW corner of plant near entrance gate
Downwind	10		sour, plastic, stale, exhausts	0	ND	ND	ND	ND	ND	ND	NA	SE corner of plant near Huron passage by final clarifiers

NA = Not Available. Testing was not performed.
ND = Non-Detect
Note 1: St. Croix published a Water Environment Federation Paper “Odor Threshold Emission Factors for Common WWTP Processes” in April 2008. Data shown in this column is the average DT from samples that have been collected by St. Croix from WWTP plants across the U.S. and Canada.

Table 3-5. Comparison of Spring, Summer and Fall Sampling Offsite Odor Source Data Summary

Offsite Locations	Gas Phase H ₂ S Concentration (average/peak)			Gas Phase Pressure (average/peak)		
	Spring	Summer	Fall	Spring	Summer	Fall
WCC Fitness Center Wet Well	NA	0 ppm / 0 ppm	NA	NA	0.0007 in. H ₂ O / 0.006 in. H ₂ O	NA
WCC Campus Manhole		3.41 ppm / 126 ppm			0.0136 in. H ₂ O / 0.321 in. H ₂ O	
Old Dixboro Manhole		9.88 ppm / 56 ppm			0.029 in. H ₂ O / 0.079 in. H ₂ O	
Plant Influent Carbon Vent Filter	0.05 ppm / 1 ppm	0.77 ppm / 6 ppm	0.01 ppm / 5 ppm	0.0445 in. H ₂ O / 0.141 in. H ₂ O	0.0577 in. H ₂ O / 0.138 in. H ₂ O	0.02 in. H ₂ O / 0.117 in. H ₂ O
Plant Influent Overflow Structure	0.06 ppm / 3 ppm	0.03 ppm / 9 ppm	0 ppm / 1 ppm	0.0036 in. H ₂ O / 0.2 in. H ₂ O	0.0035 in. H ₂ O / 0.021 in. H ₂ O	0.0002 in. H ₂ O / 0.068 in. H ₂ O
Screenings and Grit Building (onsite)	0 ppm / 1 ppm	1.03 ppm / 5 ppm	0.33 ppm / 3 ppm	NA	NA	NA
Arboretum Manhole	0.25 ppm / 15 ppm	0.21 ppm / 6 ppm	0.22 ppm / 5 ppm	-0.0077 in. H ₂ O / 0.058 in. H ₂ O	0.0145 in. H ₂ O / 0.069 in. H ₂ O	0.0002 in. H ₂ O / 0.382 in. H ₂ O

NA = Not Available. Testing was not performed.

Raw water samples were collected in the summer and fall from the influent channel in the S&G Building and from the West Flow Splitter Box. The following are the summer and fall results for dissolved sulfides, pH and temperature:

S&G Building Influent Channel

- Dissolved sulfides, summer: 0 – 0.2 mg/L
- Dissolved sulfides, fall: 0.5 mg/L
- pH, summer: 7
- pH, fall: 7
- Temperature, summer: 67 F
- Temperature, fall: 62.4

West Flow Splitter Box

- Dissolved sulfides, summer: 0 – 0.2 mg/L
- Dissolved sulfides, fall: NA
- pH, summer: 7
- pH, fall: NA
- Temperature, summer: 69 F
- Temperature, fall: NA

3.3.3 Key Observations from Summer Sampling

Key observations from the summer sampling include:

- Raw sewage inlet liquid phase sulfide levels, although higher than spring, remained low in the range of 0 to 0.2 mg/L. In general, this limits the H₂S odor emission potential. Additionally, the wastewater pH averaged approximately 7.4 between the spring and summer. The slightly alkaline pH tends to help keep the H₂S fraction of the dissolved sulfides in the ionic form which cannot be stripped into the air. Both the low sulfide concentration and slightly elevated pH reduce odor emission potential.
- In general, the odor levels in terms of DT were low plant wide. The only area where DT levels were higher than typical data was the inlet channel to the S&G Building. All other areas exhibited relatively low odor DT values compared to experiences from other typical wastewater plant data.
- The most odorous areas of the plant with the highest DT values were:
 - o The Raw Sewage Lift Station channels flowing into the S&G Building
 - o S&G Building roof exhaust
 - o Primary influent flow splitter structures (east and west)
 - o Primary clarifiers (particularly the weirs)
- Odor levels from Ann Arbor WWTP sources were generally very low compared to other wastewater plants with similar treatment processes based on comparison to the St. Croix Odor Lab data included in the sample summary table.
- Plant upwind and downwind impacts were only slightly different, with downwind at 10 DT compared to upwind at 19 DT. This was similar to the spring data at 10 DT for upwind and 17 DT for downwind. However, sampling conditions were more variable in terms of wind direction, which was shifting at times during the summer sampling period. This may explain why the upwind had a slightly higher DT than downwind. Both upwind and downwind measurements were low.
- Similar to spring, downwind odor compound measurements such as H₂S, methyl mercaptan, dimethyl sulfide and other typical wastewater odors were below detection limits which were in the 8 to 16 part per billion (ppb) range for the EPA Method 15 GC/FPD scans.
- The spring and summer truck bay data indicates that truck bay odors are relatively low except during cake loading in the December through April period when dewatered cake is loaded into open bed trucks. Dewatered biosolids cake treated with “Planet Breeze” is only loaded into trucks from December through April and the loading process only lasts for approximately 45 minutes per truck. Spring truck loading odors were measured at 16,575 DT compared to 11 to 19 DT measured during all other periods. Planet Breeze is a chemical that is combined with the dewatered biosolids cake at the facility to reduce odors from the truck when it is taken offsite to the landfill.
- Similar to spring, the odor control scrubber systems in the Dewatering Building were performing well during the summer sampling event.
- In general, the Solids Handling Building's exhaust fans were low in odor DT ranging from 8 to 12 DT. Exhaust volumes were relatively high. This combination of concentration and exhaust rate was evaluated as part of the air dispersion modeling evaluation to determine the risk of the combined exhaust odors reaching offsite.
- Several offsite manhole sources showed very high gas phase H₂S levels and the potential for intermittent pressurization. These included the WCC Campus manhole and the Old Dixboro Rd. manhole which had average summer H₂S levels in the range of 3 to 10 ppm with peaks into the range of 56 to 126 ppm.

- The remote Arboretum Manhole showed similar H₂S levels to spring data with the potential for intermittent pressurization.
- The influent lift station and screenings and grit building summer odor levels were much higher than in spring.
- Raw wastewater dissolved sulfides also tended to be higher in summer confirming the increased odor potential from the warmer wastewater, but in general dissolved sulfides in the Ann Arbor wastewater were relatively low in the range of 0.5 mg/l or less.

The Odor DT data was used to create an odor emission rate (OER) table presented in the next section. Further details on the summer sampling were presented to the City in TM 10152084-0WW-M0004, Rev. 0. The TM can be found in Appendix D.

4 Odor Dispersion Impact Modeling

Sampling results from the spring, summer, and offsite collection system monitoring were used to develop an odor emissions rate from each location tested. The following sections describe how the OER table was developed and how it was used for odor dispersion impact modeling.

4.1 Odor Emission Rate

The OER results were used as the basis for developing a dispersion model. Table 4-1 lists the projected mass of odor emissions from each location tested along with an indication of the percentage contribution to overall odor emissions by source. The table presents all odor sources where samples were sent for odor panel laboratory evaluation to determine odor DT values.

The OER table is based on summer odor data but the dispersion model also includes the seasonal differences in how biosolids are processed differently between winter, when dewatered biosolids cake is loaded and hauled in covered but open bed tractor trailer trucks, and summer when liquid biosolids is loaded into sealed liquid hauling trucks for beneficial reuse land application.



Table 4-1. Odor Emission Rate Summary Based on Summer Sampling Data

Sampling Location	DT value	Surface Area (ft ²)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric (cfm)	Process air (cfm/ft ²)	Flux Chamber Rate Total (m ³ /s/m ²)	DT OU/Sec	% of Total	Comments
Retention / EQ Building	75	3.3			325			12	0.150	Represents small cracks in the large access hatch on the northwest corner of the EQ Building and grating on the east end. Assume EQ fill rate of 3.5 MGD based on summer sampling as typical fill rate.
Raw Sewage Influent Lift Station	8313	21	1062.5	0		51	0.25907	4168	54.466	Represents open surface area above open channel gratings and edge cracks in the covers on the lift station Archimedes screw pumps.
Screen and Grit Building Exhaust Fans	211	24.9			12400			1235	16.136	Assumes four roof exhaust fans on screen and grit building at their rated cfm values.
Grit/Scum Tank Room	298	8.3			2500			352	4.594	Assumes roof exhaust fan running at rated value.
Flow Splitter Structure Primary Influent - West	1451	2458	240	5		0.098	0.00114	377	4.923	Includes open grating channels flowing into and out of the splitter box plus the open areas of the aerated structure.
Flow Splitter Structure Primary Influent - East	1451	1514	120	5		0.079	0.00104	213	2.783	Includes open channels and grating channels flowing into and out of the splitter box plus the open areas of the aerated structure.
Primary Clarifier Quiescent Zone – West Plant	163	5542	0	5		0	0.00064	54	0.703	Single clarifier running on West Plant.
Primary Clarifier Quiescent Zone – East Plant	163	11084	0	5		0	0.00064	108	1.406	Two clarifiers running on East Plant.
Primary Clarifier Weir Zone – West Plant	1507	1257	0	5		0	0.00064	113	1.474	Assumed four feet wide launder (wall to weir) with 100 feet diameter. One online.
Primary Clarifier Weir Zone – East Plant	1507	2514	0	5		0	0.00064	226	2.948	Assumed four feet wide launder (wall to weir) with 100 feet diameter. Two online.
Anoxic/Anaerobic Zone of Aeration Basin – West Plant	21	3612	0	5		0	0.00064	5	0.059	Area from one west basin online.

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Sampling Location	DT value	Surface Area (ft ²)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric (cfm)	Process air (cfm/ft ²)	Flux Chamber Rate Total (m ³ /s/m ²)	DT OU/Sec	% of Total	Comments
Anoxic/Anaerobic Zone of Aeration Basin – East Plant	21	8295	0	5		0	0.00064	10	0.136	Area from two east basins online.
Aerated Zone 1 Aeration Basin – West Plant	21	5419	2293	5		0.423	0.00279	29	0.385	Area from one west basin online. Splits aerated zones into front half.
Aerated Zone 1 Aeration Basins – East Plant	21	10838	4585	5		0.423	0.00279	59	0.771	Area from two east basins online. Split aerated zones into front half.
Aerated Zone 3 at end of Aeration Basin – West Plant	11	5419	1123	5		0.207	0.00169	9	0.123	Area from one west basin online. Splits aerated zones into back half.
Aerated Zone 3 at end of Aeration Basins – East Plant	11	10838	2245	5		0.207	0.00169	19	0.245	Area from two east basins online. Split aerated zones into back half.
Secondary Clarifier – West Plant	11	9693	0	5		0	0.00064	6	0.083	Area from one clarifier online.
Secondary Clarifiers – East Plant	11	19386	0	5		0	0.00064	13	0.166	Area from two clarifiers online.
Gravity Belt Thickener Room Exhaust (SHB)	11	19.6			36000			187	2.442	18,000 cfm rating on one fan for winter conditions but two fans assumed in summer.
Centrifuge Room Exhaust (SHB)	11	9			7000			36	0.475	Assumed two exhaust fans at rated value 3500 cfm each.
Cake Hopper Level Exhaust Air (SHB)	12	9			5000			28	0.370	Assumed one fan running at rated value.
Centrifuge (Lower) Room Conveyor Floor Exhaust Fan (SHB)	8	4			7000			26	0.345	Assumed one fan based on field observations. Largest fan rating.
SHB Truck Loading Bay (During active truck loading)	11	8.6			7000			36	0.475	Assumed two fans running at rated value. DT value from summer data. Note that winter DT for truck loading is much higher at 16575 DT. When biosolids are loaded in winter, this results in the truck bay dominating with an OER contribution of 88% of the total. Both conditions will be modeled in AERMOD.



Sampling Location	DT value	Surface Area (ft ²)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric (cfm)	Process air (cfm/ft ²)	Flux Chamber Rate Total (m ³ /s/m ²)	DT OU/Sec	% of Total	Comments
Tertiary Filter Room Exhaust	10	15.9			9200			43	0.567	Based on field measurements from four wall fans running.
Outlet of Carbon Filters (SHB)	68	3.53			9000			289	3.774	Field cfm data from two stacks at 18 inch diameter each.
Overflow Splitter Structure Headspace at plant entrance	250	4		5		0	0.00064	0.05955	0.001	

The field observations along with the OER table suggest that the following sources have the greatest percent contribution:

- The Raw Sewage Lift Station and S&G Building exhaust
- The raw influent flow splitter channels to the primary clarifiers on the east and west plants
- The primary clarifiers including the weirs and quiescent zones
- The exhaust from the carbon filters
- The gravity belt thickener room wall louver exhaust

During offsite collection system investigations and sampling, several small odor locations were also identified where the sewer system headspace showed an intermittent tendency for positive pressurization and exhausting of collection system headspace odors. These included a manhole on Old Dixboro Rd. near the intersection of Deco Ct. and exhaust from a small passive carbon odor scrubber on the collection system headspace at the entrance road leading into the plant at the lower end of Old Dixboro Rd. Both were small impact sources but both are considered in the odor dispersion modeling because of their proximity to bridge commuter traffic on South Dixboro Rd. and a home near North Dixboro Rd. where odor complaints have been reported. Odor DT for these sources is based on H₂S odor equivalents using H₂S data from Acrulog H₂S data loggers used to measure odors from the sewer in these locations. The DT equivalent assumes 1 DT = 0.0005 parts per million (ppm) per Water Environment Federation Manual of Practice 25: "Control of Odors and Emissions from Wastewater Treatment Plants".

For air exhausting from the manhole pick hole cover exhaust on Old Dixboro Rd., this equated to 19,760 DT for the small amount of untreated air leaving the pick hole. For the exhaust from the passive vent carbon system, this equated to 150 DT based on the assumption that the carbon removed at least 90% of the odor from the raw air at 1,540 DT based on the average H₂S of 0.77 ppm seen on the inlet of the carbon odor scrubber.

Odorous air volumetric flow rates were measured directly in the field at these collection system locations in cubic feet per minute (cfm). Although these locations were only intermittently positively pressured, they were modeled as though they exhausted continuously as the most conservative assumption.

Odor DT and emission rates were adjusted for winter months in the dispersion model as follows based on spring sampling data:

- During winter months (roughly November to May) the truck loading bay exhaust when trucks were not actively loading was set at 19 DT compared to 11 DT in summer. This represents normal operation without active biosolids cake truck loading.
 - o Active truck loading during winter with open-top cake trucks is based on a measured 16,575 DT at the wall mounted exhaust louvers. This is a short term, unusual case, when trucks are actively loading but was also evaluated and is presented in the dispersion modeling evaluation. Trucks take only about 30 to 45 minutes to load and one or two trucks are loaded every weekday. Consequently, this impact is intermittent and typically short-term and limited to winter months.

- Centrifuge room exhaust for winter, when centrifuge dewatering is operational, was set to a field measured value of 19 DT compared to summer when it was measured at 11 DT.
- Gravity belt thickener room exhaust rates were set at 18,000 cfm with one exhaust fan operating in winter but at 36,000 cfm with two 18,000 cfm exhaust fans in summer.

The OER results do not consider wind and weather patterns and dispersion. Therefore, it does not consider the true risk of whether these sources create potential for noticeable offsite downwind odor impacts. This evaluation was done using the EPA AERMOD dispersion model to evaluate potential for offsite impacts.

4.2 Dispersion Modeling

The complete detailed dispersion modeling analysis is presented in TM 10152084-0WW-M0006, Rev. 1 in Appendix E. This section highlights the dispersion modeling method and shows projected odor impacts for higher priority sources identified in the evaluation.

Dispersion modeling provides an improved understanding of the relative risk of creating offsite impacts for each odor source because it considers how the odors migrate from the sources to the receptors (the community). It considers terrain conditions including elevation, building downwash effects, and weather patterns. Odor dispersion modeling should be thought of as a risk assessment evaluation to determine the highest risk odor sources with the greatest potential for negative odor impacts and an overall evaluation to understand the risk level of noticeable nuisance level odors.

The dispersion model uses mathematical equations that relate emissions from a source to predicted ambient air concentrations downwind. The AERMOD dispersion model was used for this analysis. This model is recommended by the EPA and has been widely used in odor impact assessments. AERMOD is designed to assess the individual and combined impacts from multiple sources and source types such as point or area sources.

The following subsections describe the inputs developed for the Ann Arbor WWTP baseline AERMOD dispersion modeling.

4.2.1 Source Data Inputs

Source data must be characterized to show the odor concentration of the source, the volumetric emission rate of the source, the resulting mass emission of the odor, and the type of source. The source concentrations could be based on a particular odor-causing compound, such as H₂S. However, if H₂S is not the only or even the primary odor-causing compound of concern, then it might not be a good indicator of what will cause risk of offsite odor complaints.

Source data from the spring and summer Ann Arbor WWTP odor sampling indicate that the odors from the plant are caused by a variety of compounds. These included H₂S as well as low levels of reduced sulfur organic odor compounds such as methyl mercaptan (MM), dimethyl sulfide (DMS), dimethyl disulfide (DMDS) and carbonyl sulfide (CS) as well as low level ammonia and amine based odors from several biosolids sources.

As such, it is more appropriate to evaluate dispersion effects based on odors expressed as a DT level in order to consider all odorous compounds. For instance, if modeling was done solely on H₂S then sources where the reduced sulfur compounds or ammonia play a key role would not be fully considered in the dispersion impact projections. The detection threshold value DT provides an estimate of the broad spectrum odors as perceived by the odor panelist

noses, regardless of which odor causing compounds are present. DT values were used to develop the OER table estimates.

4.2.2 Terrain, Building and Odor Source Characterization Inputs

Three types of odor sources were identified:

- Point sources, such as the exhaust from the existing carbon adsorption odor control system exhaust stacks in the SHB.
- Area sources, such as the primary clarifiers, flow splitter channels and aeration basins.
- Volume sources, such as the building wall exhaust louvers and fans for building HVAC exhaust systems.

The dimensions and location of each of these sources were included in the Ann Arbor area dispersion modeling evaluation. AERMOD considers the differences in each of these types of physical odor sources.

The AERMOD dispersion model has two options for determining how the dispersion model considers the effects of land use: “urban” and “rural.” The rural option was used in this evaluation given the relatively limited degree of urbanization within three kilometers of the plant. The urban land use option is appropriate only if over half of the area within three kilometers of the source is considered to be in the urban land use category (i.e. include multi-story buildings, industrial areas, and older urban housing areas with closely spaced houses). Since this does not describe the plant area, the rural dispersion coefficients, mixing heights, and temperature gradient effects were used in the modeling analysis.

The “rural” land use option is also the more-conservative assumption, because dispersion (or dilution) of the odors is generally less under these conditions. In an urban setting, buildings promote turbulence and mixing, which enhances dispersion. Rural land use generally lacks these effects, resulting in relatively slower dispersion (and dilution) of the odors as they migrate away from the plant.

Terrain elevations and land cover type are all considered in the AERMOD set up files. This data is part of the input set up that defines the topographic elevations and land cover in the area of interest.

An aerial photograph was used as the base map to locate the individual sources when setting up the modeling input files. A receptor grid array was defined and superimposed on the site aerial map. Receptors are the locations where ambient concentrations are calculated by the dispersion model. The receptor grid used in this modeling analysis was rectangular, extending two miles from the plant with receptors located as follows:

- In general, odor receptor elevations were set at the approximate height of an average person to simulate the elevation of a person's nose.
- The rectangular grid was established with receptors spaced every 10 meters onsite and out to ¼ kilometer, then every 50 meters out to ½ kilometer, then 100 meter spacing out to just over two miles (3.5 kilometers or 2.17 miles).

Receptors were also established along the perimeter fence line of the WWTP and at the following “Sensitive Receptor” locations in the community:

- The location of a home off of North Dixboro Rd. where complaints have been reported.

- The location of a new retirement center, All Seasons Ann Arbor (All Seasons), under construction just northwest of the WWTP off of North Dixboro Rd.
- The Towsley community where odor complaints have been reported.
- The nearby St. Joseph Hospital parking lot southeast of the WWTP where odor complaints have been reported.
- The WCC fitness center parking lot south of the plant where odors have been reported.
- The WCC area south of the plant where odors have been reported.

Overall, over 8,300 receptor locations were defined in the AERMOD model evaluation in order to evaluate potential odor impact risk as far as 2.17 miles from the WWTP. Figure 4-1 shows the overall site along with the locations of the defined sensitive receptors. Figure 4-2 shows a more focused view of the WWTP odor sources. All of the highlighted zones of the plant were modeled. All blue zones were modeled as their actual structures in height, length, width and general shape so that AERMOD could do building and structure downwash effect calculations. All of the red zones represent the plant treatment processes that were assumed to be typically in service.

Figure 4-1. Overview with Sensitive Odor Receptors Locations Identified

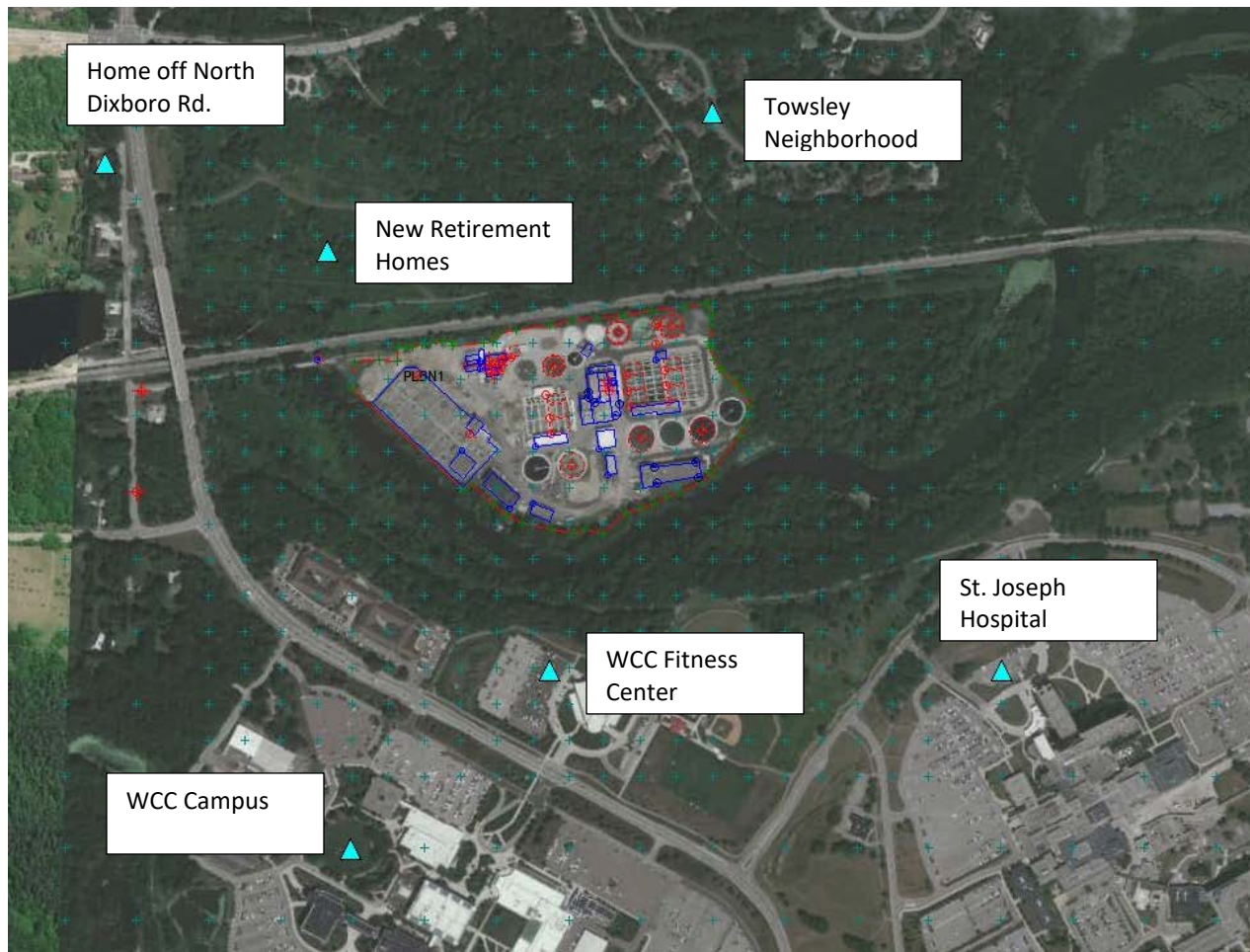


Figure 4-2. Plan view of Ann Arbor WWTP structures and process emission sources



The plant was modeled assuming normal operation with the typical number of unit processes in service. This included:

- Normal loading to the Raw Sewage Influent Lift Station
- The Screenings and Grit Building in full service
- One of the two West Primary Clarifiers in service
- Two of the four East Primary Clarifiers in service
- One of the two West Aeration Basins in service
- Two of the four East Aeration Basins in service
- One of the two West Secondary Clarifiers in service
- Two of the four East Secondary Clarifiers in service
- Tertiary Filter Building in service
- Solids Handling Building in service
 - o In winter with centrifuge dewatering and biosolids cake production
 - o In summer without centrifuge dewatering and liquid biosolids hauling

The above was modeled as the normal baseline plant configuration in order to estimate the baseline odor impact potential. In addition to this, dewatered cake biosolids loading was also modeled in order to project the potential impact during periods when a biosolids cake truck is actively being loaded. Furthermore, several off site odor sources were modeled as previously

discussed including the influent manhole off of Old Dixboro and the exhaust from the influent sewer carbon scrubber near the entrance road to the plant.

Several offsite sewer locations were not modeled because as part of the spring and summer sampling, it was determined that they either did not have any measureable odors or that they never pressurized creating potential for odorous air exhaust. These included:

- An access hatch to the wet well pump station in the green space at the WCC.
- A sealed manhole on East Huron River Dr. near the entrance to the WCC where H₂S was detected under the cover but the manhole was sealed without any pick hole openings.
- An access hatch to the pump station wet well near the WCC fitness center where H₂S odors were not detected and wet well pressurization was generally not observed.
- The Towsley neighborhood pump station where inspection did not indicate odor potential.

During the course of the February odor survey and the follow up spring, summer, and fall sampling events, no other odor sources were identified within two miles of the plant.

4.2.3 Metrological Data Inputs

The meteorological data used in this modeling analysis are from the Ann Arbor Municipal Airport. Five years of available meteorological data was used representing the years 2014 through 2018.

The dispersion model calculates odor dispersion effects every hour over the course of each year (8,760 data points, one for each hour of the year) for every receptor grid location. Using five years of meteorological data allows calculation of the potential dispersion risk for 43,800 hourly weather patterns defined by the local airport meteorological data. There were over 8,300 receptors in the model. By calculating the impact for each source, for every receptor location, for every hour of the five years, there is a high statistical probability of considering the worst-case conditions and thereby conservatively projecting the relative risk of a given odor source creating an offsite impact.

4.2.4 Modeling Approach

It should be noted that much of the odor source data was based on relatively warm weather odor generating conditions, with relatively warm wastewater, and sampling completed during summer weather. This sample timing was selected intentionally to attempt to capture higher odor-generating conditions representative of the higher odor threat times of the year. The sampling data may not represent the *absolute* highest peak odor concentration conditions that actually occur, but they are generally considered conservative.

The exception to this is for odor sources that change from summer to winter because of changes in how biosolids are processed in winter. This evaluation also considered those impacts by sampling completed in both conditions.

As such, for winter months, when odor levels from most sources may actually tend to be reduced, this assumption results in a conservative estimate of the offsite impact for sources such as the Raw Sewage Influent Lift Station, the S&G Building, primary clarifiers, and aeration basins. As an example of this potential, the S&G Building roof fans averaged near 0 ppm H₂S with peaks to 1 ppm during the week of May 8 through May 14, 2019, while averaging 1.03 ppm with peaks to 5 ppm during the week of July 31 to August 6, 2019. Odor

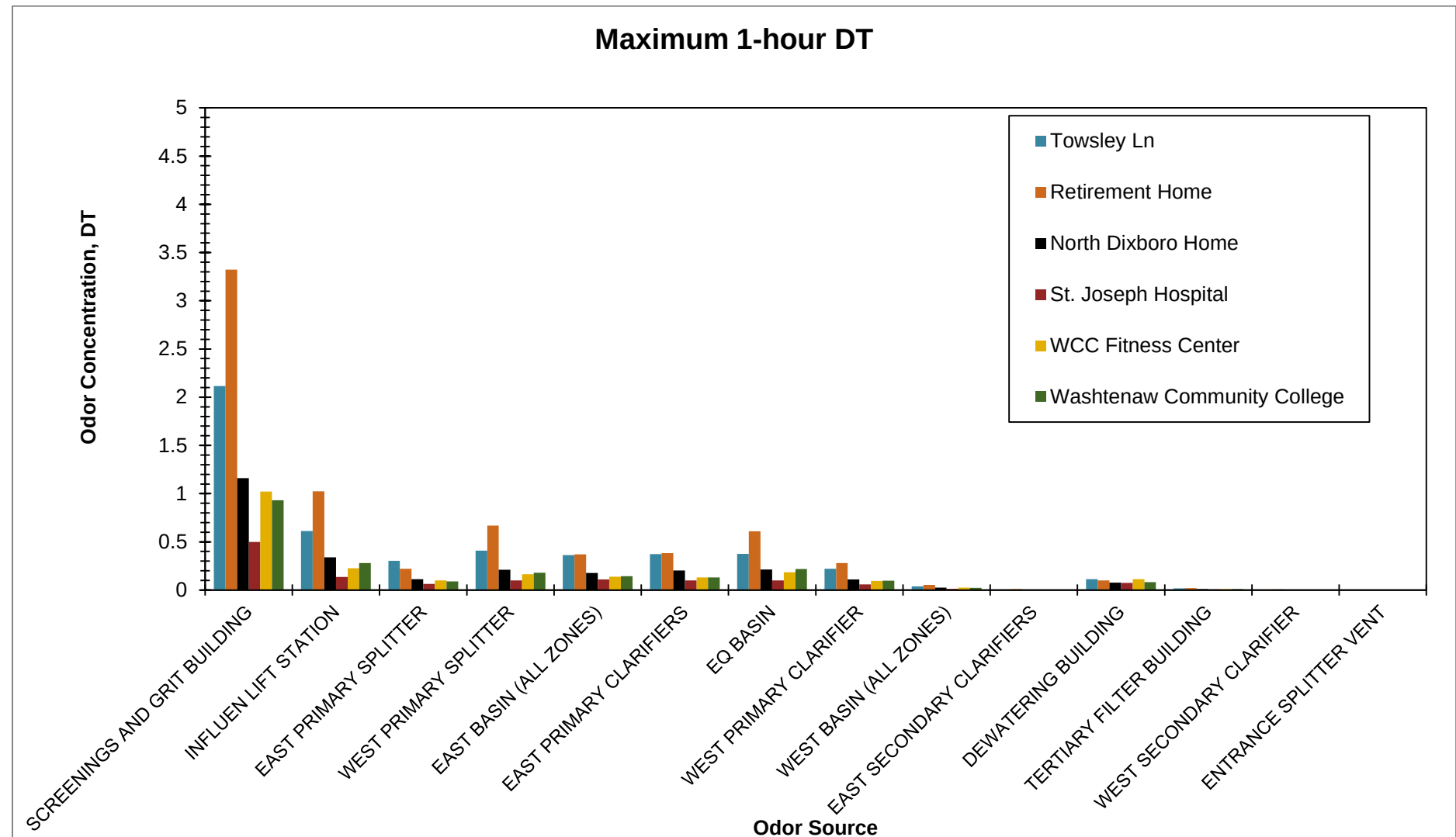
DT data from August was used in the modeling which would tend to make the model projections in winter conservative.

4.3 Projected Odor Impacts Based on AERMOD

Projected odor impacts are presented in two ways. First, as a bar chart showing impacts of the individual sources at the various sensitive receptor locations and second, as odor impact contours (called odor isopleths) showing the maximum 1-hour average DT impact calculated by the dispersion model plotted onto an aerial view. The odor contours or odor isopleths are created by connecting calculated values for the 8,300 grid points that have the same projected DT impact. As such, the outer boundary of an odor isopleth line represents the projected maximum impact distance of a source that occurred at least one time during the five years of evaluated meteorological data. This approach is therefore essentially projecting the maximum odor footprint zone potential. By establishing the baseline odor condition this evaluation can help determine if any sources are problematic and may warrant odor mitigation.

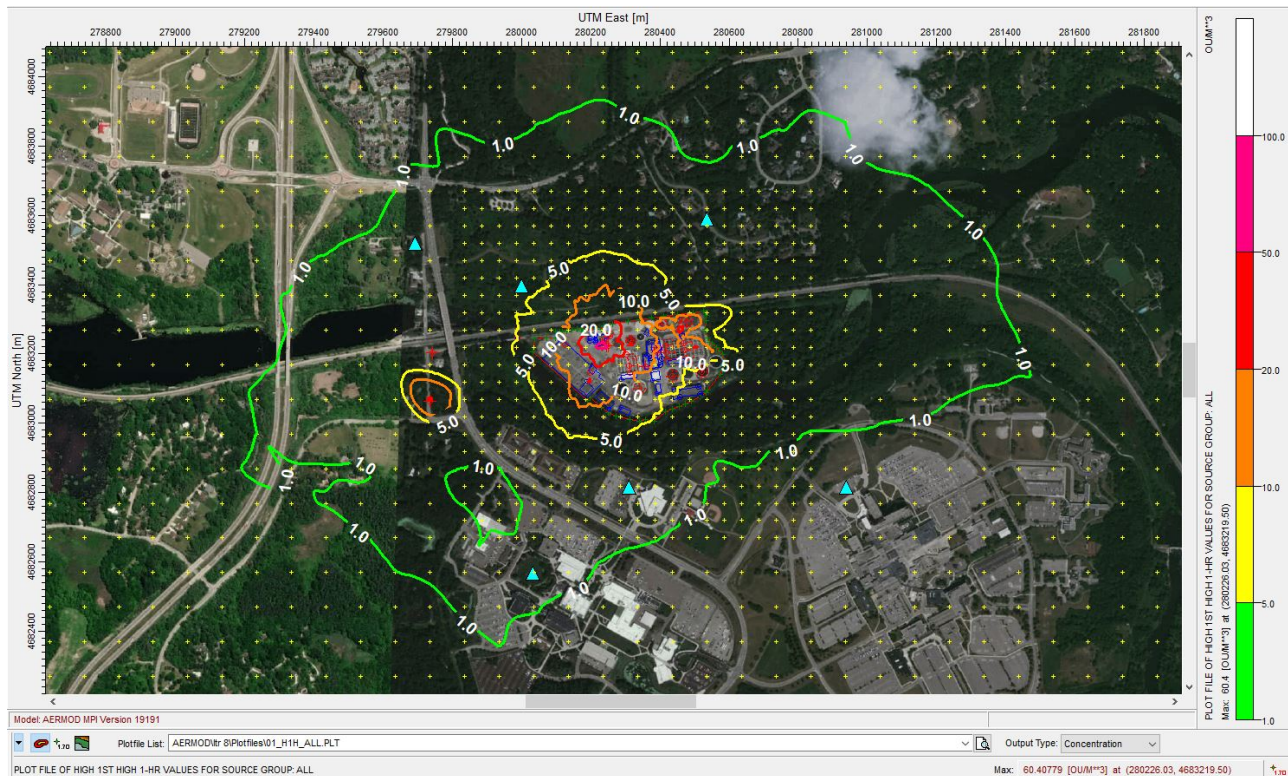
Figure 4-3 is a bar chart indicating odor concentrations from each individual source and their effect on the offsite sensitive receptors. Figure 4-4 shows these projected impacts more clearly in the maximum 1-hour odor DT impact isopleth plot for all odor sources combined.

Figure 4-3. Odor DT Impact at Key Locations: Individual Odor Sources*



*Does not include biosolids cake truck loadouts in the winter

Figure 4-4. Maximum 1-hour Odor DT Impact from all sources*



*Does not include biosolids cake truck loadouts in the winter

As determined by the OER analysis, the Raw Sewage Influent Lift Station and the S&G Building are a large percentage of the total odor emissions at the WWTP. Figure 4-5 shows the projected odor impact from the Raw Sewage Influent Lift Station and S&G Building. This includes emissions from open channel grating before and after the Archimedes screw lift pumps and spaces in the edges of the lift pump screw covers on top of the screw pumps. It also includes roof mounted exhaust fans on the S&G Building and the adjacent attached Grit Tank room.

Field investigation indicated that the grating immediately downstream of the channel carrying flow from the Archimedes screw pumps is actively exhausting air at approximately 100 to 200 feet per minute velocity. This would equate to over 1,000 cubic feet per minute (cfm) of relatively odorous air from the channel headspace. Essentially, it appears that the Archimedes screws and flowing wastewater drag odorous air along with the wastewater flow which exhausts out the grating at the end of the screw pump effluent channel. The screw pumps create turbulent conditions stripping H_2S odors from the wastewater to the channel headspace. Some emissions also escape from the Archimedes conveyor covers which are not airtight along the edges.

The evaluation indicates a 10 DT impact potential on the walking path just north of the plant with the potential for 5 DT further out at the new retirement facility and 5 to 10 DT at the Dixboro Bridge and 2 DT in the Towsley neighborhood.

Figure 4-5. Maximum 1-hour Odor DT Raw Sewage Influent Lift Station and S&G Building



The odor impact shown in Figure 4-5 may tend to over project winter impacts because the DT value used to calculate emission rate is from summertime sampling. H₂S data loggers in the S&G Building measured early spring 2019 (late winter) data averaging below the detection limit of the Acrulog data logger with peaks to 1 ppm compared to August 2019 data averaging 1.03 ppm peaking to 5 ppm. Based solely on H₂S odors, the winter impacts may therefore be as much as 1/5th of the projected impacts based on the measured summer time DT.

Based solely on the dispersion plots, the influent pump station and Screenings and Grit Building roof exhaust fans are considered high risk sources, particularly during warmer wastewater months.

Biosolids cake truck loading during the winter months at the SHB is also a high risk source. Cake trucks in winter are open bed with live bottom screw conveyors rapidly loading stored biosolids cake to the open truck bed. The stored biosolids cake sealed in the large storage bins has time to become septic and odorous. Cake odors are emitted into the room space as the cake falls into the truck bed. By contrast in the summer, liquid biosolids are discharged into a small nozzle on the top of the truck which is then sealed closed. This liquid biosolids have also been pre-treated with a lime slurry. Liquid truck loading was much less odorous resulting in only 11 DT measured while a truck was being loaded.

Figure 4-6 shows a comparison plot of the projected SHB impact with a winter biosolids cake truck loading, assuming 16,575 DT. With the higher 16,575 DT measured during cake truck loading, the AERMOD model indicates the potential for distant 5 DT impacts to all of the defined sensitive odor receptors and up to 10 to 20 DT offsite to the north of the plant and out to Dixboro Road. While it should be clear that this is only possible during the limited times with winter biosolids cake truck loading, the potential impact and odor footprint is large making this a high priority odor source.

Figure 4-6. SHB Maximum 1-hour Odor DT with a Biosolids Cake Truck Loading In-Progress

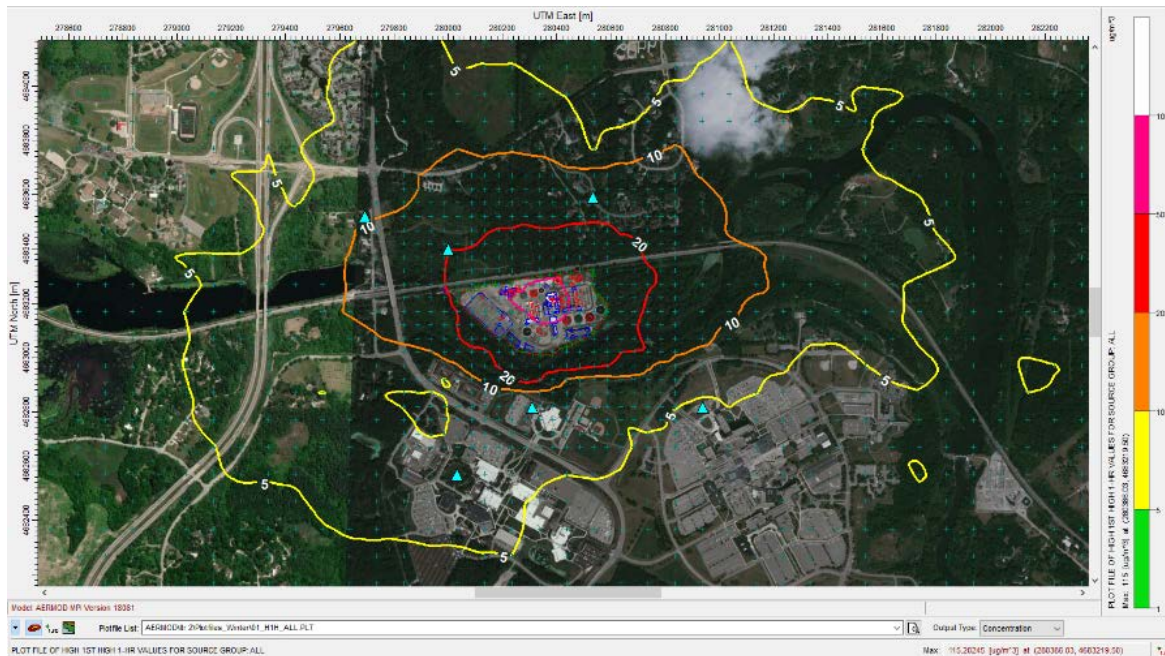
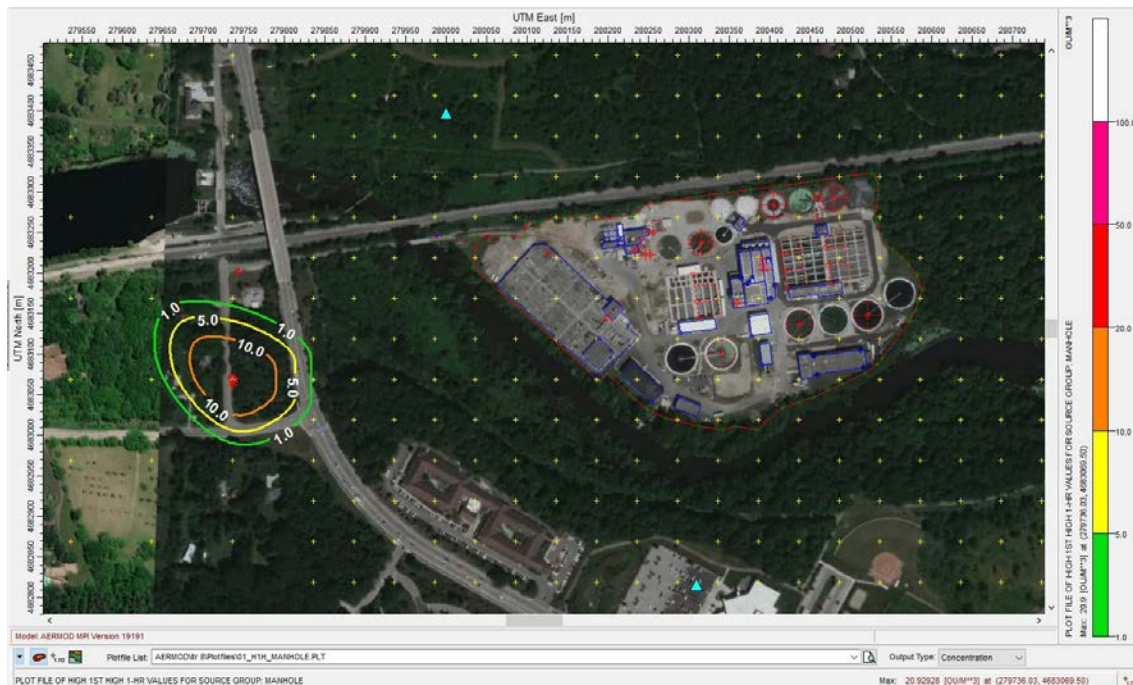


Figure 4-7 shows the isopleth plot for the manhole exhaust near Old Dixboro Rd. AERMOD projections for the exhaust from the Old Dixboro Rd. manhole pick hole indicates impacts up to 10 DT in the roadway next to the manhole on Old Dixboro and the potential for up to 5 DT impact on the main commuter roadways.

Figure 4-7. Old Dixboro Rd. Manhole Maximum 1-hour Odor DT



Isopleths odor impact plots and observations for other onsite and offsite locations that were included in the dispersion model can be found in a comprehensive document #10152084-

OWW-M0006 – Dispersion Modeling, Rev. 1 in Appendix E. This section highlighted the higher risk sources.

4.3.1 Dispersion Model Conclusions

Odor impacts within two miles of the plant appear to be limited to several small collection system odor sources and several sources from the WWTP. Based on AERMOD dispersion modeling, the overall odor impact potential could exceed 5 DT under normal baseline operating conditions reaching offsite to the north of the WWTP to the walking path, the new retirement home location, and towards the Towsley community. The Dixboro manhole emissions showed potential for 5 to 10 DT impact on Old Dixboro Rd. and to commuter traffic near the bridge.

With the exception of winter biosolids truck loading, odor impacts are not projected to reach further offsite to the hospital or other locations, but winter biosolids loading is considered at risk further offsite from the WWTP.

The potential for this to occur is limited by hourly weather patterns and may not be frequent, but AERMOD evaluations indicate that impacts are possible. The evaluation determines the most conservative case projecting where odors are predicted to occur at least once during some portions of the five years of meteorological data used in the evaluation.

The priority odor sources having the most impact as a result of the dispersion modeling are:

- The S&G Building roof exhaust fans
- The Raw Sewage Influent Lift Station
- The SHB truck bay exhaust during winter biosolids loading periods.

The most odorous impact potential is predicted for short term winter loadings of biosolids cake trucks. Although only one or two trucks are loaded during weekdays from November/December to April/May and it takes 30-45 minutes to load each truck, the loading process' potential for distant offsite odor impacts is significant. AERMOD projections show the ability to reach a 5 to 10 DT impact level for all of the sensitive odor receptors identified in this evaluation.

4.4 Selecting an Odor Impact Criteria Goal

The results of the subjective surveys, spring and summer sampling and dispersion modeling activities were shared during a December 12, 2019 meeting attended by the City of Ann Arbor WWTP staff, area stakeholders, and HDR. The purpose of the meeting was for the City and HDR to present the odor study findings and discuss the selection of an odor impact criteria goal with area stakeholders. HDR shared during the meeting that the selection of an odor impact criteria should consider all of the following:

- Odor concentration expressed as a DT value
- Odor impact duration
- Number of offsite exceedances allowed

While the acceptable DT impact level should also consider the relative offensiveness and character of the odor, the following general guidelines were offered in understanding the impacts of various DT levels from typical WWTP odor sources:

- Odor impacts in the range of at least 5 to 10 DT are typically required in order to be noticed above background community odor levels; longer duration or very frequent events at or above this level will create a risk of generating odor complaints.
- If impacts are significantly above 10 DT, then the likelihood of odor complaints rises.
- If the impacts are projected to be above 50 DT, then odor complaints are likely no matter how long the duration or how infrequently they occur.

Ann Arbor does not have a specific odor DT impact criterion set in local codes. Therefore, the area stakeholders and WWTP staff decided to set a reasonable numeric odor impact goal that minimizes the risk of negatively impacting neighbors. The agreed upon odor impact goal was decided to be 5 DT at 100% compliance based on AERMOD dispersion modeling projections. Based on this, odor control technologies were evaluated to meet this goal for the high priority sources identified.

5 Odor Technology Screening and Evaluation

The purpose of this section is to provide screening of odor control technology options for higher priority odor sources at the existing Ann Arbor WWTP. Based on the odor sampling and odor dispersion modeling, the highest priority odor sources that risk negative offsite odor impacts are the Raw Sewage Influent Lift Station, the S&G Building exhaust and the SHB biosolids cake truck bay odors during winter dewatered biosolids cake loading.

The technology evaluation identified a short list of odor control technology options considered for these high risk sources and provides a detailed evaluation of the short listed options with cost estimates.

This evaluation utilized data collected in spring and summer sampling events and baseline dispersion modeling performed under the technical memos listed below which have been included as appendices in this final report:

- Appendix C - TM 10152084-0WW-M0002 Spring Odor Source Sampling Summary, Rev. 0 dated July 10, 2019
- Appendix D - TM 10152084-0WW-M0004 Summer Odor Source Sampling Summary, Rev. 0 dated October 18, 2019
- Appendix E - TM 10152084-0WW-M0006 Dispersion Modeling Results, Rev. 1 dated January 3, 2020

5.1 Odor Characterization of Priority Odor Sources

The technology evaluation focused on odor control for two areas:

- Raw Sewage Influent Lift Station wastewater channels and the Screenings and Grit Building collected and grouped together as one source
- Solids Handling Building truck bay loading as a separate source

5.1.1 Lift Station and Screening and Grit Building

Sources of odorous air for the S&G Building area include the Raw Sewage Influent Lift Station, Screenings and Grit Building exhausted air and the adjacent attached Grit Tank room. Existing record drawings were utilized to calculate recommended ventilation needs. Using 12 air changes per hour (ACH) for these areas resulted in an approximate ventilation rate of 18,000 cfm. This consists of capturing and treating all air from the S&G Building that is currently exhausted through roof mounted HVAC exhaust fans plus additional ventilation to capture and

vent the channel headspaces from the Archimedes lift pumps and channels in the adjacent influent lift station.

Process air emissions from the Raw Sewage Influent Lift Station and channels was reported at approximately 5 to 16 ppm H₂S while the S&G Building air ranged from 1 to 5 ppm. Very low levels of MM and DMS were also detected totaling to less than 0.4 ppm. As such, H₂S is considered the dominate odor causing compound for this odor control system location.

5.1.2 Solids Handling Building Truck Bay

Odor control for the SHB Truck Bay is based on dewatering operations during winter months. Cake trucks in winter are open bed with live bottom screw conveyors rapidly loading stored biosolids cake to the open truck bed. Cake odors are emitted into the room space as the cake falls into the truck bed. Existing record drawings were utilized to determine the volume within the truck bay and targeting 12 ACH which resulted in an approximate ventilation rate of 19,000 CFM. It should be noted that the current HVAC ventilation system appears to have been sized for approximately 6 ACH. A higher odor ventilation and capture rate capability is recommended for the proposed odor control application during the short term truck loadings that take approximately 45 minutes each.

During winter periods of biosolids cake loading in the truck bay, H₂S averaged approximately 4 ppm with other sulfur organics compounds including MM, DMS, and carbonyl sulfide reported at 1.5 ppm in the truck bay exhaust. As such, odor control in this location would have to treat both H₂S and reduced sulfur organic compound odors.

For purposes of screening alternative odor control technologies, average concentrations of H₂S were calculated using a weighted average of the concentration and ventilation rates from each source. Recommended design criteria for this evaluation are summarized in Table 5-1.

Table 5-1. Odor Characterization Alternative Technology Screening Criteria

Location	Ventilation Rate (cfm)	H ₂ S (ppm)	Other Sulfur Organics Compounds (ppm)
Screenings and Grit Building	18,000	3.5	Less than 0.5
Solids Handling Building	19,000	4	1.5

Odor control options considered should be able to treat 99% or more of the H₂S odors as well as provide broad spectrum odor removal of 90% for all odors as measured by odor panel analysis. Odor DT reduction requirements will ensure that the reduced sulfur organic compound are addressed because this includes consideration of all odors in the air stream.

5.2 Liquid Phase Odor Control Treatment Options

There are various organic and inorganic compounds which can cause domestic wastewater odors, however H₂S is often the predominant odor causing compound. For this reason, liquid phase treatment often focuses on preventing or removing H₂S by adding chemicals to the wastewater stream. There are a wide range of liquid phase odor control options, a brief summary of several options is summarized in Table 5-2 below.

Table 5-2. Liquid Phase Odor Control Treatment Options

Liquid Phase Odor Control Treatment Options	Description	Notes
Nitrate Addition	The formation of H ₂ S is reduced by providing alternative metabolic paths to suppress sulfur-reducing anaerobic bacteria activity.	This approach would require dosing chemical upstream of the wastewater plant to either prevent H ₂ S formation in the incoming sewer or to provide sufficient time to oxidize any H ₂ S already formed. This may be impractical for Ann Arbor, particularly since there are multiple incoming sewer lines that only combine at the influent lift station area. Initial annual cost were developed in this evaluation.
Aeration or Oxygen Injection	Ambient air or pure oxygen is injected into the waste stream to oxidize sulfides that are present and to inhibit growth of sulfur-reducing bacteria that generate additional sulfides under anaerobic conditions.	Similar to nitrate, this approach would require dosing chemical upstream of the wastewater plant to either prevent H ₂ S formation in the incoming sewer or to provide sufficient time to oxidize any H ₂ S already formed. This may be impractical or overly costly for Ann Arbor to provide in multiple upstream locations.
Chemical Oxidation	Chemical oxidizing agents are added to the waste stream to oxidize dissolved H ₂ S to sulfates, which are not released as volatile odors.	Oxidation options including sodium hypochlorite or hydrogen peroxide as oxidizing agents which were priced and included in this evaluation.
pH Stabilization	The pH of the waste stream is changed either to inhibit growth of H ₂ S-producing bacteria or to keep H ₂ S in solution in its ionic forms.	Not considered viable at the WWTP. The incoming sulfide concentrations are already low so the benefit of pH control would be minimal. Further, the incoming pH is already slightly alkaline.
Sulfur Precipitation or Sequestration	Metal salts (typically iron) are added to the waste stream to form a metal sulfide precipitate with the dissolved sulfide, thus removing it from the wastewater and preventing release into the air. Other sulfide scavenging chemicals are also available.	Option was further evaluated using iron salts and included screening level pricing.
Inhibition	Sulfur reducing bacteria (SRB) can be inhibited by adding chemicals such as antraquinone or by seeding with enzymes or bacteria-based products that help promote biology that does not include SRBs.	Not considered applicable at the WWTP as many of these are not proven in this type application.

Each of these liquid phase treatment options would require some means of introducing the chemicals to the wastewater stream in the form of chemical storage, pumps, spill containment, and potential enclosure for protection from weather. This screening evaluation only focused on calculating an approximate annual chemical cost. These calculations are based on treating a flow rate of 17 million gallons per day (MGD) with an initial H₂S concentration of 0.5 mg/L. A summary of the anticipated dose, chemical cost and annual cost is summarized in Table 5-3.

Table 5-3. Annual Chemical Cost for Liquid Phase Odor Control Treatment

Odor Control Treatment	Dose	Chemical Cost (Delivered)	Annual Chemical Cost
Sodium Hypochlorite	15 lb/lb H ₂ S	\$ 0.22/lb	\$ 684,000
Hydrogen Peroxide	4 lb/lb H ₂ S	\$ 0.30/lb	\$ 62,000
Ferric Chloride	12 lb/lb H ₂ S	\$ 0.24/lb	\$ 245,000
Ferrous Chloride	7 lb/lb H ₂ S	\$ 0.38/lb	\$172,000
Bioxide (Nitrate)	7.2 lb/lb H ₂ S	\$ 1.03/lb	\$192,000

Liquid phase treatment options costs range from \$62,000 to \$684,000 annually. These annual costs do not include the initial capital cost associated with the chemical feed equipment or an enclosure.

Additionally, chemicals such as hydrogen peroxide have a long reaction time requirement (about 30 minutes) and require adequate time and mixing to achieve complete reaction resulting in the need for the chemical to be injected far enough upstream of the point where odor could be released.

Other considerations of liquid phase treatment options include increased sludge volumes due to the solid precipitate for iron salts and the potential effect on nutrient-removal systems by adding unexpected nitrogen loads with bioxide if overdosed.

Further, the degree of odor control that can be achieved with liquid phase treatment is limited and would not be as effective as capturing and then treating odor emissions. Since the liquid phase sulfides are already low and the annual chemical costs would be high, liquid phase treatment is not recommended for Ann Arbor WWTP's high priority sources.

5.3 Gas Phase Odor Control Treatment Options

Gas phase odor control treatment requires effective capture and ventilation of odors to contain them and convey the odorous air to treatment. Alternative odor control technologies were considered to identify technologies that can handle the odor load while fitting within the limited available footprint onsite. The following gas phase odor control technologies were initially considered:

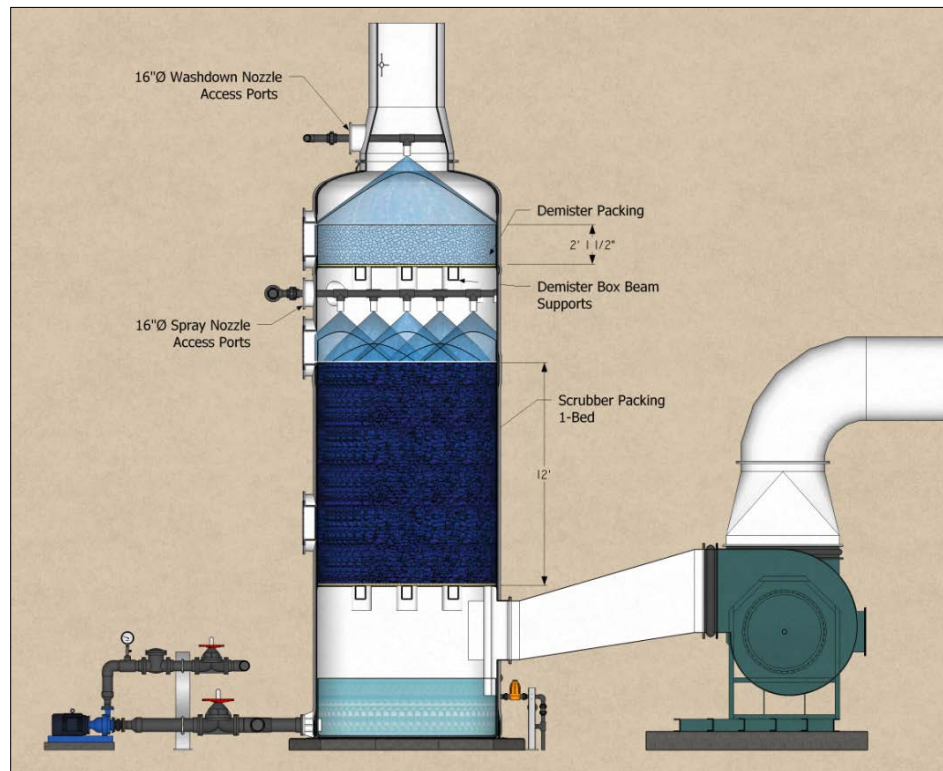
- Wet chemical scrubber (packed tower)
- Activated carbon adsorption
- Biofilter system
- Biotower system
- Ozone and ionization system

5.3.1 Wet Chemical Scrubber

Wet chemical (packed tower) scrubbers are the most common form of wet scrubber used for odor control and are a proven technology for H₂S-based odors. These systems are effective in situations with high odor concentrations and large air flows.

Odorous air enters the bottom of the reaction vessel and flows upward through a bed of packing media while contacting a downward-flowing scrubbing solution. The treated air is exhausted out the top of the tower and then out through an exhaust stack. Scrubbing solution chemicals (typically caustic and sodium hypochlorite for H₂S control) enhance the solution's ability to absorb and oxidize H₂S. This solution is collected in a sump at the bottom of the tower and recirculated to the top by a recirculation pump. A typical single stage, countercurrent wet chemical scrubber with recirculation pumps and fan closure is shown below in Figure 5-1.

Figure 5-1. Typical Wet Chemical Scrubber Layout with Fan Enclosure



Advantages of packed tower scrubbers are that they are a proven technology with a long track record, their effectiveness in removing H_2S at high concentrations, their start/stop flexibility, or throttle down/up capabilities if the odor load changes.

Disadvantages include the cost and risk of handling potentially challenging chemicals, such as caustic and sodium hypochlorite, and the need for periodic cleanings using strong acids due to fouling of the packing and tower internals. Additionally, a chemical storage facility would be needed for caustic and sodium hypochlorite creating a larger overall footprint for the system.

Packed tower chemical scrubbers are considered potentially applicable and are included in a shortlist of options that were evaluated in more detail later in this report.

5.3.2 Activated Carbon Absorption

Carbon adsorption units are often used to remove low odor levels in foul airstreams. At H_2S concentrations averaging consistently below 5 to 10 ppm, carbon absorbers can reduce H_2S concentrations to very low levels and can be cost effective. Carbon adsorption can also remove a wide range of other odorous contaminants, such as organic compounds that are not as effectively removed by standard wet scrubbers designed for removing H_2S . Once the carbon is spent, it must be regenerated or replaced. The difficulty and cost of carbon replacement is a key consideration, but with relatively low odor loading, carbon can be a very effective option.

There are various carbon bed configurations, including single bed, dual bed, and radial bed configurations. Traditional larger carbon adsorbing units typically have dual beds in a single vessel where odorous air enters the middle of the treatment vessel. A fan induces flow through upper and lower media beds of activated carbon. After passing through the carbon beds, treated air is exhausted through a stack on top of the vessel. A radial bed system has an inner ring of carbon where the odorous air generally enters around the carbon, migrates through the carbon into the center of the vessel and finally out a central exhaust stack.

Figure 5-2 provides section views of a typical dual bed and radial bed configuration.

Figure 5-2. Schematic of Dual Bed (left) and Radial (right) Carbon Beds



Advantages of carbon absorption systems are that they can provide cost effective removal of H_2S at average concentrations lower than 5 to 10 ppm and that no chemical storage or metering is required. Carbon also has a relatively small footprint requirement, especially when utilizing a radial bed configuration.

Disadvantages include the decreased life expectancy of carbon as influent H_2S concentrations increase resulting in potential for high carbon replacement demands, the expense to replace the carbon beds in terms of fresh carbon, and the labor necessary to change out the beds.

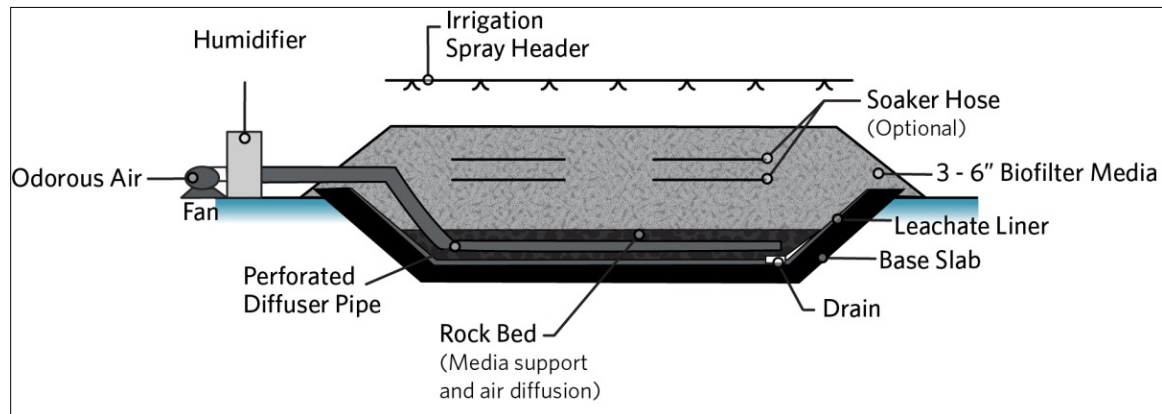
Given the relatively low odor loads at the Ann Arbor WWTP, carbon is potentially viable for the application and was shortlisted for further evaluation.

5.3.3 Biofilter System

Biofilters consist of media (wet compost, soil, wood chips, or manufactured materials) used to grow bacteria that consume odorous compounds. Some biofilter media systems use manufactured inert media that resist decaying and collapsing. The life cycle of these systems is projected to be 10 years or longer with some media systems coming with 10 year warranties.

In a typical biofilter, odorous air is blown into the bottom of the biofilter bed and flows up through the biofilter. The air comes in contact with the bacteria growing the biofilter media, which biologically oxidizes the H_2S to a non-odorous form. Treated air migrates out of the filter bed and into the atmosphere. Figure 5-3 provides a schematic of a typical open bed earthen berm style biofilter. Biofilter beds can also be provided in concrete vessels or vendor supplied reactors.

Figure 5-3. Schematic of a Typical Biofilter System



For efficient odor removal, the biofilter media must be maintained. Spray nozzles, soaker hoses, or air humidifiers can be used to keep media moist for the bacteria. The H_2S -consuming bacteria produce an acid byproduct that tends to lower the pH of the media. Sustained low pH can cause the media to degrade more rapidly and require replacement.

Advantages of biofilters are their effectiveness to treat a wide variety of odor-causing compounds and their ease of maintenance. Biofilters typically do not require additional chemicals.

Disadvantages include a relatively large footprint, which is required because the systems typically are sized for a minimum of 45 to 60 seconds of empty bed contact time (EBCT), and the typical life of organic media of roughly 2 to 5 years, after which the media must be rebuilt.

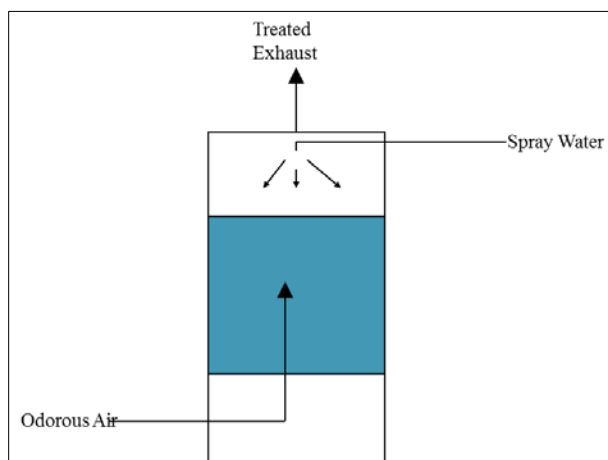
Long life media biofilters (10 years or longer) were shortlisted for more detailed evaluation. The biofilters for Ann Arbor require less EBCT, 45 seconds, because the manufactured media gets better performance. Therefore, the system requires a smaller overall footprint compared to bark/mulch style biofilters.

5.3.4 Biotower System

Like biofilters, biotowers consist of solid media where bacteria are grown to consume odorous compounds. The key difference is that the biotower media are completely inert; the required nutrients for the biology comes from spray water consisting of either plant effluent water or a source supplemented with dilute fertilizer. Biotowers also require shorter EBCT (typically 10 to 15 seconds) when compared to biofilters and are typically best suited to H_2S related odors.

Figure 5-4 provides a schematic of a typical biotower.

Figure 5-4. Schematic of a Typical Biotower System



Advantages of biotowers are a smaller footprint (compared to biofilters) due to a shorter EBCT and the ability to stack the media higher, and the use of inert media, which is resistant to decay and compaction with a longer bed life.

Disadvantages are that biotowers are generally less effective on some of the other reduced sulfur organic compounds. Biotowers can also be sensitive to starvation if the odor source odor levels (H_2S) is to low or intermittent. This may be problematic for the relatively low odor levels from the Ann Arbor Lift Station and S&G Building and is a fatal flaw for the Solids Handling Building Truck Bay, which is an intermittent odor source.

Although biotowers utilize less space than biofilters, biotowers utilize more space than carbon systems or chemical scrubbers, which have vessel contact times of 2 to 3 seconds compared to 10 to 15 seconds for biotowers.

Biotowers were short listed for pricing comparison for the S&G Building source, but may not be well suited for the low odor loads predicted at Ann Arbor which will be considered in the evaluation.

5.3.5 Ozone and Ionization Systems

Ion generators use either ionization tubes or ultraviolet (UV) bulbs to impart a charge (negative, positive, or both) to gas molecules in the air, causing the ionized gas molecules to react with odorous compounds. Some ion generators also emit a very small amount of ozone as a byproduct of the ion generation. The electron-altered oxygen then reportedly groups into ion clusters of oxygen molecules. The ions react with compounds such as H_2S .

One example of an ionization system is the *NEUTRALOX*® Photoionization unit by Ambio. In this unit, odorous air passes through a dust filter, through a UV reactor to initiate chemical reactions and create oxidants for further degradation, and finally through a catalyst to provide additional degradation. The system works under negative pressure conditions through the use of a fan downstream of the unit. Figure 5-5 shows a photograph of an installation of a *NEUTRALOX*® Photoionization unit.

Figure 5-5. Photograph of a NEUTRALOX® Photoionization Unit Installation



Advantages of ozone and ionization systems are that no storage tank or chemicals are required.

One disadvantage is dealing with the potential for ozone. Any odor-control system that uses ozone must not expose people to measurable levels of ozone in the work environment. The time-weighted average exposure limit set by the Occupational Safety and Health Administration is 0.1 ppm, and the value imminently dangerous to life and health is 5 ppm.

Additional disadvantages include problematic maintenance requirements for ionization tube replacements and the size of the proposed system, which Ann Arbor's would be on the larger end of the vendor's installation list. As such, experience at this size is limited.

Due to the limited manufacturers and experience on this option, the proprietary nature of the ionization units, and the potential safety risk, ozone and ionization systems were not shortlisted or further evaluated.

5.3.6 Gas Phase Odor Control Technology Screening Summary

The following gas phase odor control technologies were shortlisted and were further evaluated for the combined odor control system for the Influent Lift Station and S&G Building:

- Option 1 – Wet Chemical Scrubber (Packed Tower)
- Option 2 – Activated Carbon Adsorption
- Option 3 – Biotower System
- Option 4 – Biofilter System

Due to the seasonal and intermittent odorous air from the truck bay in the Solids Handling Building, biotowers and biofilters are not recommended for that odor because with biological systems the odorous air must always be present to support biological control.

Additionally, due to the limited footprint and need to provide on demand odor control (only while trucks are being loaded), wet chemical scrubbers are not recommended because they are not as easy to start and stop as carbon. Carbon absorption is recommended for the truck bay due to its ability to be used seasonally and intermittently, ability to be regularly started and stopped, and small footprint. Due to the intermittent use, it is anticipated that the carbon media life will be prolonged, lasting as long as 3 years.

The subsequent section will present the four (4) alternatives described above for gas phase odor control treatment of odorous air from the Influent Lift Station and S&G Building.

5.4 Options Evaluation

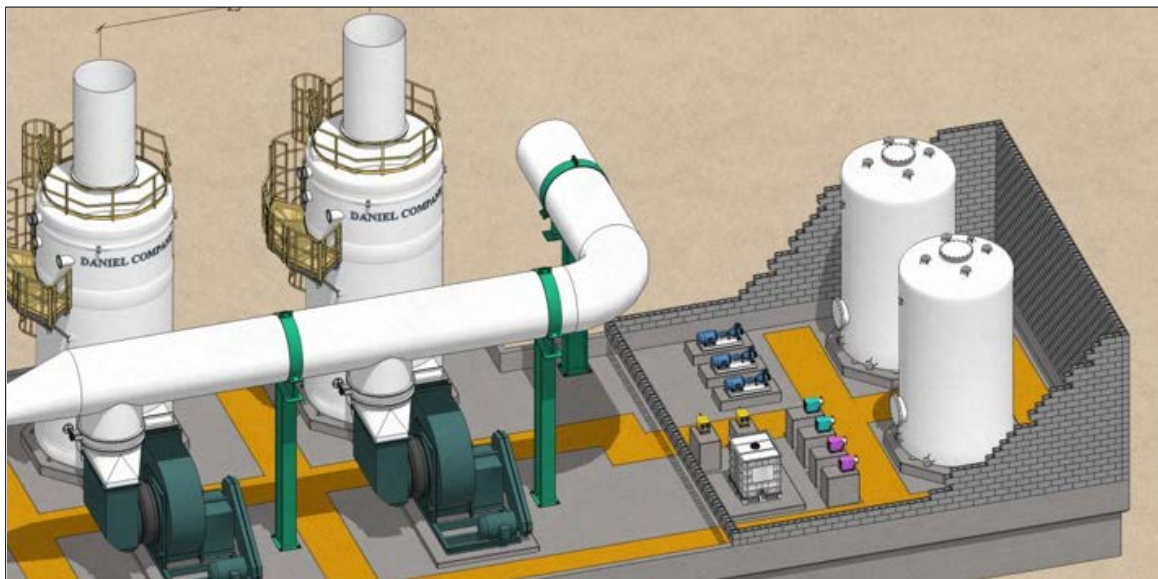
The alternative technologies that were shortlisted in the previous section are described in more detail and evaluated for providing odor control for the Influent Lift Station and S&G Building using an analysis approach that considers both non-economic and economic (cost) factors.

5.4.1 Option 1 – Wet Chemical Scrubbers (Packed Tower)

Option 1 is considered and priced as two parallel, single-stage packed tower chemical scrubbers. The system would be sized to handle 12 ACH at 18,000-cfm. The system would include two (2) 7-foot-diameter scrubbers with odorous air fans blowing air into them. The system would require chemical storage and containment for caustic and sodium hypochlorite. The chemical systems and pumps are conceived to be housed in an enclosed building to protect the tanks and chemical metering pumps from weather and freezing. The scrubbers and odorous air fans are conceived as outdoor systems with the fans including an outdoor enclosure. The enclosure protects the fan from weather and reduces potential for noise impacts from the fans. Figure 5-6 provides an example layout of a single-stage packed tower adjacent to an enclosed chemical storage building.

Only one tower would be operated at a time with the other available as backup or for use when media cleaning maintenance is needed on the other unit. Potential exists for cost savings if only one scrubber train is provided, however this would add the risk of odor impacts during any chemical scrubber maintenance events. Since these could typically be scheduled, this may be acceptable but the more conservative design approach is included in this evaluation.

Figure 5-6. Packed Tower Chemical Scrubber Layout

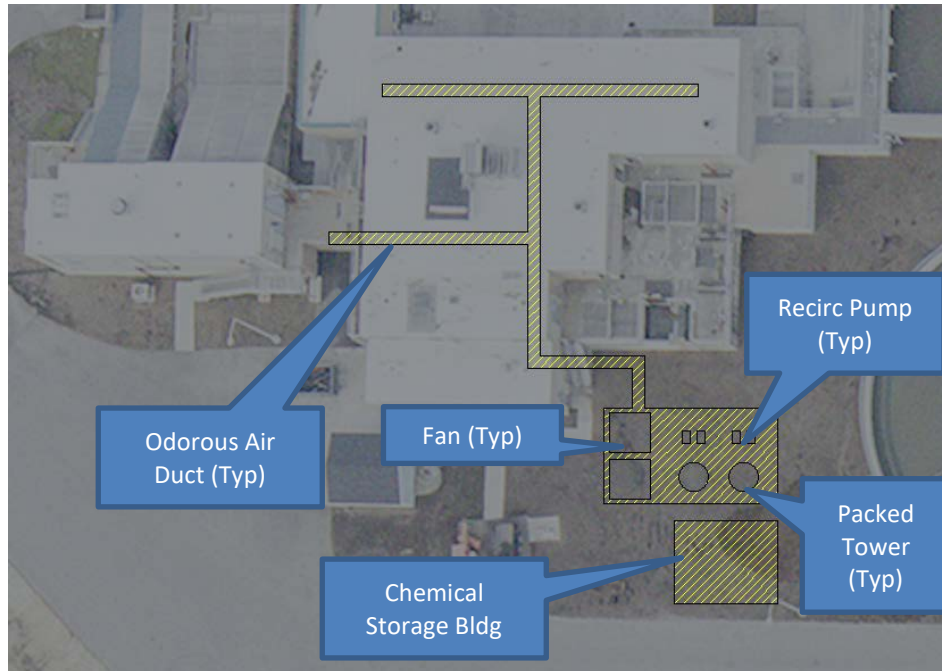


New ducting would be added to transport odorous air from the Influent Lift Station channels, S&G Building, and the adjacent attached Grit Tank room to a common duct routed to the chemical scrubbers. The duct would penetrate the roof of the S&G Building and be routed south toward the chemical scrubbers. The duct would be supported off the existing buildings with knee braces and u-shaped duct supports. Between the S&G Building and the packed tower chemical scrubbers, elevated supports similar to those shown in Figure 5-6 would be provided.

The required scrubber pad for two (2) 7-foot-diameter scrubbers, recirculation pumps and fans is estimated as 23 feet by 42 feet for this equipment adjacent to a building that is

approximately 25 feet by 20 feet for housing the chemical storage tanks and chemical metering pumps. Figure 5-7 shows the proposed location of the duct alignment, tanks, and chemical storage building.

Figure 5-7. Proposed Location of Packed Tower Chemical Scrubber



As mentioned, this option is sized for each packed tower scrubber to handle the full load of 18,000 cfm of odorous to provide full redundancy during periods of maintenance and periodic cleanings. Pricing for the evaluation assumes one media replacement in the 20-year life cycle evaluation. A cost summary is included in Appendix F.

Advantages of Option 1 are:

- Proven and reliable technology.
- Effective in treating odorous air and ability to handle varying odor loads.
- Ability to turn the systems on and off whenever required.
- Multiple vendors available for competitive bid.
- Full redundancy.

Disadvantages of Option 1 are:

- Requires handling of challenging chemicals, including caustic and sodium hypochlorite for normal operation.
- Requires periodic use of acid (such a sulfuric acid) for acid washing of scaling that builds up on packed tower media inside the scrubbers.
- Larger overall footprint (relative to carbon) due to the need for chemical storage facilities.

5.4.2 Option 2 – Activated Carbon Adsorption

Option 2 is considered and priced as dual bed carbon adsorption units. As previously described, there are several carbon adsorption unit configurations. Radial flow carbon systems would allow treatment with a single unit and be lower in cost. Dual beds were however priced in this evaluation because this approach provided full redundancy for carbon change outs.

Similar to the chemical scrubber option, potential for cost savings would be possible with a single train but this evaluation is priced based on the more conservative approach.

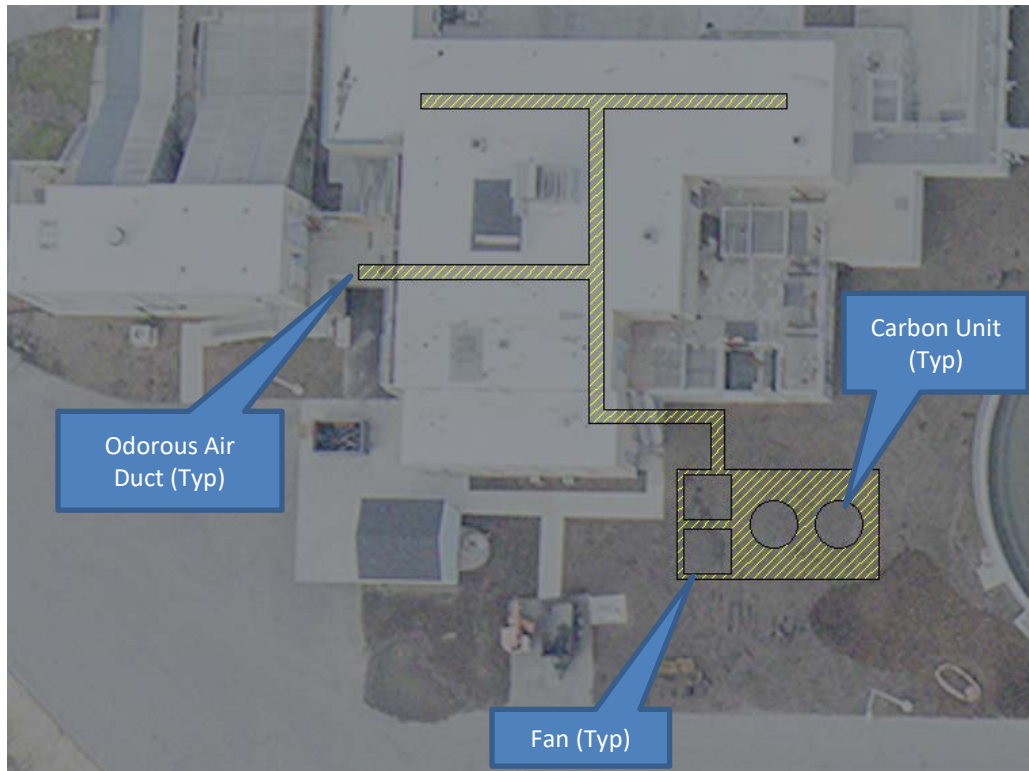
The carbon adsorption units would require two (2) 10-foot-diameter vessels with odorous air fans. The units and odorous air fans are considered as outdoor systems. Larger 12 foot diameter units could also be considered in final design detailing if additional carbon capacity is desired by City staff. Figure 5-8 depicts a dual bed carbon adsorption unit.

Figure 5-8. Dual Bed Carbon Absorption Unit



The required pad is estimated as 22 feet by 44 feet for the fans and carbon adsorption units. New ducting, similar to the alignment described for Option 1, would transport the odorous air to the proposed location of the odor control equipment. Figure 5-9 shows the proposed location of the odor control equipment and duct.

Figure 5-9. Proposed Location of Dual Bed Carbon Absorption Units



This option is sized for each carbon adsorption unit to handle 9,000 cfm of odorous air. During normal operation, both carbon adsorption units would be in operation. Each unit would be equipped with a variable frequency driven (VFD) fan to allow increased flow to each unit. This allows for partial redundancy during periods of maintenance for replacement of media. The redundancy is not full capacity but would be acceptable during scheduled carbon change outs that are short in duration.

Advantages of Option 2 are:

- Proven and reliable technology.
- Effective treatment of both H₂S and organic-based odor compounds.
- Limited maintenance, low operation and maintenance (O&M) cost, and operator friendly.
- Does not utilize potentially corrosive, difficult chemicals.
- Multiple vendors available for competitive bid.

Disadvantages of Option 2 are:

- Potential risk for decreased life expectancy of carbon if influent H₂S concentrations increase, resulting in potential high carbon-replacement demands. However, with the expected loading, the carbon life is projected to be at least two years at the Influent Lift Station and S&G Building location.
- Expense to replace carbon bed in terms of fresh carbon and labor necessary to change out the beds.

It is worth noting that in lieu of two (2) dual bed 10-foot-diameter vessels, the 18,000 cfm odorous air could be treated with a single radial bed 12-foot diameter vessel. This could result in a capital cost savings of approximately 15% and provide an overall smaller footprint. However, providing odor control with a single vessel would result in no redundancy during

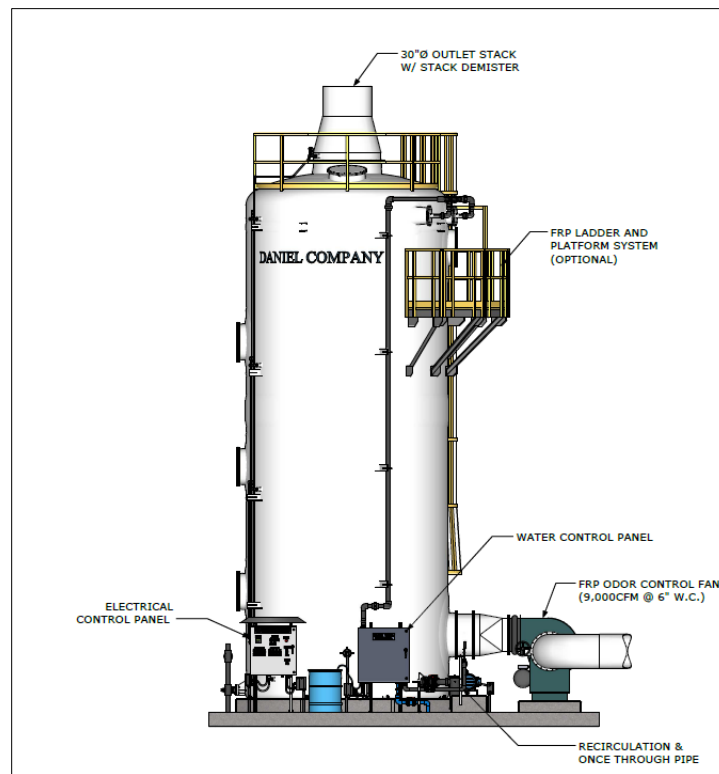
periods of maintenance such as periodic carbon replacement which is anticipated after two years of operation.

5.4.3 Option 3 – Biotower Systems

Option 3 consists of biotower systems. As conceived, it would take two (2) 12-foot diameter biotowers, approximately 38 feet tall to treat the 18,000 cfm air flow. These units would be located outdoors on a concrete pad along with their respective recirculation pumps and fans. The pad would be approximately 24 feet by 40 feet. Both biotowers would be operated at all times because biological systems required operation. If one of the towers were taken down, then VFD operation would allow the other to be operated at higher airflows for short periods.

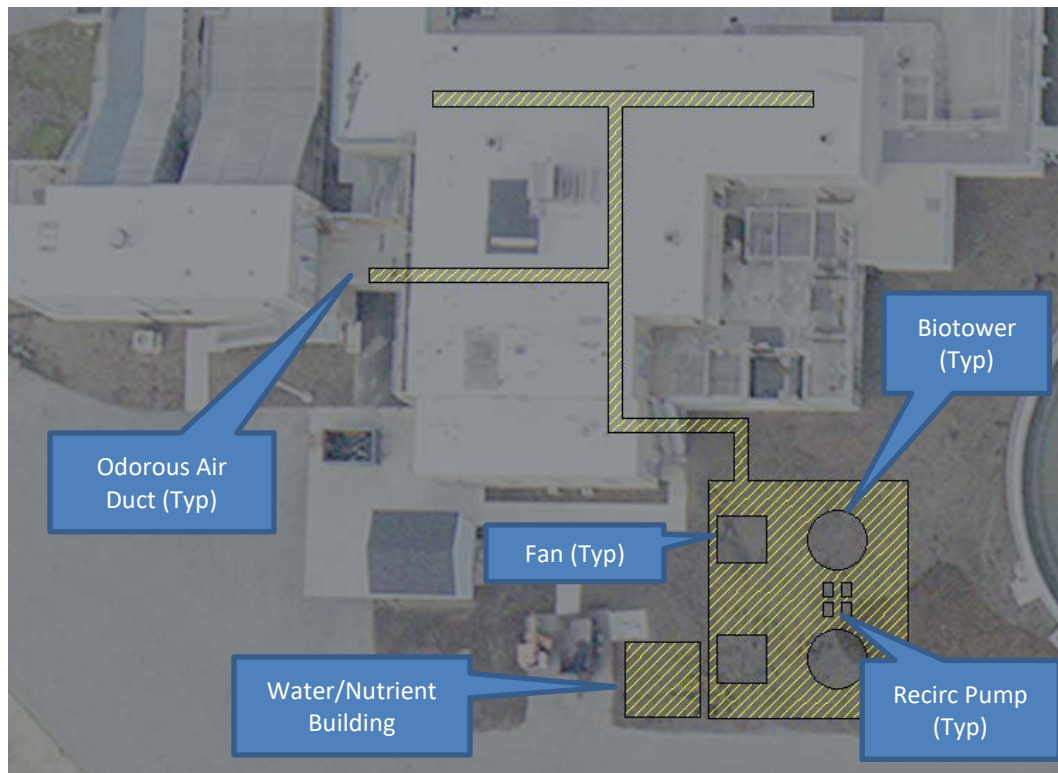
Adjacent to the pad for the biotowers would be a small building that is approximately 15 feet by 15 feet for housing the water control panel and nutrient storage tank. Figure 5-10 provides an example layout of a biotower, fan and recirculation pump.

Figure 5-10. Biotower Layout



New ducting, similar to the alignment described for Option 1, would transport the odorous air to the proposed location of the odor control equipment. Figure 5-11 shows the proposed location of the odor control equipment and duct.

Figure 5-11. Proposed Location of Biotower Units



Advantages of Option 3 are:

- Proven and reliable technology as long as the odor source is continuous.
- Effective treatment of H₂S odors.
- Limited maintenance, low O&M cost, and operator friendly.
- Does not utilize potentially corrosive, difficult chemicals.
- Multiple vendors available for competitive bid.

Disadvantages of Option 3 are:

- Biotowers are living systems that require initial acclimation of the biology and they must remain in service to keep the biology alive and thriving. In this evaluation, it is assumed that both biotowers run all the time.
- Because they are biological systems, the minimum odorous food source (H₂S) needs to be sufficient to sustain the biological activity. This may be problematic given the low predicted H₂S levels, particularly during winter months.
- Because the systems are biological, consideration must also be given to cooler winter conditions and the inlet air temperature from the odor sources. Sustained odorous air temperature below 40°F is not desirable. Since the bulk of the air is from a preheated building, this is not considered problematic but should to be considered.
- Biotowers are very effective on H₂S odors and to a lesser degree on mercaptans, so long as sufficient EBCTs are used (15 seconds is recommended). They can be less effective on other reduced sulfur organic based odors.

5.4.4 Option 4 – Biofilter Systems

Option 4 consists of long-life manufactured media biofilter systems providing 45 second EBCT at 18,000 cfm. The biofilter as conceived and priced would include three (3) biofilter cells so that if one cell were out of service for future media replacement, the system would still provide 30-seconds EBCT during that maintenance event with the remaining cells still in operation.

Media replacement would be rare given the media comes with a 10-year warranty and expectation that it would last even longer. Pricing for the evaluation assumes one media replacement in the 20-year life cycle evaluation.

The system evaluated assumes upstream pre-humidification with a primary and redundant odorous air fan. Figure 5-12 shows a photograph of a 95,000 cfm system treating plant-wide odors at a WWTP in Virginia. This option at Ann Arbor is conceived to be partially below grade similar to the Virginia application.

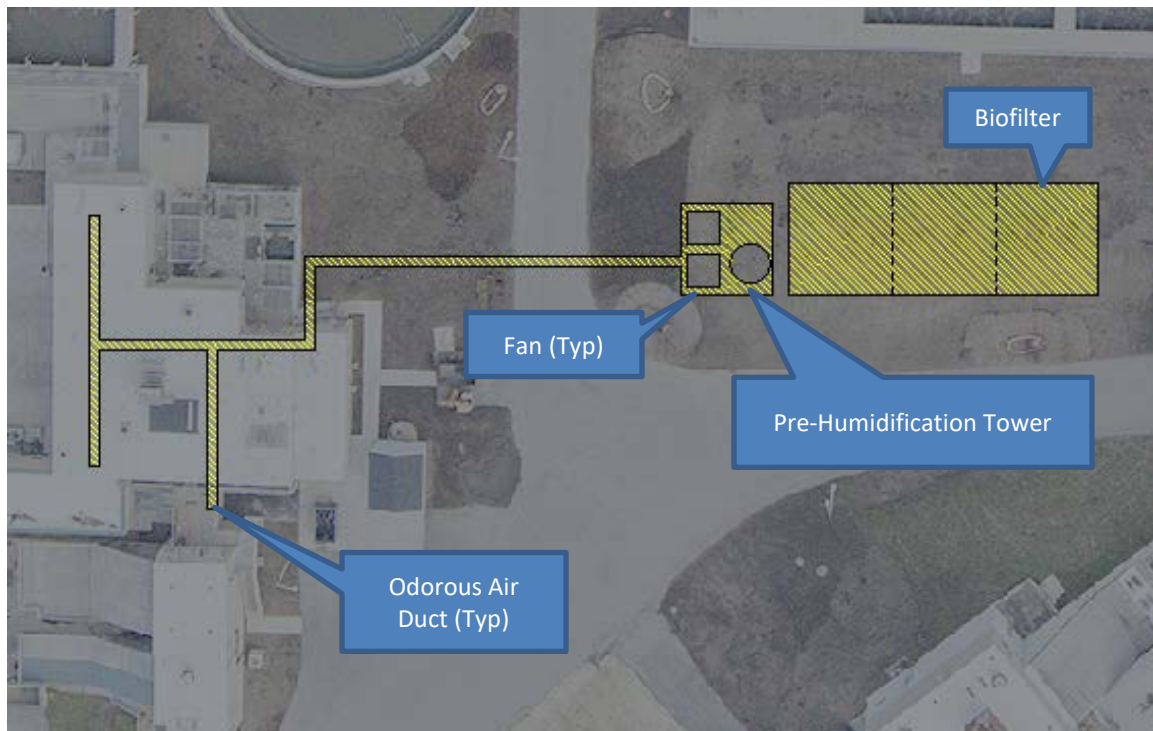
Figure 5-12. Photo of a Long-Life Media Biofilter System



The biofilter vessel is concrete and would include an air plenum under the media, concrete coating to protect the concrete from long term corrosion, cover over the filter, and short dispersion stacks. The photograph above shows a covered biofilter with short exhaust stacks to promote stack dispersion.

Based on 45 seconds EBCT with all three (3) cells, the footprint of the biofilter would be approximately 34 feet by 94 feet using 5 feet of media. Adjacent to the biofilter would be an additional concrete pad approximately 28 feet by 28 feet for housing the pre-humidification system and primary/redundant fans. Due to the size of the biofilter, the proposed location will need to be farther away from the source of the odorous air resulting in more ductwork. Figure 5-13 shows the proposed location of the odor control equipment and duct. As shown in Figure 5-13, this location would also require a road crossing for the odorous air duct.

Figure 5-13. Proposed Location of Biofilter



Advantages of Option 4 are:

- Long EBCT results in effective treatment of both H₂S and organic-based odor compounds.
- Limited maintenance, low O&M cost, and operator friendly.
- Does not utilize potentially corrosive, difficult chemicals.

Disadvantages of Option 4 are:

- The long EBCT and limited depth of the media results in a large footprint, which would be difficult to find available space at the site.
- Limited number of vendors with strong experience in manufactured media biofilters. Biorem is the primary vendor. If this option were pursued, consideration should be given to pre-selection and pre-negotiation.
- Biofilters are living systems that require initial acclimation of the biology and they must stay in service to keep the biology alive. The system shown in the Figure 5-12 photo has been running non-stop for over ten years as of 2019.
- Because the systems are biological, consideration must be given to cooler winter conditions, and the inlet air temperature from the odor sources. Sustained odorous air temperature below 40°F is not desirable.

5.5 Technology Evaluations

The four options discussed above were evaluated using an analysis approach that considers both non-economic and economic (cost) factors. For the economic analysis, capital cost estimates, annual O&M costs, and 20-year present worth were developed, allowing evaluation of the relative benefit-to-cost ratio of the four options being considered.

5.5.1 Non-Economic Evaluation

Five criteria were identified for the non-economic evaluation. These criteria are listed and defined below in Table 5-4.

Table 5-4. Non-Economic Screening Criteria and Definitions

Criteria	Defining Issues
Odor control effectiveness	<ul style="list-style-type: none"> Is effective in preventing community exposure to nuisance-level odors Achieves at least 99% H₂S removal Achieves at least 90% overall odor reduction in terms of odor units (OUs or DTs) Takes advantage of natural dispersion by having an elevated exhaust stack
Technical reliability and proven technology	<ul style="list-style-type: none"> Proven track record in full-scale wastewater treatment applications Reputable, recognized technology with successful verifiable installations Reputable, financially viable companies that can provide and support the technology Multiple vendors available for bid competition
Compatibility with existing treatment plant and plant processes	<ul style="list-style-type: none"> Implementable and constructible on site and within the constraints of construction sequencing Required space (footprint) Aesthetics (visual and noise impacts on neighbors)
O&M complexity	<ul style="list-style-type: none"> Operator safety O&M mechanical complexity Start-up issues (acclimation) Need for potentially hazardous chemicals Operator acceptance Required media replacement
Sustainability	<ul style="list-style-type: none"> Carbon footprint Energy use

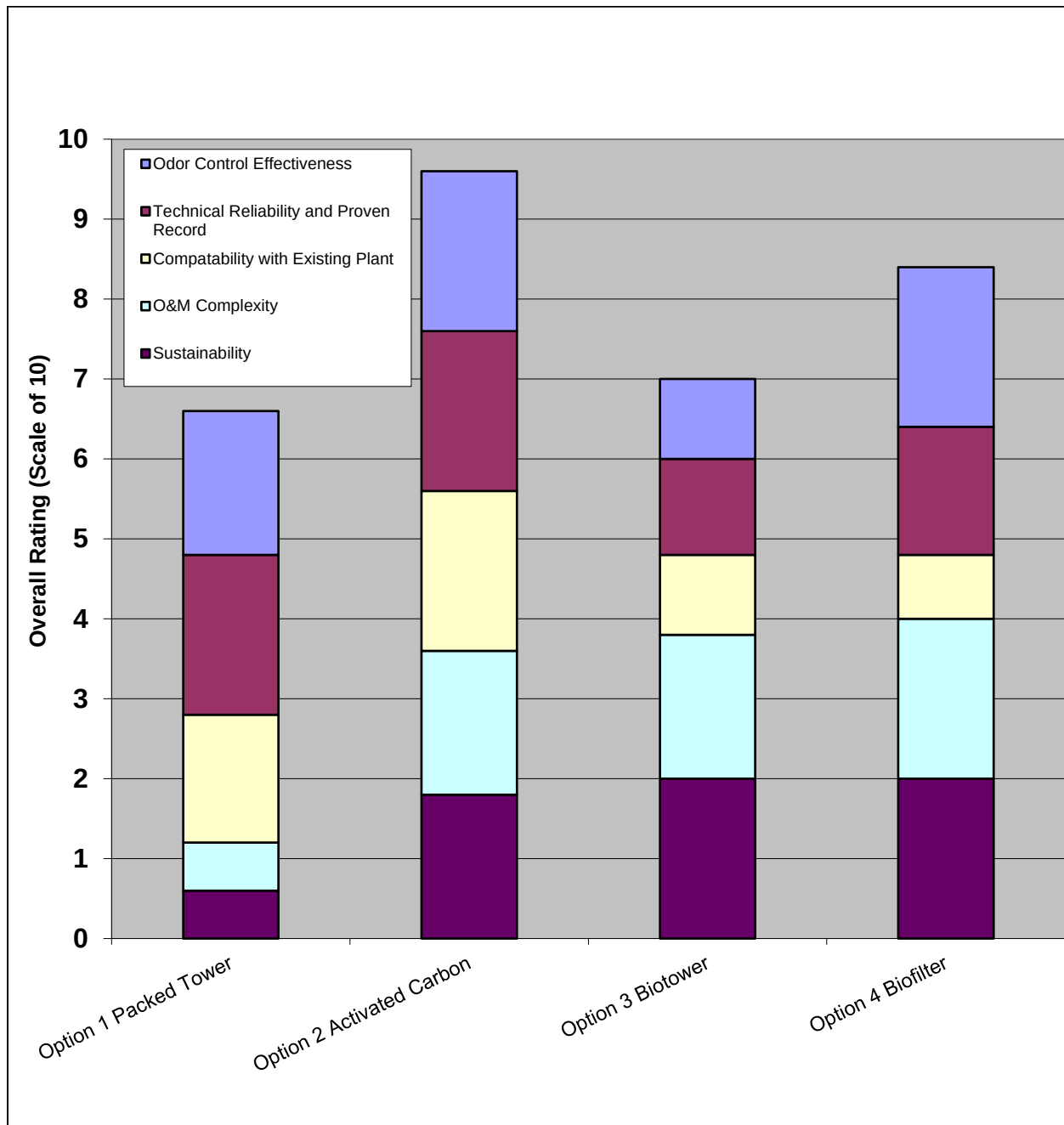
For each non-economic criterion, each option was rated on a scale of 0 to 10, where 10 is the highest and most desirable score. Each non-economic criterion was weighted equally at 20 percent. The ratings and weightings were then used to create overall benefit scores for the four options evaluated.

The non-economic evaluation for the four options is summarized in Table 5-5. Figure 5-14 provides a graphical summary of the non-economic evaluation. Overall scores shown in Figure 5-14 have been normalized such that a perfect score in all categories would total to 10.

Table 5-5. Non-Economic Evaluation Summary of Options

Criteria	Option 1 Packed Tower	Option 2 Activated Carbon	Option 3 Biotower	Option 4 Biofilter	Comments
Odor Control Effectiveness	9	10	5	10	Biofilter received best rating for broad spectrum odor removal. Chemical scrubber, activated carbon, and biotower are effective at removing anticipated concentrations.
Technical Reliability and Proven Record	10	10	6	8	All technologies have proven track records. Long life media biofilter vendors with significant experience are limited. Biotowers were rated lower still because of concern that they might not perform well at the very low odor loads in Ann Arbor.
Compatibility with Existing Plant	8	10	5	4	Activated carbon has the smallest footprint. Chemical scrubbers and biotowers have slightly larger footprint due to need for additional chemical storage/nutrient facilities. Biofilters have the largest footprint due to the 45 second EBCT.
O&M Complexity	3	9	9	10	Derated chemical scrubbers for having to handle caustic and hypochlorite. Derated activated carbon for media replacement. Derated biotowers for added pumps and controls compared to carbon or biofilters.
Sustainability	3	9	10	10	Derated chemical scrubbers for carbon footprint related to chemicals. Derated activated carbon due to change out of media and impact of carbon manufacturing.
Total =	33	48	35	42	

Figure 5-14. Non-Economic Criteria Comparison of Options



Without considering cost to build and operate these systems, the activated carbon option has the highest non-economic rating. This is because of the relatively low odor loading which allows the carbon to last two or more years before change outs and the fact that the carbon system footprint would be smaller and carbon can be effective on both H₂S and low level reduced sulfur odor compounds. The WWTP plant staff are also familiar with carbon since it is used in the existing SHB odor scrubbers.

5.5.2 Economic Evaluation

Comparative cost estimates were developed for each of the options evaluated. Cost estimates include both capital costs and annual O&M costs to develop a 20-year present worth (PW) economic understanding.

Capital costs include line items for equipment costs for readily identifiable items, as well as percentage markups for unknown costs for general conditions, field painting, mechanical systems, electrical, and instrumentation. In addition, the following markups were included in the capital cost estimates:

- 15 percent for installation costs
- 30 percent for unknown contingency
- 15 percent for contractor overhead and profit
- 5 percent for mobilization and bonds

Engineering design and construction services cost estimates are not included in this analysis. They would be similar for all options.

Annual O&M costs include the following:

- Option 1 – Wet Chemical Scrubbers (Packed Tower)
 - o Cost for power to run fans, recirculation pumps, and chemical feed pumps.
 - o Chemical costs (sodium hydroxide and sodium hypochlorite).
 - o Water costs. This evaluation assumes the cost of treated water but plant effluent water may suffice and negate the need to carry this cost.
 - o Media replacement assumed to occur once during 20-year PW.
- Option 2 – Activated Carbon Adsorption
 - o Cost for power to run fans.
 - o Media replacement assumed to occur every two years.
- Option 3 – Biotower System
 - o Cost for power to run fans, recirculation pumps, and chemical feed pumps.
 - o Water and nutrient costs. Similarly, plant effluent water may suffice for both water and nutrient supplement.
 - o Media replacement assumed to occur once during 20-year PW.
- Option 4 – Biofilter System
 - o Cost for power to run fans, recirculation pumps, and chemical feed pumps.
 - o Water and nutrient costs. Similarly, plant effluent water may suffice for both water and nutrient supplement.
 - o Media replacement assumed to occur once during 20-year PW.

Annual O&M costs for power assumed 24 hours per day / 7 days a week operation using \$0.07/kWh. Additionally, each option includes an annual cost for maintenance as a percentage of the total capital costs.

The primary purpose of these cost estimates was to allow for comparison of each option, thereby allowing selection of the recommended odor control alternative based on consideration of the cost to build, operate, and maintain the system.

Table 5-6 summarizes the cost estimates for each option, including estimated capital cost, annual O&M cost, and 20-year present worth.

Table 5-6. Comparative Cost Estimate Summary of each Option

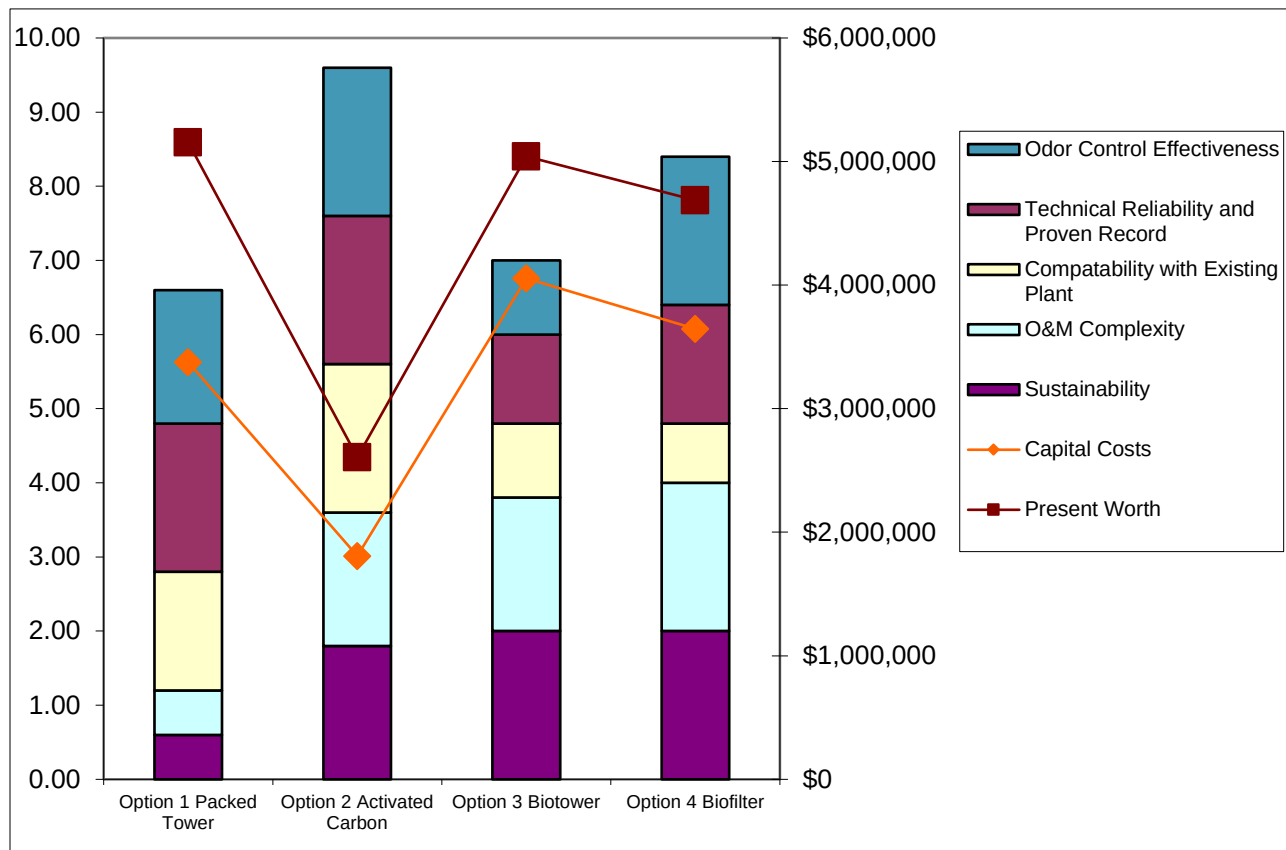
	Option 1 Packed Tower	Option 2 Activated Carbon	Option 3 Biotower	Option 4 Biofilter
Capital	\$3,380,000	\$1,810,000	\$4,050,000	\$3,640,000
O&M	\$155,000	\$69,700	\$86,200	\$90,900
20-year PW	\$5,160,000	\$2,610,000	\$5,040,000	\$4,690,000

The activated carbon absorption (Option 2) has the lowest capital cost, O&M cost, and 20-year present worth. The biotower (Option 3) has the highest capital and 20-year present worth cost. The packed tower chemical scrubbers (Option 1) and biofilter (Option 4) land in the middle of the other two options with similar capital and 20-year present worth costs. The O&M cost for the packed tower chemical scrubbers (Option 1) is highest because of the annual cost associated with chemicals.

5.5.3 Overall Evaluation (Non-Economic and Economic)

Results from both the non-economic evaluation and economic evaluation are presented in a single graphic in Figure 5-15.

Figure 5-15. Overall Evaluation (Non-Economic and Economic) Criteria Comparison



Overall, activated carbon adsorption (Option 2) is the most attractive non-economic and economic treatment option for the Influent Lift Station and S&G Building.

Option 2 provides the highest non-economic score relative to the other technologies because of its odor control effectiveness, reliability and proven track record, and compatibility within the existing plant. Option 2 also provides a capital and present worth cost lower than all other options. Option 2 is recommended.

The other three options evaluated – packed tower chemical scrubbers (Option 1), biotowers (Option 3) and biofilters (Options 4) – provide viable options for treatment of the odorous air but at a higher capital and O&M cost. All three of these options have a larger footprint than the carbon option. Future expansion or space planning at the WWTP may prohibit the biofilter from being sited nearby the odor source due to its large footprint. The biotower option is potentially less viable because of the relatively low H₂S levels anticipated.

An activated carbon system for the SHB Truck Bay during winter biosolids loading also is recommended due to the odor source being intermittent. The cost of a carbon system is approximately \$1.75 million.

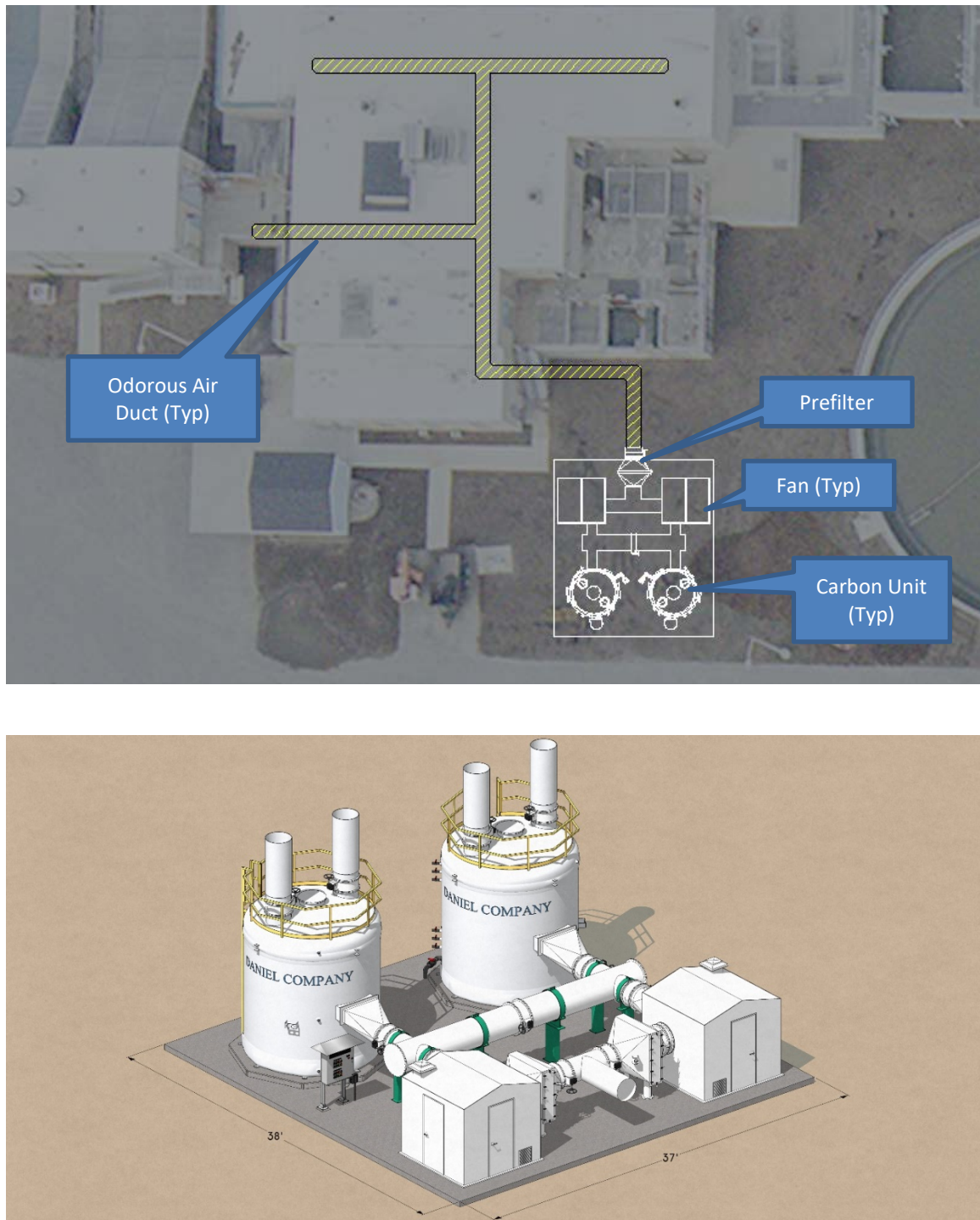
6 Conclusions and Recommendations

The technology evaluation characterized the odor load and ventilation rate at the WWTP, presents odor control technologies, provides an evaluation of those technologies, and identifies the most attractive non-economic and economic treatment option.

Findings and recommendations are summarized below:

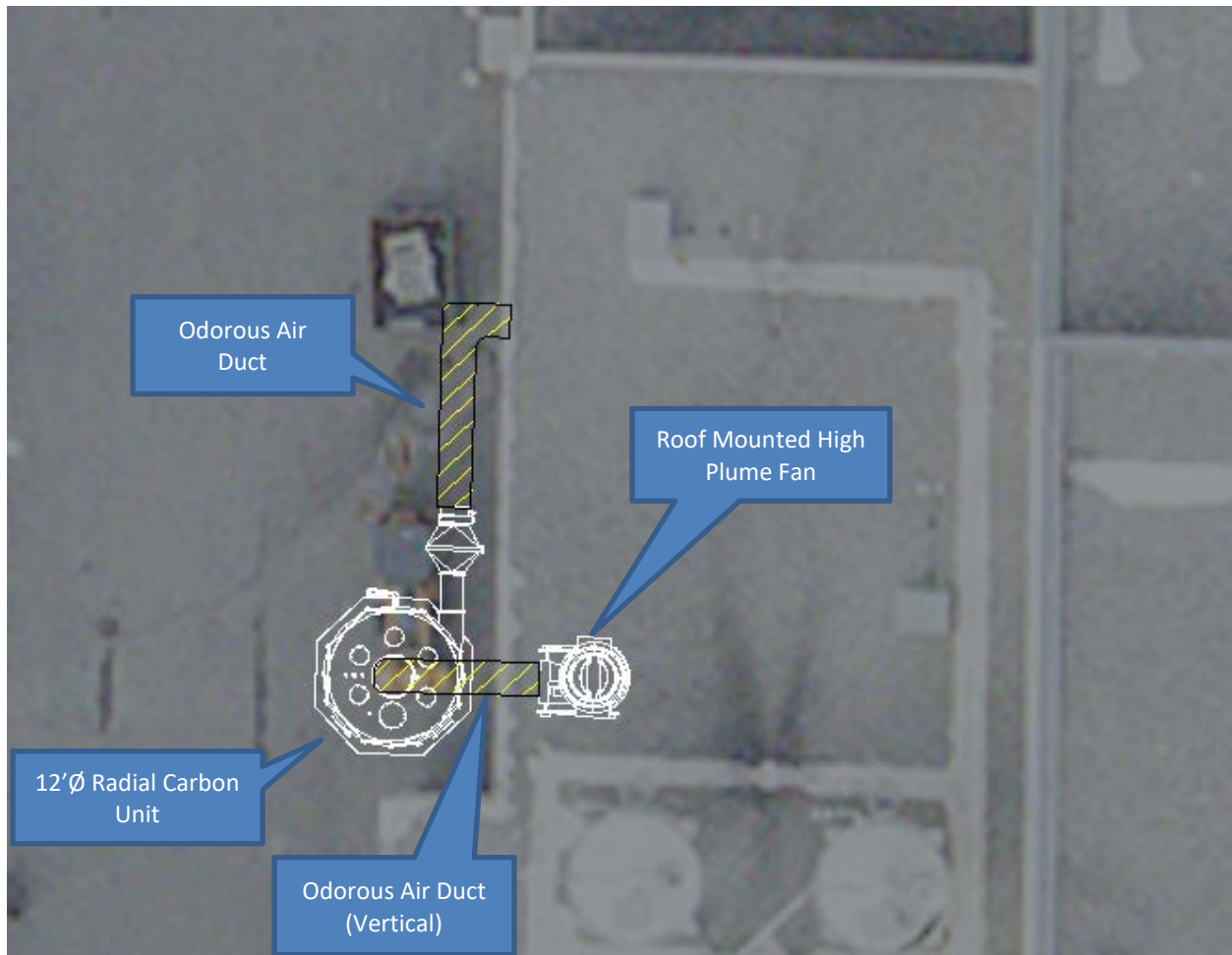
- The Influent Lift Station and S&G Building odors should be captured and treated using carbon adsorption systems. Figure 6-1 shows the general location and nature of the recommended system. Equipment vendor drawings are included in Appendix G for the recommended option.

Figure 6-1. Recommended Influent Lift Station and Screenings and Grit Building Carbon Odor Control (Proposed Location Layout (Top), Equipment Rendering (Bottom))



- The SHB Truck Bay air should be captured and treated with a single carbon adsorption system. Figure 6-2 shows the general location of the system. The carbon would be at grade with an elevated exhaust stack on top of the SHB to promote dispersion. The elevated stack can either be by means of a roof mounted high plume exhaust fan or if preferred, the fan can be on the ground by the carbon unit with a stack extension up to the roof. Figure 6-2 depicts the high plume fan approach.

Figure 6-2. Recommended SHB Truck Bay Carbon Odor Control Proposed Location Layout (Top), Carbon Equipment Rendering (Bottom Left), High Plume Fan Photograph (Bottom Right)



- In both of the carbon installations, the carbon vessels would be insulated to minimize condensation and freezing potential during cold weather. All drain lines would be heat traced and insulated. Installations would include a prefilter for removal of grease and particulate before the carbon units.
- Any ground level fans would be housed in a noise and weather protective enclosure.
- The final carbon vessel selection for the Influent Lift Station and S&G Building can be revisited during predesign to decide whether redundancy is warranted or if cost savings is desired by using a single larger radial flow carbon unit.
- The carbon vessel for the SHB Truck Bay is recommended as a single radial flow carbon unit as this location only relies on the carbon during winter truck loading.
- It is recommended that the fans be fitted with VFDs, particularly for the truck bay so that the ventilation rate can be relatively low when trucks are not actively being loaded.
- Manholes on Old Dixboro Rd. and at the WCC should be fitted with manhole inserts such as the “Peacemaker” systems used in other Ann Arbor locations. This type of system is also shown in Figure 6-3.

Figure 6-3. Manhole based odor control: “Peacemaker” style manhole insert (left), Goose neck external carbon canister (right)



- For the remote manhole near the University of Michigan Hospital in the Arboretum, a goose neck style carbon venting system is recommended so that the carbon can be more easily changed without removal of the manhole cover. This type system is also shown in Figure 6-3.
- Odorous air ducts on the existing sludge tanks were observed to be closed. It is recommended that these be opened to allow for headspace ventilation. Figure 6-4 shows a photo of the damper in question.

Figure 6-4. Dampers on the existing odorous air duct from the sludge tank systems



- Odorous air ducts on the exhaust from the cake storage bins should be fully opened in order to maximize venting the cake bins. Field inspection indicated these dampers were partially closed. Figure 6-5 provides a photo of the dampers at the biosolids cake bins.

Figure 6-5. Dampers on top of the existing biosolids cake bins



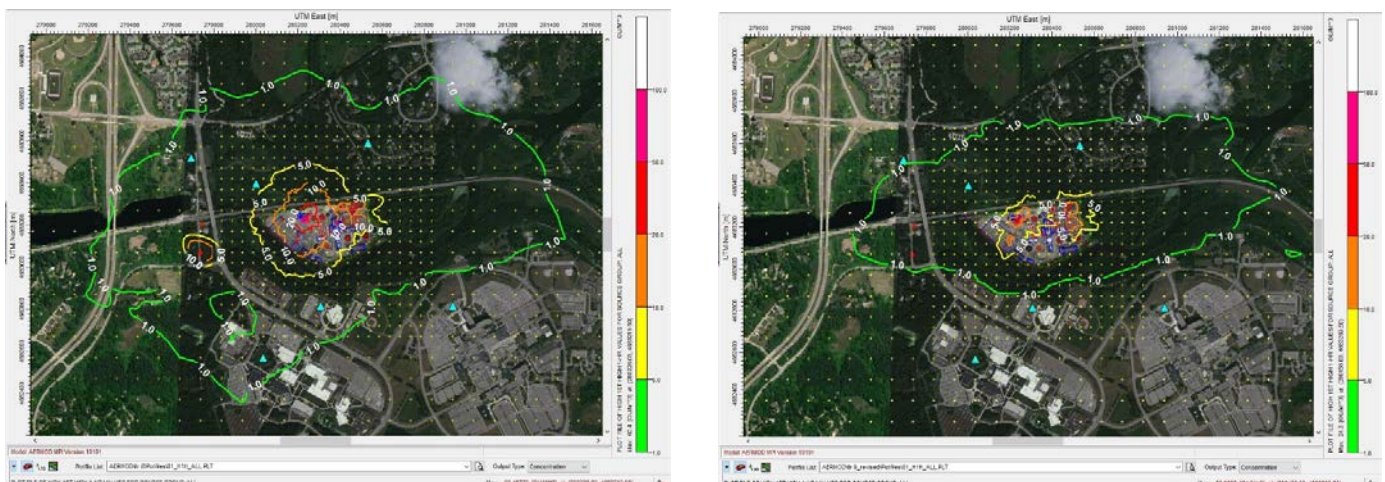
- Provide a new met station to provide, at a minimum, wind speed and direction. The weather station should have the capability of continuous data logging of short term and hourly average values. The station should also have downloading capability to a centralized computer control system in the plant's control room. It is proposed that the met station be installed on the EQ basin but final location should be field verified with equipment vendor. Figure 6-6 illustrates the met station sensor and console. Additional information on the met station can be found in Appendix H. It should also be noted that the plant has an existing met station located on top of the SHB. This can be maintained supplementing wind data at the higher elevation. A met station on the EQ tank would report wind conditions lower in the plant closer to the elevation of most of the potential odor sources.

Figure 6-6. Met Station Dampers console (left) and sensor (right)



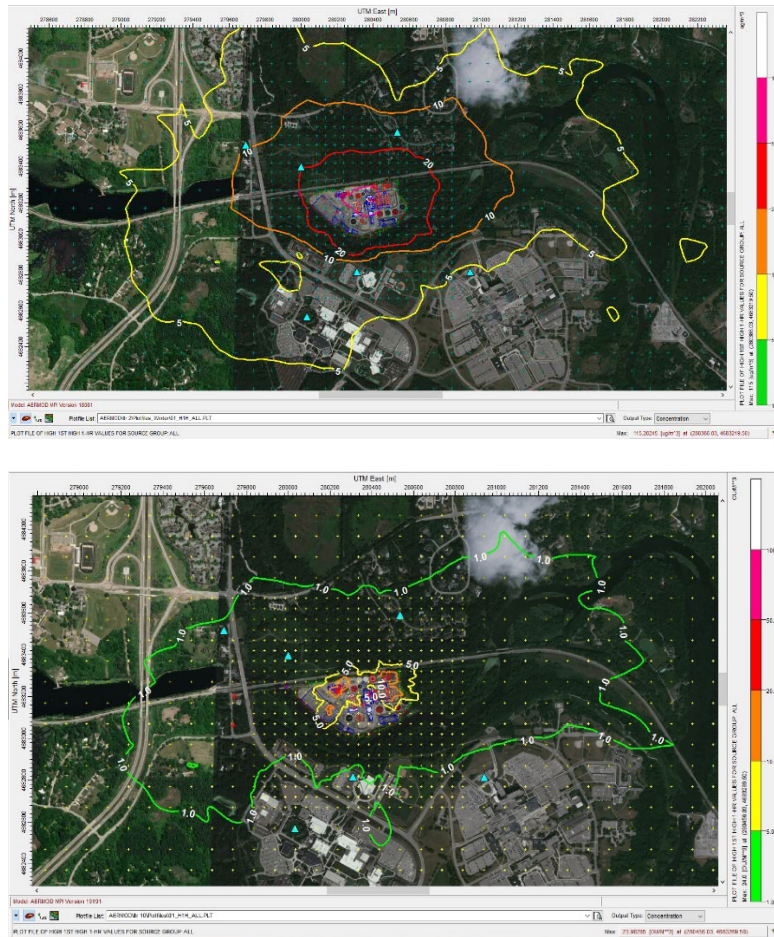
The odor dispersion model was used to evaluate the reduced odor impact if these recommendations are implemented. Figure 6-7 shows the reduce impact remaining of continuous odor sources after the Influent Lift Station and S&G Building and manhole odors are controlled. Figure 6-8 includes consideration of short term odors during winter biosolids truck loading and shows the odor reduction provided by carbon for the SHB Truck Bay.

Figure 6-7. Comparison of Odor Impacts: Current baseline impact with all continuous odor sources (Left), Future odor impact after odor control is implemented (Right)



The dispersion modeling of odor control system at the Influent Lift Station and S&G Building would show a 5 DT impact goal is met 100% of the time in terms of potential impact to the neighbors. The highest remaining potential impact locations are Towsley neighborhood and the new retirement homes but the maximum 1-hour projected impact is well below the 5 DT goal 100% compliance goal at approximately 1.3 DT for Towsley and 1.5 DT for the retirement homes.

Figure 6-8. Comparison of Truck Bay Winter Biosolids loading Odors: Current condition with Truck Bay (Top), Future carbon treatment for Winter Biosolids Truck Bay loading (Bottom)



The dispersion modeling evaluation including a new truck bay biosolids carbon scrubber also shows that a 5 DT impact goal is met 100% of the time in terms of potential impact to the neighbors. There is a slight increase in the 1 DT impact potential in Figure 6-8 compared to Figure 6-7, but this would only occur when trucks are actively loading (~two hours/day in winter only).

The highest remaining potential impact locations are Towsley and the new retirement homes but the maximum 1-hour projected impact is well below the 5 DT 100% compliance goal at approximately 1.3 DT for Towsley and 2.0 DT for the retirement homes.

Additional modeling evaluation was done to consider overall odor exceedance impacts. The odor plots in Figure 6-7 and 6-8 assume 100% compliance based on the five years of meteorological data used in the evaluation. A frequency impact analysis indicates that with the odor mitigation measures implemented, that all of the six identified sensitive receptor locations stay below even a 1 DT impact 99% of the time. The implementation of the recommended mitigation measures would more than meet the 5 DT max-hour 100% compliance goal and would achieve 1 DT 99% of the time.



Appendix A. 10152084-0WW-M0001-Odor Subjective Survey, Rev. 1



Technical Memorandum

Document Number: 10152084-0WW-M0001 (Rev. 1)

To: Chris Englert, City of Ann Arbor WWTP
From: Chris Easter, HDR
Josh Prusakiewicz, HDR
Robert Bowker, Bowker and Associates (HDR sub)
Date: July 10, 2019
Subject: Ann Arbor WWTP Odor Subjective Surveys and Follow-up Sampling
Recommendations, Rev. 1
City of Ann Arbor WWTP Odor Study

Purpose and Introduction

This memorandum presents the observations of the initial odor source subjective site survey completed by HDR and Bowker and Associates (team) on February 12 and 13, 2019, and a follow up spring survey during warmer weather on April 18, 2019. This site odor survey and discussions at the kick off meeting during the mornings of February 12 and 13 resulted in the initial source sampling recommendations presented at the end of this technical memorandum (TM). The survey performed by the team on February 12 focused on the wastewater plant itself while the February 13 survey began with observing a cake truck loading, followed by field tours of key collection systems locations offsite. The team performed an April survey which repeated the February kickoff meeting survey during warmer spring conditions and is presented as a comparison of winter and spring conditions.

Initial February Subjective Site Odor Survey Observations

The following section outlines field odor observations made by the team during the initial kickoff meeting odor survey held February 12 and 13, 2019. A comparison of observations during the follow up survey in April 2019 is presented later in this memorandum. Observations for each source are provided using a subjective source rating scale:

- 0 = no detectable odors
- 1 = very faint odors
- 2 = faint odor
- 3 = moderate, possible nuisance odor
- 4 = strong, very unpleasant odor
- 5 = very strong, not fit to breathe

Odor descriptors were also listed for each location. For instance, rotten egg like hydrogen sulfide (H_2S), musty, diaper, rancid, fishy, or urine were used. A subjective, offsite potential odor impact rating of low, medium, or high probability to create offsite impacts was also assigned for each location. Although subjective in nature (opinion based on field observation), the following guidelines define the low, medium and high offsite impact ratings.

- A low rating means that based on subjective observations (opinion) that the combination of the perceived odor levels and the nature of the odor source was unlikely to cause offsite odor impacts.
- A medium rating indicates that the potential for noticeable offsite odor impact may exist and that field sampling and follow up evaluation should be considered.



- A high rating indicates significant perceived potential for offsite impact is high and that this source warrants further evaluation and sampling.

Weather during the February 12 and 13 site visit was cold with intermittent mixed rain and snow, temperatures ranging from 20 to 34 degrees Fahrenheit (F.) and light winds. Snow was heavier on February 13. Table 1 summarizes subjective observations by source taken by both HDR and Bowker & Associates for onsite locations, and Table 2 summarizes observations for offsite locations. These data should be viewed only as an initial survey, as a follow up survey and sampling will be completed during warmer weather seasons of the year.

The survey completed on April 18, 2019 took place during warmer spring weather, temperatures in the mid 60 degree F. range, with light southerly winds estimated at 10 mph.

TABLE 1 – ONSITE ODOR SUBJECTIVE OBSERVATIONS BY SOURCE LOCATION DURING INITIAL FEBRUARY SUBJECTIVE SURVEY

Location	Source Rating	Off-site Impact Potential Rating	Odor Observations	Comments
Flow Equalization Basin	1 - 2	Low	Faint localized smell of sewer odor at open grating and hatch crack locations: diaper like, very low H ₂ S. Jerome field measurement was non-detect but unit may have been impacted by cold.	Comments: Low risk of impacts to the adjacent road at plant entry and railroad path adjacent to plant. The location has limited fugitive emissions and likely has only a localized impact as long as hatches are closed. Recommended sampling: Field H ₂ S and evaluation for Reduced Sulfur (RS) compounds and Odor Panel workup. Sample under roof hatch covers.
Raw Sewage Lift Station Rising Well	2 - 3	Medium	Low level H ₂ S and sewer like odors (diapers and urine)	Comments: Small but open surfaces on channels leaving screw pump discharge into the rising well entering the Screen and Grit Building and odorous air leaks around the screw pump covers. Recommended sampling: Field H ₂ S, RS and Odor Panel workup. Sample under channel grating.
Screen and Grit Building	3 - 4	Medium to High	H ₂ S and sewage odors.	Comments: The building interior was open to multiple screens, grit classifiers, open grating over the channels and open dumpsters for storing screenings and grit. The room was odorous. Room exhaust was through roof mounted fans that exhaust untreated odorous air. Recommended sampling: Field H ₂ S, RS and Odor Panel workup. Sample room exhaust at the fan.
Teacup Effluent Discharge Room	2 - 3	Low	Low level sewage odors and H ₂ S potential. Sour diaper odors.	Comments: Similar to adjacent Screen and Grit Building; the room has roof fan exhaust of untreated odorous air. Recommended sampling: Field H ₂ S, RS and Odor Panel workup. Sample room exhaust at the fan.
Screen and Grit Effluent channels	3	Low to Medium	Low level H ₂ S and diapers	Comments: There is open grating over turbulent channel flow. Recommended sampling: Field H ₂ S, RS, and Odor Panel workup. Sample under grating or use flux chamber if possible.
Flow Split Structure	3 - 4	Medium to High	Diapers, low H ₂ S and other reduced sulfur organics	Comments: Very turbulent flow on effluent weirs and aerated surface. Recommended Sampling: Field H ₂ S, RS and Odor Panel workup. Sample using flux chamber.

Location	Source Rating	Off-site Impact Potential Rating	Odor Observations	Comments
Primary Clarifiers (East and West)	2 - 3	Medium to High	Diapers and urine smell. Low level H ₂ S potential.	Comments: Uncovered sludge center riser, quiescent and weir zones. East and West clarifiers are very similar. Recommended sampling: Weirs and quiescent zone sampling to be done separately. Field H ₂ S, RS and Odor Panel Flux chamber sampling.
Aeration Basins (East and West)	1 - 2	Low to Medium	Musty	Comments: Anoxic and aerated zones. Recommended sampling: Un-aerated zone, lead zone and end of the aerated zones. Three per basin. Flux Chamber samples. Do one representative basin.
Gravity Belt Thickener Room	2	Low to Medium	Musty , fishy	Comments: Room odors were musty and fishy smelling. Room air is vented through wall mounted exhaust fans. Recommended sampling: Sample room air vented out the wall for dispersion modeling. Field H ₂ S, RS and Odor Panel.
Dewatering Odor Control Systems	-	-	-	Comments: none Recommend sampling: Inlet and outlet of ammonia scrubber for performance check. Recommended sampling: Inlet and outlet of any carbon absorber units online. Sampling should include amine scans with colorimetric tubes as well as field H ₂ S, RS and Odor Panel.
Centrifuge Dewatering	3 - 4	Medium	Rancid and fecal odors	Comments: none Recommended sampling: Room outlet air at the exhaust fans. Evaluate Field H ₂ S, amine, RS and odor panel. One sample on the upper centrifuge floor and one on the lower floor with the discharge chutes and conveyors.
Cake Hopper upper level	3 - 4	Medium	Fecal and Rancid	Comments: none Recommended sampling: Room outlet air at the exhaust fans. Evaluate for Field H ₂ S, amine, RS and odor panel. One sample on wall exhaust.
Cake Truck Room	4 - 5	Medium to High	Fecal and Rancid	Comments: none Recommended sampling: Truck room outlet air to the exhaust fans. Evaluate for Field H ₂ S, amine, RS and Odor Panel.

Location	Source Rating	Off-site Impact Potential Rating	Odor Observations	Comments
				One sample on wall exhaust location with and without a truck loading if possible and a third with a truck loading when lime treatment is occurring during summer operation.
Secondary Clarifiers	0 - 1	Low	Musty to non-detect	Comments: Odor panel and RS sampling not needed. Assume typical DT data for dispersion modeling.
Tertiary Filters	0 - 1	Low	Musty	Recommended sampling: Field sampling scan for H ₂ S. Comments: Only low level wall exhaust fan odors.
				Recommended sampling: Grab samples for odor DT close to WWTP fence line on hospital side.

TABLE 2 – OFFSITE ODOR SUBJECTIVE OBSERVATIONS BY SOURCE LOCATION DURING INITIAL FEBRUARY SUBJECTIVE SURVEY

Location	Source Rating	Off-site Impact Potential Rating	Odor Observations	Comments
Overflow Structure	0 - 1	Low	Faint to no odors	Comments: No significant odors noticed, but note it was a cold winter day. Recommended sampling: To be determined (TBD)
Vent Vault Carbon Canister	0	Low	No odors noticed	No exhaust noted from the carbon. Carbon was reported as not having been changed for an extended period. Suspect it may be blocked.
Manhole by dam on Old Dixboro Rd., under northwest side of bridge	0	Low	No odors or exhaust noticed	Comments: none Recommended sampling: TBD
Manholes near intersection of Chalmers and Huron River Dr.	0	Low	No odors or exhaust noticed	Comments: Cold winter snow and ice may be impacting odor potential during field observation. Ann Arbor Staff report odors here in summer. Recommended sampling: TBD
Manhole by Nichols Arboretum Park Entrance	0	Low	No odors noticed	Comments: Cold winter snow and ice may be impacting odor potential during field observation. Ann Arbor Staff report odors here in summer. Recommended sampling: TBD

Key Observations for Initial February Subjective Survey

Equalization Basin

The flow equalization basin was mildly odorous with a sewer-like, diaper odor and low levels of H_2S . The odor emissions were localized and limited to cracks in access hatches and small grating openings on the tank above the connection of flow from influent channel grates. The tank top is shown in Figure 1. Odors were significant enough that they might be noticed on the adjacent roadway entering the plant during filling operations but unlikely to reach offsite.

FIGURE 1: EQUALIZATION BASIN



Plant staff report that the EQ basin is often used (occasionally daily) for general plant flow equalization purposes. On initial construction, the basin was fitted with large supply air fans and an ozone chamber to treat the exhaust air. The ozone system did not work and has been out of service for a long period. The fans are only used if personnel enter the tank to help clear the space and control the environment. Staff do not report extensive corrosion in the tank which would suggest H_2S exposure, but this should be verified.

The risk of odor impact is odorous air displacement when the tank is filling or potential for cross winds to pull headspace air from the tank and downwash the odors over the side of the elevated tank.

Raw Sewage Lift Station

Figure 2 shows photos of the raw sewage lift station. Flow enters the lift station from the 78 inch diameter interceptor, some of which is lifted into the plant with Archimedes screw pumps. The screw pumps are loosely covered with corrugated covers but are not fully sealed nor vented to odor control. The remaining interceptor flow into the plant combines with the screw pump discharge flow and goes into the plant Screen and Grit Building. Just prior to the Screen and Grit Building, the channels have open grating which release localized odors. These localized untreated odors are considered medium risk of reaching offsite with moderate potential for nuisance level odors and therefore warrant odor sampling and further evaluation. Sampling will move the study from subjective opinion to defining the risk based on data and dispersion modeling.

FIGURE 2: RAW SEWAGE LIFT STATION (LEFT) AND RISING WELL (RIGHT)



Screen and Grit Building

Figure 3 shows photos inside the Screen and Grit Building. Wastewater channels are open to the room through grating. Screens are open to the room as are grit classifiers. Screenings and grit are stored in open top dumpsters. The building workspace was odorous and did not include odor control. Exhaust air from the building was released untreated from roof mounted exhaust fans.

Process equipment included three screens and two grit removal systems along with multiple enclosed screw conveyors for conveying collected screenings. Grit was discharged directly from the classifier chutes to the dumpster below. The effect of the untreated exhaust fan odors was considered a medium to high risk of impacting off site receptors based on criteria definitions presented above.

FIGURE 3: SCREEN AND GRIT BUILDING



Teacup Effluent Discharge Room

The adjacent teacup effluent discharge room was small, with a single roof exhaust fan. Figure 4 shows one of the two open tanks that collect effluent from the teacups for return back to the plant. These are older tanks from original grit removal systems that still accept reduced flow from the teacups.

FIGURE 4: TEACUP EFFLUENT DISCHARGE ROOM



Screen and Grit Effluent Flow Splitter Structure

Open grating covered channels convey screened effluent through grit removal to the flow splitter structure. The exposed wastewater was odorous with low level sewage odors and H₂S. Figure 5 shows photos of this.

FIGURE 5: GRIT REMOVAL AND FLOW SPLITTER CHANNELS



Primary Clarifiers

The East and West Plant primary clarifiers are similar comprised of center riser wells, a circular quiescent settling zone and outboard weirs and launders. There are two West Plant clarifiers and four East Plant clarifiers. Odors noticed were low level H₂S and diaper like. Staff report that they do not always operate all six clarifiers.

Due to the size of the open surface and the presence of raw wastewater, the primary clarifiers are considered a medium to high risk source with potential to impact off site receptors. Figure 6 shows photos of the clarifiers.

FIGURE 6: PRIMARY CLARIFIERS



Aeration Basins

The East and West Plant aeration basins are very similar with un-aerated, anaerobic and anoxic zones followed by tapered aeration. Odors were low-level, musty odors typical of aeration basins. Field observations suggest low to potentially medium risk of impacting offsite with very faint musty odors based on criteria definitions presented above. Figure 7 shows photos of the aeration basins.

FIGURE 7: AERATION BASIN



Gravity Belt Thickening Room

The Solids Handling Building houses biosolids storage tanks, gravity belt thickening for waste activated sludge, centrifuge dewatering for blended biosolids and cake load-out facilities. The gravity belt thickener room also houses the existing odor control systems that include a water-only ammonia scrubber for sources that tend to be impacted by ammonia and carbon adsorption systems to treat the remaining odors. Air in this room is not captured and treated.

The odor control systems shown in Figure 8 provide treatment of 4,400 cubic feet per minute (cfm) of ammonia-laden air from the head space of the biosolids holding tanks. The air then enters three 6,150 cfm radial flow carbon units to polish this air and treat the remaining air collected from the centrifuge cake discharge chutes, centrate chutes, gravity thickeners/blend storage bins, waste activated sludge tank and biosolids cake hoppers.

FIGURE 8: ODOR SCRUBBER SYSTEMS (WET SCRUBBER LEFT, CARBON ADSORBERS RIGHT)



Centrifuge Room

The centrifuge room is vented by wall fans. The room air was odorous. The most odorous sources (the centrifuge cake discharge chutes) are vented directly to odor control below the floor level of the centrifuge room. The residual room odors from the screw conveyor systems left the room offensively odorous with this untreated air vented by wall fans.

FIGURE 9: CENTRIFUGE ROOM EXHAUST FANS



Cake Truck Room

There are two truck bays in the Cake Truck Room which are each fitted with four large cake hoppers and live bottom unloading screws to unload cake from the hoppers into trucks. The same truck bays were also fitted with liquid sludge loading systems. During winter, biosolids are dewatered with centrifuges, stored in the hoppers and hauled to landfill for disposal. Once winter breaks in April, and farm land application is possible, liquid biosolids are treated with lime

to elevate the pH for stabilization. The stabilized biosolids are loaded into tanker trucks for hauling to land application sites.

FIGURE 10: TRUCK LOADOUT HOPPERS AND TRUCK BAY



Odors differ during these two periods, so both will be sampled. Untreated odors exhaust goes out the wall mounted exhaust fans shown in Figure 10. Odors are also more intense when cake trucks are being loaded compared to liquid biosolids loading. This was observed the morning of February 13. Figure 11 shows a cake truck from that morning. The loading process took approximately 40 minutes, during which the odors were noticeably intense.

FIGURE 11: CAKE TRUCK LOADOUT



Final Clarifiers

The final clarifiers were not odorous during the site visit. Clarifier effluent weirs were fitted with covers for algae control. No odor capture or control was provided. Odor risk from the clarifiers is very low. Figure 12 shows views of a final clarifier.

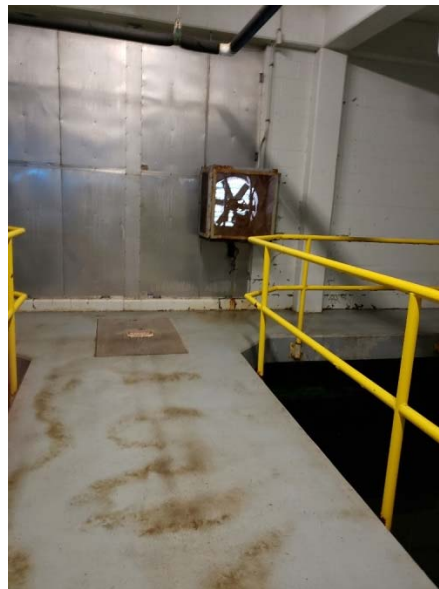
FIGURE 12: FINAL CLARIFIER



Tertiary Filters

The tertiary filters were low in odor, even inside the building. The wall exhaust louvers shown in Figure 13 are close to the plant boundary, on the side near the hospital and may be considered for summer sampling if odors are noticed.

FIGURE 13: TERTIARY FILTER WALL LOUVER



Collection System Interceptor

Collection system tours were completed on February 13. An overflow structure near the entrance to the plant is shown in Figure 14.

FIGURE 14: OVERFLOW STRUCTURE



The top of the structure has openings around access hatches. The structure passes flow from incoming lines (24, 36, and 42 inch in diameter) and is cross connected to allow direct overflow into a 78 inch diameter interceptor sewer. As such, if the overflow structure headspace were to pressurize during an overflow event, odors may escape at this location due to openings around the access hatches.

Figure 15 shows an odor air capture vault just upstream of this overflow structure. Staff report that this small structure includes a hard-plumbed carbon canister to allow for interceptor exhaust treatment. No exhaust was observed. These two locations are however considered suspect and warrant investigation. These two locations are close to the bridge area near the plant entrance which has received odor complaints. The vent structure is also near several manholes at the plant entrance road where staff report occasional odors. Odalog H₂S monitoring and sewer pressurization monitoring is recommended.

FIGURE 15: VENT VAULT



Manholes on the 78 inch interceptor along Old Dixboro Road on the northwest side of the bridge were also observed (Figure 16). This area is also near the bridge where odor complaints have occurred. No exhaust was noted during the site visit, but the manhole was covered in snow at the time. If this manhole is observed to outgas during spring, it should also be monitored.

FIGURE 16: MANHOLES ON THE 78 INCH LINE INTO THE PLANT



Figure 17 shows photos of manhole covers near the corner of Chalmers and Huron River Drive. Staff report odors in this area. The manholes are adjacent to a waterway. The profile of the sewer should be investigated to see if a siphon effect here might cause pressurization and outgassing. If this is true then this area should also be sampled with Odalog and pressure monitoring equipment.

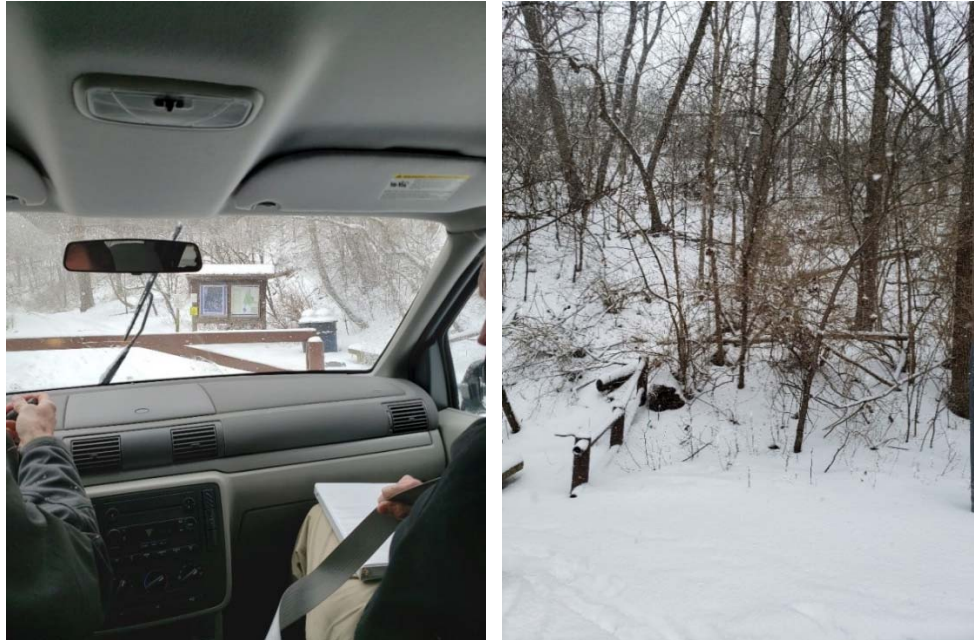
FIGURE 17: MANHOLES NEAR CHALMERS AND HURON RIVER DR.



Figure 18 shows photos near the Arboretum area, close to the University of Michigan Hospital complex. A manhole on the hillside near the entrance to a park walkway is suspect. No odors

were noted during the tour, but this location has been the site for odor complaints. The sewer profile here may also result in pressurization and outgassing of sewer odors. Sewer pipe profiles will be reviewed and this location should be included in Odalog and pressurization monitoring plans.

FIGURE 18: ARBORETUM



Key Observations for Spring Subjective Survey

The spring survey was performed by the team on April 18, 2019 during warmer spring weather at approximately 65 degrees F., as compared to the winter conditions during the initial February survey. The comparative data is summarized in Table 3. The following bulleted statements include direct subjective comparison by source.

- The EQ tank ratings remained low with perceptions that the covered tank odor impact potential was low.
- The screw pump lift station ratings remained low. Localized odors onsite were noted but potential for offsite impact was perceived as low to medium.
- Screen and Grit Building odors remained similar with ratings suggesting potential for offsite impact to the north.
- The Teacup Effluent Discharge Room remained relatively low with similar ratings to the February observations.
- The Screen and Grit effluent channel and flow splitter structure was similar to that observed in February with offsite impact potential perceived as medium to high.
- The primary clarifiers were similar if slightly worse than observed in February with a noted impact potential of medium to high.
- The aeration basins' odor was perceived as similar to slightly lower in April than in February.
- The final clarifiers were similar to February with low impact potential.



- The tertiary filters were similar to February with low impact potential.
- The truck bay cake unloading was similarly bad with a high impact potential particularly during active truck loading.
- The gravity belt thickener room was slightly worse in spring with a medium odor impact potential rating.
- The centrifuge dewatering room was lower in perceived odors during spring with a low projected impact potential.
- The upper level above the cake hoppers was slightly worse during spring, potentially impacted by the truck unloading event.

In addition to the above the following offsite observations were made.

- The overflow structure at the entrance of the plant and the sewer manholes on the 78 inch interceptor along Old Dixboro Road leading into the plant including the carbon vent structure appeared to have very low level odor impacts that were localized at the structure. These are being sampled and will be reported elsewhere once complete. Positive pressurization and outgassing may be present at these locations.
- The Nichols Arboretum manhole was observed to have positive pressurization and was exhausting odorous air. This confirmed the need to monitor this location for both H₂S and pressure.
- The Towsley Neighborhood Pump Station was observed at the wet well. No odors were observed at this pump station.
- The Fitness Center at Washtenaw Community College (WCC) Pump Station was observed. Odor potential was low but the station will be monitored in the summer given its location in an active community parking lot and because odor complaints have been logged in this general location.
- The WCC Pump Station located in the green space on campus was observed. No odors were observed at this pump station.
- The WCC sewer manhole at the northwest driveway off Huron River Dr. was observed. No odors were observed at this manhole.
- Walking inspection of manholes around the Saint Joseph Mercy Ann Arbor Hospital did not identify any noticeable odor source from the hospital collection system.

TABLE 3: COMPARISON OF INITIAL FEBRUARY 2019 SURVEY WITH APRIL 2019 SURVEY OBSERVATIONS

Location	Source Rating February 2019	Off-site Impact Potential Rating February 2019	Source Rating April 2019	Off-site Impact Potential Rating April 2019
Flow Equalization Basin	1 - 2	Low	0 - 1	Low
Raw Sewage Lift Station	2 - 3	Medium	2	Low to Medium
Screen and Grit Building	3 - 4	Medium to High	3 - 4	Medium to High
Teacup Effluent Discharge Room	2 - 3	Low	2 - 3	Low to Medium
Flow Split Structure	3 - 4	Medium to High	3 - 4	Medium to High
Primary Clarifiers (East and West)	2 - 3	Medium to High	3	Medium to High
Aeration Basins (East and West)	1 - 2	Low to Medium	1 - 2	Low
Gravity Belt Thickener Room	2	Low to Medium	3	Medium
Centrifuge Dewatering	3 - 4	Medium	1 - 2	Low
Cake Hopper upper level	3 - 4	Medium	4	Medium
Cake Truck Bay	4 - 5	Medium to High	4 - 5	High
Secondary Clarifiers	0 - 1	Low	1	Low
Tertiary Filters	0 - 1	Low	0 - 2	Low



Appendix B. 10152084-0WW-M0003-Air Sampling Investigation Work Plan, Rev. 1



Air Sampling Investigation Work Plan

City of Ann Arbor Area Odor Study

Document # 10152084-0WW-M0003

Revision: 1

Ann Arbor, MI
July 23, 2019



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1 Overview

The City of Ann Arbor's Wastewater Treatment Plant (WWTP) processes sanitary sewage received from the City's collection system. The system treats the sewage onsite through an equalization basin, lift station, headworks (screenings and grit removal), primary clarifiers, aeration basins, secondary clarifiers, tertiary filters, ultraviolet disinfection, and biosolids management systems. The odorous air from the head space of the biosolids holding tanks is captured and sent to a wet ammonia scrubber followed by carbon filter units for final polishing. Odorous air from a covered gravity thickener and two covered blend tanks 1 and 2, and cake hoppers is also collected and treated.

Figure 1-1 provides a simplified process flow diagram of the plant. Figure 1-2 provides an aerial view of the WWTP. Figure 1-3 provides a map of the odor complaint locations from 2016 – present.

The purpose of this air sampling investigation work plan is to gather air quality data from different odor source locations both onsite and offsite. The data collected will be used to perform air dispersion modeling of high priority odor sources. Based on the results of the modeling, odor mitigation measures will be evaluated to help Ann Arbor create an action plan moving forward. This plan will provide the basis for deciding any potential future actions to most effectively manage offsite nuisance odors.

Figure 1-1. Simplified Plant Process Flow Diagram

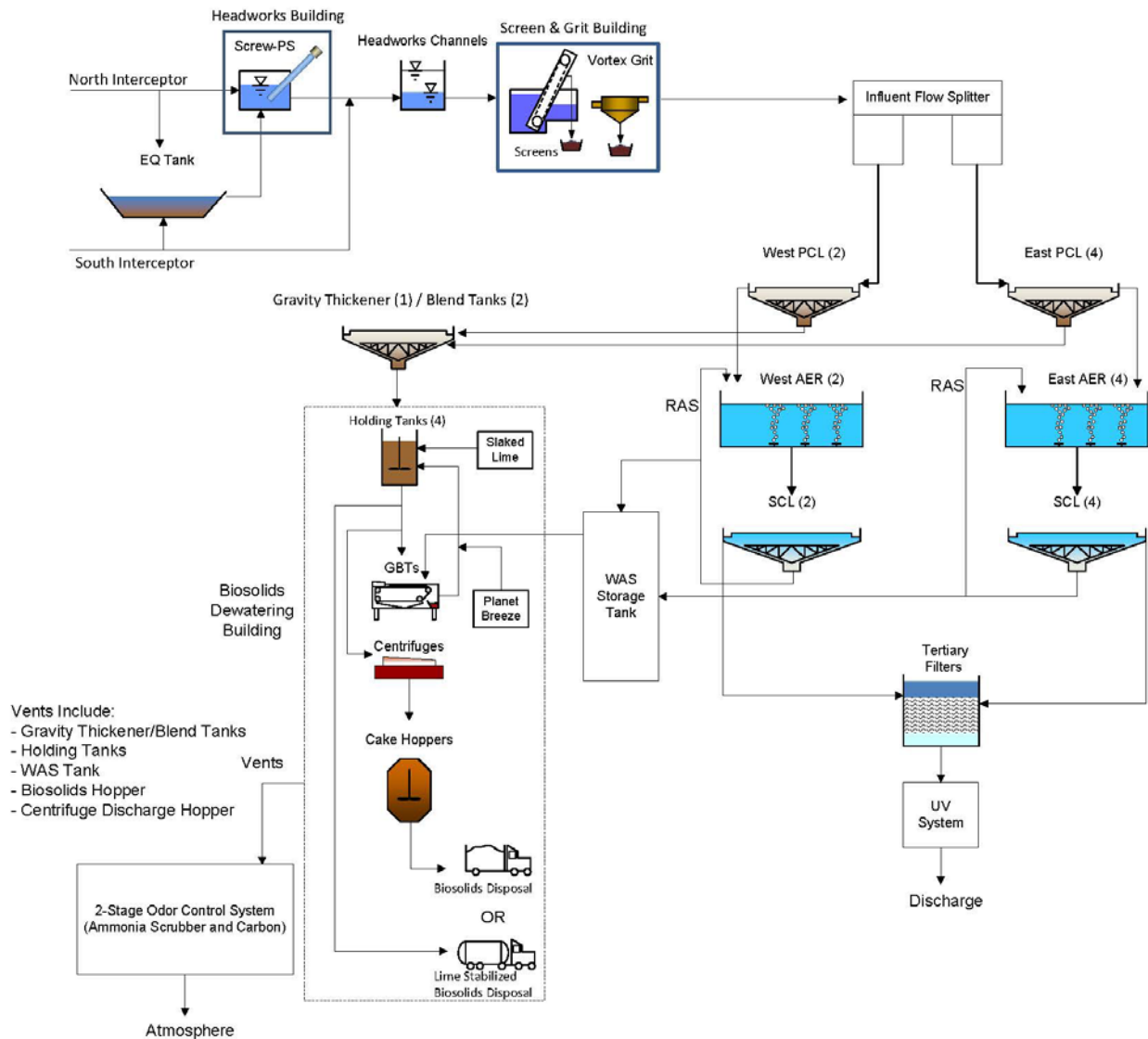
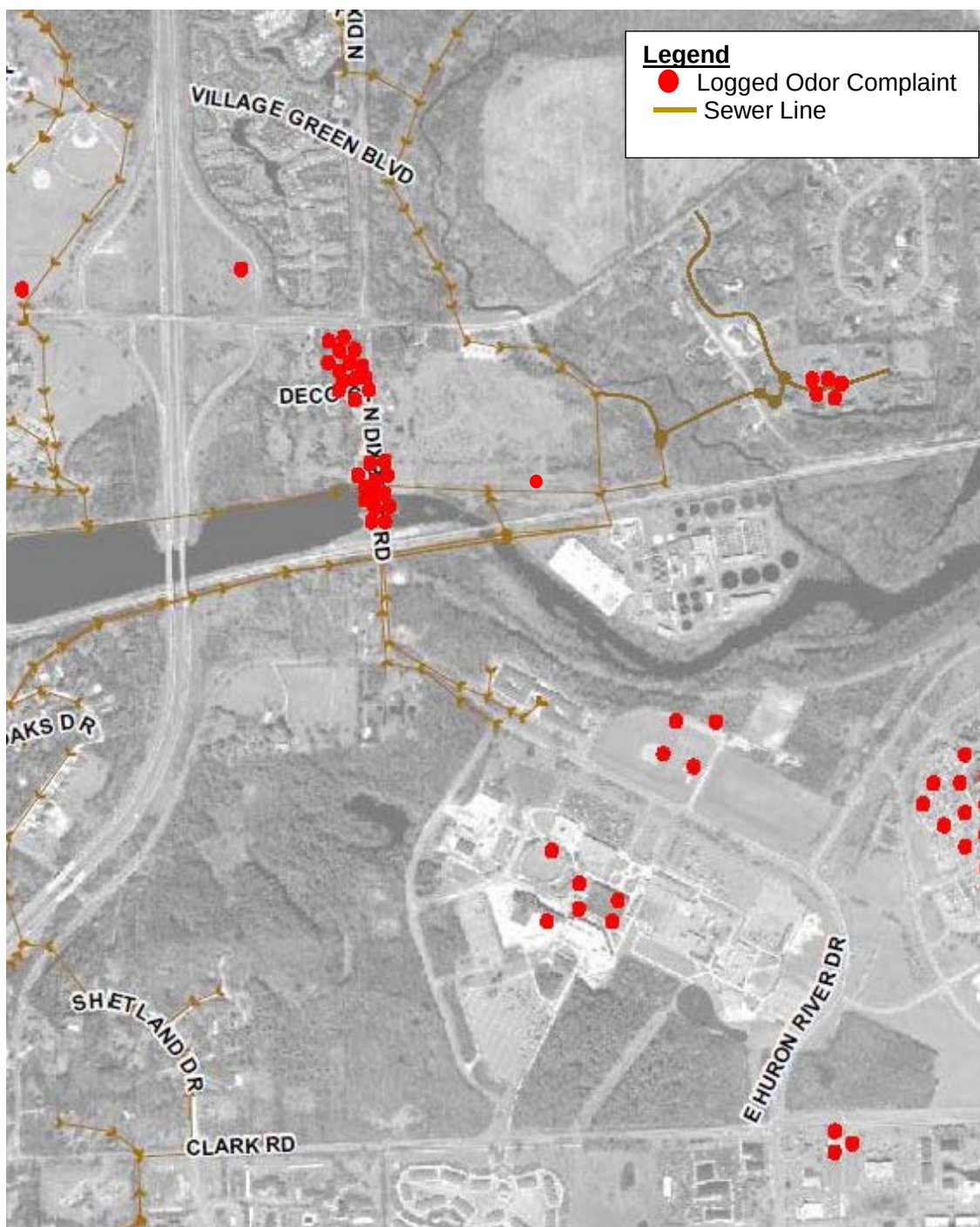


Figure 1-2. Plant Aerial View of WWTP



Figure 1-3. Map of Odor Complaint Locations from 2016 – present



Review of complaints appear to focus on five areas as follows:

1. The Dixboro Road Bridge area west by northwest of the plant.
2. The Washtenaw Community College fitness center south of the plant.
3. The Towsley community area northeast of the plant.
4. The St. Joseph Hospital area southeast of the plant.
5. The Washtenaw Community College campus green space near a pump station.

This sampling plan addresses each of these five areas. The Dixboro Road Bridge area may be impacted by pressurization of manholes in the incoming collection system and at an overflow splitter structure near the wastewater plant entrance. Flow from the fitness center lift station and college lift station may move odorous air downstream to these influent lines at the plant. The discharge point may carry downhill to the manholes on the incoming collection system line where an existing passive carbon system is already in place at the plant entrance. The carbon system and overflow structure are included in the sampling work plan that follows.

The Towsley subdivision area has small diameter gravity sewer lines connected to a single pump station. The pump station and its force main discharge to the City of Ann Arbor collection system was investigated in April 2019. Based on HDR's and Bowker and Associates' investigation, no odors were observed at this pump station or manholes throughout the community. Therefore, the pump station will not be included in this work plan.

The St. Joseph Hospital collection system feeds into a lift station that discharges into the Ypsilanti Community Utilities Authority (YCUA) wastewater collection system. A number of complaints are logged in this location to warrant an improved understanding of the locations of these complaints and whether the collection system is a potential source or not. Further field investigation was conducted in April 2019 to understand this area. Based on HDR's and Bowker and Associates' investigation, no noticeable odor sources could be identified during a walkdown of the manholes around the hospital campus' collection system. Therefore, the hospital will not be included in this work plan.

The Washtenaw Community College (WCC) fitness center and campus' green space lift stations also discharge into the City of Ann Arbor collection system and are also locations for periodic odor complaints. These areas were field inspected in April 2019 by HDR and Bowker and Associates. Based on the investigation of both areas, it was determined that the fitness center lift station odor potential was low but the station will be monitored in the summer given its location in an active community parking lot and because odor complaints have been logged. The WCC green space lift station had no odors present at the time of investigation. However, this lift station discharges into a manhole at the northwest driveway off East Huron River Dr. The manhole also collects discharge from the WCC fitness center lift station and is at a high point in the collection system. This manhole gravity feeds to the City of Ann Arbor WWTP. The manhole was observed and odor potential was low, but the manhole will be monitored in the summer given its location in the collection system. The sampling for both of these locations are addressed in this work plan.

2 Air Sampling Investigation Work Plan

The following section provides an overview of the recommended odor sampling based on the February 12 and 13, 2019 and April 18, 2019 site visits by the HDR Project Team. Sampling locations, test procedures and requirements are summarized in Table 1. The sampling plan includes:

- Onsite Liquid Phase Sampling
- Onsite Gas Phase Sampling
 - o Odor Panel Analysis

- o Gas Chromatograph (GC) Scan for reduced sulfur organic based odor compounds
 - o Hydrogen sulfide (H₂S) sampling
 - o Amine and ammonia sampling
- Onsite Seasonal Sampling
- Offsite Collection Systems Sampling

For all sampling that occurs, adjustments to the sampling plan and procedures may be required in the field to accommodate plant and offsite collection operating conditions. Field notes will be recorded to capture this information.

2.1 Onsite Liquid Phase Sampling

Liquid phase wastewater sampling will include field grab samples for dissolved sulfides, pH, and temperature. This data will help define the odor risk potential for the wastewater. Dissolved sulfides will be measured using either Gastec colorimetric sulfide tubes or a Chemetrics Sulfide Test kit. This data will be collected by HDR on the plant influent during winter, spring, summer and fall periods in order to assess potential for seasonal variations. Dates of sampling will be determined by HDR and City of Ann Arbor.

2.2 Onsite Gas Phase Sampling

Real time field gas phase sampling will be completed for H₂S using a Jerome H₂S analyzer provided by HDR. Tedlar bag samples will be used by Charles Schmidt (CE Schmidt) and HDR to collect air samples for odor panel and gas chromatograph analysis. Tedlar bag air samples will be shipped overnight for laboratory analysis for Odor Panel workups and GC scans as described below.

Gas phase testing from open plant source locations (process tanks) will use an EPA flux chamber for collecting samples at a controlled air flux rate such that the data can be effectively used for follow-up dispersion modeling.

Odor panel analysis will follow ASTM E 679 Standard of Practice. The GC analysis will be based on ASTM D 5504 and include a standardized scan for species of reduced-sulfur, organic-based odor compounds often observed from wastewater treatment plant processes. This scan also analyzes for H₂S (a non-organic-based, reduced-sulfur odor compound).

Where possible, airflow rate measurements (building exhaust fan rates) will be measured using a hot wire anemometer. Exhaust fan performance data will also be used, as needed. Water surface emission rates will be based on controlled flux rates using an EPA flux chamber.

2.2.1 Seasonal Sampling

Sampling will occur during all four seasons (winter, spring, summer and fall).

The largest sampling event will occur in summer when the warm wastewater has the greatest potential for odor generation and release. More intensive odor source sampling is planned for summer to ensure odor impacts during this higher risk season is well defined.

During the warmer land application season, slaked lime slurry is added to lime stabilize the liquid biosolids prior to land application from May to November each year.

Spring sampling will also be done that is focused on operational differences between how biosolids are treated and disposed in winter and early spring compared to summer. During spring sampling, the sampling plan will be limited to the dewatering truck bay, centrifuge dewatering exhaust, carbon system inlet and outlet and up wind and downwind samples.

During the winter/spring months, trucks haul dewatered cake offsite for landfill disposal. Planet Breeze is added to the thickened waste activated sludge (WAS) during the centrifuge dewatering season (December – April) to minimize odors.

See Table 2-1 below for specific locations and testing requirements for the spring sampling event. Both CE Schmidt and HDR will be onsite to complete the spring and summer sampling events.

Table 2-1. Recommended Onsite Odor Source Spring Sampling Plan (with Planet Breeze December - April)

Sampling Location	Type of Sample	Number of Odor Panel Tests	Number of ASTM DD-5504 TRS Tests	Number of Field H ₂ S Tests	Number of Field Ammonia and Amine Tests	Number of Liquid pH Tests	Number of Liquid Sulfides Tests	Comments
Dewatering Centrifuge Room exhaust	Grab	1	1	1	1			Grab sample (GS) of room exhaust air.
Dewatering Truck Bay	Grab	2	2	2	2			GS of room exhaust. One without truck loading and one with truck loading.
Upwind of plant	Ambient grab sample	1	1	1				
Downwind of plant	Ambient grab sample	1	1	1				
Inlet to Ammonia Scrubber	Grab				1			
Outlet of Ammonia scrubber	Grab				1			
Inlet to carbon filters (common)	Grab	1	1	1	1			GS on common inlet to carbon systems.
Outlet of carbon filters	Grab	2	2	2	2			Assumes 2 of 3 scrubbers in service.
QC Blank	Grab	1	1					
Totals =		9	9	8	8	0	0	

As mentioned, slaked lime is mixed with liquid biosolids annually from May until the end of November and is land applied. A summer sampling event will occur to capture the differences (if any) in odors between the spring and summer biosolids activities. During the summer sampling event, a total of 23 sample locations are planned to be tested onsite. See Table 2-2 below for specific locations and testing requirements.

Table 2-2. Recommended Onsite Odor Source Summer Sampling Plan (no Planet Breeze May – November)

Sampling Location	Type of Sample	Number of Odor Panel Tests	Number of ASTM DD-5504 TRS Tests	Number of Field H ₂ S Tests	Number of Field Ammonia and Amine Tests	Number of Liquid pH Tests	Number of Liquid Sulfides Tests	Comments
Equalization Basin	Grab	1	1	1			1	
Raw Water Influent Lift Station	Grab	1	1	1		1	1	Grab Sample (GS) under open grating downstream of screw pumps.
Screen and Grit Building Exhaust Fan	Grab	1	1	1				GS on building exhaust at roof fan intake.
Grit Tank Room	Grab	1	1	1				GS on building roof fan intake.
Screen and Grit Building Effluent Rising Well / Flow Splitter Structure Primary Influent	Flux Chamber	1	1	1			1	Flux chamber sample on open turbulent wastewater upstream of weirs.
Primary Quiescent zone	Flux Chamber	1	1	1				Flux chamber sample on one representative primary clarifier.
Primary Weir zone	Flux Chamber	1	1	1				Flux chamber sample over representative primary weir zone.
Aeration Basin Anoxic/Anaerobic zone	Flux Chamber	1	1	1				Flux chamber on the initial un-aerated zone in aeration basins.
Aerated Zone 1 Aeration Basin	Flux Chamber	1	1	1				Flux chamber on initial aerated zone of aeration basins (pick one representative basin).
Aerated Zone 3 at end of Aeration Basin	Flux Chamber	1	1	1				Flux chamber on effluent end of representative aeration basin.

Table 2-2. Recommended Onsite Odor Source Summer Sampling Plan (no Planet Breeze May – November)

Sampling Location	Type of Sample	Number of Odor Panel Tests	Number of ASTM DD-5504 TRS Tests	Number of Field H ₂ S Tests	Number of Field Ammonia and Amine Tests	Number of Liquid pH Tests	Number of Liquid Sulfides Tests	Comments
Gravity Belt Thickener Room Exhaust	Grab	1	1	1	1			GS of representative room exhaust air.
Dewatering Centrifuge Room exhaust	Grab	2	2	2	2			One GS of room exhaust air at upper centrifuge floor and one GS of room exhaust air at lower floor with the discharge chutes and conveyors.
Cake Hopper Level Exhaust Air	Grab	1	1	1	1			GS of room exhaust air at upper level.
Dewatering Truck Bay	Grab	2	2	2	2			GS of room exhaust. One GS without truck loading and one with truck loading.
Secondary Clarifier Quiescent zone	Flux Chamber	1	1	1				
Tertiary Filter Room Exhaust	Grab	1	1	1				GS of room exhaust.
Upwind of plant	Ambient grab sample	1	1	1				
Downwind of plant	Ambient grab sample	1	1	1				
Inlet to Ammonia Scrubber	Grab				1			
Outlet of Ammonia scrubber	Grab				1			
Inlet to carbon filters (common)	Grab	1	1	1	1			GS on common inlet to carbon systems.
Outlet of carbon filters	Grab	2	2	2	2			Assumes 2 of 3 scrubbers in service.



Table 2-2. Recommended Onsite Odor Source Summer Sampling Plan (no Planet Breeze May – November)

Sampling Location	Type of Sample	Number of Odor Panel Tests	Number of ASTM DD-5504 TRS Tests	Number of Field H ₂ S Tests	Number of Field Ammonia and Amine Tests	Number of Liquid pH Tests	Number of Liquid Sulfides Tests	Comments
Headspace of Overflow Structure at plant entrance	Grab	1		1	1			
QC Blank	Grab	1	1					
Totals =		25	24	24	12	1	3	

2.3 Onsite Seasonal Sampling

Onsite seasonal sampling will also be completed as follows by HDR:

1. Deploy a H₂S Acrulog near a roof exhaust fan in the Screen and Grit Building for one week during each of the four seasons.
2. Grab samples for liquid phase sulfides on raw wastewater flowing into the Screen and Grit Building during each of the four seasons.
3. Monitor air both upwind and downwind of the WWTP using the Jerome H₂S meter. Readings will be taken by HDR on pre-determined dates during the four seasons.
 - a. If Jerome H₂S meter readings are detected then perimeter low level Acrulogs will also be deployed.
4. Nasal Ranger readings will be taken if downwind odors are detected. Readings will be taken by HDR on pre-determined dates during the four seasons.

See Table 2-3 below for additional sampling details.

2.4 Offsite Collection System Sampling

H₂S Acrulogs and pressurization loggers will be deployed at the following locations in order to define potential for odor emissions outside of the plant fence line from the collection system and surrounding areas. Acrulogs will capture H₂S data only and pressure monitors will capture differential pressure only.

1. Overflow structure near plant entrance
2. Vent vault carbon canister near plant entrance road
3. Nichols Arboretum manhole
4. Manhole on South Dixboro Rd. hill entering plant
5. WCC Fitness Center Lift Station
6. WCC Manhole S-18b at northwest driveway entrance off East Huron River Dr.

Table 2-3 below provides a summary of the Onsite and Offsite Seasonal Sampling that will occur as a part of the study:

Table 2-3. Onsite and Offsite Seasonal Sampling Locations and Testing

Sample Location	Sample Duration	Sample Method	Sample Type	Number of Samples	Analytical Test Method
Screen and Grit Building Roof Exhaust Fan	One week in spring, summer, fall and winter.	Acrulog Deployment	Field	4	Acrulog H ₂ S Monitoring
Upwind perimeter	One week in spring, summer, fall and winter.	Jerome Meter	Field	4	H ₂ S Testing
Downwind perimeter	One week in spring, summer, fall and winter.	Jerome Meter	Field	4	H ₂ S Testing
Screen and Grit Building Raw Wastewater	One grab sample in spring, summer, fall and winter.	Grab Sample	Field	4	Liquid phase sulfides, temperature and pH
Nichols Arboretum	One week in spring, summer, fall and winter.	Pressure Monitoring and Acrulog Deployment	Field	4	Pressure transmitter and Acrulog H ₂ S monitoring
Overflow Structure	One week in spring, summer, fall and winter.	Pressure Monitoring and Acrulog Deployment	Field	4	Pressure transmitter and Acrulog H ₂ S monitoring
Vent Vault Carbon Canister (Plant Entrance)	One week in spring, summer, fall and winter.	Pressure Monitoring and Acrulog Deployment	Field	4	Pressure transmitter and Acrulog H ₂ S monitoring
Manhole on South Dixboro Rd. hill entering plant	One week in summer.	Pressure Monitoring and Acrulog Deployment	Field	1	Pressure transmitter and Acrulog H ₂ S monitoring
WCC Fitness Center Lift Station	One week in summer.	Pressure Monitoring and Acrulog Deployment	Field	1	Pressure transmitter and Acrulog H ₂ S monitoring
WCC Manhole S-18b at northwest driveway entrance off East Huron River Dr.	One week in summer.	Pressure Monitoring and Acrulog Deployment	Field	1	Pressure transmitter and Acrulog H ₂ S monitoring

Figure 2-1 shows photos of typical Acrulog and pressure monitoring systems that will be rented from Detection Instruments and installed by HDR in the offsite locations identified above. HDR will need support from the City of Ann Arbor and permission from private/other parties for manhole cover removal and sampling equipment placement. All interested stakeholders are welcomed to observe the sampling and Acrulog placement in the manholes.

Figure 2-1. Acrulog and Pressurization Testing Gear



2.4.1 Offsite Collection System and Surrounding Areas Spring Survey Recommendations and Field Notes

As a follow-up to the February 2019 subjective survey field observations during cold weather and heavy snow, the following were recommendations to be performed during the April 2019 subjective survey. HDR and Bowker and Associates completed the April 2019 subjective survey and the field notes are included with each recommendation.

1. Perform field observation of the WCC lift station. A direct field inspection is recommended during the April 2019 spring sampling trip. If this investigation suggests potential odor impacts caused by this location, then seasonal sampling will be added.
 - o Field notes from April 2019 survey: The WCC lift station in the green space on campus was observed. No odors were present at the time of observation. The WCC sewer manhole at the northwest driveway off East Huron River Dr. was also observed. No odors were observed at this manhole but recommend that this be monitored for H_2S and pressure during the summer as it also receives discharge from the WCC lift station.
2. Perform field observation of the Towsley lift station wet well site. This system feeds to the larger 78-inch Ann Arbor gravity line. A direct field inspection of the wet well and the area where the force main discharges into a manhole on the 18-inch gravity line leading to the 78-inch gravity sewer line is recommended. Again, if this spring inspection indicates potential odor emission issues, this location will be added to the seasonal sampling.
 - o Field notes from April 2019 survey: The Towsley Neighborhood lift station was observed at the wet well. No odors were observed at this pump station. This location will not be sampled.
3. Improved understanding of the exact locations of complaints in and near the St. Joseph Hospital complex. If complaints cluster near collection system locations they will be field inspected and sewer elevation profile views of the system in those locations will be reviewed. This system does not discharge to the Ann Arbor wastewater plant but odor complaints are logged for this general area. The source of

these odor complaints have not been identified and may be from the WWTP or from the Hospital. Therefore, both the City of Ann Arbor sewer system and the St. Joseph Hospital collection systems will be evaluated. If this spring inspection indicates potential odor emission issues then location(s) will be added to the seasonal sampling.

- o Field notes from April 2019 survey: A walking inspection of manholes around the St. Joseph Mercy Ann Arbor Hospital did not identify any noticeable odor source from the hospital collection system. This location will not be sampled.

3 PPE and Safety

Appropriate Personal Protective Equipment (PPE) will be worn when collecting samples including hard hat, chemical resistant safety glasses, reflective vests, hearing protection (if necessary), gloves and appropriate footwear. The sampling team will consist of at least two members (buddy system), one HDR member and Charles Schmidt (CE Schmidt). Some areas may require working around roadways, traffic and open water (i.e., clarifiers). Traffic diversion techniques and equipment will be provided and used by HDR and City of Ann Arbor to ensure sample collection and equipment placement can occur safely. A pre-job briefing will be conducted with City staff knowledgeable about the safety risks before each sample event to evaluate any additional hazards. A post-job brief will be conducted at the end of the entire sample event. The following is a listing information for emergency services:

Emergency phone number: 911

Nearest hospital: St. Joseph Mercy Emergency Room, 3501 McAuley Dr., Ypsilanti, MI 48197

Phone: 734-712-3456

4 Sampling Coordination

Contact information for key personnel involved in the sampling events are as follows:

City of Ann Arbor Contacts

Chris Englert

cenglert@a2gov.org

734-794-6450 ext. 43823

Earl Kenzie

ekenzie@a2gov.org

734-794-6450

Keith Sanders

ksanders@a2gov.org

734-794-6450

HDR Contacts

Josh Prusakiewicz

josh.prusakiewicz@hdrinc.com

734-637-1295

Chris Easter
chris.easter@hdrinc.com
804-615-9572

CE Schmidt Contacts

Charles Schmidt
schmidtce@aol.com
530-529-4256

A City of Ann Arbor representative shall be assigned by the City as the onsite point person for the planning, sampling and coordination of the sampling event. The identified person shall be responsible for helping coordinate access to onsite and offsite sampling areas and answering questions HDR/CE Schmidt have during the onsite sampling events. HDR and CE Schmidt are to take field notes to capture any changes in plant operation that may adversely affect the sampling event such as plant upsets, shutdowns, operational changes, etc. If such a situation occurs, the City, HDR and CE Schmidt will make a decision as to the best path forward.

HDR/CE Schmidt staff performing the sampling shall have access to a location that includes a sink, work area and storage space for equipment and sample bags for the duration of the sampling event. Excess sample volumes shall be disposed of at the direction of onsite personnel.

Sample bags and supplies are to be shipped to the following address:

City of Ann Arbor Wastewater Treatment Plant
Attn: Chris Englert, Senior Utility Engineer
49 Old Dixboro Rd.
Ann Arbor, MI 48105



Appendix C. 10152084-0WW-M0002-Spring Odor Source Sampling Summary, Rev. 0



Technical Memorandum

Document Number: 10152084-0WW-M0002 (Rev. 0)

To: Chris Englert, City of Ann Arbor WWTP
From: Chris Easter, HDR
Josh Prusakiewicz, HDR
CE Schmidt (HDR Sub)
Date: July 10, 2019
Subject: Spring Odor Source Sampling Summary, Rev. 0
City of Ann Arbor WWTP Odor Study

Purpose and Introduction

This memorandum presents the odor source sampling data collected at the Ann Arbor Wastewater Treatment Plant (WWTP) during the spring odor sampling event by HDR and CE Schmidt (team) on April 17, 2019. The sampling performed was a result of the February 2019 odor subjective survey recommendations provided by HDR and Bowker and Associates. The recommendations and subjective survey results can be found in document 10152084-0WW-M0001 – Ann Arbor WWTP Odor Subjective Surveys, Rev. 1.

The spring odor source sampling focused on specific areas within the plant where odor impacts may change during spring and summer months due to changes in biosolids dewatering and disposal approaches. Appendix 1 attached provides a more detailed summary of the sampling from CE Schmidt (HDR's sampling sub-consultant) and includes laboratory reports. Also included in this memorandum is the spring hydrogen sulfide (H_2S) and pressure measurements obtained from four on-site and off-site locations.

Field odor sampling was performed by the team on April 17, 2019. The temperature was approximately 65 degrees F. The plant operations were considered normal. The primary purpose of this spring sampling was to obtain odor source data typical for this time of year when biosolids cake processing and disposal is based on the plant hauling dewatered cake to landfill.

Hydrogen sulfide (H_2S) and pressure monitors were installed at four locations on-site and off-site to obtain measurements from May 7 – 14, 2019. The purpose of this was to see if H_2S was present at the location and to determine if pressurization occurs such that the odor "exhausts" to the atmosphere.

Spring Odor Source Sampling

Detailed field sampling was completed during the April sampling event for H_2S using a Jerome H_2S Analyzer, along with real-time scans for ammonia (NH_3) and amine based odorants where needed. Additionally, Tedlar bag samples were collected for Odor Panel and Gas Chromatograph/Sulfur Chemiluminescence Detection (GC/SCD) analysis.

Odor panel analysis was completed following the ASTM E679 Standard of Practice. The GC analysis following ASTM 5504 included a standardized scan for 20 species of reduced-sulfur



organic odorants often detected from wastewater processes, as well as H_2S . This analysis scanned for the following compounds often present in WWTP applications:

- Hydrogen sulfide
- Carbonyl sulfide
- Methyl mercaptan
- Ethyl mercaptan
- Dimethyl sulfide
- Carbon disulfide
- Isopropyl mercaptan
- tert-Butyl mercaptan
- n-Propyl mercaptan
- Ethyl methyl sulfide
- Thiophene
- Isobutyl mercaptan
- Diethyl sulfide
- n-Butyl mercaptan
- Dimethyl disulfide
- 3-Methylthiophene
- Tetrahydrothiophene
- 2,5-Dimethylthiophene
- 2-Ethylthiophene
- Diethyl disulfide

Table 1 summarizes the sampling results from the Odor Panel Analysis and ASTM GC analysis, as well as field measurements for H_2S and ammonia related odors. Ammonia odors are listed with amines because the field colorimetric tubes cross measure these compounds. The ammonia and amine based odors during this sampling are very likely due to polymer as part of the thickening and dewatering process. Field observations suggest a fishy odor in the processes where ammonia or amines were detected. This is often from the polymer. Data collected during planned sampling this coming summer may show higher ammonia levels once lime slurry addition becomes part of seasonal biosolids processing when the liquid biosolids are hauled for land application. Sampling will be performed to evaluate this ammonia potential to see if it occurs or not.



Table 1: Spring Sampling On-site Odor Source Data Summary from April 17, 2019

Source Location	Ann Arbor Odor D/T	St. Croix Paper D/T ¹	Odor Description	H ₂ S (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
Truck Loading Bay (No truck loading)	19		sour, stale, plastic, swampy	0	ND	ND	0.04	0.13	0.10	Truck bay had not been used for 24 hours
Truck Loading Bay (During active truck loading)	16,575	1,638	sewage, sulfur, garbage, manure, fecal, rotten sludge	3.40	0.80	0.60	ND	0.12	ND	Actively loading cake to truck in closed truck bay. Very odorous. H ₂ S levels approaching OSHA limits
Ammonia Scrubber Inlet			NA						2 (NH ₃)	Only sampled odor NH ₃ in order to check performance
Ammonia Scrubber Outlet			NA						ND (NH ₃)	Only sampled NH ₃ in order to check performance. Data suggests effective removal of low level NH ₃ odors
Carbon Units' Inlet	11,730		feces, rotten sludge, sewage, dirty toilet, outhouse, fecal	0.96	0.25	0.26	0.35	0.03	ND	
Carbon Unit 1 Outlet	82	202	sour, rotten manure, garbage, sewage, rotten sludge, mercaptan	ND	ND	0.12	ND	ND	ND	
Carbon Unit 2 Outlet	45	202	sour, feces, manure, rotten vegetable garbage, rotten mercaptan, rotten spinach, dirty toilet, outhouse	ND	ND	0.07	0.05	ND	ND	
Centrifuge Room Exhaust	19		sour, stale, vegetation, salty, plastic, burning plastic, smoky, burnt	ND	ND	ND	ND	ND	ND	
Upwind	10		sour, stale, plastic, burnt plastic, vegetation mushrooms, salty	ND	ND	ND	ND	ND	ND	
Downwind	17		sour, stale, plastic, vegetation, candle wax	ND	ND	ND	ND	ND	ND	

Note 1: St. Croix published a Water Environment Federation Paper “Odor Threshold Emission Factors for Common WWTP Processes” in April 2008. Data shown in this column is the average D/T from samples that have been collected by St. Croix from WWTP plants across the U.S. and Canada.

Key observations from the spring odor source data include the following:

- Plant upwind and downwind impacts were only slightly different with downwind at 17 DT compared to upwind at 10 DT. While this may suggest a slight contribution to downwind fence line odors from the plant, the difference is minor. All downwind odor compound measurements such as H₂S, methyl mercaptan, dimethyl sulfide and other typical wastewater odors were below detection limits which are in the part per billion (ppb) range. The minor difference in upwind and downwind DT could also be explained in that the downwind on the day of sampling was adjacent to the river on the east corner of the plant. Figure 1 shows the upwind and downwind sampling locations.
 - It should be noted that upwind and downwind sampling was not during the cake truck load out period.

FIGURE 1: UPWIND AND DOWNWIND SAMPLING LOCATIONS AT ANN ARBOR WWTP



- Cake truck bay odors were dramatically higher during the truck bay load out at 16,575 DT. This is higher than typically recorded at other plants and may be due to the cake being septic during sealed cake bin storage. Truck load out lasted approximately 45 minutes.

- o The average odor DT data reported in a St. Croix Odor Lab Paper for truck bays was 1,638 DT with a range of 76 to 65,613 DT. The 75th percentile value was 3,883 DT. So the Ann Arbor data point is higher than average and higher than 75% of the data reported by St. Croix where 23 truck bays were sampled. Field observation during HDR's spring sampling was that the truck bay was very odorous during load out with high levels of H₂S, methyl mercaptan, and dimethyl sulfide odors. Based on the field data, it is recommended that plant staff wear a four-gas meter (detects oxygen, carbon monoxide, hydrogen sulfide, and lower explosive limit) if they are in the truck bay during the loading process.
- The scrubber systems in the dewatering building were performing well.
 - o The water ammonia pre-scrubber was removing all of the 2 ppm ammonia load
 - o The carbon systems were providing over 99% reduction in odor DT with outlets at 45 and 82 DT. Anything below 100 DT would be considered excellent performance for carbon.
 - o The carbon was allowing low level dimethyl sulfide and dimethyl disulfide breakthrough which resulted in the low DT exhaust still being described as rotten manure, rotten vegetables, and sour odors.
- The centrifuge room exhaust was low in odor in terms of DT and detectable reduced sulfur organic compounds with a DT of only 19.

For additional information, please refer to Appendix 1 for CE Schmidt's technical memorandum, data, and lab reports for the April 2019 odor source testing.

Seasonal Sampling at On-site and Offsite Locations

H₂S and pressure monitors were installed by HDR and WWTP staff at four locations on-site and offsite on May 7, 2019. The Acrulog monitors collected one week of field data from May 7 to May 14 which included real-time collection of H₂S, pressure, temperature and humidity in each location. Measurements for both parameters were taken every three minutes during the duration of the testing. The screen and grit building location did not collect pressure data. The Acrulogs were removed after one week and the data collected was downloaded. The following sections provide a summary of each location and the data collected.

Influent Carbon Vent Filter

H₂S and pressure monitors were installed by HDR and WWTP staff in the inlet piping to the carbon vent filter in the structure at the plant entrance. Upon removing the filter from the piping, it was found that a bird had built a nest in the outlet piping of the filter, blocking air flow from properly exiting. During testing, the filter was not connected to the inlet pipe and a blind flange was installed in order to collect pressure measurements. Figure 2 below shows where the H₂S and pressure monitors were installed.

FIGURE 2: CARBON VENT FILTER INLET PIPE



H₂S and pressure monitors were installed here.

During the week, the H₂S measurements in the carbon filter inlet pipe averaged 0.05 ppm, with a maximum reading of 1 ppm. The pressure readings averaged 0.0445 in. H₂O, with a maximum reading of 0.141 in. H₂O. This information indicates that the filter does see positive pressurization nearly all the time and that H₂S is present. Localized odors could therefore be a risk which reinforces the importance and value of the existing carbon system being in place and maintained. During re-installation of the filter, the bird nest was removed and a bird screen was installed on the outlet pipe. Figure 3 below shows the H₂S data and Figure 4 shows the pressure data in blue. Temperature is green, humidity is purple and monitor battery volts is red.



FIGURE 3: H₂S READINGS FOR INFLUENT CARBON VENT FILTER MAY 7-14, 2019

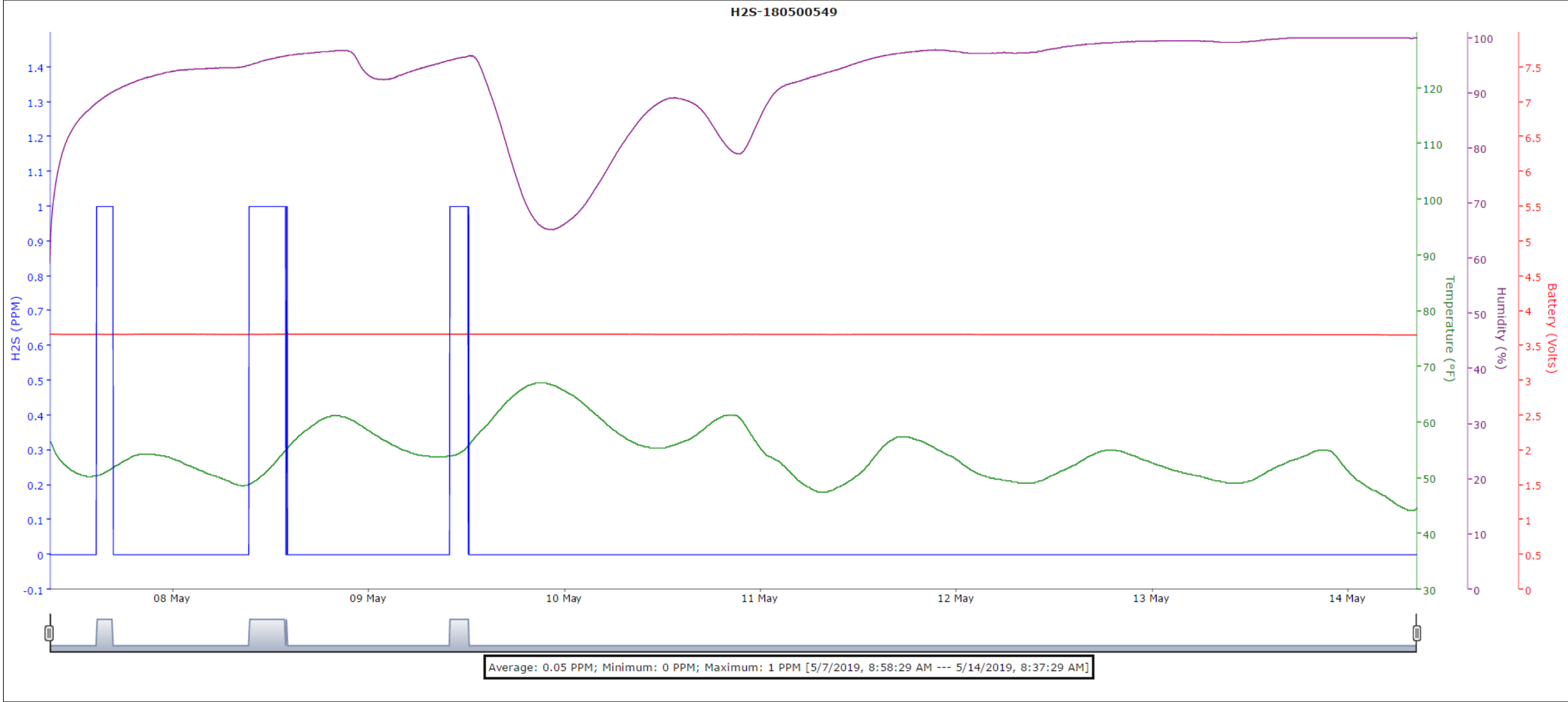
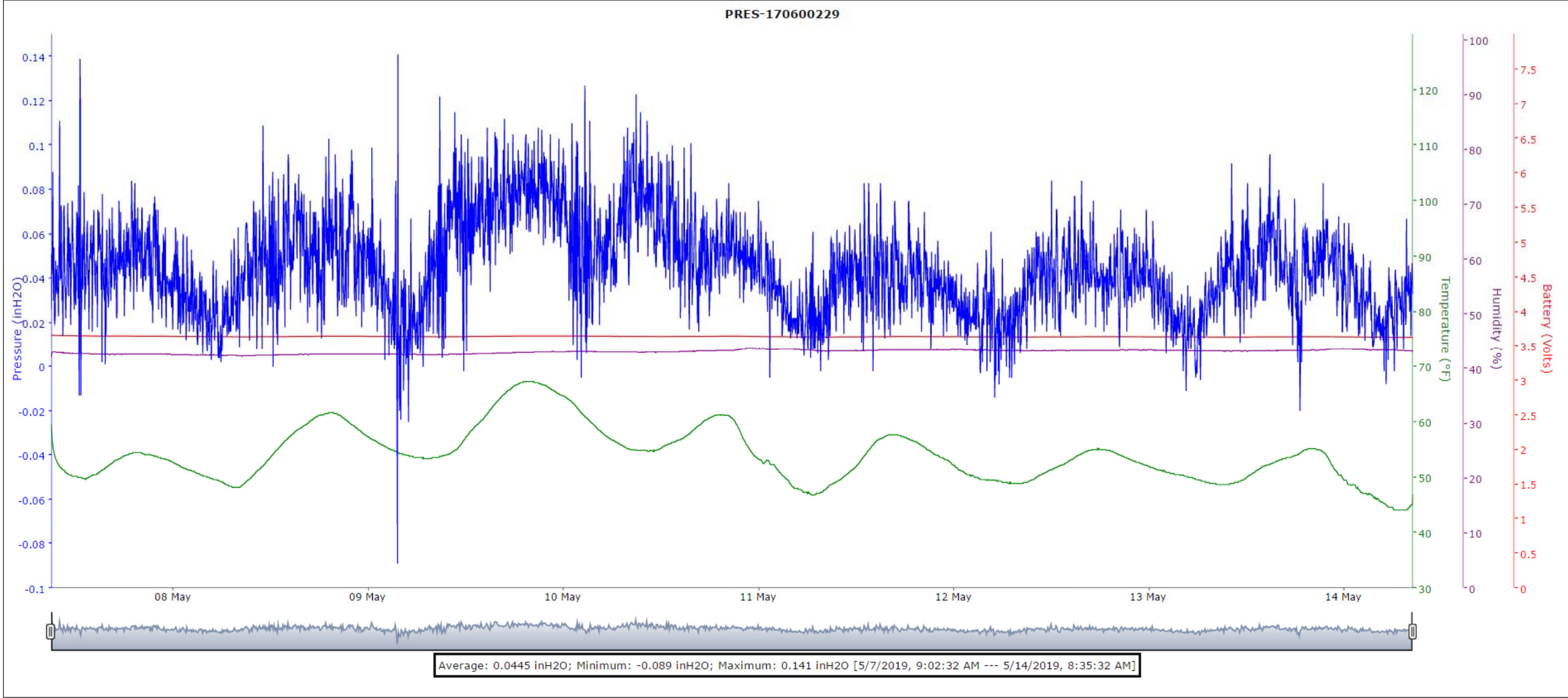




FIGURE 4: PRESSURE READINGS FOR INFLUENT CARBON VENT FILTER MAY 7-14, 2019



Influent Overflow Structure

H₂S and pressure monitors were installed by HDR in the overflow structure at the plant entrance. Figure 5 below shows that the H₂S and pressure monitors were installed on the northeast side of the structure (downstream of the overflow weir). The hatch was then re-installed for the week long testing with the monitors located just below the hatch cover.

FIGURE 5: INFLUENT OVERFLOW STRUCTURE



During the week, the H₂S measurements in the overflow structure averaged 0.06 ppm, with a maximum reading of 3 ppm. The pressure readings averaged 0.0036 in. H₂O, with a maximum reading of 0.2 in. H₂O. This information indicates that the overflow structure does see pressurization and that H₂S is present. This data will be used during follow-up dispersion modeling to determine the risk of off-site odor impacts from this location. Figure 6 below shows the H₂S data and Figure 7 shows the pressure data.

FIGURE 6: H₂S READINGS FOR INFLUENT OVERFLOW STRUCTURE MAY 7-14, 2019

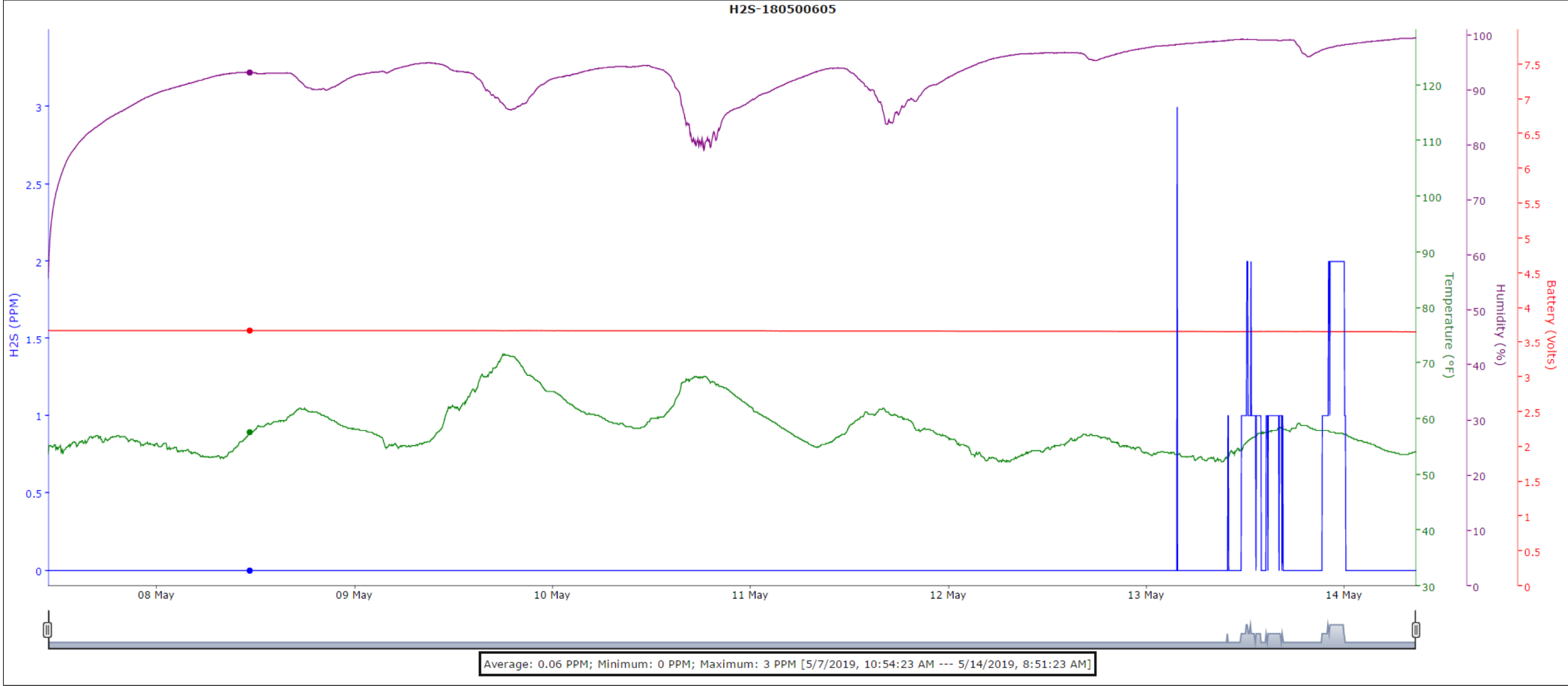
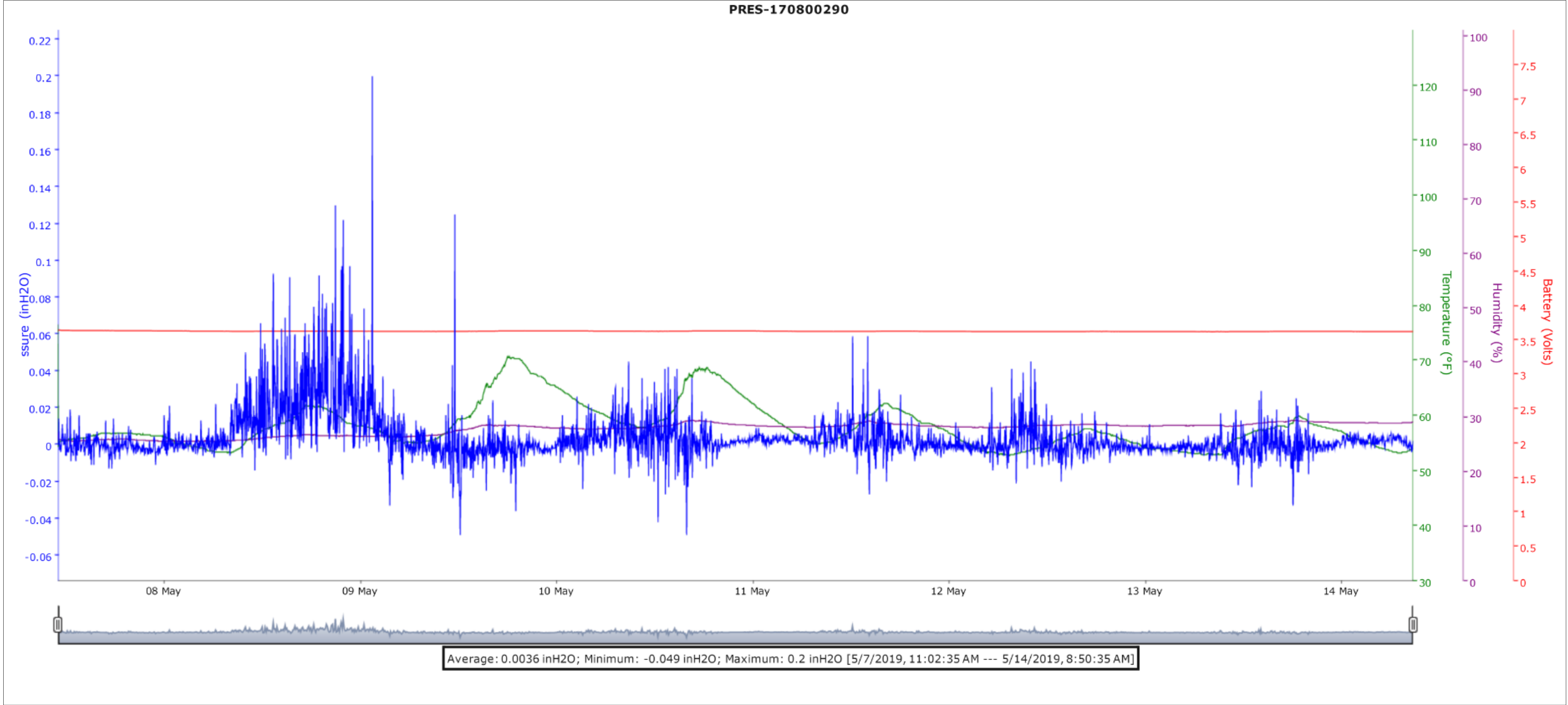




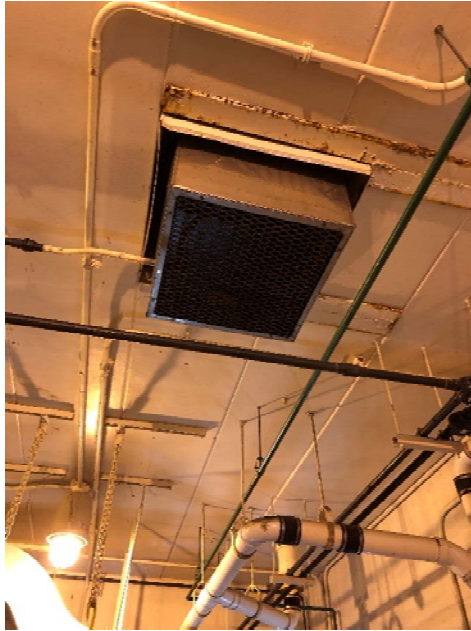
FIGURE 7: PRESSURE READINGS FOR INFLUENT OVERFLOW STRUCTURE MAY 7-14, 2019



Screen and Grit Building

A H₂S monitor was installed by HDR on the inlet of the Screen and Grit Building Exhaust fan RF-25. Figure 8 below shows where the H₂S monitor was installed. The monitor was hung by a piece of rope from the screen.

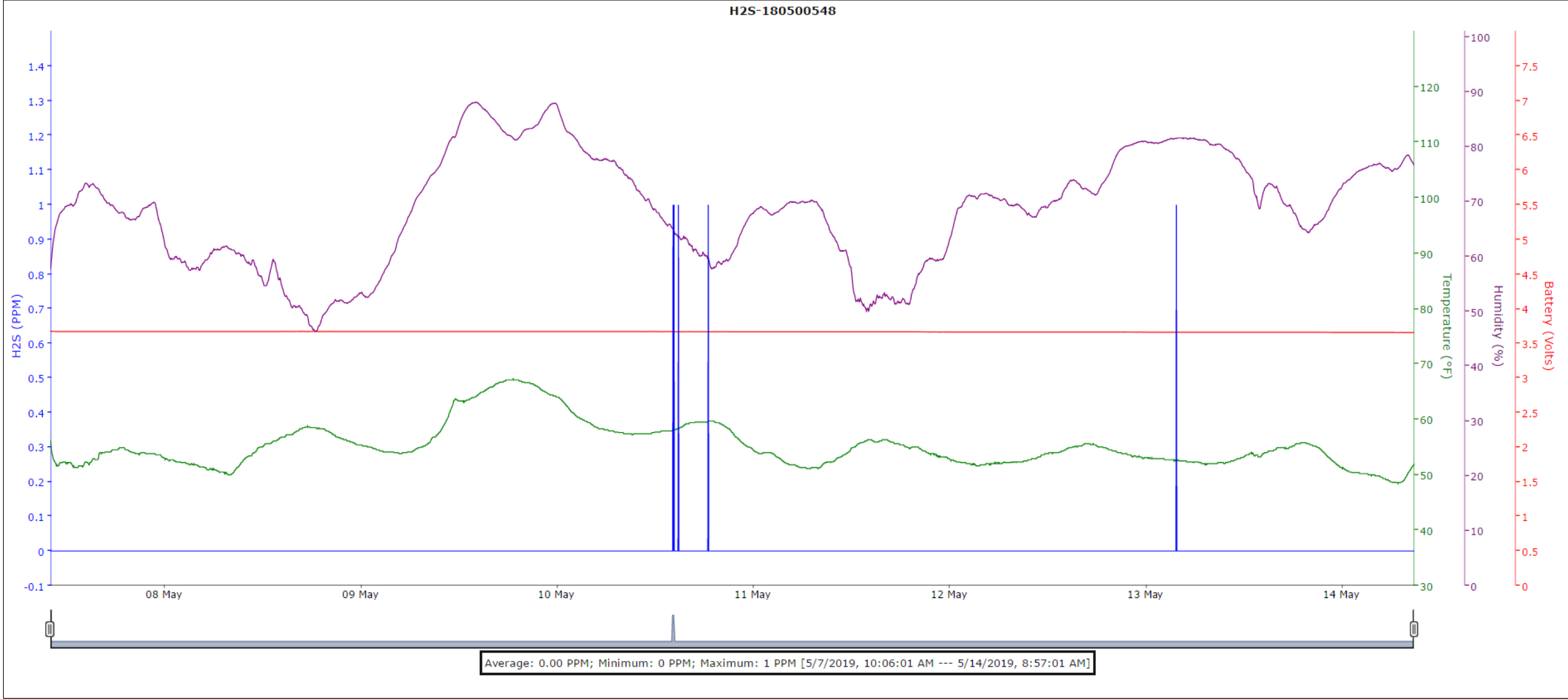
FIGURE 8: INLET OF SCREEN AND GRIT BUILDING EXHAUST FAN RF-25



During the week, the H₂S measurements at the inlet of the fan were typically near 0 ppm, with a maximum reading of 1 ppm. This information indicates that very low H₂S is present. Figure 9 below shows the H₂S data. Pressure measurements were not taken at this location.



FIGURE 9: H₂S READINGS FOR INLET OF SCREEN AND GRIT BUILDING EXHAUST FAN RF-25 MAY 7-14, 2019



A raw water sample was also taken by HDR in the Screen and Grit Building at the screens on May 7, 2019. The liquid phase sulfide level was 0.05 mg/L, pH was 7.72 and the temperature was 25°C. After discussion with WWTP staff, the temperature reading on the instrument was probably inaccurate. It was indicated that temperature is typically around 15°C during the time period when the sample was taken. This liquid sulfide level is low, suggesting that incoming wastewater H₂S odor potential was relatively low during this spring sample event.

Arboretum Manhole

H₂S and pressure monitors were installed by HDR in the Arboretum Manhole by the University of Michigan Hospital. The pick hole for the manhole was open to the atmosphere and was exhausting at the time of installation. Figure 10 below shows where the H₂S and pressure monitors were installed. The manhole cover was then re-installed for the week long testing.

FIGURE 10: ARBORETUM MANHOLE



During the week, the H₂S measurements in the Arboretum Manhole averaged 0.25 ppm, with a maximum reading of 15 ppm. The pressure readings averaged -0.0088 in. H₂O, with a maximum reading of 0.058 in. H₂O. This information indicates that the Arboretum does experience pressure variations ranging from negative to positive and that H₂S is present. Figure 11 below shows the H₂S data and Figure 12 shows the pressure data.



FIGURE 11: H₂S READINGS FOR ARBORETUM MANHOLE MAY 7-14, 2019

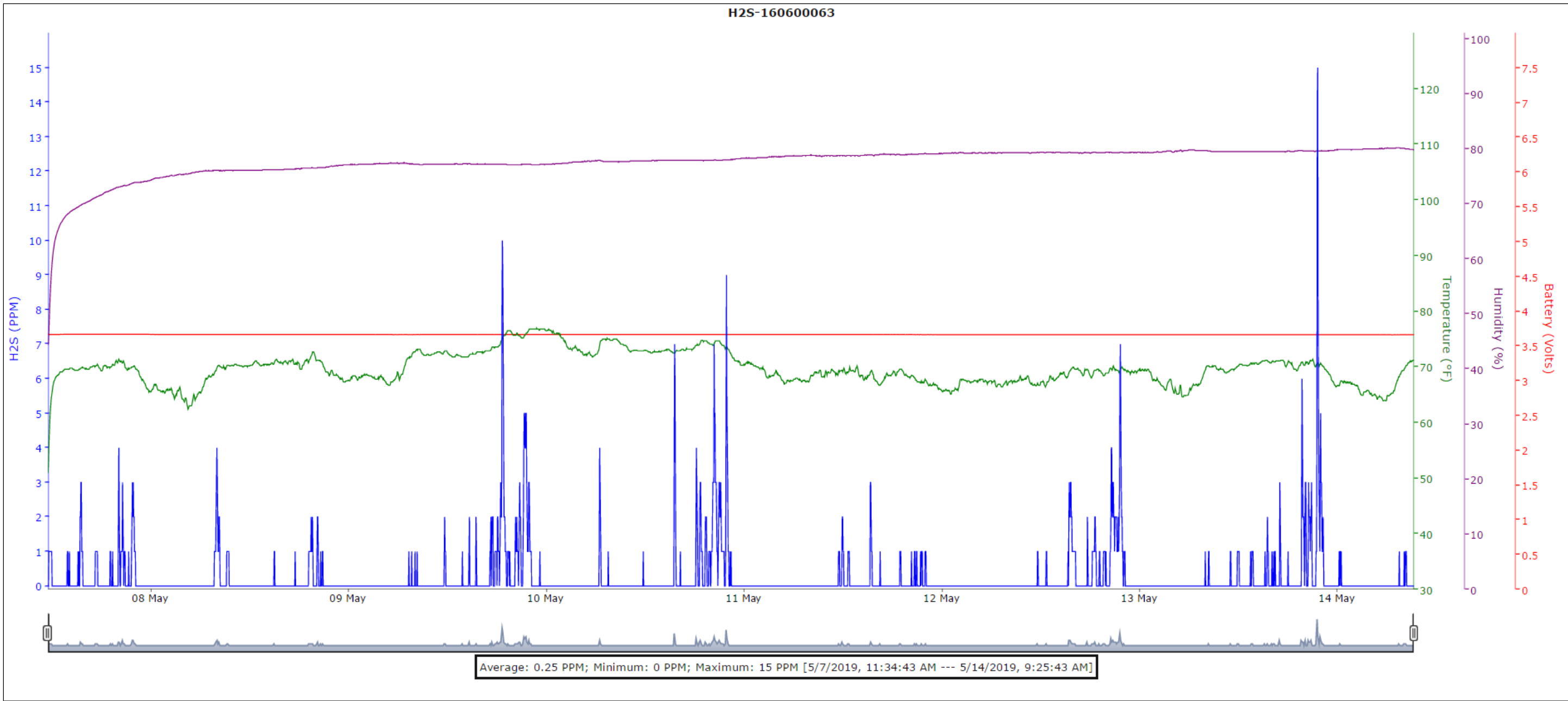
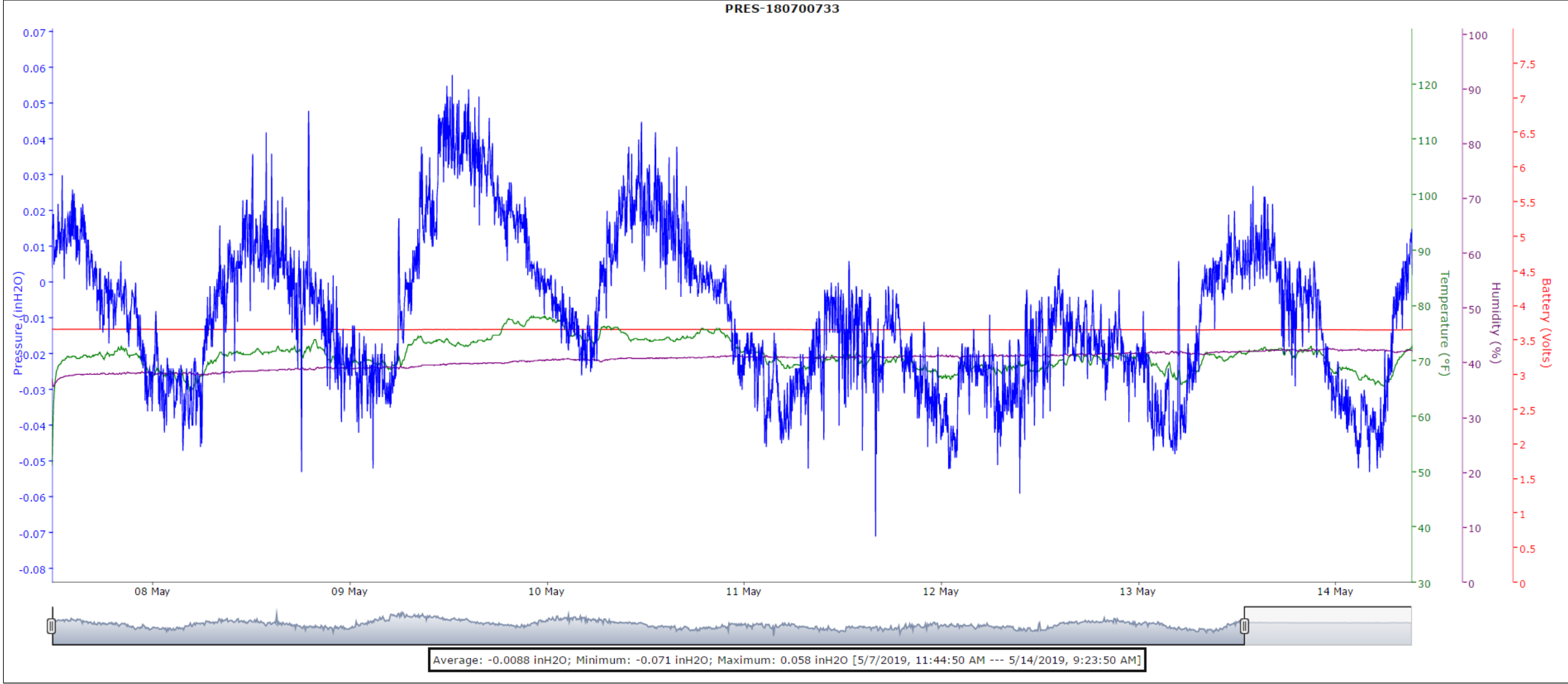




FIGURE 12: PRESSURE READINGS FOR ARBORETUM MANHOLE MAY 7-14, 2019





APPENDIX 1:

CE Schmidt Technical Memo for Ann Arbor WWTP Spring Sampling

CE Schmidt, Ph.D.
Environmental Consultant

May 30, 2019

Mr. Chris Easter
HDR Engineering, Inc.
4880 Sadler Road, Suite 400
Glen Allen, VA 23060

Dear Mr. Easter:

Enclosed please find a copy of the revised Technical Memorandum for the Spring sampling event at the Ann Arbor WWTP conducted last month. Included in the Technical Memorandum are the scanned copies of the field forms, chain-of-custody forms, and lab reports later.

If you have any questions, please feel free to call.

Sincerely,

A handwritten signature in black ink, appearing to read "CE Schmidt", with a long horizontal flourish extending to the right.

CE Schmidt, Ph.D.

Attachments - Technical Memorandum

TECHNICAL MEMORANDUM

Results of the Spring Sampling Event Conducted
At the Ann Arbor WWTP, Ann Arbor, Michigan

Prepared For:

Mr. Chris Easter
HDR Engineering, Inc.
4880 Sadler Road, Suite 400
Glen Allen, VA 23060

Prepared By:

Dr. C.E. Schmidt
Environmental Consultant
19200 Live Oak Road
Red Bluff, California 96080

May 2019

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V. Summary	7

Attachments

A- Emissions Measurement Data Sheets
B- Chain of Custody, Calibration Data, and Certifications
C- Lab Reports

References

EXECUTIVE SUMMARY

This Technical Memorandum documents the field testing activities and the results of the spring screening program conducted with HDR, Inc. at the City of Ann Arbor Wastewater Treatment Plant (WWTP). The testing team consisting of CE Schmidt, Chris Easter, and Josh Prusakiewicz. Testing was conducted on April 17, 2019.

Testing for the spring screening was conducted during typical winter/spring season operations which includes dewatering biosolids and removal off site by loading haul trucks as opposed to summer season removal of liquid biosolids and land application. Planet breeze deodorant was used to reduce the odor source and thus minimize the potential off site odor impact to the surrounding community.

The screening program included collecting ambient air and process air at various locations for odor and odorous compounds in ambient air onsite and onsite process air gas streams. Testing included sampling procedures for air quality including real-time hydrogen sulfide measurement using a Jerome 631X instrument and ammonia/amines using colorimetric detection tubes. Grab samples were collected for olfactory odor analysis by ASTM E-679 and reduced sulfur compounds using USEPA Method TO-15 (GC/FPD detector). Not all species were monitored at all locations. These activities were conducted by HDR, Inc.

There primary goals of the project were to:

- 1) Collect source data on odor and odorant compound concentrations in the solids handling building before and during biosolids truck loading;
- 2) Collect source data on odor and odorant concentrations in the centrifuge room;
- 3) Collect source data on the efficiency of the carbon filters in the dewatering building;
- 4) Collect source data on the efficiency of the ammonia scrubber in the dewatering building; and
- 5) Determine the air quality upwind and downwind of the WWTP

In total, 12 screening activities were performed and nine (9) sets of grab samples for odor and reduced sulfur species were performed including quality control testing as described below.

DATE	TIME	SOURCE
4/17/2019	721	Truck Loading Bay- No Truck
4/17/2019	832	Ammonia Scrubber Exhaust
4/17/2019	835	Ammonia Scrubber Inlet- NH3 Only
4/17/2019	837	Ammonia Scrubber Inlet- Amines Only
4/17/2019	939	Ambient Air Downwind of WWTP
4/17/2019	958	Truck Loading Bay- Truck Loading
4/17/2019	1016	Ambient Air Upwind of WWTP
4/17/2019	1046	Inlet To Carbon Filters; Common Line

DATE	TIME	SOURCE
4/17/2019	1106	Carbon Filter Outlet Unit 1, South
4/17/2019	1133	Carbon Filter Outlet Unit 2, Middle
4/17/2019	1150	Centrifuge Room Exhaust
4/17/2019	1215	Media Blank

This Technical Memorandum documents the testing that was performed, comments on the quality control data collected, and reports the results of the assessment. These screening data reported for process gas streams, along with process flow data, can be used to estimate air emissions of study compounds from those processes tested.

I. INTRODUCTION

This technical memorandum describes the field testing that was conducted in order to assess the air quality and air emissions of odor and odorous compounds from key process and key locations on and around the WWTP. A spring-time screening event was conducted with HDR, Inc. at the City of Ann Arbor WWTP located in Ann Arbor, Michigan. The testing team consisting of CE Schmidt, Chris Easter, and Josh Prusakiewicz. Testing was conducted on April 17th, 2019. A site visit was also performed for the up-coming summer testing event. The screening activity included assessing odor and odorous compound sources and ambient air from key processes and locations on the facility and upwind and downwind of the facility.

This memorandum includes a discussion of the testing methodology, quality control procedures, results, discussion of the results, and summary statements. The actual site emissions estimates and control efficiency calculations are reported elsewhere.

II. TEST METHODOLOGY

The spring screening event included:

- 1) Sampling process ambient air or room air for ammonia and amine compounds using color detection tubes;
- 2) Sampling process gas or room air for hydrogen sulfide using a real time Jerome 631X hydrogen sulfide analyzer;
- 3) Collecting process gas, room air, or ambient air in Tedlar bags for olfactory odor analysis using ASTM Method E-679; and
- 4) Collecting process gas, room air or ambient air in Tedlar bags for reduced sulfur species using USEPA Method TO-15 (GC/FPD)

Grab samples for real time screening (colorimetric tube detection and hydrogen sulfide field instrument) were performed by sampling ambient air outdoors, in rooms, or through ports in process duct work. Likewise, grab samples were collected in Tedlar bags for offsite analysis from ambient air, room air, or process air using a decompression lung device. All grab samples collected for offsite analysis were logged in on chain-of-custody sheets, sealed in shipping containers, and shipped to the laboratories for next day delivery and analysis.

III. QUALITY CONTROL

The application and frequency of the project Quality Control procedures were developed to meet the program data quality objectives and were executed without exception.

Field Documentation – A field notebook containing data forms, including sample chain-of-custody (COC) forms, was maintained for the testing program. Attachment A contains the Screening Data Forms.

Chain-of-Custody – COC forms were used for field data collection. Field data were recorded on the Chain-of-Custody forms provided in Attachment B.

ASTM E679 for Olfactory Odor

Method Quality Control – All method QC testing as indicated by the laboratory was within method specifications, and these data indicate acceptable method performance.

Field System Blank – One media (field) blank sample (O-009) was analyzed as a blind QC sample. The blank level was 23 DT, which is a bit high for this laboratory and typical blank levels. Upwind and downwind odor levels were lower than the blank level (upwind 10 DT, downwind 17 DT). These data indicate that the sample or the analysis of the blank sample was not representative of typical blank levels. A typical blank level for this analysis at this laboratory is between 7-to-10 DT. One consideration given these data is to discount those sample results below 23 DT, although this is not recommended. It is more likely that this sample was contaminated or experienced a problem during analysis.

Method Precision – Replicate samples were not collected for the screening activity thus no statement can be made regarding method precision.

USEPA Method TO-15 for Hydrogen Sulfide and Speciated Sulfur Compounds

Method Quality Control – All method QC testing as indicated by the laboratory was within method specifications, and these data indicate acceptable method performance.

Laboratory Method Blank Sample – One method blank sample was performed by the laboratory. No compounds were detected in the blank sample above method reporting limits (see Table 1) which varied per compound. Twenty compounds were included in the analysis. These data indicate acceptable method performance.

Laboratory Control Recovery Analysis Sample – One laboratory QC sample was analyzed in replicate for accuracy and precision. The standard sample was recovered within the QC limits ranging from 97%-to-114%, and the sample precision was within relative standard deviation for all 20 compounds. These data indicate acceptable performance for reduced sulfur compounds.

IV. RESULTS AND DISCUSSIONS

A summary of the field sample collection for the spring screening activity along with the results of the odor analysis as reported by the laboratory are provided in Table 1. All field data for the screening activity are reported on Table 1 or on the Screening Data Forms. Reduced sulfur data reported in concentration units are found on Table 2.

The upwind and downwind odor and reduced sulfur compound air quality showed little difference. For both upwind and downwind, the reduced sulfur compound data were non-detect. The odor concentration data upwind of the facility had an odor concentration of 10 DT and the downwind odor concentration was 17 DT showing a potential of offsite odor. Winds were light and dispersion conditions were good, and the odor descriptions for both the upwind and downwind samples were typical of vegetation and the nearby river but not that of sewage or fecal matter.

Testing in the truck loading bay in the dewatering building just prior to loading had an odor level of 19 DT (low) and a level of 16,575 DT (high) during loading which is impressive. High levels of hydrogen sulfide, carbonyl sulfide, methyl mercaptan, and dimethyl sulfide were measured during the truck loading supporting the high olfactory odor levels. The truck bay doors were closed during loading. It is likely that the loading of the dewatered biosolids is one of the high odor sources onsite during the winter/spring season when solids are dewatered as opposed to other biosolids management practice.

Based on the screening of ammonia and amines using colorimetric tube detection, the ammonia scrubber in the dewatering building showed good removal of ammonia and amines. No odor samples were collected from the ammonia scrubber. Control efficiencies can be calculated along with emission rate data for odor and species knowing the flow from the ammonia scrubber.

The inlet to the carbon filters in the dewatering building showed high odor (11,730 DT) and reduced sulfur species concentration of hydrogen sulfide, carbonyl sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide. The carbon filters demonstrated good removal of odor and reduced sulfur species by showing very low odor levels in both outlets tested (45 DT-to-85 DT) and low reduced sulfur species concentrations as well (non-detect for sulfur species except for low levels of dimethyl sulfide and dimethyl disulfide in one outlet). Control efficiencies can be calculated along with emission rate data for odor and species knowing the flow from the carbon filters.

The exhaust room air from the centrifuge room in the dewatering building showed odor concentration levels similar to the truck loading bay room prior to loading at 19 DT. The truck loading sample was taken during loading around 10:00 am and the centrifuge room air sample was taken around 2:00 pm; these rooms may exchange room air. It is likely that once the trucks are loaded and removed that the room ventilation is such that the greater room air odor levels drop down to a relatively low odor concentration and remains there during winter/spring season operational activities.

V. SUMMARY

A spring season screening activity was conducted at that City of Ann Arbor WWTP in April of 2019. Odor sources were investigated by collecting ambient air or process air gas samples where both field and laboratory methods were used to assess odor and odor species levels. Testing was conducted for the purpose of generating a data base for understanding odor sources, potential ambient air impacts from odor sources, and for planning purposes supporting future sampling events. The following is a summary of activities and results associated with this objective:

- Screening level odor and odor species sampling was conducted using standard sampling methods and laboratory methods to better understand odor sources and their potential impacts offsite in the surrounding community.
- Field and laboratory quality control data indicate acceptable data quality for ASTM E679 (olfactory odor) and USEPA Method TO-15 for speciated reduced sulfur compounds. The method blank level for the odor sample was higher than typical method blank levels. No clear reason for this was determined.
- These screening-level field and laboratory data can be used to satisfy the program objectives. Emission rate data using these process exhaust concentration data are reported elsewhere.

REFERENCES

- 1) Chris Easter, HDR. City of Ann Arbor WWTP Sampling Plan, 2019.

ATTACHMENT A

EMISSION MEASUREMENT DATA SHEETS

Table 1. Spring Sampling Event; Ann Arbor WWTP, April 17, 2019.

DATE	TIME	SOURCE	NH3 T	Amine T	H2S	Odor	TRS	ODOR	ODOR	ODOR	ODOR CHARACTER	COMMENT
			(ppmv)	(ppmv)	(ppmv)	ID	ID	DT	SL a	SL a		
4/17/2019	721	Truck Loading Bay- No Truck	0.1	ND	0.002/0.004	O-001	S-001	19	0.63	0.77	sour, stale, plastic, vegetation, swampy	Truck Bay unused for 24 hours
4/17/2019	832	Ammonia Scrubber Exhaust	ND	ND	NA	NA	NA	NA	NA	NA	NA	
4/17/2019	835	Ammonia Scrubber Inlet- N3 Only	2	NA	NA	NA	NA	NA	NA	NA	NA	
4/17/2019	837	Ammonia Scrubber Inlet- Amines Only	NA	1.5	NA	NA	NA	NA	NA	NA	NA	
4/17/2019	939	Ambient Air Downwind of WWTP	NA	NA	0.002/0.002	O-002	S-002	17	0.59	0.86	sour, stale, plastic, vegetation, candle wax	Half way between front gate and pump shed, 2-5 mph; easterly flow
4/17/2019	958	Truck Loading Bay- Truck Loading	ND	ND	5.3	O-003	S-003	16,575	0.60	0.71	sewage, sulfur, garbage, manure, fecal, rotten sludge	H2S at 2.5 ppmv soon after start, 6.9 max, 4.4 ppmv as sample collected
4/17/2019	1016	Ambient Air Upwind of WWTP	NA	NA	0.002/0.002	O-004	S-004	10	LOW	LOW	sour, stale, plastic, burnt plastic, vegetation mushrooms, salty	East end of WWTP at tree line near river, 1-2 mph; easterly flow
4/17/2019	1046	Inlet To Carbon Filters; Common Line	ND	ND	3.9/3.7	O-005	S-005	11,730	0.51	0.78	feces, rotten sludge, sewage, dirty toilet, outhouse, fecal	
4/17/2019	1106	Carbon Filter Outlet Unit 1, South	0.1	0.2/0.3	0.023/0.022	O-006	S-006	82	0.59	0.72	sour, rotten manure, garbage, sewage, rotten sludge, mercaptan	
4/17/2019	1133	Carbon Filter Outlet Unit 2, Middle	ND	ND	0.016/0.016	O-007	S-007	45	0.67	0.73	sour, feces, manure, rotten vegetable garbage, rotten mercaptan, rotten spinach, dirty toilet, outhouse	
4/17/2019	1150	Centrifuge Room Exhaust	ND	ND	0.003/0.003	O-008	S-008	19	0.63	0.73	sour, stale, vegetation, salty, plastic, burning plastic, smoky, burnt	Center of retangular exhaust screen
4/17/2019	1215	Media Blank	NA	NA	NA	O-009	S-009	23	0.55	0.78	fresh cut wood, wood chips, pencil lead, plastic, musty, vegetation	Ultra high purity air; <0.01 ppmv hydrocarbon content

ND- Not detected
NA- not applicable
NH3 T- ammonia tube
Amine T- amine tube
H2S- hydrogen sulfide by Jerone 631X instrument
SLa/SLb- Steven's Law Contants

Table 2. Summary of Reduced Sulfur Species Concentration Data.

SOURCE	H2S-F	TRS	H2S	H2S	CS	CS	MM	MM	EM	EM	DMS	DMS	CDS	CDS	iPM	iPM	EMS
	(ppmv)	ID	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)
Truck Loading Bay- No Truck	0.002/0.004	S-001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia Scrubber Exhaust	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonia Scrubber Inlet- N3 Only	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonia Scrubber Inlet- Amines Only	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ambient Air Downwind of WWTP	0.002/0.002	S-002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Truck Loading Bay- Truck Loading	5.3	S-003	3,356.3	4,687.8	117.1	288.4	794.5	1,566.6	ND	ND	585.6	1,491.0	ND	ND	ND	ND	ND
Ambient Air Upwind of WWTP	0.002/0.002	S-004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inlet To Carbon Filters; Common Line	3.9/3.7	S-005	962.4	1,344.20	28.3 J	69.6 J	249.9	492.7	ND	ND	262.1	667.3	ND	ND	ND	ND	ND
Carbon Filter Outlet Unit 1, South	0.023/0.022	S-006	ND	ND	ND	ND	ND	ND	ND	ND	122.5	312.0	ND	ND	ND	ND	ND
Carbon Filter Outlet Unit 2, Middle	0.016/0.016	S-007	ND	ND	ND	ND	ND	ND	ND	ND	69.1	175.9	ND	ND	ND	ND	ND
Centrifuge Room Exhaust	0.003/0.003	S-008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Media Blank	NA	S-009	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lab Blank	NA	Lab	<16.2	<22.6	<9.7	<23.9	<16.2	<31.9	<17.1	<43.2	<17.8	<45.3	<18.4	<57.3	<17.1	<53.5	<17.1

H2S-F- Hydrogen sulfide measured with field analyzer

H2S- Hydrogen sulfide

CS- Carbonyl sulfide

MM- Methyl mercaptan

EM- Ethyl mercaptan

DMS- Dimethyl sulfide

CDS- Carbon disulfide

iPM- i-Propyl Mercaptan

EMS- Ethyl methyl sulfide

nPM- n-Propyl mercaptan

Thio- Thiophene

IBM- Isobutyl mercaptan

DES- Diethyl sulfide

tBM- t-Butyl mercaptan

nBM- n-Butyl mercaptan

DMDS- Dimethyldisulfide

3MT- 3-Methylthiophene

THT- Tetrahydrothiophene

2,5-DMT- 2,5-Dimethylthiophene

DEDS- Diethyldisulfide

2ET- 2-Ethylthiophene

J- value estimated, below reporting limit

Table 2. Summary of Reduced Sulfur Species Concentration Data.

ems	nPM	nPM	Thio	Thio	IBM	IBM	DES	DES	iBM	iBM	nBM	nBM	DMDS	DMDS	3MThio	3MThio	THT	THT	2,5-DMT	2,5-DMT
(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)	(ppbv)	(ug/m3)
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	345.8	1,335.0	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	46.1 J	178.1 J	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
<63.4	<17.2	<53.6	<18.3	<63.1	<17.7	<65.5	<16.8	<62.1	<17.2	<63.5	<17.2	<63.5	<18.1	<69.8	<17.6	<70.7	<17.2	<62.2	<19.0	<87.3

Table 2. Summary of Reduced Sulfur Species Concentration Data.

DEDS	DEDS	2ET	2ET
(ppbv)	(ug/m3)	(ppbv)	(ug/m3)
ND	ND	ND	ND
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
<17.6	<80.9	<17.3	<86.6

SURFACE SCREENING DATA FORM

DATE 4/17/19 SAMPLERS CBS/JP/CB

LOCATION TRUCK UNLOADING - NO TRUCK

SURFACE DESCRIPTION SOUTH EXHAUST FAN

CURRENT ACTIVITY _____

INSTRUMENT TYPE 631X I.D. NO. 631-1021 TYPE _____ ID No. _____ FACTORY CALIB

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT BASELINE DATA _____

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AMBIENT CONCENTRATIONS _____

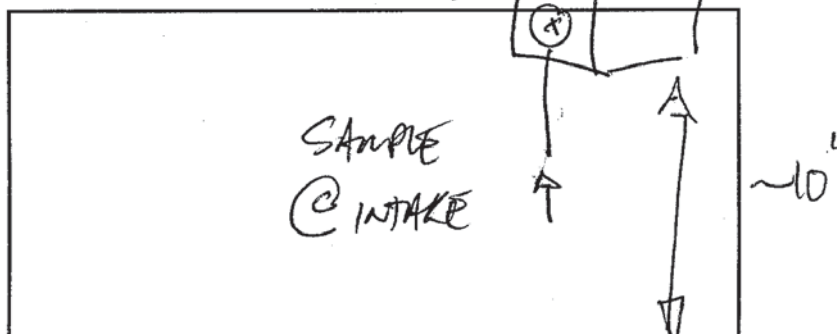
PHOTO TAKEN: Yes ☒ No ☐ _____

AMBIENT CONDITIONS: Sun ☐ P.Sun ☐ Cloudy ☒ Wind at 5', _____ mph Wind at Seal, _____ mph LIGHT WINDS 0-2 MPH
TEMP _____ RAIN: Yes ☐ No ☒ Comment _____

TIME	LOCATION	READING	READING	READING	COMMENT
	ID	(H ₂ S)	(NH ₃)	(AMINES)	
0721	EXH. FAN	ppmv	ppmv	ppmv	0-001
0724	4				S-001
0726		0.002			
		0.004			
0732			0.1	ND	SLIGHT COLOR CHANGE NO COLOR CHANGE

COMMENTS:

SITE DIAGRAM:



DATE 7/17/19 SAMPLERS CS HPLC

LOCATION AMMAN, JORDAN

SURFACE DESCRIPTION 10/10

CURRENT ACTIVITY _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT BASELINE DATA

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AMBIENT CONCENTRATIONS _____

PHOTO TAKEN: Yes ☒, No ☐ _____

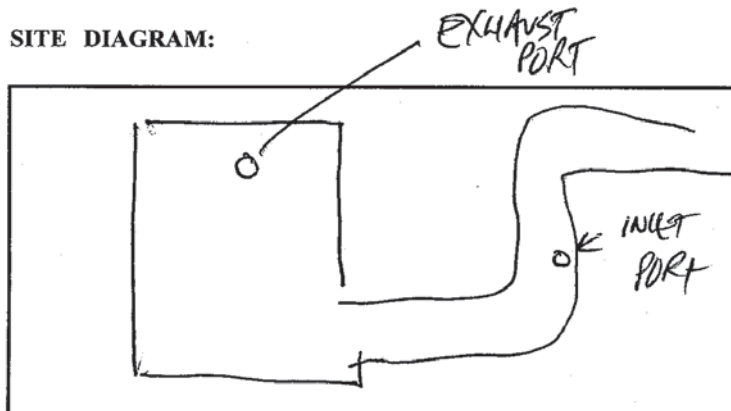
AMBIENT CONDITIONS: Sun ☐ P.Sun ☐ Cloudy ☐ Wind at 5', ____ mph Wind at Seal, ____ mph

TEMP _____ RAIN: Yes ☐ No ☐ Comment _____

TIME	LOCATION ID	READING (NA)	READING (WHz)	READING (AMINUS)	COMMENT
					NHx
0832	SLRUB EXHAUST		ND	ND	NEG FLOW) EXHAUST
0835	TVES	NA	2 PPM	—	POSITIVE FLOW) INLET
0837		NA	—	1.5 PPM	")

COMMENTS:

SITE DIAGRAM:



DATE 11/1/11 SAMPLERS AS/PL

LOCATION DOWNWIND OF WWF

SURFACE DESCRIPTION

CURRENT ACTIVITY

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT BASELINE DATA

INSTRUMENT CALIBRATION/ QC: ZERO ____ BLANK ____ SPAN ____ PRE CHECK ____ POST CHECK ____

AMBIENT CONCENTRATIONS

PHOTO TAKEN: Yes ☐ No ☐ _____

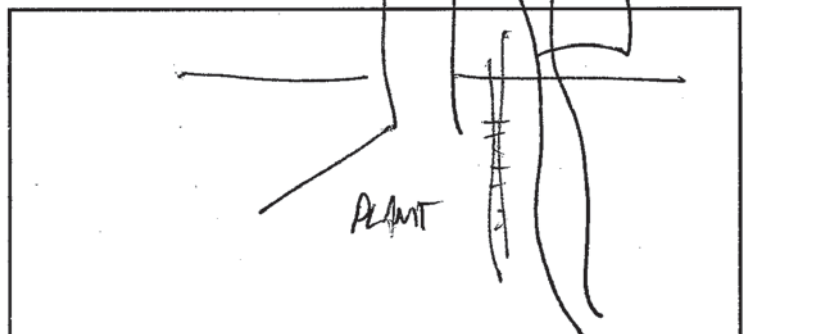
AMBIENT CONDITIONS: Sun ☐ P.Sun ☐ Cloudy ☐ Wind at 5', mph Wind at Seal, mph

TEMP _____ **RAIN:** Yes ☐ No ☐ **Comment** _____

[illegible]

COMMENTS:

SITE DIAGRAM:



SURFACE SCREENING DATA FORM

DATE 4/17/19 SAMPLERS CEB/JP/CE

LOCATION TRUCK LOADING

SURFACE DESCRIPTION _____

CURRENT ACTIVITY _____

INSTRUMENT TYPE 631 X I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT BASELINE DATA _____

INSTRUMENT CALIBRATION/ QC: ZERO ☒ BLANK _____ SPAN _____ PRE CHECK ☒ POST CHECK _____
 AMBIENT CONCENTRATIONS _____

PHOTO TAKEN: Yes ☒ No ☐ _____

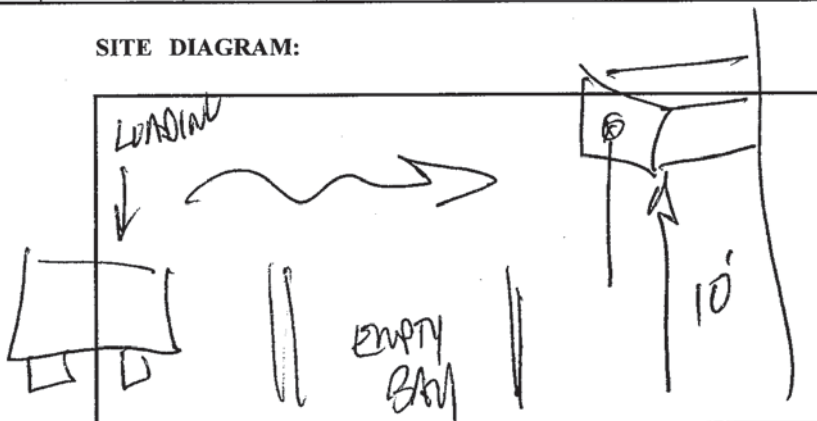
AMBIENT CONDITIONS: Sun ☐ P.Sun ☐ Cloudy ☐ Wind at 5', _____ mph Wind at Seal, _____ mph
 TEMP _____ RAIN: Yes ☐ No ☐ Comment _____

TIME	LOCATION	READING	READING	READING	COMMENT
	ID	(H ₂)	(NH ₃)	(AMINE)	
0948	START	2.5 AMU			SCREEN GROUPE
		4.6			(PURGED LINE)
		6.9			
0952		5.3			
0958	S-003 0-003				START OK
1002	S-003	4.4			
		4.4			
1003	AMINE NH ₃		ND		ND BOTH
1000	AMINES		-	ND	

TRUCK
LOADING
+
RAKING

COMMENTS:

SITE DIAGRAM:



SURFACE SCREENING DATA FORM

DATE 4/17/19 SAMPLERS CS/JP/CE

LOCATION UPWIND OF LWTP

SURFACE DESCRIPTION _____

INSTRUMENT TYPE 631X I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT BASELINE DATA

INSTRUMENT CALIBRATION/ QC: ZERO _____ BLANK _____ SPAN _____ PRE CHECK _____ POST CHECK _____

AMBIENT CONCENTRATIONS

PHOTO TAKEN: Yes ☐ No ☐ _____

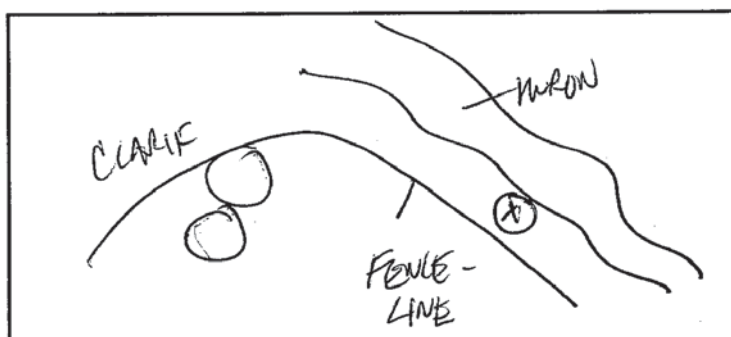
AMBIENT CONDITIONS: Sun ☐ P.Sun ☒ Cloudy ☐ Wind at 5', ___ mph Wind at Seal, ___ mph

TEMP _____ RAIN: Yes ☐ No ☒ Comment _____

[illegible]

E

LN



DATE 7/1/77 SAMPLERS W/S/W

LOCATION INLET TO CHESAN LAKE

SURFACE DESCRIPTION Common (Only 1) Intel P40

CURRENT ACTIVITY

INSTRUMENT TYPE 031X I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT BASELINE DATA

INSTRUMENT CALIBRATION/ OC: ZERO BLANK SPAN PRE CHECK _____ POST CHECK _____

AMBIENT CONCENTRATIONS

PHOTO TAKEN: Yes ☐ No ☐ _____

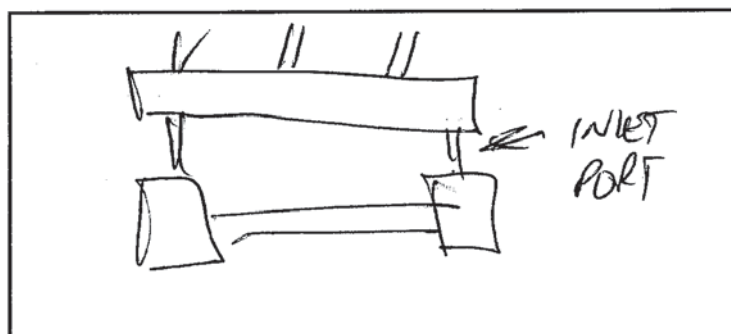
IN BLDG

AMBIENT CONDITIONS: Sun ☐ P.Sun ☐ Cloudy ☐ Wind at 5', ___ mph Wind at Seal, ___ mph

TEMP _____ RAIN: Yes ☐ No ☐ Comment _____

[illegible]

SITE DIAGRAM: 3 2



SURFACE SCREENING DATA FORM

DATE 4/17/19 SAMPLERS CBS

LOCATION CARBON FILTER OUTLET - STACK/UNIT #1 SOUTH

SURFACE DESCRIPTION _____

INSTRUMENT TYPE U31X I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT CALIBRATION/ QC: ZERO ____ BLANK ____ SPAN ____ PRE CHECK ____ POST CHECK ____
AMBIENT CONCENTRATIONS

PHOTO TAKEN: Yes ☒ No ☐ _____

PHOTO TAKEN: Yes ☒ No ☐

AMBIENT CONDITIONS: Sun ☐ P.Sun ☒ Cloudy ☐ Wind at 5', 2-5 mph Wind at Seal, mph

TEMP RAIN: Yes ☐ No ☐ Comment

[illegible]

A hand-drawn diagram showing a vertical stack of three circles. The bottom circle is labeled "South" and has an arrow pointing to it from the right.

SITE DIAGRAM:

A hand-drawn site diagram within a rectangular frame. It depicts a vertical structure with several arrows: one pointing up from the top, one pointing left from the middle, and one pointing right from the bottom. To the right of the structure, the text '~4' OFF ROOF' is written.

SURFACE SCREENING DATA FORM

DATE 4/17/19 SAMPLERS CS/JP/CE

LOCATION CARB FILTER OUTLET STACK #2

SURFACE DESCRIPTION _____

CURRENT ACTIVITY _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT BASELINE DATA _____

INSTRUMENT CALIBRATION/ QC: ZERO ☒ BLANK _____ SPAN _____ PRE CHECK ☒ POST CHECK _____

AMBIENT CONCENTRATIONS _____

PHOTO TAKEN: Yes ☒ No ☐ _____

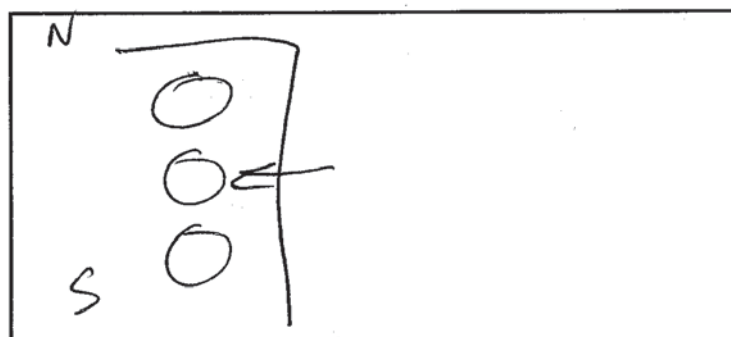
AMBIENT CONDITIONS: Sun ☐ P.Sun ☒ Cloudy ☐ Wind at 5', 2-5 mph Wind at Seal, _____ mph

TEMP _____ RAIN: Yes ☐ No ☒ Comment _____

TIME	LOCATION	READING	READING	READING	COMMENT
	ID	(H ₂ S)	(NH ₃)	(AMINE)	
		ppm	ppm	ppm	
1124		0.016			
		0.016			
1133	O-007				
1135	S-007				
1140			ND	—	NO TRACE
			—	NO	NO COLOR CHANGE
1143					

COMMENTS:

SITE DIAGRAM:



DATE 7/17/11 SAMPLERS 25/1/11
LOCATION CENTRIFUGE ROOM EXHAUST
SURFACE DESCRIPTION

INSTRUMENT TYPE 1031X I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ I.D. NO. _____ TYPE _____ ID No. _____

INSTRUMENT TYPE _____ **I.D. NO.** _____ **TYPE** _____ **ID No.** _____

INSTRUMENT BASELINE DATA

INSTRUMENT CALIBRATION/ QC: ZERO ☒ BLANK ☐ SPAN ☐ PRE CHECK ☒ POST CHECK ☐
AMBIENT CONCENTRATIONS

PHOTO TAKEN: Yes ☒ No ☐ _____

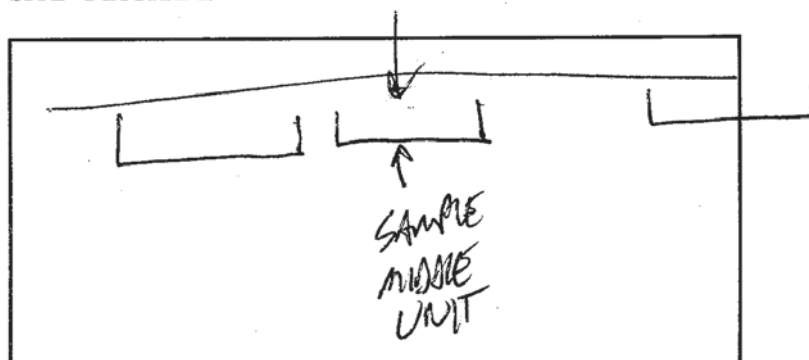
AMBIENT CONDITIONS: Sun ☐ P.Sun ☐ Cloudy ☒ Wind at 5', ___ mph Wind at Seal, ___ mph
TEMP ☐ **RAIN:** Yes ☐ No ☒ Comment _____

[illegible]

COMMENTS:

UGRA

SITE DIAGRAM:



ATTACHMENT B

CHAIN OF CUSTODY
CALIBRATION DATA
CERTIFICATIONS

05/18

ENVIRONMENTAL

Analytical Service, Inc.

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

CHAIN OF CUSTODY RECORD

Project Number		Project Name		Quote		Requested TAT	
REPORT TO:		Matrix		SDG		Analytical Tests	
Attention		A - Ambient Air					
Company		SG - Soil Gas					
Address		S - Source					
City, State, Zip		I - Indoor Air					
Phone/Fax							
e-mail							
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Laboratory ID
0-001	4/17/14	0721					
0-002		0924	0443	0939			
0-003		1003	0958				
0-004		1016					
0-005		1016					
0-006		1106					
0-007		1135	1133				
0-008		1150					
Comments 0-009 ↓ 211							
BILLING INFORMATION:							
ATTENTION	SAMPLED BY		Date/Time		COC Number		
Company			4/17/14		Cooler Temp		
Address			1250		Airbill		
City, State, Zip	RECEIVED FOR LAB						
Purchase Order							

ENVIRONMENTAL

Analytical Service, Inc.

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

CHAIN OF CUSTODY RECORD

Project Number		Project Name		Quote		Requested TAT	
REPORT TO:		Matrix		Analytical Tests		Comments	
Attention	Company	Address	City, State, Zip	Phone/Fax	e-mail	Matrix	Comments
GR SCHMIDT	GR SCHMIDT	19200 LIVERMORE RD	RED BLUFF CA 94520	530.521.1216	GRSCHMIDT@AOL.COM	A - Ambient Air	7/14/19
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Laboratory ID
S-001	4/17/19	0721					
S-002	4/17/19	0743					
S-003	4/17/19	1002					
S-004	4/17/19	1020					
S-005	4/17/19	1048					
S-006	4/17/19	1113					
S-007	4/17/19	1135					
S-008	4/17/19	1202					
Comments		S-009		1212			
BILLING INFORMATION:		SAMPLED BY		Date/Time		COC Number	
ATTENTION	Company	Address	City, State, Zip	Purchase Order			
GR SCHMIDT	GR SCHMIDT	19200 LIVERMORE RD	RED BLUFF CA 94520				
RECEIVED FOR LAB							

ATTACHMENT C

LABORATORY REPORTS



Thursday, May 02, 2019

Sample Delivery Group (SDG 219187
EAS Project Number: 17424

Chuck Schmidt
C.E. Schmidt
19200 Live Oak Road
Red Bluff, CA 96080

Chuck ,

Enclosed is the analytical report for the samples received and analyzed by
Environmental Analytical Service, Inc. for the following Project.

Client Project Name: Ann Arbor/HDR
PO Number:
Client Project Number None Given
Sample Event Date: 4/17/19

If you have any questions on the report or the analytical data please contact me at
(805) 781-3585.

Sincerely,

Steven D. Hoyt Ph.D.
Laboratory Director

SDH/LIMS

Laboratory Report

Project Name:

Ann Arbor/HDR

EAS SDG Number: 219187

Client Project Manager: Chuck Schmidt

Prepared For:

C.E. Schmidt

19200 Live Oak Road

Red Bluff

CA 96080

Project Number: 17424

Sample Event Date: 4/17/19

Received Date: 4/18/2019

Report Date: 5/2/2019

Project Number: None Given

PO Number:

This is the Laboratory Report for the samples in the indicated Sample Delivery Group (SDG). Each sample received in the group is assigned a Laboratory ID number. The combination of the SDG number and the Lab ID number is a unique identifier for the sample.

This Report Contains:

Laboratory Work Order

Project Sample Media

Laboratory Case Narrative and Chain of Custody

Method Description (when applicable)

Quality Control Reports

Analytical Reports

NELAC Certification: Florida E871125

173 Cross Street, San Luis Obispo, CA 93401 (805) 781-3585

Laboratory Work Order

SDG Number: 219187

Project Number: 17424

Client: Chuck Schmidt

Received: 4/18/2019

C.E. Schmidt

SAMPLE DESCRIPTION AND ANALYSIS REQUESTED

Client Sample ID	EAS Lab No.	Analysis Requested	Date Sampled
S-001	219187 1	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-002	219187 2	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-003	219187 3	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-004	219187 4	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-005	219187 5	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-006	219187 6	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-007	219187 7	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-008	219187 8	EPA 15 M Reduced Sulfur Gases	4/17/2019
S-009	219187 9	EPA 15 M Reduced Sulfur Gases	4/17/2019

Project Sample Media

SDG Number: 219187

The following sample media was used for this Sample Delivery Group (SDG). The Sample Media column identifies the type of media. For canisters, the Sample Media Batch gives the canister number followed by the cleaning batch number, which is a unique identification. Canisters that are received with sub-ambient pressures are pressurized to about 5 psig. The initial pressure of the canister when it is received is recorded along with the final pressure after pressurization. The canister dilution factor is the ratio of the final to initial pressure. The results are adjusted for the can dilution factor.

SDG	Lab ID	Client Sample No.	Sample	Batch	Pressure, torr		Can
			Media		Initial	Final	
219187	1	S-001		100			
219187	2	S-002		100			
219187	3	S-003		100			
219187	4	S-004		100			
219187	5	S-005		100			
219187	6	S-006		100			
219187	7	S-007		100			
219187	8	S-008		100			
219187	9	S-009		100			

Laboratory Case Narrative

EAS SDG Number: 219187

Project Number: 17424

Client: C.E. Schmidt

The Laboratory Case Narrative for the SDG is below. The Chain of Custody form(s) follow the Laboratory Case Narrative.

Sample Control Narrative

The samples were all received in good condition and with proper preservation.

Analytical Methods

The methods used for sample analysis are listed on the Analytical Report header, and have been modified as described in the EAS Quality Manual..

Case Narrative

QC Narrative

All analyses met EAS method criteria as defined in the Quality Manual, except as noted in the report or QC reports with data qualifiers.

Subcontract Narrative

No sample analysis was subcontracted for this project

Laboratory Certification

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness other than the condition(s) noted above. The Laboratory Report is property of EAS and its client. The entire report has been reviewed and approved.



Date Approved: 5/2/2019

Steven D. Hoyt, Ph.D.
Environmental Analytical Service
Laboratory Director

CHAIN OF CUSTODY RECORD

Project Number	Project Name	Quote	Requested TAT
REPORT TO: Attention: <u>CR SCHMIDT</u> Company: <u>CR SCHMIDT</u> Address: <u>19200 WAREDALE RD</u> City, State, Zip: <u>RED BLUFF CA 96001</u> Phone/Fax: <u>530.529.4216</u> e-mail: <u>SCHMIDT@CRS.AOL.COM</u>			
Sample Description	Sample Date	Start Time	Stop Date
S-001	4/17/19	0924	
S-002	↓	0943	0943
S-003	↓	1002	
S-004		1020	
S-005	↓	1048	
S-006	↓	1113	
S-007	↓	1135	
S-008	↓	1202	
Comments: S-009 ↓ 1212			
Matrix	Flow Reg Number	Canister Number	Stop Time
A - Ambient Air			
SG - Soil Gas			
S - Source			
I - Indoor Air			
Matrix	Initial Pressure	Final Pressure	Laboratory ID
SG	NA	NA	01
↓	↓	↓	02
↓	↓	↓	03
↓	↓	↓	04
↓	↓	↓	05
↓	↓	↓	06
↓	↓	↓	07
↓	↓	↓	08
↓	↓	↓	09
Comments: 7D-14 TRS 20 Ambient			
Comments:			
BILLING INFORMATION:			
ATTENTION	(STEVE) CRS	SAMPLED BY	CR Schmidt
Company	CRS	Date/Time	4/17/19
Address			1300
City, State, Zip		RECEIVED FOR LAB	
Purchase Order		Signature	4/18/19 10:00
		COC Number	
		Cooler Temp	
		Airbill	

Quality Control Report

EAS SDG Number 219187

Project Number: 17424

QC Narrative

Samples were analyzed in a daily analytical batch (DAB) designated by a QC batch number, and were analyzed using EAS standard laboratory QC specified in the EAS Quality Manual which may be different than the referenced agency method. Any deviations from the EAS QC criteria are flagged in the Laboratory Control Reports or in the sample Analytical Reports.

Standard Laboratory QC Report

Unless project specific QC was requested, this Section containing the standard laboratory QC (Level 2) supplied with the Analytical Reports. Each sample is analyzed in a Daily Analytical Batch (DAB) which includes the method blank, a laboratory control spike (LCS) and a laboratory control duplicate (LCD). A Daily Analytical Batch QC report is supplied for each method requested.

Method Blank

The method blank is a laboratory generated sample which assesses the degree to which laboratory operations cause a false positive. The target analytes in the analytical reports for a daily analytical batch are "B" flagged if their concentrations are present in the Method Blank above the RL, unless the result is greater than ten times the blank value..

Laboratory Control Spike

A laboratory control spike is a well characterized matrix similar to the sample which is spiked and run in duplicate with each Daily Analytical Batch. The laboratory control spike results are reported as a percent recovery. The QC Criteria for the control spike is listed in the Laboratory Control Report. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report. The control spike contains an abbreviated list of compounds in the method, and may contain compounds not on the target list for the specified report.

Laboratory Control Duplicate

The laboratory control duplicate is a duplicate analysis of the laboratory control spike, a standard, or a sample depending on the method. The results are reported as a relative percent difference (RPD). The criteria for the duplicate is in the Laboratory Control Report for the Daily Analytical Batch. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report.

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: LABQC

Laboratory ID: B04199

File Name: B04199B
Sample ID: METHOD BALNK
Can/Tube#:
QC_Batch: 041919-GCP

Date Sampled:
Date Analyzed: 04/19/19
Can Dilution Factor: 1.00
Air Volume: 10.00 ml
Time: 11:19

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

Date: 04/19/19

QC_Batch: 041919-GCP

CAS#	Compound	Standard Recovery	Standard Recovery	LCL %	UCL %	RSD %	RSD Limit
7783-06-4	Hydrogen Sulfide	101	99	80	120	1	15
463-58-1	Carbonyl Sulfide	100	101	80	120	1	15
74-93-1	Methyl Mercaptan	107	97	80	120	6	15
75-08-1	Ethyl Mercaptan	104	102	80	120	5	15
75-18-3	Dimethyl Sulfide	104	104	80	120	7	15
75-15-0	Carbon Disulfide	100	109	80	120	8	15
75-33-2	i-Propyl Mercaptan	100	99	80	120	0	15
624-89-5	Ethyl Methyl Sulfide	102	98	80	120	2	15
107-03-9	n-Propyl Mercaptan	101	102	80	120	2	15
110-02-1	Thiophene	94	106	80	120	6	15
513-44-0	Isobutyl Mercaptan	98	97	80	120	5	15
352-93-2	Diethyl Sulfide	95	102	80	120	4	15
75-66-1	t-Butyl Mercaptan	89	98	80	120	12	20
109-79-5	n-Butyl Mercaptan	96	96	80	120	6	20
624-92-0	Dimethyl Disulfide	91	108	80	120	8	20
616-44-4	3-Methylthiophene	88	114	80	120	13	20
110-01-0	Tetrahydrothiophene	103	105	80	120	7	20
638-02-8	2,5-Dimethylthiophene	88	112	80	120	12	20
110-81-6	Diethyl Disulfide	87	114	80	120	13	20
872-55-9	2-Ethylthiophene	89	108	80	120	10	20

RSD = Relative standard deviation of triplicate standard analysis

Limits are based on fixed laboratory analysis by GC/FPD

Analytical Reports

EAS SDG Number 219187

Project Number: 17424

The following pages contain the certified Analytical Reports for the samples submitted in the Sample Delivery Group (SDG) and are in order of the EAS Lab ID number. All of the analytical methods used are modifications of the published methods. Procedural method modifications, QC modifications, QC Criteria modifications, target lists, definitions of detection limits, and flags are all explained in detail in the EAS Quality Manual.

The Analytical Report has columns for the method detection limit (MDL), the reporting limit (RL), and the Amount. The Amount is the concentration of the compound in the sample. The report usually has the results reported with two commonly used units. The MDL, RL, and Amount are adjusted for the canister dilution factor and any dilution caused by sample matrix effects.

NELAC CERTIFICATION

EAS is accredited by the National Environmental Laboratory Accreditation (NELAC) with the Florida Department of Health, one of the NELAC certifying states. EAS is certified for the EPA TO-15, EPA TO-11 and EPA TO-4 methods. A list of accredited compounds is available on request.

DETECTION LIMITS

MDL: The MDL is lowest concentration that can be measured to be statistically above the noise level and is determined using the EPA 2016 method which uses the standard deviation of replicate measurements made over time. The method also incorporates systematic instrumentation blank levels. See Quality Manual for detailed explanation.

RL: The reporting limit (RL) is the lowest concentration that can be reliably reported for each compound that meets the QC Criteria for the method, background levels, or project specific considerations. The QC criteria level for the method blank is to be less than the RL. See Quality Manual for more information.

DATA FLAGS

In the standard report, if a compound is not detected above the method detection limit, a "ND" is in the Amount column. The flag column is used for both the not detect flag and for any data flags.

B - This compound was detected in the batch method blank above the reporting limit and is greater than one tenth the amount in the sample.

E - This compound exceeds the calibration range for this sample volume.

J - The amount reported is estimated because it was below the RL and could be below the lowest calibration point, have higher uncertainty, or could be the result of system background

UNITS

PPBV or PPMV: Parts-per-billion (or million) by volume is a mole (volume) ratio of the moles of analyte divided by the moles of air (gas). This is the primary unit used to report air or gas concentrations and is independent of temperature and pressure.

UG/M3 OR MG/M3: The reported result was calculated based on 1 atm pressure and a temperature of 25C. The conversion from PPBV is: $UG/M3 = PPBV \times MW/24.46$ where 24.46 is the gas constant and MW is the Compounds Molecular Weight (sometimes called Formula Weight)

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219187

Analytical Method:

EPA 15

Laboratory ID:

1

File Name: 1918701B
Sample ID S-001
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 7:24
Date Analyzed: 04/19/19 Time: 12:17
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219187

Laboratory ID:

2

File Name: 1918702A
Sample ID S-002
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 9:43
Date Analyzed: 04/19/19 Time: 12:42
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219187

Analytical Method:

EPA 15

Laboratory ID:

3

File Name: 1918703B
Sample ID S-003
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 10:02
Date Analyzed: 04/19/19 Time: 15:58
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	3,356.3	22.6	67.7	4,687.8	
463-58-1	Carbonyl Sulfide	9.7	29.1	117.1	23.9	71.7	288.4	
74-93-1	Methyl Mercaptan	16.2	48.5	794.5	31.9	95.6	1,566.6	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	585.6	45.3	135.9	1,491.0	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219187

Analytical Method:

EPA 15

Laboratory ID:

4

File Name: 1918704A
Sample ID: S-004
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 10:20
Date Analyzed: 04/19/19 Time: 13:33
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219187

Analytical Method:

EPA 15

Laboratory ID:

5

File Name: 1918705A
Sample ID S-005
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 10:48
Date Analyzed: 04/19/19 Time: 13:58
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	962.4	22.6	67.7	1,344.2	J
463-58-1	Carbonyl Sulfide	9.7	29.1	28.3	23.9	71.7	69.6	
74-93-1	Methyl Mercaptan	16.2	48.5	249.9	31.9	95.6	492.7	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	262.1	45.3	135.9	667.3	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	345.8	69.8	209.5	1,335.0	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219187

Analytical Method:

EPA 15

Laboratory ID:

6

File Name: 1918706A

Sample ID S-006

Can/Tube#: TBAG

QC_Batch: 041919-GCP

Date Sampled: 04/17/19

Time: 11:13

Date Analyzed: 04/19/19

Time: 14:22

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	122.5	45.3	135.9	312.0	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219187

Laboratory ID:

7

File Name: 1918707A
Sample ID S-007
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 11:35
Date Analyzed: 04/19/19 Time: 14:26
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	69.1	45.3	135.9	175.9	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	46.1	69.8	209.5	178.1	J
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219187

Laboratory ID:

8

File Name: 1918708A
Sample ID S-008
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 12:02
Date Analyzed: 04/19/19 Time: 15:10
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219187

Analytical Method:

EPA 15

Laboratory ID:

9

File Name: 1918709A
Sample ID S-009
Can/Tube#: TBAG
QC_Batch: 041919-GCP

Date Sampled: 04/17/19 Time: 12:12
Date Analyzed: 04/19/19 Time: 15:34
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	



Odor Science & Engineering, Inc.

105 Filley Street, Bloomfield, CT 06002
(860) 243-9380 Fax: (860) 243-9431

April 22, 2019

Chuck E. Schmidt
19200 Live Oak Road
Red Bluff, CA 96080

schmidtce@aol.com

RE: Odor Panel Analysis
OS&E Project No. 2130-M-00
Project Name: Ann Arbor/HDR

Dear Chuck:

This letter presents the results of the recent odor panel analyses conducted by Odor Science & Engineering, Inc. (OS&E) for your Ann Arbor/HDR sampling project. A total of nine (9) samples were collected by on-site personnel on April 17th, 2019. The odor samples were collected into 12 liter Tedlar gas sampling bags provided by OS&E. Immediately following sample collection, the bags were shipped via priority overnight a.m. delivery service to OS&E's Olfactory Laboratory in Bloomfield, CT for sensory analysis. All of the samples arrived intact under chain of custody.

Upon arrival the samples were analyzed by dynamic dilution olfactometry using a trained and screened odor panel of 8 members. The odor panelists were chosen from OS&E's pool of panelists from the Greater Hartford area who actively participate in ongoing olfactory research and represent an average to above average sensitivity when compared to a large population. The samples were quantified in terms of dilution-to-threshold (D/T) ratio and odor intensity in accordance with ASTM Methods E-679-04 and E-544-10, respectively. The odor panelists were also asked to describe the odor character of the samples at varying dilution levels. The odor panel methodology is further described in Attachment A.

The results of the odor panel test are presented in the attached Table 1.

We appreciate the opportunity to assist you on this project. Please feel free to call Martha O'Brien or me if you have any questions concerning these results.

Sincerely,
ODOR SCIENCE & ENGINEERING, INC.

Gary K. Grumley
Associate Scientist

Table 1. Results of dynamic dilution olfactometry analysis – April 18th, 2019
Chuck E. Schmidt: Ann Arbor/HDR
OS&E Project No. 2130-M-00

Sampling Information			Odor Conc. D/T ⁽¹⁾	Stevens' Law Constants ⁽²⁾		Odor Character ⁽³⁾
Date	Time	ID		a	b	
4/17/19	07:21	0-101	19	.63	.77	sour, stale, plastic, vegetation, swampy
4/17/19	09:39	0-102	17	.59	.86	sour, stale, plastic, vegetation, candle wax
4/17/19	09:58	0-103	16,575	.60	.71	sewage, sulfur, garbage, manure, fecal, rotten sludge
4/17/19	10:16	0-104	10	--	--	sour, stale, plastic, burnt plastic, vegetation, mushrooms, salty
4/17/19	10:46	0-105	11,730	.51	.78	feces, rotten sludge, sewage, dirty toilet, outhouse, fecal
4/17/19	11:06	0-106	82	.59	.72	sour, rotten manure, garbage, sewage, rotten sludge, mercaptan
4/17/19	11:33	0-107	45	.67	.73	sour, feces, manure, rotten vegetable garbage, rotten mercaptan, rotten spinach, dirty toilet, outhouse
4/17/19	11:50	0-108	19	.63	.73	sour, stale, vegetation, salty, plastic, burning plastic, smoky, burnt
4/17/19	12:15	0-109	23	.55	.78	fresh cut wood, wood chips, pencil lead, plastic, musty, vegetation

1. D/T = dilutions-to-threshold
 2. Stevens' Law correlates odor concentration (C) and odor intensity (I): $I = aC^b$. The constants a and b were determined by regression analysis based on the intensity ratings of the odor panel at varying dilution levels. $I = 0-8$ (based on the n-butanol intensity scale), C = odor concentration (D/T) typical of ambient odor levels.
 3. Summary of all odor character descriptors used by the odor panelists at varying dilution levels.
- Sample too low for Dose Response calculation

ATTACHMENT A
Odor Science & Engineering, Inc.
Odor Panel Methodology

Measurement of Odor Levels by Dynamic Dilution Olfactometry

Odor concentration is defined as the dilution of an odor sample with odor-free air, at which only a specified percent of an odor panel, typically 50%, will detect the odor. This point represents odor threshold and is expressed in terms of "dilutions-to-threshold" (D/T).

Odor concentration was determined by means of OS&E's forced choice dynamic dilution olfactometer. The members of the panel who have been screened for their olfactory sensitivity and their ability to match odor intensities, have participated in on-going olfactory research at OS&E for a number of years.

In olfactometry, known dilutions of the odor sample were prepared by mixing a stream of odor-free air with a stream of the odor sample. The odor-free air is generated in-situ by passing the air from a compressor pump through a bed of activated charcoal and a potassium permanganate medium for purification. A portion of the odor free air is diverted into two sniff ports for direct presentation to a panelist who compares them with the diluted odor sample.

Another portion of the odor-free air is mixed in a known ratio with the odor from the sample bag and is then introduced into the third sniff port. A panelist is thus presented with three identical sniff ports, two of which provide a stream of odor-free air and the third one a known dilution of the odor sample. Unaware of which is which, the panelist is asked to identify the sniff port which is different from the other two, i.e., which contains the odor. The flow rate at all three nose cups is maintained at 3 liters per minute.

The analysis starts at high odor dilutions. Odor concentration in each subsequent evaluation is increased by a factor of 2. Initially a panelist is unlikely to correctly identify the sniff port which contains an odor. As the concentration increases, the likelihood of error is reduced and at one point the response at every subsequently higher concentration becomes consistently correct. The lowest odor concentration at which this consistency is first noticed, represents the **detection odor threshold** for that panelist.

As the odor concentration is increased further in the subsequent steps, the panelist becomes aware of the odor character, i.e. becomes able to differentiate the analyzed odor from other odors. The lowest odor concentration at which odor differentiation first becomes possible, represent the **recognition odor threshold** for the panelist. Essentially all of OS&E's work is done with recognition odor threshold. By definition the threshold odor is equal to 1 D/T (i.e. the volume of odorous air after dilution divided by the volume before dilution equals one).

The panelists typically arrive at threshold values at different concentrations. To interpret the data statistically, the geometric mean of the individual panelist's thresholds is calculated.

The olfactometer and the odor presentation procedure meet the recommendations of ASTM Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits (ASTM E679-04). The analysis was carried out in the OS&E Olfactory Laboratory in Bloomfield, Connecticut.

Odor Intensity

Odor intensity is determined using reference sample method with n-butanol as the reference compound (ASTM Method E-544-10). The n-butanol odor intensity scale is based on n-butanol vapor as odorant at eight concentrations. The concentration increases by a factor of two at each intensity step, starting with approximately 15 ppm at step 1.

Odors of widely different types can be compared on that scale just like the intensities of the lights of different colors can be compared to the intensity of standard, e.g. white light. Odor character and hedonic tone are ignored in that comparison. Odor intensities are routinely measured as part of the dynamic dilution olfactometry measurements. The n-butanol vapor samples are presented to the panelists in closed jars containing the standard solutions of n-butanol in distilled water. The vapor pressure above the butanol solutions corresponds to the steps on the n-butanol scale. To observe the odor intensity, a panelist opens the jar and sniffs the air above the liquid. The panelist then closes the jar so that the equilibrium vapor pressure of butanol can be re-established before the next panelist uses the jar. The odor in the jar is compared with unknown odor present at the olfactometer sniff port.

The relationship between odor concentration and intensity can be expressed as a psychophysical power function also known as Steven's law (Dose-Response Function). The function is of the form:

$$I = aC^b$$

where:

I = odor intensity on the butanol scale

C = the odor level in dilution-to-threshold ratio (D/T)

a,b = constants specific for each odor

The major significance of the dose-response function in odor control work is that it determines the rate at which odor intensity decreases as the odor concentration is reduced (either by atmospheric dispersion or by an odor control device).

Odor emissions are used as input to an odor dispersion model, which predicts odor impacts downwind under a variety of meteorological conditions. Whether or not an odor is judged objectionable depends primarily in its intensity. The dose-response constants are used to convert predicted ambient odor concentration to intensity levels. OS&E experience has shown that odors are almost universally considered objectionable when their intensity is 3 or higher on the 8-point n-butanol scale. In general, the lower the intensity, the lower the probability of complaints.

Odor Character Description

Odor character refers to our ability to recognize the similarity of odors. It allows us to distinguish odors of different substances on the basis of experience. We use three types of descriptors, general such as "sweet", "pungent", "acid", etc. or specific references to its source such as "orange", "skunk", "paint", "sewage", etc., or to a specific chemical, e.g. "methyl mercaptan", "butyric acid", or "cyclohexane". In the course of the dynamic dilution olfactometry measurements, the odor panelists are asked to describe the character of the odors they detect.



Appendix D. 10152084-0WW-M0004-Summer Odor Sampling Summary, Rev. 0



Technical Memorandum

Document Number: 10152084-0WW-M0004 (Rev. 0)

To: Chris Englert, City of Ann Arbor WWTP
From: Chris Easter, HDR
Josh Prusakiewicz, HDR
CE Schmidt (HDR Sub)
Date: October 18, 2019
Subject: Summer Odor Source Sampling Summary, Rev. 0
City of Ann Arbor WWTP Odor Study

Purpose and Introduction

This memorandum presents the odor source sampling data collected at the Ann Arbor Wastewater Treatment Plant (WWTP) during the summer odor sampling event by HDR and CE Schmidt (team) on July 31 and August 1, 2019 as well as field testing of various onsite and offsite locations from July 30 through August 6, 2019. The sampling performed was a result of the February and April 2019 odor subjective survey recommendations provided by HDR and Bowker and Associates and reviewed with City staff. The recommendations and subjective survey results can be found in document 10152084-0WW-M0001 – Ann Arbor WWTP Odor Subjective Survey, Rev. 1.

The initial spring odor source sampling focused on specific areas within the plant where odor impacts may change during winter and summer months due to changes in biosolids dewatering and disposal approaches in the different seasons. The shift in disposal approaches occurs in early spring from winter landfill disposal of dewatered biosolids cake to summer land application of liquid biosolids. The spring sampling captured the winter months' biosolids dewatering impacts. The spring sampling is presented in 10152084-0WW-M0002 – Ann Arbor WWTP Spring Odor Source Sampling Summary, Rev. 0. This technical memorandum summarizes only the summer sampling recently completed. Differences between the spring sampling event and summer sampling event are highlighted and discussed herein.

Summer field odor sampling was performed by the team on July 31 and August 1, 2019. The ambient temperatures ranged from 60 to 80 degrees Fahrenheit from early morning to late afternoon on both days. Weather was clear and sunny without rain. One treatment train (primary clarifier + aeration basin + secondary clarifier) for the west plant and two treatment trains (2 primary clarifiers + 2 aeration basins + 2 secondary clarifiers) for the east plant were in service at the time of sampling. Plant flows were 16.5 MGD on July 31, 2019 and 17.1 MGD for August 1, 2019. For liquid phase results, units will be expressed in milligrams per liter (mg/L) and gas (odor) phase results will be expressed in parts per million (ppm). The typical BOD loading in the raw influent had a range of 152.8 to 156.4 mg/l with an influent pH of 7.4 to 7.5. Plant operational conditions and wastewater loading were considered representative of normal conditions during summer sampling.



Liquid biosolids hauling was active allowing sampling of the truck bay with liquid biosolids as compared to the spring when dewatered biosolids cake loading odors were sampled.

Hydrogen sulfide (H₂S) monitors were installed in seven locations and pressure monitors were installed at six of these locations on-site and offsite to obtain summer data. These locations are shown on maps and described in greater detail later in this report. The locations included:

- The activated carbon vent filter on the inlet interceptor to the plant (H₂S and pressure)
- The overflow structure near the WWTP entrance (H₂S and pressure) on influent 42" sewer
- The Screen and Grit building exhaust (H₂S only)
- Manhole #71-61488 on Old Dixboro Rd. near the plant entrance (H₂S and pressure)
- Arboretum manhole #71-69257 near the University of Michigan Hospital (H₂S and pressure)
- Washtenaw Community College (WCC) Fitness Center Lift Station Wet Well (H₂S and pressure)
- WCC driveway manhole S-18b (H₂S and pressure)

The purpose of these monitors was to see if H₂S was present at the location and to determine if pressurization occurs such that the odor "exhausts" to the atmosphere from key offsite manhole locations. An H₂S monitor was also installed at an exhaust fan in the plant's Screen and Grit Building to evaluate how levels changed during the day and night.

Summer Odor Source Sampling

Similar to the spring sampling, detailed field sampling was completed during the summer sampling for H₂S using a Jerome H₂S Analyzer, along with real-time scans for ammonia (NH₃) and amine based odorants where needed. Additionally, Tedlar bag samples were collected for Odor Panel and Gas Chromatograph/Flame Photometric Detection (GC/FPD) analysis.

Odor panel analysis was completed following the ASTM E679 Standard of Practice. The GC analysis following EPA Method 15M for a standardized scan for 20 species of reduced-sulfur organic odorants often detected from wastewater processes, as well as H₂S. This analysis scanned for the following compounds often present in WWTP operations:

- | | |
|------------------------|-------------------------|
| • Hydrogen sulfide | • Thiophene |
| • Carbonyl sulfide | • Isobutyl mercaptan |
| • Methyl mercaptan | • Diethyl sulfide |
| • Ethyl mercaptan | • n-Butyl mercaptan |
| • Dimethyl sulfide | • Dimethyl disulfide |
| • Carbon disulfide | • 3-Methylthiophene |
| • Isopropyl mercaptan | • Tetrahydrothiophene |
| • tert-Butyl mercaptan | • 2,5-Dimethylthiophene |
| • n-Propyl mercaptan | • 2-Ethylthiophene |
| • Ethyl methyl sulfide | • Diethyl disulfide |

Table 1 summarizes the sampling results from the Odor Panel Analysis and the GC/FPD analysis, as well as field measurements for H₂S and ammonia and amine related odors. Ammonia odors are listed with amines because the field colorimetric tubes cross measure these compounds. The spring ammonia and amine based odors were very likely due to polymer as part of the biosolids thickening and dewatering process. During summer, biosolids dewatering is not done and centrifuge dewatering is not active. The data indicates lower odor levels in the summer related to dewatering and truck loadings than in the spring. During summer lime is mixed with the liquid biosolids as part of the stabilization process before it is hauled away for land application. This lime addition creates added potential for ammonia release due to pH shifts.

Some of the samples were grab samples such as process room, wall louvers or carbon filter exhausts. Others were taken using an Environmental Protection Agency (EPA) approved flux chamber in order to capture a controlled odor emission directly from the surface of process basins. Figure 1 shows a photo of a flux chamber used during aeration basin sampling. Flux chamber samples included:

- Primary influent flow splitter channel
- Primary clarifier quiescent and weir zones
- Aeration basin un-aerated and aerated zones
- Secondary clarifier quiescent zone

FIGURE 1: SUMMER SAMPLING USING AN EPA FLUX CHAMBER





Dilution to Threshold Methodology

An explanation of dilution to threshold (D/T) methodology can be found in Appendix 1 – CE Schmidt Technical Memorandum. For the purposes of this document, Detection Threshold (DT) is the term used in odor laboratory analysis while Dilution to Threshold (D/T) relates to regulatory code guidance.

An explanation of Odor Panel Methodology is provided below. Additional information is included in the Appendix 1's Attachment A "Odor Science & Engineering, Inc. (OS&E) – Odor Panel Methodology."

Measurement of Odor Levels by Dynamic Dilution Olfactometry

Odor concentration is defined as the dilution of an odor sample with odor-free air, at which only a specified percent of an odor panel, typically 50%, will detect the odor.

Odor concentration was determined by means of OS&E's forced choice dynamic dilution olfactometer. The members of the odor panel have been screened for their olfactory sensitivity. This ensures panelist are representative removing panelist who are either under or oversensitive.

In olfactometry, known dilutions of the odor sample were prepared by mixing a stream of odor-free air with a stream of the odor sample. The odor-free air is generated in-situ by passing ambient air from a compressor pump through a bed of activated charcoal and a potassium permanganate medium for purification. A portion of the odor free air is diverted into two sniff ports for direct presentation to a panelist who compares them with the diluted odor sample.

...The analysis starts at high odor dilutions. Initially a panelist is unlikely to correctly identify the sniff port which contains an odor. As the concentration increases, the likelihood of error is reduced and at one point the response at every subsequently higher concentration becomes consistently correct. The lowest odor concentration at which this consistency is first noticed, represents the detection odor threshold (DT) for that panelist. The DT therefore represents the dilution required to make the odor just barely perceptible to the odor panel and is an expression of the odor concentration in terms of how many times it had to be diluted with odor free air.



Table 1: Summer Sampling On-site Odor Source Data Summary from July 31 and August 1, 2019

Sampling Location	Ann Arbor Odor Panel DT	St. Croix Paper	Odor Description	H ₂ S field number (ppm)	H ₂ S Lab (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Diethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
Retention / EQ Building	75		sour, sewage, sulfur, rotten vegetables, garbage, sour milk, earthy, dirt	0.006	ND	ND	ND	ND	ND	ND	NA	Sample taken during Retention / EQ Basin filling period at a roof hatch.
Raw Sewage Influent Lift Station	8313	3158	H ₂ S, rotten sewage, sulfur, rotten eggs, garbage	16.5	5.1	0.175	ND	ND	0.147	ND	NA	Sample taken midday August 1, 2019. The area was noticeably odorous in the immediate area around the lift station and inlet to the screenings building.
Screen and Grit Building Exhaust Fan	211	719	H ₂ S, rotten sewage, sulfur, rotten eggs	0.27	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Sampled from inside the room near screens at 11:18AM August 1, 2019. Acrulog H ₂ S data ranged from 0 to 5 ppm this week at this location with an average of 1 ppm. The Acrulog average was slightly higher than during the field grab sample event.
Scum Tank Room	298	682	rotten sewage, sulfur, sulfides, rotten eggs, H ₂ S, rotten garbage	0.13	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Sampled from inside the room near tankage.
Flow Splitter Structure Primary Influent – West	1451	2552	sour, rotten eggs, garbage, sewage, sulfur, H ₂ S	1.9	ND	ND	ND	ND	ND	ND	0.1 (NH ₃) 0.2 (Amine)	Sampled with flux chamber in the West Flow Splitter Structure on July 31 at 1:53 pm. Odorous in the field. Turbulence noted from aeration and weirs. Smell of odor was observed above open grating covered channels from the Screen and Grit Building leading into the West Flow Splitter Structure and as well as open grating leading into the East Flow Splitter Structure.
Primary Clarifier Quiescent Zone – East Plant	163	947	skunk, mercaptan, rotten garbage, sludge, feces	0.029	ND	ND	ND	ND	ND	ND	0.1 (NH ₃) 0.2 (Amine)	Sampled midday July 31, 2019.



Sampling Location	Ann Arbor Odor Panel DT	St. Croix Paper	Odor Description	H ₂ S field number (ppm)	H ₂ S Lab (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Diethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
Primary Clarifier Weir Zone – East Plant	1507	2322	sour, sewage, sulfur, H ₂ S, rotten garbage, rotten eggs, sludge, feces	1	ND	ND	ND	ND	ND	ND	ND (NH ₃) 0.1 (Amine)	Sampled midday July 31, 2019. Weir turbulence and bubble transport were present.
Anoxic/Anaerobic Zone of Aeration Basin – East Plant	21	134	sour, H ₂ S, sewage, rotten sludge, garbage, vegetables, skunk, mercaptan, vomit	0.045	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Aerated Zone 1 Near Front of Aeration Basin – East Plant	21	134	sour, H ₂ S, sewage, rotten sludge, garbage, vegetables, skunk, mercaptan	0.014	0.0138	ND	ND	0.044	ND	ND	ND (NH ₃) ND (Amine)	
Aerated Zone 3 Near end of Aeration Basin – East Plant	11	134	sulfur, H ₂ S, gassy, swampy, earthy, cleaning products, plastic	0.0097	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Secondary Clarifier Quiescent Zone – East Plant	11	96	sour, sewage, gassy, sulfur, rotten, plastic, cleaning products	0.001	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	The quiescent zone was the only area sampled as the weirs were covered.
Gravity Belt Thickener Room Exhaust	11	868	sour, sewage, sulfur, wet cardboard, earthy, chlorine, new vinyl	0.005	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Centrifuge Room Exhaust	11	1105	sour, light sewage, rubber, plastic, cleaning chemicals	0.001	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Note that centrifuge dewatering was offline as summer liquid biosolids disposal was active and dewatered biosolids cake was not being made.
Cake Hopper Level Exhaust Air	12		sour, rotten eggs, garbage, vegetables, sewage, old urine, chlorine, earthy, dirt, plastic	0.01	ND	ND	ND	ND	ND	ND	1.5 (NH ₃) ND (Amine)	
Centrifuge (Lower) Room Conveyor Floor Exhaust Fan	8		sulfur, sewage, plastic, cleaning chemicals, chlorine, new vinyl	0.006	ND	ND	ND	ND	ND	ND	ND (NH ₃) 0.2 (Amine)	Note that centrifuge dewatering was offline as summer liquid biosolids disposal was active and dewatered biosolids cake was not being made.



Sampling Location	Ann Arbor Odor Panel DT	St. Croix Paper	Odor Description	H ₂ S field number (ppm)	H ₂ S Lab (ppm)	Methyl Mercaptan (ppm)	Dimethyl Sulfide (ppm)	Diethyl Sulfide (ppm)	Dimethyl Disulfide (ppm)	Carbonyl Sulfide (ppm)	Ammonia or Amine (ppm)	Comments
Truck Loading Bay (During active truck loading)	11	1638	sour, sulfur, sewage, garbage, urine, outhouse, feces, fishy, plastic	0.0017	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	Truck was being loaded during sample collection.
Tertiary Filter Room Exhaust	10		sour, H ₂ S, rotten, sewage, plastic, rubber	0	ND	ND	ND	ND	ND	ND	NA	
Inlet of Carbon Filters (common)	620		sewage, sulfur, sludge, rotten vegetables, garbage, outhouse, earthy, dirt	0.15	ND	ND	ND	ND	ND	ND	1.3 (NH ₃) ND (Amine)	
Outlet of Carbon Filters	69 to 75	202	sulfur, sewage, rotten vegetables, garbage	0.05 to 0.055	ND	ND	0.1 to 0.11	ND	0.117 to 0.136	ND	1.5 to 2 (NH ₃) 2 to 4 (Amine)	Two samples were collected; one from Carbon Filter Stack #2 and one from Carbon Filter Stack #3.
Overflow Splitter Structure Headspace at plant entrance	250		rotten sewage, cabbage, garbage, feces, manure, outhouse, sulfur, urine	0.002	ND	ND	ND	ND	ND	ND	NA	
Ammonia Scrubber Inlet	No odor lab test			NA	ND	ND	ND	ND	ND	ND	20 (NH ₃) >20 (Amine)	
Ammonia Scrubber Outlet	No odor lab test			NA	ND	ND	ND	ND	ND	ND	ND (NH ₃) ND (Amine)	
Upwind	19		sour, sulfur, vegetation, wet grass, plastic, exhaust	0	ND	ND	ND	ND	ND	ND	NA	NW corner of plant near entrance gate
Downwind	10		sour, plastic, stale, exhausts	0	ND	ND	ND	ND	ND	ND	NA	SE corner of plant near Huron passage by final clarifiers

NA = Not Available. Testing was not performed.

ND = Non-Detect

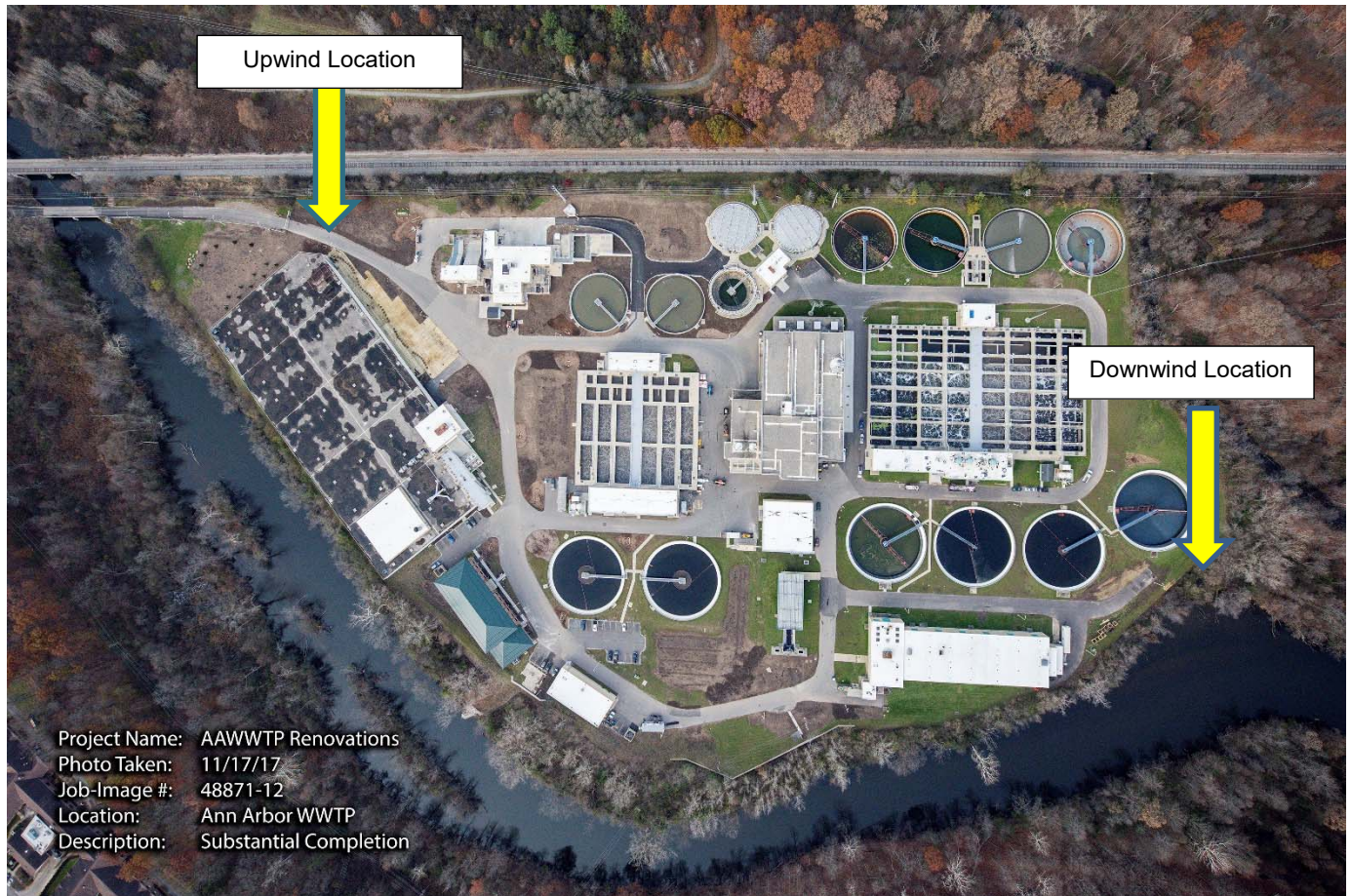
Note 1: St. Croix published a Water Environment Federation Paper "Odor Threshold Emission Factors for Common WWTP Processes" in April 2008. Data shown in this column is the average DT from samples that have been collected by St. Croix from WWTP plants across the U.S. and Canada.



Key observations from the summer odor source data include the following:

- Raw sewage inlet liquid phase sulfide levels were very low in the range of 0.1 to 0.2 mg/L. In general, this limits the H₂S odor emission potential. Additionally, the wastewater pH averaged approximately 7.4. The slightly alkaline pH tends to help keep the H₂S fraction of the dissolved sulfides in the ionic form which cannot be stripped into the air. Both the low sulfide concentration and slightly elevated pH reduce odor emission potential.
- In general, the odor levels in terms of Detection Threshold (DT) were low plant wide. The only area where DT levels were higher than typical data was the inlet channel to the Screen and Grit Building. All other areas exhibited relatively low odor DT values compared to experiences from other typical wastewater plant data.
- The most odorous areas of the plant with the highest DT values were:
 - o The Raw Sewage Lift Station area channels flowing into the Screen and Grit Building
 - o Primary influent flow splitter structures (east and west)
 - o Primary clarifiers (particularly the weirs)
 - o Screen and Grit Building roof exhaust.
- Odor levels from Ann Arbor WWTP sources were generally very low compared to other wastewater plants with similar treatment processes. Where odors were detectable, they included:
 - o H₂S
 - o Low levels of reduced sulfur organic compounds such as methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and diethyl sulfide
 - o Ammonia and amine based odors
- Plant upwind and downwind impacts were only slightly different, with downwind at 10 DT compared to upwind at 19 DT. This was similar to the spring data at 10 DT for upwind and 17 DT for downwind. However, sampling conditions were more variable in terms of wind direction, which was shifting at times during the summer sampling period. This may explain why the upwind had a slightly higher DT than downwind. Both upwind and downwind measurements were low. These agreed reasonably well with a plant fence line perimeter check on August 1, 2019, using a Nasal Ranger where field DT readings on the fence line ranged from 2 to 7 DT and Jerome H₂S readings ranged from 0 to 0.003 ppm.
 - o Similar to spring, downwind odor compound measurements such as H₂S, methyl mercaptan, dimethyl sulfide and other typical wastewater odors were below detection limits which were in the 8 to 16 part per billion (ppb) range for the EPA Method 15 GC/FPD scans. Figure 2 shows the upwind and downwind sampling locations.

FIGURE 2: UPWIND AND DOWNWIND SAMPLING LOCATIONS AT ANN ARBOR WWTP



- Truck bay odors were lower in summer when a truck was loading at 11 DT, similar to spring truck bay data when a truck was not being loaded at 19 DT. Both of these values are very low compared to when a cake truck was being loaded during the spring sampling event at 16,575 DT. Dewatered biosolids cake treated with Planet Breeze is only loaded into trucks from December through April and the loading process only lasts for approximately 45 minutes per truck.
 - o The spring and summer truck bay data indicates that truck bay odors are relatively low except during cake loading in the December through April period when dewatered cake is loaded into open bed trucks.
- Similar to spring, the odor control scrubber systems in the Dewatering Building were performing well during the summer sampling event.
 - o The ammonia scrubber had higher ammonia loads in summer than spring (21 ppm compared to 2 ppm) but was able to remove all of the ammonia. The higher ammonia levels in summer are likely due to the addition of lime for biosolids stabilization during the summer land application period.
 - o The carbon scrubber filter odor control system was providing over 89% reduction in odor DT with outlet values of 69 and 75 DT. As mentioned for the spring



sampling summary, anything below 100 DT in the exhaust would be considered excellent performance for carbon.

- o Similar to spring, the carbon filters were allowing low level dimethyl sulfide and dimethyl disulfide breakthrough as well as some ammonia which resulted in the low DT exhaust still being described as sulfur, sewage and rotten vegetables.
- In general, the dewatering building's exhaust fans were low in odor DT ranging from 8 to 12 DT. Exhaust volumes were relatively high. This combination of concentration and exhaust rate will be evaluated as part of the air dispersion modeling evaluation to determine the risk of the combined exhaust odors reaching offsite.

The Odor DT data was used to create an odor emission rate (OER) estimate presented in Table 2. The OER table lists the projected mass of odor emissions along with an indication of the percentage contribution to overall plant odor emissions.



Table 2: Odor Emission Rate Summary Based on Summer Sampling Data from July 1 and August 1, 2019

Sampling Location	DT value	Surface Area (ft ²)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric (cfm)	Process air (cfm/ft ²)	Flux Chamber Rate Total (m ³ /s/m ²)	DT OU/Sec	% of Total	Comments
Retention / EQ Building	75	3.3			325			12	0.150	Represents small cracks in the large access hatch on the northwest corner of the EQ Building and grating on the east end. Assume EQ fill rate of 3.5 MGD based on summer sampling as typical fill rate.
Raw Sewage Lift Station	8313	21	1062.5	0		51	0.25907	4168	54.466	Represents open surface area above open channel gratings and edge cracks in the covers on the lift station Archimedes screw pumps.
Screen and Grit Building Exhaust Fans	211	24.9			12400			1235	16.136	Assumes four roof exhaust fans on screen and grit building at their rated cfm values.
Grit/Scum Tank Room	298	8.3			2500			352	4.594	Assumes roof exhaust fan running at rated value.
Flow Splitter Structure Primary Influent - West	1451	2458	240	5		0.098	0.00114	377	4.923	Includes open grating channels flowing into and out of the splitter box plus the open areas of the aerated structure.
Flow Splitter Structure Primary Influent - East	1451	1514	120	5		0.079	0.00104	213	2.783	Includes open channels and grating channels flowing into and out of the splitter box plus the open areas of the aerated structure.
Primary Clarifier Quiescent Zone – West Plant	163	5542	0	5		0	0.00064	54	0.703	Single clarifier running on West Plant.
Primary Clarifier Quiescent Zone – East Plant	163	11084	0	5		0	0.00064	108	1.406	Two clarifiers running on East Plant.
Primary Clarifier Weir Zone – West Plant	1507	1257	0	5		0	0.00064	113	1.474	Assumed four feet wide launder (wall to weir) with 100 feet diameter. One online.
Primary Clarifier Weir Zone – East Plant	1507	2514	0	5		0	0.00064	226	2.948	Assumed four feet wide launder (wall to weir) with 100 feet diameter. Two online.
Anoxic/Anaerobic Zone of Aeration Basin – West Plant	21	3612	0	5		0	0.00064	5	0.059	Area from one west basin online.
Anoxic/Anaerobic Zone of Aeration Basin – East Plant	21	8295	0	5		0	0.00064	10	0.136	Area from two east basins online.



Sampling Location	DT value	Surface Area (ft2)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric (cfm)	Process air (cfm/ft2)	Flux Chamber Rate Total (m3/s/m2)	DT OU/Sec	% of Total	Comments
Aerated Zone 1 Aeration Basin – West Plant	21	5419	2293	5		0.423	0.00279	29	0.385	Area from one west basin online. Splits aerated zones into front half.
Aerated Zone 1 Aeration Basins – East Plant	21	10838	4585	5		0.423	0.00279	59	0.771	Area from two east basins online. Split aerated zones into front half.
Aerated Zone 3 at end of Aeration Basin – West Plant	11	5419	1123	5		0.207	0.00169	9	0.123	Area from one west basin online. Splits aerated zones into back half.
Aerated Zone 3 at end of Aeration Basins – East Plant	11	10838	2245	5		0.207	0.00169	19	0.245	Area from two east basins online. Split aerated zones into back half.
Secondary Clarifier – West Plant	11	9693	0	5		0	0.00064	6	0.083	Area from one clarifier online.
Secondary Clarifiers – East Plant	11	19386	0	5		0	0.00064	13	0.166	Area from two clarifiers online.
Gravity Belt Thickener Room Exhaust	11	19.6			36000			187	2.442	18,000 cfm rating on one fan for winter conditions but two fans assumed in summer.
Centrifuge Room Exhaust	11	9			7000			36	0.475	Assumed two exhaust fans at rated value 3500 cfm each.
Cake Hopper Level Exhaust Air	12	9			5000			28	0.370	Assumed one fan running at rated value.
Centrifuge (Lower) Room Conveyor Floor Exhaust Fan	8	4			7000			26	0.345	Assumed one fan based on field observations. Largest fan rating.
Truck Loading Bay (During active truck loading)	11	8.6			7000			36	0.475	Assumed two fans running at rated value. DT value from summer data. Note that winter DT for truck loading is much higher at 16575 DT. When biosolids are loaded in winter, this results in the truck bay dominating with an OER contribution of 88% of the total. Both conditions will be modeled in AERMOD.
Tertiary Filter Room Exhaust	10	15.9			9200			43	0.567	Based on field measurements from four wall fans running.
Outlet of Carbon Filters	68	3.53			9000			289	3.774	Field cfm data from two stacks at 18 inch diameter each.
Overflow Splitter Structure Headspace at plant entrance	250	4		5		0	0.00064	0.05955	0.001	



The field observations along with the OER table suggests that the following sources have the greatest percent contribution:

- The Raw Sewage Lift Station and Screen and Grit Building exhaust
- The raw influent flow splitter channels to the primary clarifiers on the east and west plants
- The primary clarifiers including the weirs and quiescent zones
- The exhaust from the carbon filters
- The gravity belt thickener room wall louver exhaust

The OER table does not consider wind and dispersion and does not therefore consider the true risk of whether these sources create potential for noticeable offsite odor impacts. This evaluation will be done using the EPA AERMOD dispersion model to evaluate potential for downwind impacts and will be presented as a separate technical memorandum.

For additional information, please refer to Appendix 1 for CE Schmidt's technical memorandum, data, and lab reports for the July/August 2019 odor source testing.

Seasonal Sampling at Onsite and Offsite Locations

H₂S and pressure monitors were installed by HDR and WWTP staff at seven locations onsite and offsite on July 30, 2019. The location for these are shown Figure 3. Six of these were offsite and related to collection system locations.

The monitors collected one week of field data from July 30 to August 6, 2019 which included real-time collection of H₂S, pressure, temperature and humidity at each location. Measurements for parameters were taken every three minutes for the duration of the testing period. The Screen and Grit Building location did not collect pressure data while pressure data was taken at all six of the other locations in order to see if potentially odorous exhaust air from manholes and wet wells was pressurizing and therefore potentially exhausting odorous air. The following sections provide a summary of each location and the data collected.

FIGURE 3: SEASONAL SAMPLING ONSITE AND OFFSITE LOCATIONS DURING SUMMER



Arboretum Manhole

H₂S and pressure monitors were installed by HDR in the Arboretum manhole #71-69257 located near the University of Michigan Hospital. The pick hole for the manhole was open to the atmosphere and was exhausting at the time of installation. Figure 4 shows where the monitors were installed and Figure 5 shows how they were installed. The manhole cover was then re-installed for the week long testing, allowing the pressure monitor to be exposed to the air outside the manhole.

FIGURE 4: ARBORETUM MANHOLE #71-69257 ODOR EQUIPMENT INSTALLATION LOCATION

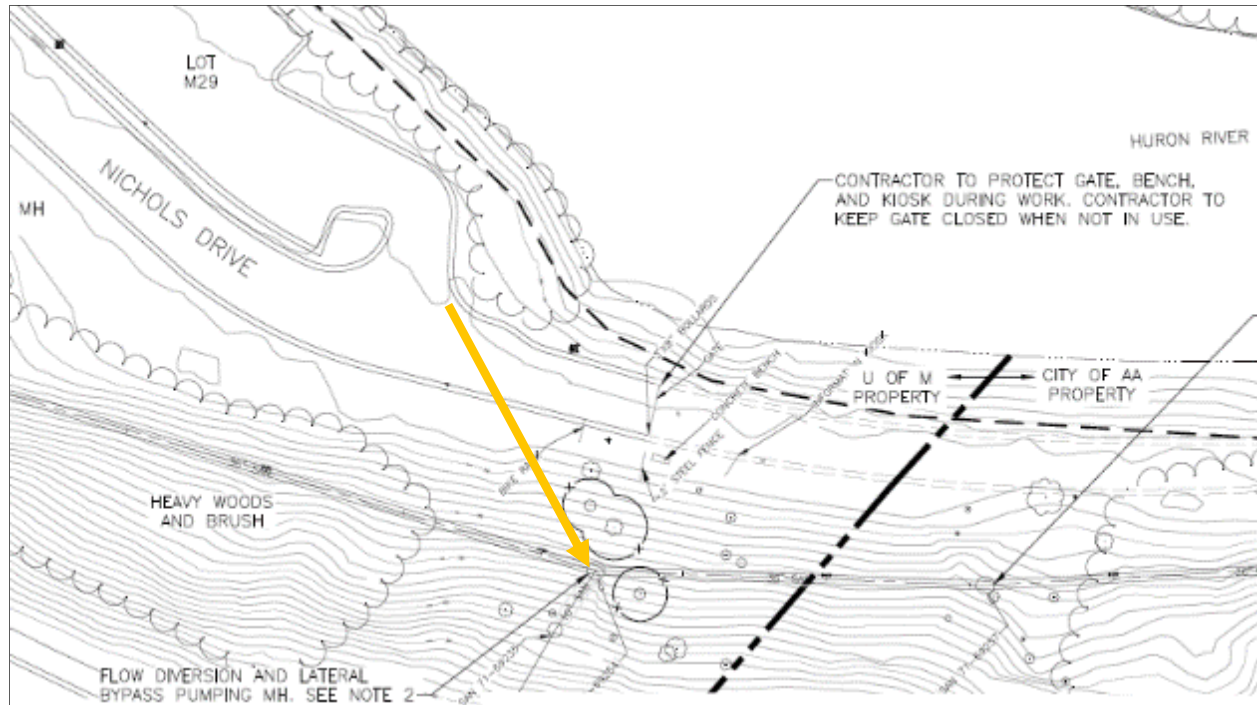


FIGURE 5: ARBORETUM MANHOLE





During the week, the H₂S measurements in the Arboretum Manhole averaged 0.21 ppm, with a maximum reading of 6 ppm. The pressure readings averaged 0.0145 in. H₂O, with a maximum reading of 0.069 in. H₂O. This information indicates that the Arboretum does see a small amount of cyclic pressurization and that H₂S is present. Figure 6 below shows the H₂S data and Figure 7 shows the pressure data, both in blue. Temperature is green, humidity is purple and monitor battery volts is red. This was similar to data observed during the spring sampling event.

FIGURE 6: H₂S READINGS FOR ARBORETUM MANHOLE JULY 30 - AUGUST 6, 2019

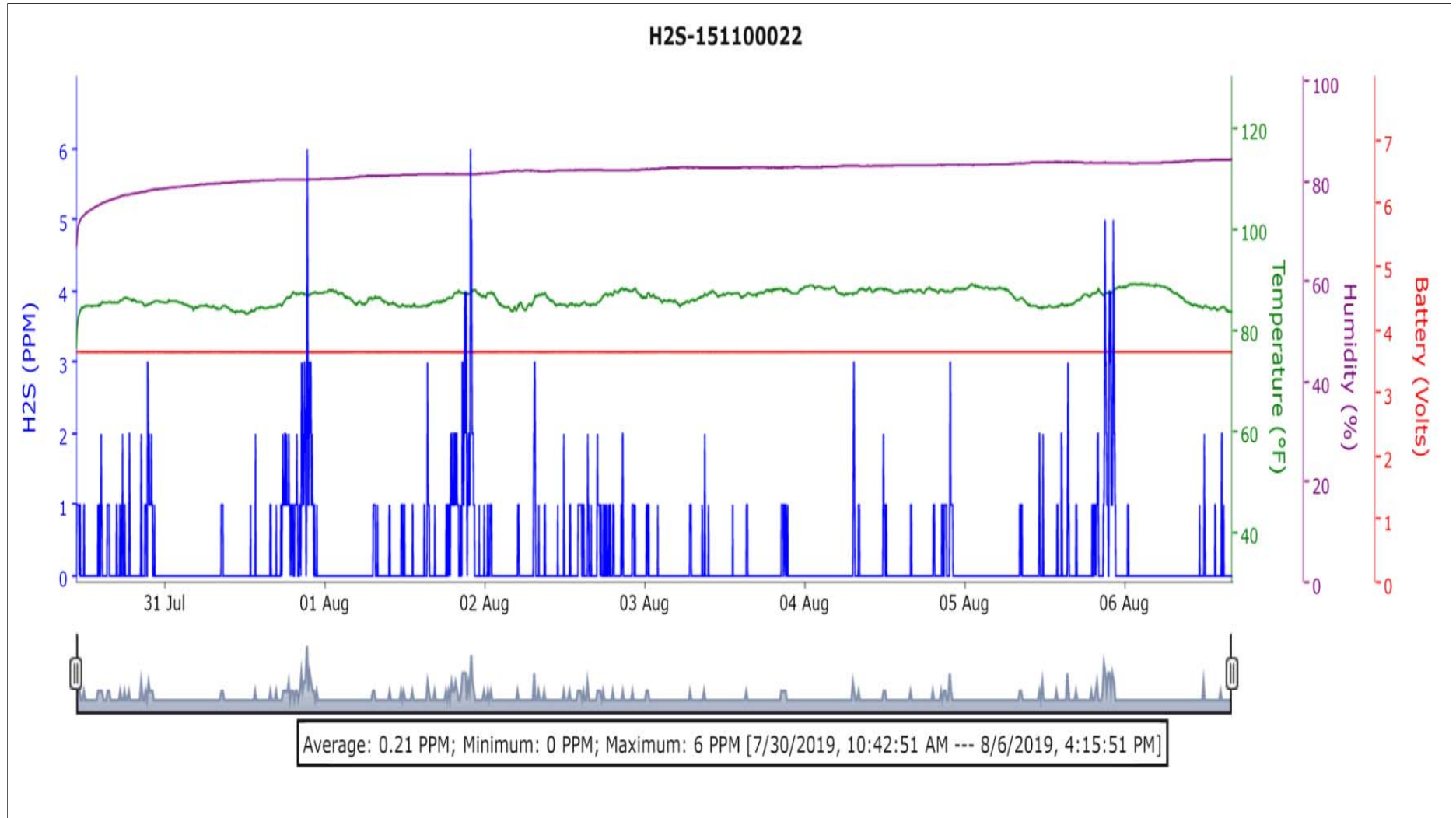
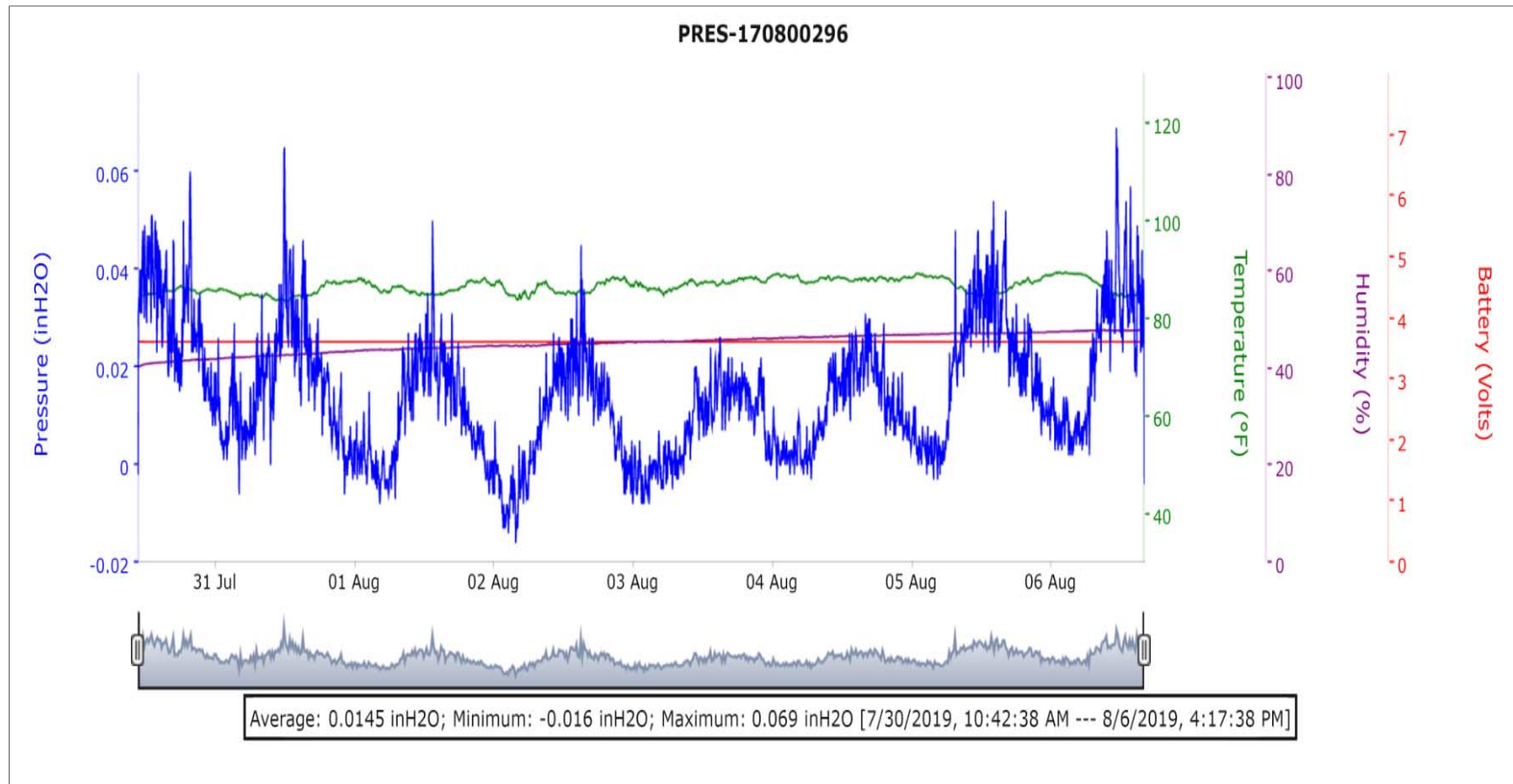


FIGURE 7: PRESSURE READINGS FOR ARBORETUM MANHOLE JULY 30 - AUGUST 6, 2019



Washtenaw Community College Fitness Center Lift Station

H₂S and pressure monitors were installed by HDR in the WCC Fitness Center Lift Station. The monitors were suspended from a metal bar inside the lift station that would not be disturbed during weekly maintenance. The exhaust line was fed through the handle in the cover of the lift station to ensure the pressure monitor was exposed to the atmosphere for the duration of the testing week.

FIGURE 8: WCC FITNESS CENTER LIFT STATION ODOR EQUIPMENT INSTALLATION LOCATION

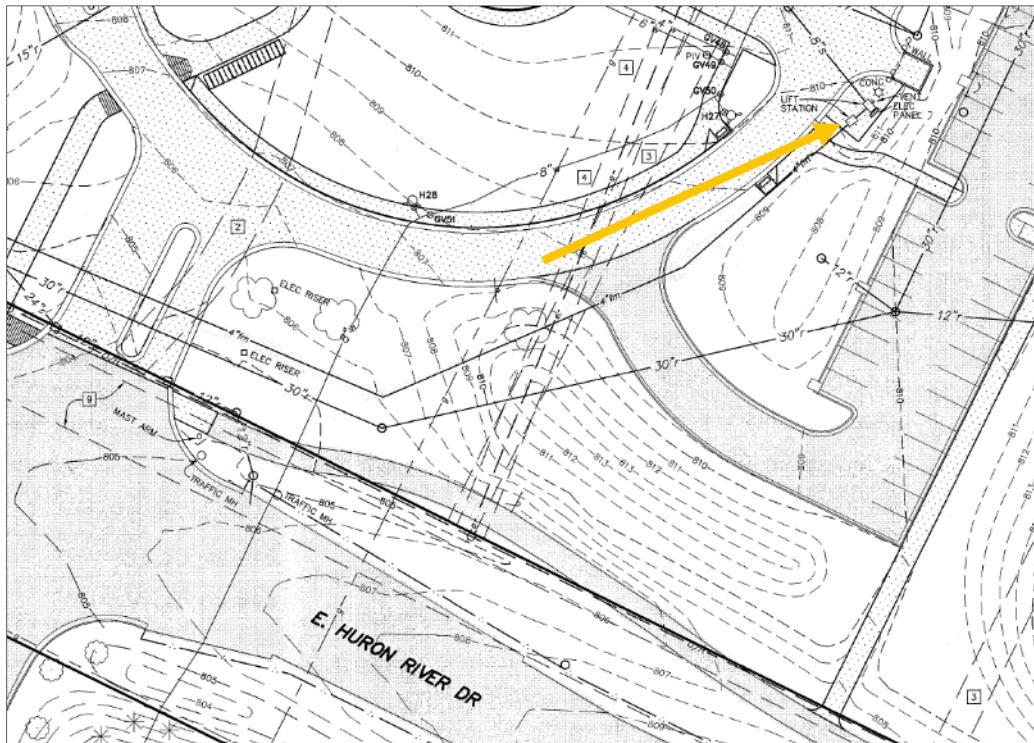


FIGURE 9: WCC FITNESS CENTER LIFT STATION





During the week, the H₂S measurements in the WCC Fitness Center Lift Station averaged 0 ppm, with a maximum reading of 0 ppm meaning the levels were always the lowest the monitor can detect which has a detection range of 0 – 200 ppm. The pressure readings averaged 0.0007 in. H₂O, with a maximum reading of 0.006 in. H₂O. This information indicates that the WCC Fitness Center Lift Station experiences an extremely small amount of pressurization but there was no H₂S measured at this location. Figure 10 below shows the H₂S data and Figure 11 shows the pressure data.

FIGURE 10: H₂S READINGS FOR WCC FITNESS CENTER LIFT STATION JULY 30 - AUGUST 6, 2019

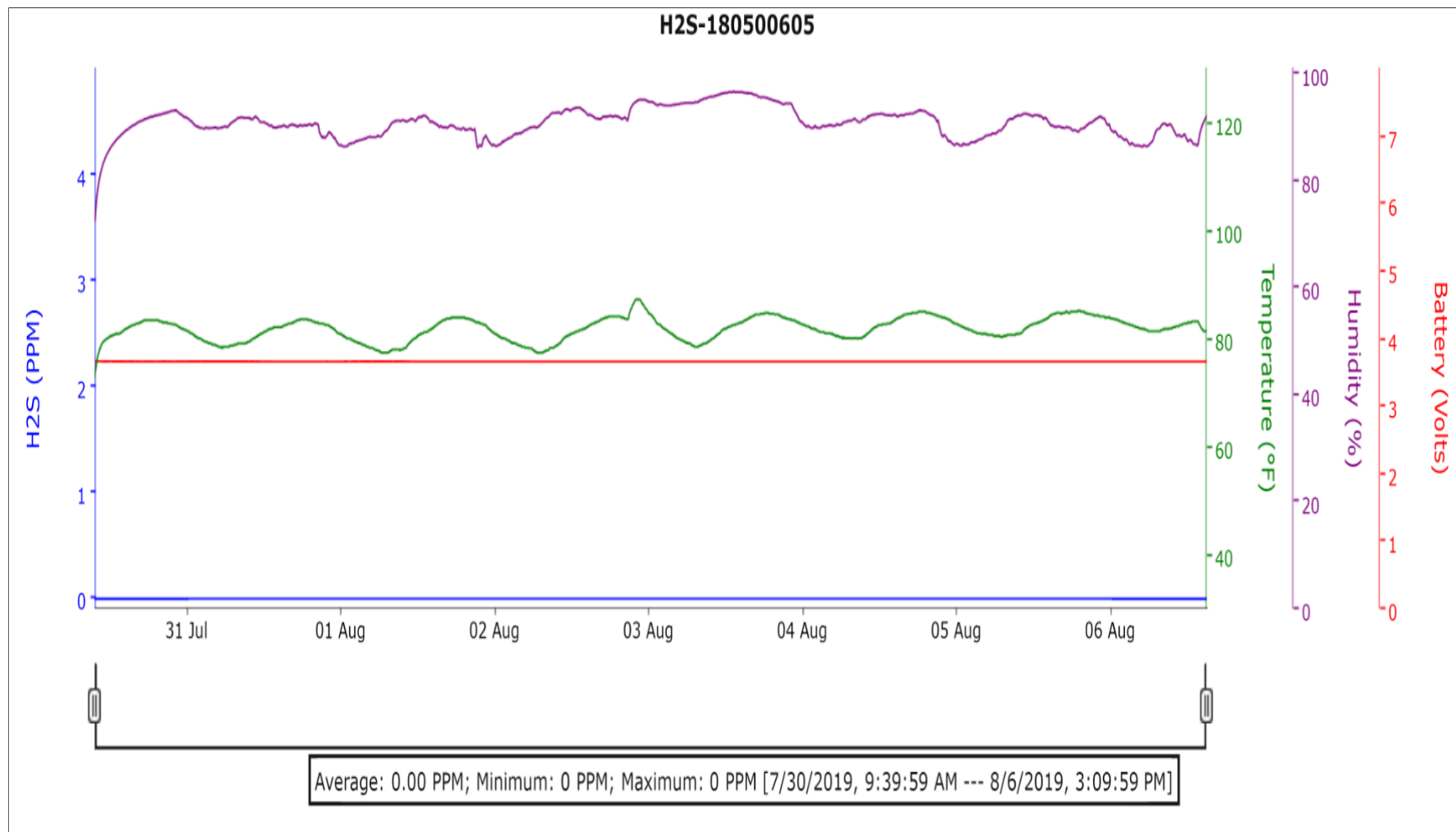
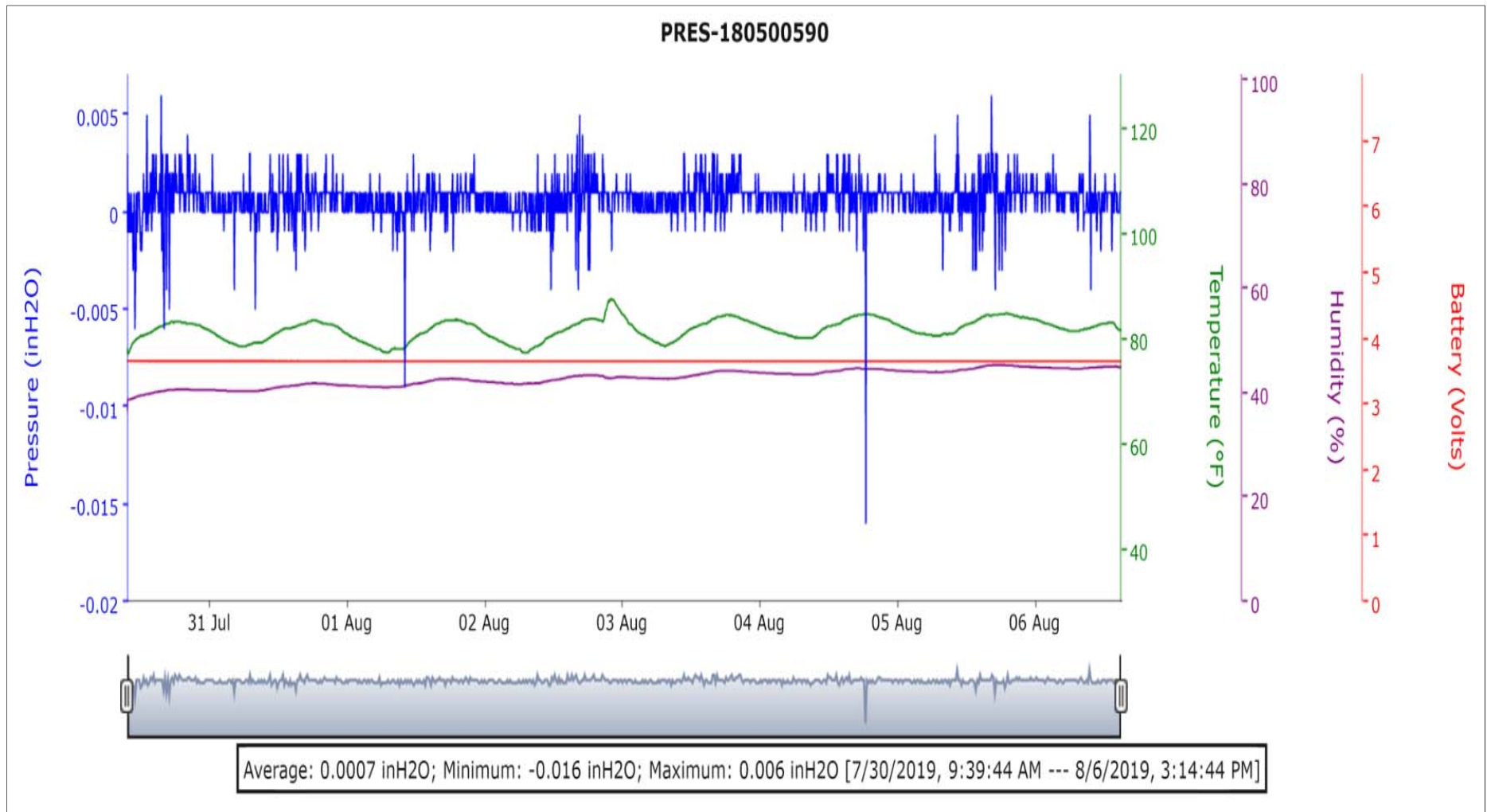


FIGURE 11: PRESSURE READINGS FOR WCC FITNESS CENTER LIFT STATION JULY 30 - AUGUST 6, 2019



Washtenaw Community College Driveway Manhole

H₂S and pressure monitors were installed by HDR in the WCC Driveway Manhole #S-18b located near the college's northwest driveway entrance on E. Huron River Drive. There was no pick hole on the manhole cover that was open to the atmosphere. When reinstalled, the manhole cover was purposely not closed completely, leaving it to exhaust at the time of installation to ensure accuracy of the pressure monitor readings. This manhole receives flow from the college's lift station and the WCC Fitness Center lift station and is gravity fed to the Old Dixboro sewer line into the plant. Figure 12 shows where the H₂S and pressure monitors were installed and Figure 13 shows the manhole.

FIGURE 12: WCC DRIVEWAY MANHOLE S-18B ODOR EQUIPMENT INSTALLATION LOCATION

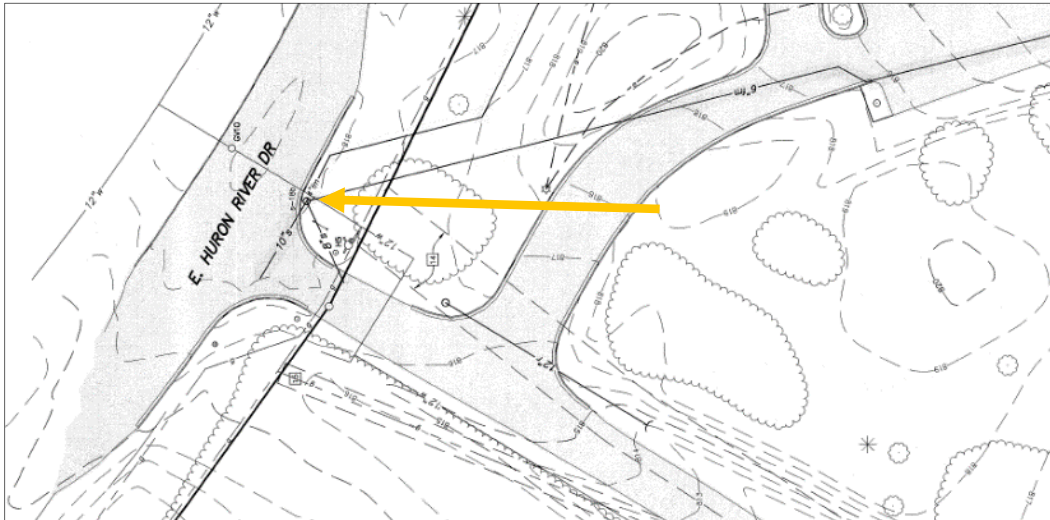


FIGURE 13: WCC DRIVEWAY MANHOLE





During the week, the H₂S measurements in the WCC Driveway Manhole averaged 3.41 ppm, with a maximum reading of 126 ppm. The pressure readings averaged 0.0136 in. H₂O, with a maximum reading of 0.321 in. H₂O. This information indicates that the WCC Driveway Manhole does see positive pressurization and that there is a significant amount of H₂S present. To the degree that the manhole might not be tightly sealed, fugitive odors are therefore possible. Figure 14 below shows the H₂S data and Figure 15 shows the pressure data.

FIGURE 14: H₂S READINGS FOR WCC DRIVEWAY MANHOLE JULY 30 - AUGUST 6, 2019

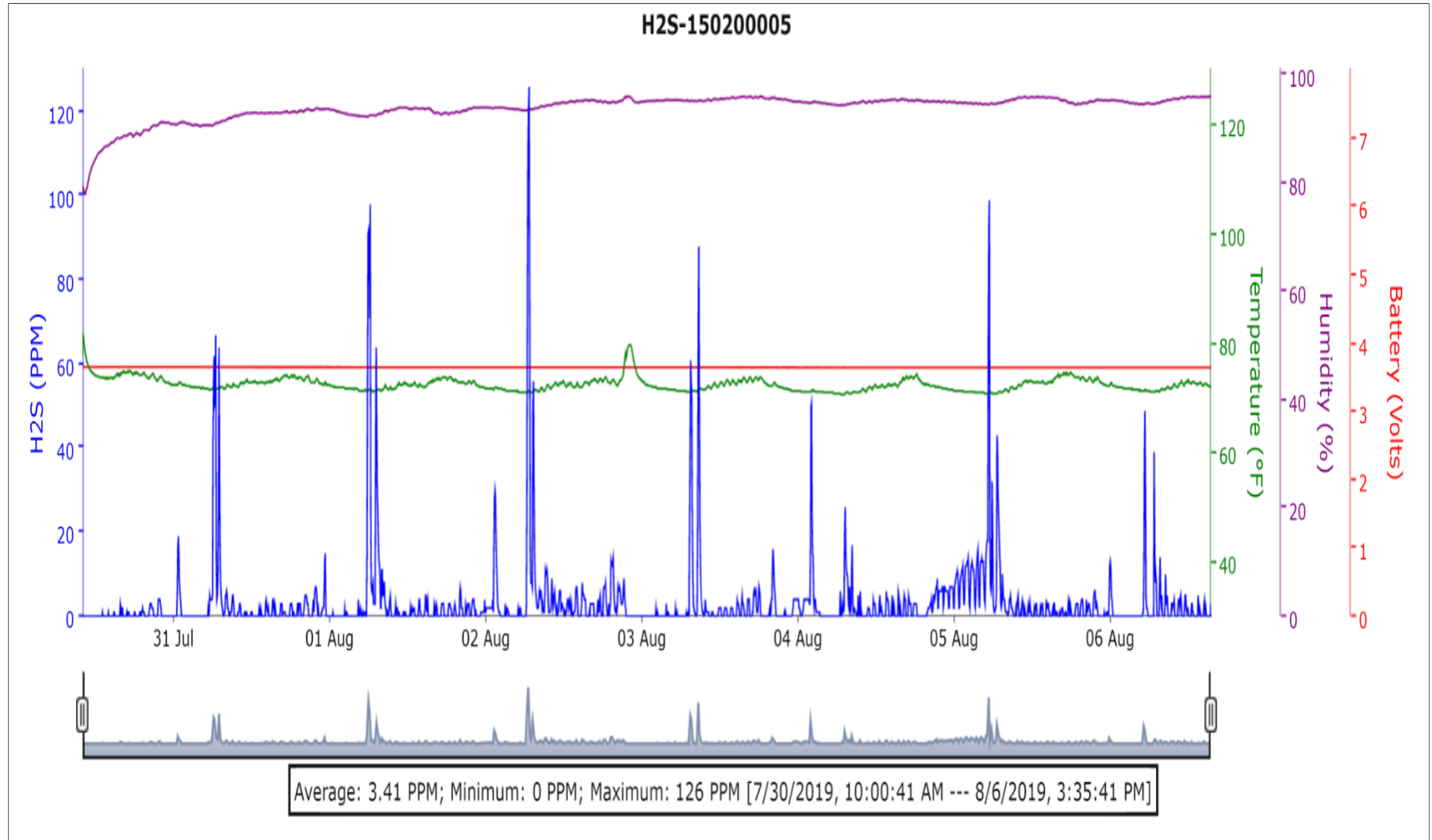
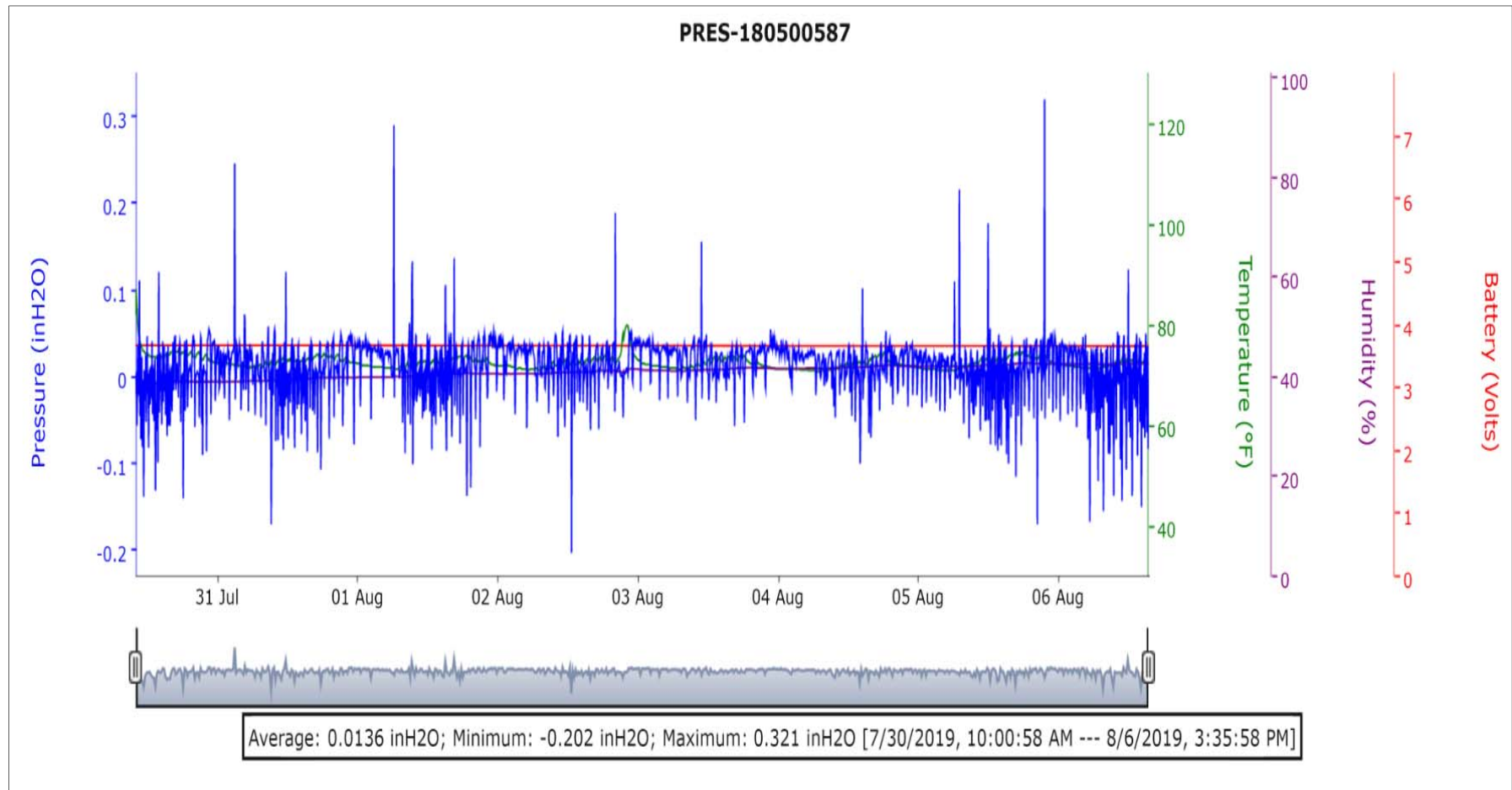


FIGURE 15: PRESSURE READINGS FOR WCC DRIVEWAY MANHOLE JULY 30 - AUGUST 6, 2019



Old Dixboro Manhole

H₂S and pressure monitors were installed by HDR in the Old Dixboro Manhole #71-61488 located near the entrance of the Ann Arbor WWTP. This manhole is located alongside the road. The pick hole for the manhole was open to the atmosphere and was exhausting at the time of installation. Figure 16 below shows where the H₂S and pressure monitors were installed and Figure 17 shows the manhole. The manhole cover was re-installed for the week long testing, allowing the pressure monitor to be exposed to the air outside the manhole.

FIGURE 16: ODOR EQUIPMENT INSTALLATION LOCATIONS NEAR PLANT ENTRANCE

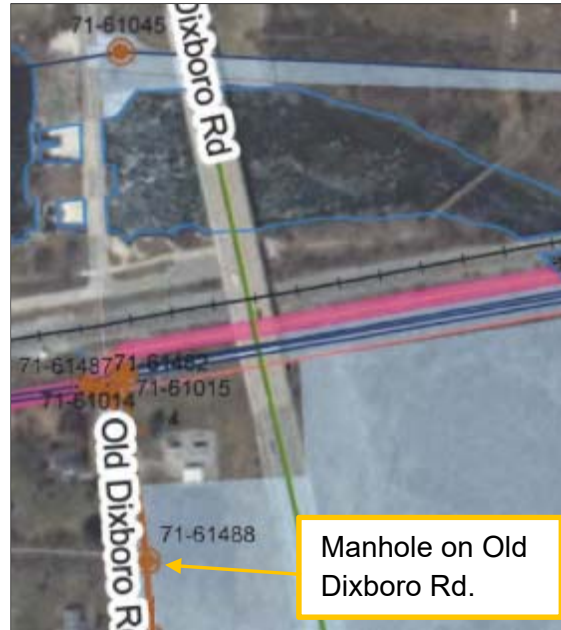


FIGURE 17: OLD DIXBORO MANHOLE #71-61488





During the week, the H₂S measurements in the Old Dixboro Manhole averaged 9.88 ppm, with a maximum reading of 56 ppm. The pressure readings averaged 0.029 in. H₂O, with a maximum reading of 0.079 in. H₂O. This information indicates that the manhole on Old Dixboro does see a small amount of pressurization and that there is a high amount of H₂S present. Figure 18 below shows the H₂S data, and Figure 19 shows the pressure data.

FIGURE 18: H₂S READINGS FOR SOUTH DIXBORO MANHOLE JULY 30 - AUGUST 6, 2019

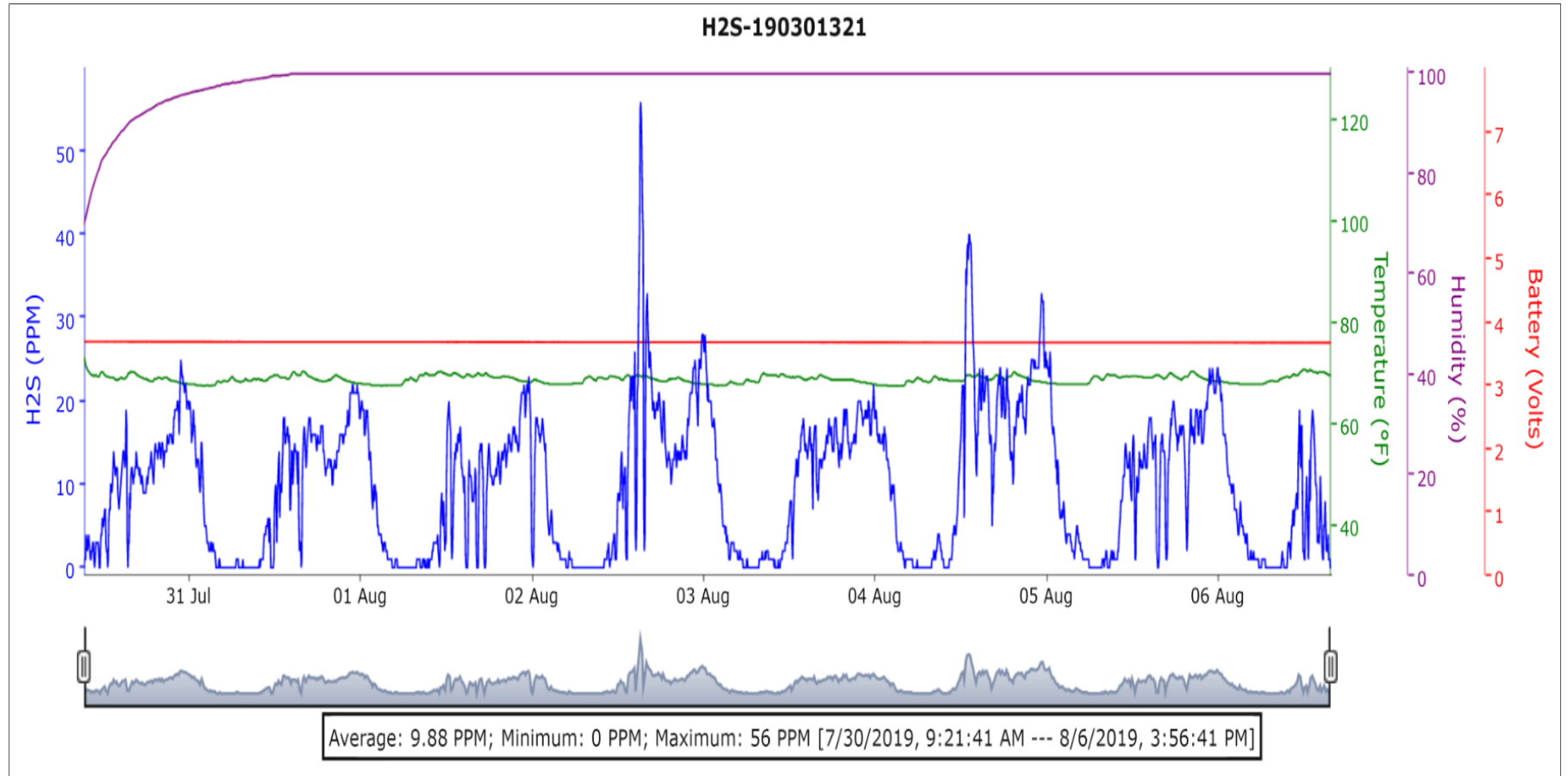
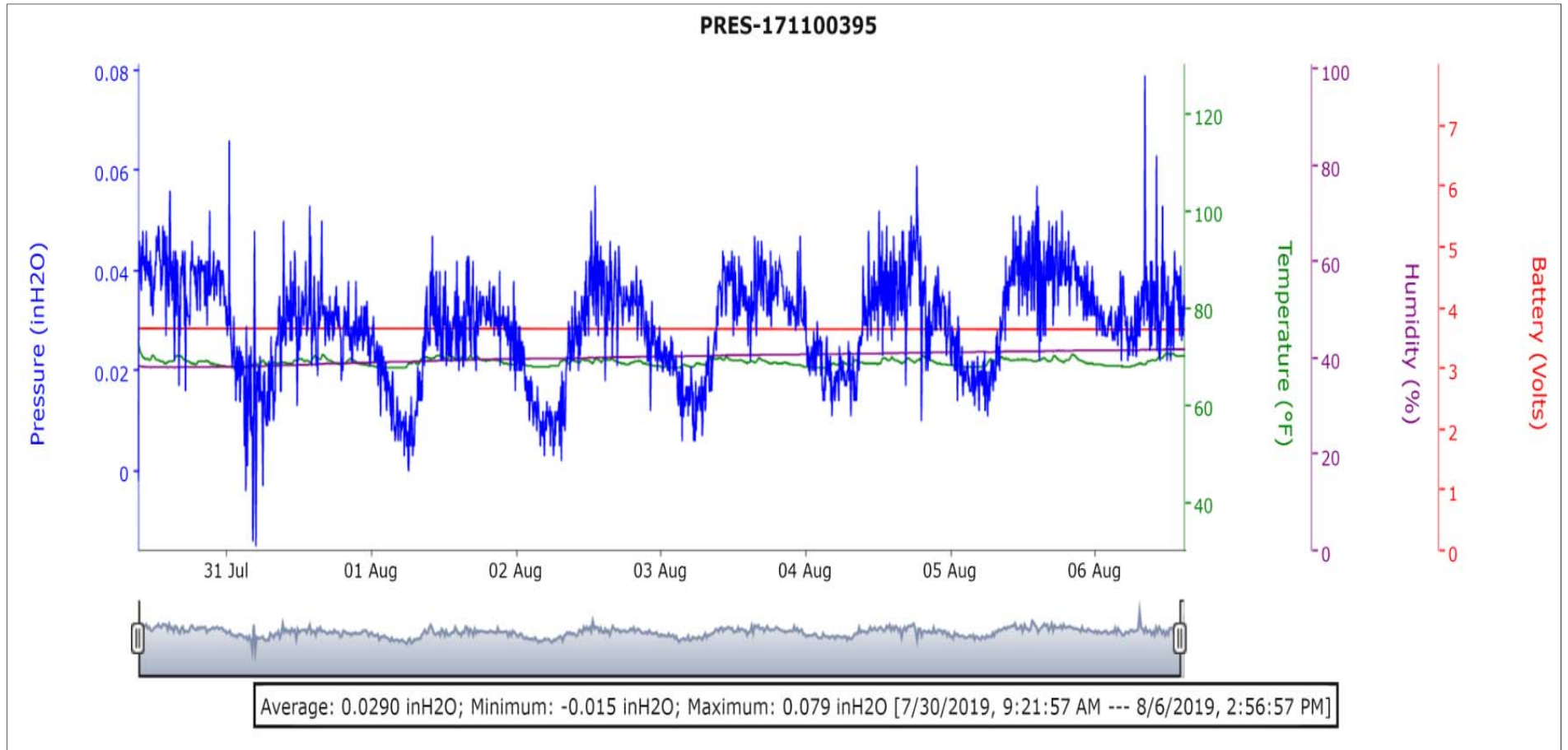


FIGURE 19: PRESSURE READINGS FOR SOUTH DIXBORO MANHOLE JULY 30 - AUGUST 6, 2019



Influent Carbon Vent Filter

H₂S and pressure monitors were installed by HDR and WWTP staff in the inlet piping to the carbon vent filter located in the structure at the plant entrance. The influent carbon vent filter vents the headspace of the area where the 10" sewer, 24" interconnect and 36" interceptor influent meet at the plant entrance. During testing, the carbon filter was not connected to the inlet pipe and a blind flange was installed in order to collect pressure and H₂S measurements. This was the same sampling method used during spring sampling. Figure 20 below shows where the H₂S and pressure monitors were installed and Figure 21 shows the pipe where the monitors were installed.

FIGURE 20: ACTIVATED CARBON VENT FILTER

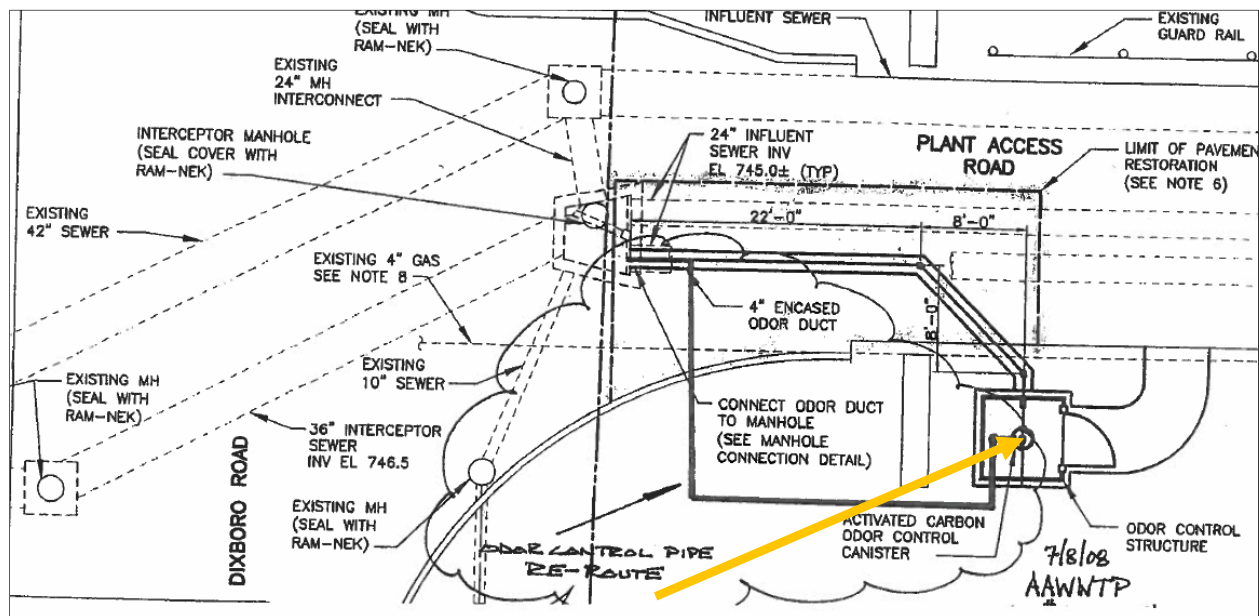


FIGURE 21: CARBON VENT FILTER INLET PIPE



H₂S and pressure monitors were installed here.



During the week, the H₂S measurements in the carbon filter inlet pipe averaged 0.77 ppm, with a maximum reading of 6 ppm. The pressure readings averaged 0.0577 in. H₂O, with a maximum reading of 0.138 in. H₂O. This information indicates that the filter does see positive pressurization nearly all the time and that H₂S is present. Localized odors could therefore be a risk which reinforces the importance and value of the existing carbon system being in place and maintained. Figure 22 shows the H₂S data and Figure 23 shows the pressure data, both in blue.

FIGURE 22: H₂S READINGS FOR INFLUENT CARBON VENT FILTER JULY 30 - AUGUST 6, 2019

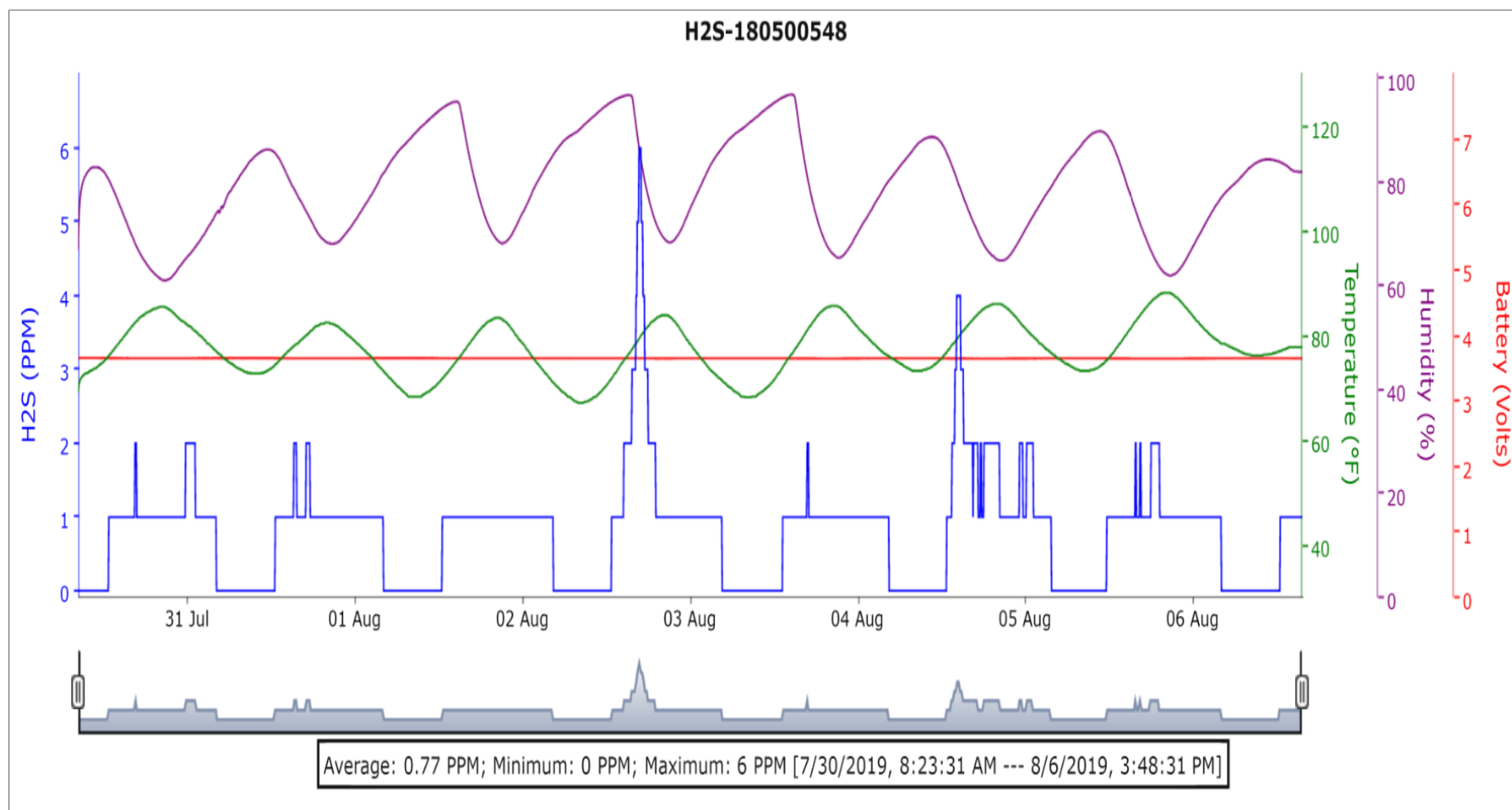
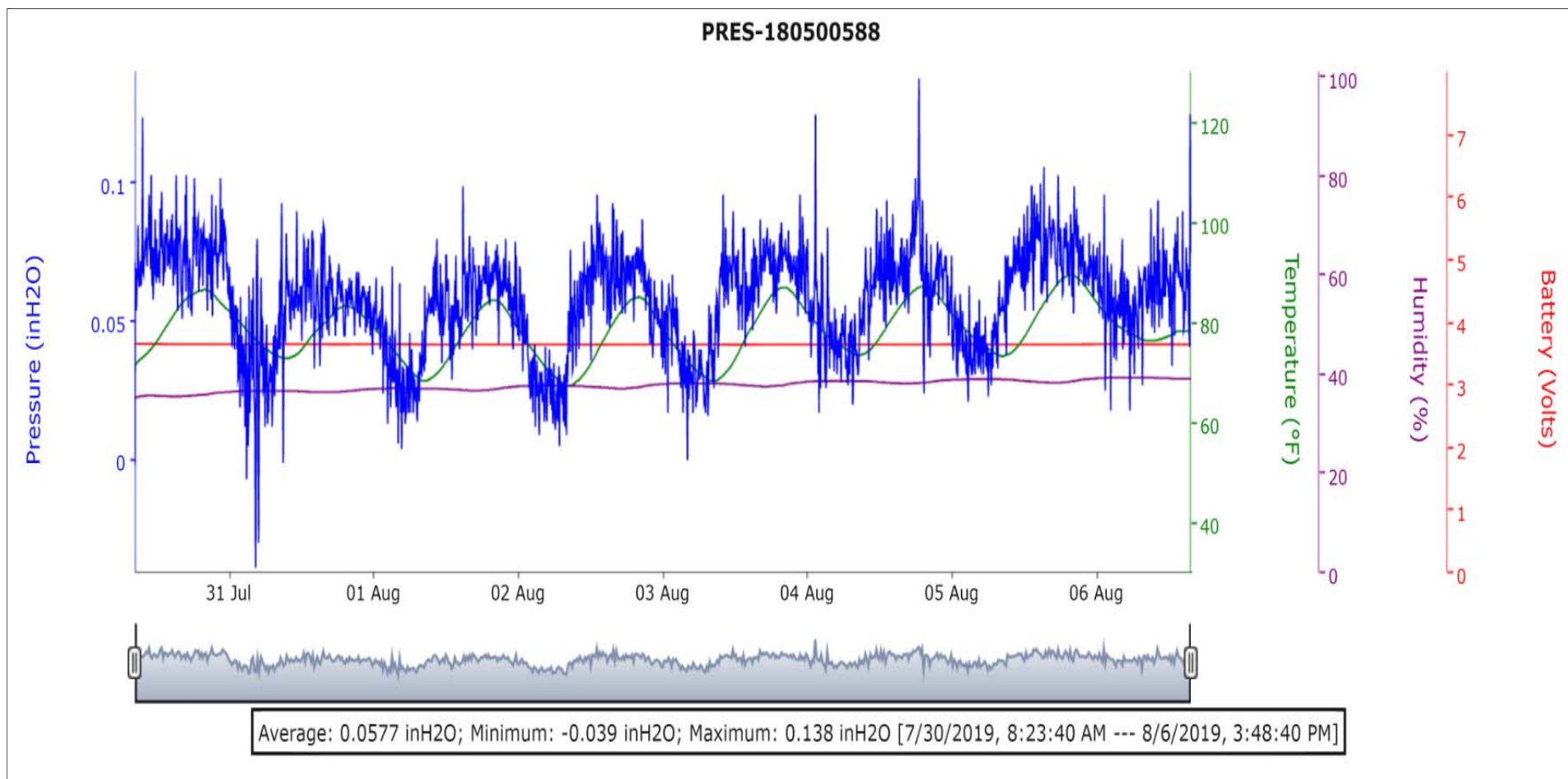


FIGURE 23: PRESSURE READINGS FOR INFLUENT CARBON VENT FILTER JULY 30 - AUGUST 6, 2019



Influent Overflow Structure

H₂S and pressure monitors were installed by HDR and WWTP staff in the overflow structure on the influent 42" sewer line along the plant entrance. See Figure 24 for location. Figure 25 below shows that the H₂S and pressure monitors were installed on the northeast side of the structure (downstream of the overflow weir). The hatch was then re-installed for the week long testing with the monitors located just below the hatch cover.

FIGURE 24: LOCATION OF INFLUENT OVERFLOW STRUCTURE



FIGURE 25: INFLUENT OVERFLOW STRUCTURE WITH MONITORS





During the week, the H₂S measurements in the overflow structure averaged 0.03 ppm, with a maximum reading of 9 ppm. The pressure readings averaged 0.0035 in. H₂O, with a maximum reading of 0.021 in. H₂O. This information indicates that the overflow structure does see a small amount of pressurization and that H₂S has a daily diurnal cycle. This data will be used during follow-up dispersion modeling to determine the risk of off-site odor impacts from this location. Figure 26 below shows the H₂S data and Figure 27 shows the pressure data.

FIGURE 26: H₂S READINGS FOR INFLUENT OVERFLOW STRUCTURE JULY 30 - AUGUST 6, 2019

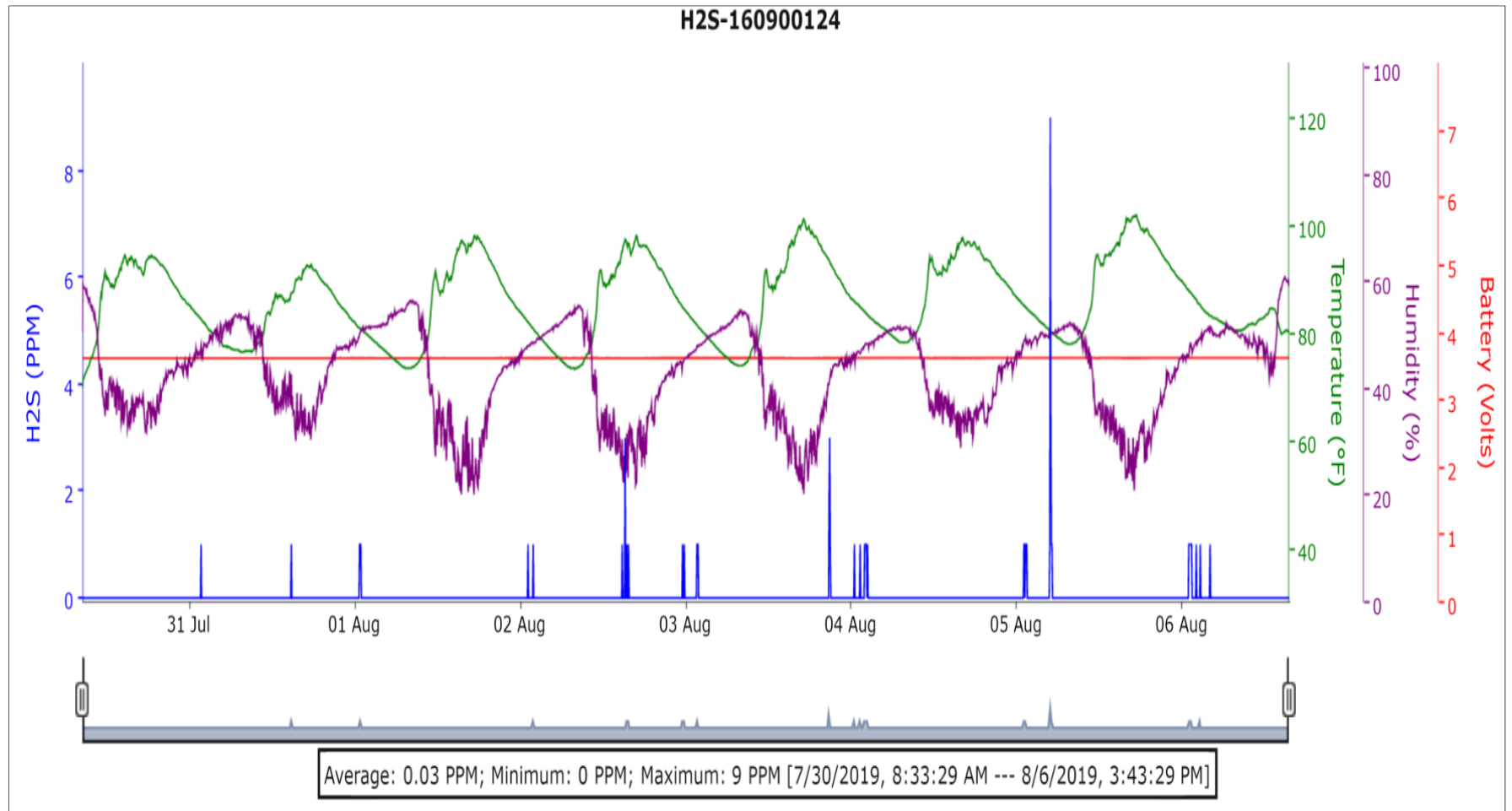
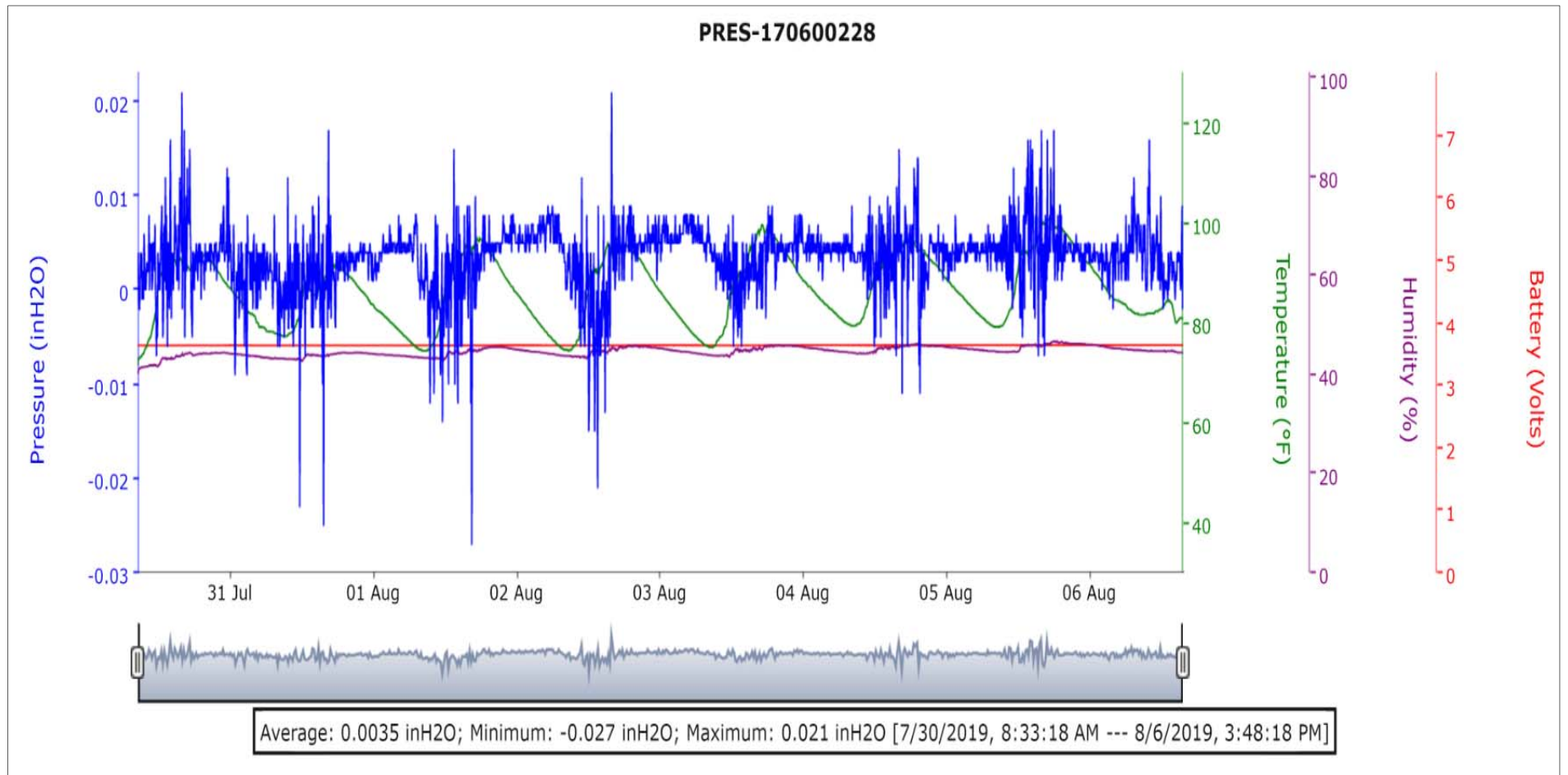


FIGURE 27: PRESSURE READINGS FOR INFLUENT OVERFLOW STRUCTURE JULY 30 - AUGUST 6, 2019



Screen and Grit Building

An H₂S monitor was installed by HDR on the inlet of the Screen and Grit Building Exhaust fan RF-25. Figure 28 shows the location and Figure 29 shows how the H₂S monitor was installed. The monitor was placed just beneath the fan screen.

FIGURE 28: INLET OF SCREEN AND GRIT BUILDING EXHAUST FAN RF-25

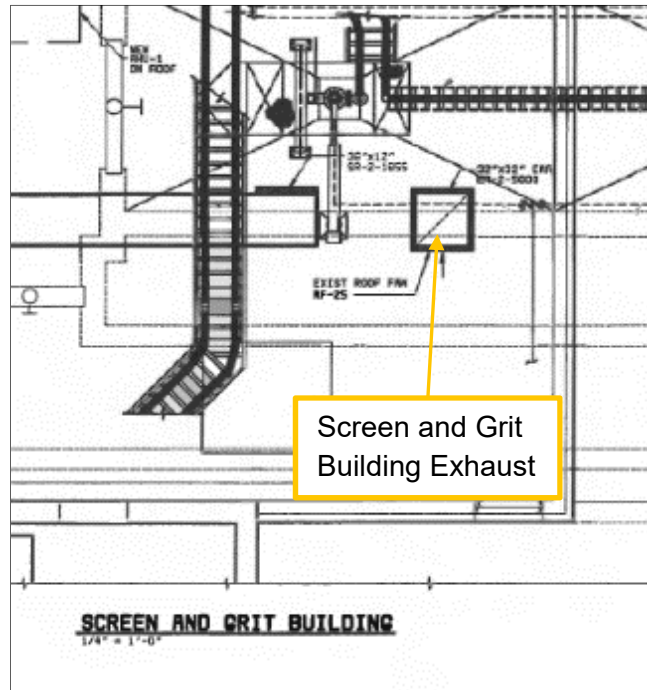


FIGURE 29: INLET OF SCREEN AND GRIT BUILDING EXHAUST FAN RF-25

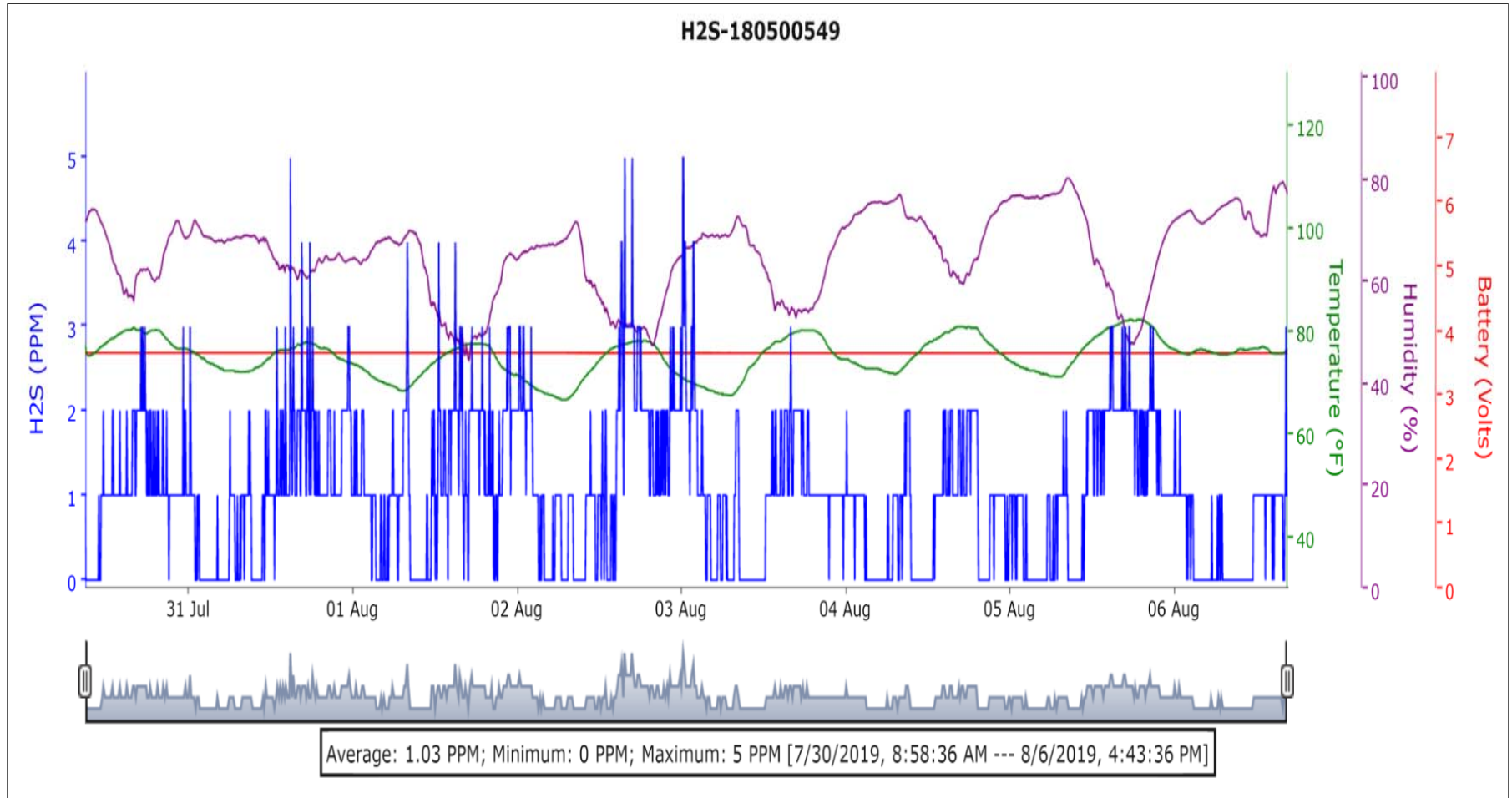




The H₂S measurements at the inlet of the fan were on average 1.03 ppm, with a maximum reading of 5 ppm during the week that data was collected. This information indicates that H₂S is present, and the data shows it maintained a constant presence in the Screen and Grit Building. Figure 30 below shows the H₂S data. Pressure measurements were not taken at this location as the fans force ventilate the building. AERMOD dispersion modeling will use the fan exhaust ratings to calculate odor emission exhaust contribution from this source.

It should also be noted that room exhaust H₂S levels based on the H₂S data logger peaked as high as 5:1 (5 ppm versus 1 ppm average). Field H₂S data when the odor DT samples were taken were relatively low at 0.27 ppm on the field Jerome meter in the general room space and 1 ppm reported in the Acrulog H₂S data log monitor for this same time stamp at the roof exhaust fan. As such, the DT sample value at 211 DT may represent a low value compared to the peak of 5 ppm H₂S. That is, the DT grab sample taken at 11:11 AM on August 1, 2019 may have been lower than peak observations based solely on H₂S concentrations. Consideration of this will be included in the dispersion modeling evaluation.

FIGURE 30: H₂S READINGS FOR SCREEN AND GRIT BUILDING EXHAUST FAN RF-25 JULY 30 - AUGUST 6, 2019





APPENDIX 1:

CE Schmidt Technical Memo for Ann Arbor WWTP Summer Sampling

CE Schmidt, Ph.D.
Environmental Consultant

August 16, 2019

Mr. Chris Easter
HDR Engineering, Inc.
4880 Sadler Road, Suite 400
Glen Allen, VA 23060

Dear Mr. Easter:

Enclosed please find a copy of the Technical Memorandum for the Summer Testing event at the Ann Arbor WWTP conducted last month. Included in the Technical Memorandum are the scanned copies of the field forms and chain-of-custody forms. The data are in excel and the lab reports are PDF files.

If you have any questions, please feel free to call.

Sincerely,

A handwritten signature in black ink, appearing to read "CE Schmidt", with a long horizontal flourish extending to the right.

CE Schmidt, Ph.D.

Attachments - Technical Memorandum

TECHNICAL MEMORANDUM

Results of the Summer Testing Event Conducted
At the Ann Arbor WWTP, Ann Arbor, Michigan

Prepared For:

Mr. Chris Easter
HDR Engineering, Inc.
4880 Sadler Road, Suite 400
Glen Allen, VA 23060

Prepared By:

Dr. C.E. Schmidt
Environmental Consultant
19200 Live Oak Road
Red Bluff, California 96080

August 2019

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II. Test Methodology	4
III. Quality Control	5
IV. Results and Discussions	6
V. Summary	7

Attachments

A- Emissions Measurement Data Sheets
B- Chain of Custody, Calibration Data, and Certifications
C- Lab Reports

References

EXECUTIVE SUMMARY

This Technical Memorandum documents the field testing activities and the results of the Summer Testing event conducted with HDR, Inc. at the City of Ann Arbor Wastewater Treatment Plant (WWTP). The testing team consisted of CE Schmidt and Chris Easter and Josh Prusakiewicz from HDR, Inc. Testing was conducted on July 31 and August 1, 2019.

Testing for the summer testing event was conducted during typical summer season operations which includes land application of liquid biosolids. Biosolids are removed offsite by loading liquid biosolids into tanker trucks as opposed to winter/spring season removal as dewatered cake biosolids. Planet breeze deodorant was used during the winter/spring seasons when dewatered cake is loaded into open top trucks to reduce the odor source and thus minimize the potential off site odor impact to the surrounding community during transport to the landfill. During the summer, liquid biosolids are pre-treated with a lime slurry and loaded directly into closed top tanker trucks for hauling to land application sites.

The summer testing program included collecting air at various locations for odor and odorous compounds in onsite ambient and process air gas streams. Testing also included measured 'flux' at key locations in the process using the U.S. EPA surface emission isolation flux chamber (flux chamber). Testing included sampling procedures for air quality including real-time hydrogen sulfide measurement using a Jerome 631X instrument and ammonia/amines using colorometric detection tubes. Grab samples were collected for olfactory odor analysis by ASTM E-679 and reduced sulfur compounds using USEPA Method TO-15 (GC/FPD detector). Not all species were monitored at all locations. These activities were conducted by HDR, Inc. and CE Schmidt.

The primary goals of the summer testing project were to:

- 1) Collect source data on odor and odorant compound concentrations in the solids handling building during liquid biosolids truck loading;
- 2) Collect source data on odor and odorant concentrations in the centrifuge room when centrifuge dewatering is not active;
- 3) Collect source data on the efficiency of the odor control system carbon filters in the dewatering building;
- 4) Collect source data on the efficiency of the odor control ammonia scrubber in the dewatering building;
- 5) Determine the air quality upwind and downwind of the WWTP;
- 6) Measure the flux of study compounds using a flux chamber at key points in selected processes for study compounds.

In total, 26 sources were measured. There were 24 grab samples for odor, 23 grab samples for reduced sulfur species, and 20 samples taken for ammonia/amine detection, including quality control testing as described below.

SOURCE	Sample Type
Summer Testing Event	-
Secondary Clarifier SC-3, Quiescent Zone	Surface Flux
Aerated Zone 3 at End of Basin	Surface Flux
Downwind Ambient Air, SE Corner	Ambient Air (Grab)
Dewatering Truck Bay, Truck Loading	Room Air (Grab)
Aerated Zone 1 Aeration Basin	Surface Flux
Aeration Basin Anoxic/Anaerobic Zone	Surface Flux
Upwind Ambient Air, NW Corner	Ambient Air (Grab)
Primary Clarifier E-3, Quiescent Zone	Surface Flux
Primary Clarifier E-3, Weir Zone	Surface Flux
Tertiary Filter Exhaust Fan	Room Air (Grab)
Headspace of Overflow Structure	Room Air (Grab)
Screen & Grit Building Effluent; Splitter Box	Surface Flux
Dewatering Centrifuge Room Exhaust	Room Air (Grab)
Outlet of Carbon Filter Vent #2, Biosolids Bldg	Process Vent (Grab)
Outlet of Carbon Filter Vent #3, Biosolids Bldg	Process Vent (Grab)
Cake Hopper Level Exhaust Air	Room Air (Grab)
Lower Dewatering Centrifuge Room	Room Air (Grab)
Gravity Belt Thickener Room Exhaust	Room Air (Grab)
Inlet To Carbon Filters; Common Line	Process Vent (Grab)
Inlet to Ammonia Scrubber	Process Vent (Grab)
Outlet to Ammonia Scrubber	Process Vent (Grab)
Grit/Scum Tank Room	Room Air (Grab)
Screen/Grit Building Exhaust	Room Air (Grab)
Headworks Influent Lift Station	Well Air Under Grate (Grab)
Equalization (Retention) Basin Exhaust	Roof Vent Room Air (Grab)
Media Blank	QC

This Technical Memorandum documents the testing that was performed, comments on the quality control data collected, and reports the results of the assessment. These measurement data reported for process gas streams, along with process flow data, and the flux data can be used to estimate air emissions of study compounds from those processes tested. The ambient air samples provide some indication of the odor levels coming onto the site and also leaving the site on the day tested.

I. INTRODUCTION

This technical memorandum describes the field testing that was conducted in order to assess the air quality and air emissions of odor and odorous compounds from key process and key locations on and around the WWTP. A summer season testing event was conducted with HDR, Inc. at the City of Ann Arbor WWTP located in Ann Arbor, Michigan. The testing team consisted of CE Schmidt and Chris Easter and Josh Prusakiewicz from HDR, Inc. Testing was conducted on July 31 and August 1, 2019. The testing activity included: assessing odor and odorous compound sources, ambient air and room air from key processes and locations on the facility, upwind and downwind of the facility, and flux chamber testing at seven plant processes for the determination of measured emission rate.

This memorandum includes a discussion of the testing methodology, quality control procedures, results, discussion of the results, and summary statements. The actual site emissions estimates and control efficiency calculations are reported elsewhere.

II. TEST METHODOLOGY

The summer screening event included:

- 1) Sampling process ambient air or room air for ammonia and amine compounds using color detection tubes;
- 2) Sampling process gas or room air for hydrogen sulfide using a real time Jerome 631X hydrogen sulfide analyzer;
- 3) Collecting process gas, room air, or ambient air in Tedlar bags for olfactory odor analysis using ASTM Method E-679;
- 4) Collecting process gas, room air or ambient air in Tedlar bags for reduced sulfur species using USEPA Method TO-15 (GC/FPD); and
- 5) Flux chamber testing at key locations for project study compounds.

Grab samples for real time screening (colorimetric tube detection and hydrogen sulfide field instrument) were performed by sampling ambient air outdoors, in rooms, or through ports in process ductwork. Likewise, grab samples were collected in Tedlar bags for offsite analysis from ambient air, room air, process air, and the flux chamber using a decompression lung device. All grab samples collected for offsite analysis were logged in on chain-of-custody sheets, sealed in shipping containers, and shipped to the laboratories for next day delivery and analysis.

Testing for surface flux was conducted using the U.S. EPA recommended Surface Isolation Flux Chamber (USEPA Radian Corporation, February 1986)². The technical protocol followed for this work is documented in the sampling plan titled "Air Sampling Investigation Work Plan"¹. Flux chamber sampling was performed on unit processes as per the testing protocol.

The operation of the surface flux chamber is given below:

- 1) Flux chamber, sweep air, sample collection equipment, and field documents were located on-

site.

- 2) The site information, location information, equipment information, date, and proposed time of testing were documented on the Emissions Measurement Field Data Sheet.
- 3) The exact test location was selected and placed about 0.5” to 1” into the liquid surface sealing the side walls of the chamber.
- 4) The sweep air flow rate (ultra-high purity (UHP) air) was initiated and the rotometer, which stabilizes the flow rate, was set at 5.0 liters per minute. A constant sweep air flow rate was maintained throughout the measurement for each sampling location.
- 5) Flux chamber data were recorded every residence interval (6 minutes) for five intervals, or 30 minutes.
- 4) At steady-state (assumed to be greater than 5 residence intervals), the screening by colorimetric tube and real time analyzer for hydrogen sulfide was performed. After screening, sample collection was performed by interfacing the sample media container to the purged sample line and filling the Tedlar bag containers (reduced sulfur species and odor) with sample gas. Additional real-time data collection included surface and air temperatures inside and outside of the flux chamber.
- 7) After sample, the sample collection information was documented on the appropriate data sheets.
- 8) After sampling, the flux measurement was discontinued by shutting off the sweep air, removing the chamber, and securing the equipment. The chamber was cleaned as necessary by dry wipe with a clean paper towel and the sample lines were purged with UHP air. All samples were preserved as per the method specifications, packaged, and delivered to the laboratories for analysis.
- 9) Sampling locations were recorded on the field data sheet. The equipment was then relocated to the next test location and steps 1) through 8) were repeated.

III. QUALITY CONTROL

The application and frequency of the project Quality Control procedures were developed to meet the program data quality objectives and were executed without exception.

Field Documentation -- A field notebook containing data forms, including sample chain-of-custody (COC) forms, was maintained for the testing program. Attachment A contains the Screening Data Forms.

Chain-of-Custody -- COC forms were used for field data collection. Field data were recorded on the Chain-of-Custody forms provided in Attachment B.

ASTM E679 for Olfactory Odor

Method Quality Control – All method QC testing as indicated by the laboratory was within method specifications, and these data indicate acceptable method performance.

Field System Blank – One media (field) blank sample (O-211) was analyzed as a blind QC sample. The blank level was 10 DT, which is very typical for this laboratory and other blank sample levels. Upwind and downwind odor levels were the same or higher than the blank. The downwind sample was 10 DT and the upwind sample was 19 DT.

Method Precision – Replicate samples were not collected for the screening activity thus no statement can be made regarding method precision.

USEPA Method TO-15 for Hydrogen Sulfide and Speciated Sulfur Compounds

Method Quality Control – All method QC testing as indicated by the laboratory was within method specifications, and these data indicate acceptable method performance.

Method Blank Sample- Two method blank sample analyses were performed by the laboratory. No compounds were detected in the blank samples above method reporting limits (see Table 2) which varied per compound (9.7-to-19 ppbv). Twenty compounds were included in the analysis. These data indicate acceptable method performance.

Field Method Blank Sample- One method blank sample was performed by the laboratory. No compounds were detected in the blank sample above method reporting limits (see Table 2) which varied per compound (9.7-to-19 ppbv). Twenty compounds were included in the analysis. These data indicate acceptable method performance.

Laboratory Control Recovery Analysis Sample – Two laboratory QC samples were analyzed in replicate for accuracy and precision. The standard sample was recovered within the QC limits ranging from 71%-to-127%, and the sample precision was within relative standard deviation criteria for all 20 compounds. These data indicate acceptable performance for reduced sulfur compounds.

IV. RESULTS AND DISCUSSIONS

A summary of the field sample collection for the summer screening activity along with the results of the odor analysis as reported by the laboratory are provided in Table 1. All field data for the summer event test activities are reported on Table 1 along with the odor concentration (DT) data. Reduced sulfur data reported in concentration units (ppbv and ug/m3) are found on Table 2. Reduced flux data for the seven flux chamber tests are found in Table 3; flux units are either DT/m2,min (odor) and mg/m2,min (field ammonia, amine, hydrogen sulfide, and reduced sulfur species data). Note that data from the winter/spring screening event are shown on Tables 1 and 2 for comparison purposes. Field data sheets and notebook recordings are provided in Attachment A, sample chain-of-custody forms in Attachment B, and lab reports in Attachment C.

The upwind and downwind odor and reduced sulfur compound air quality showed little difference. For both upwind and downwind, the reduced sulfur compound data were non-detect. The odor concentration data upwind of the facility had an odor concentration of 19 DT and the downwind odor concentration was 10 DT showing very little potential of offsite odor on the day sampling occurred. Winds were light and dispersion conditions were good, and the odor descriptions for both the upwind and downwind samples were typical of vegetation and the nearby river but not that of sewage or fecal matter.

Testing in the truck loading bay was near detection limits or ambient levels and that was not surprising given that sludge was not dewatered but removed as liquid in tanker trucks for land application as is the practice during the summer season. The loading of biosolids in the winter/spring season in the dewatering building was very high in the truck loading bay by comparison (winter/spring odor level of 16,575 DT).

Based on the screening of ammonia and amines using colorimetric tube detection, the ammonia scrubber in the dewatering building showed good removal of ammonia and amines. No odor samples were collected from the ammonia scrubber. Control efficiencies can be calculated along with emission rate data for odor and species knowing the flow from the ammonia scrubber.

The inlet to the carbon filters in the dewatering building in the summer showed lower odor as compared to the winter/spring screening (620 DT for summer vs. 11,730 DT for winter/spring). This is likely due to the fact that lower odor liquid biosolids are loaded into trucks in the summer and higher odor dewatered biosolids cake is loaded in the winter/spring. The carbon filter inlet had a field screening for ammonia at 1.3 ppmv and H2S at 0.15 ppmv, and no detectible reduced sulfur species from the laboratory-analyzed bag sample. Note that ammonia scavenges reduced sulfur species in the Tedlar bag which may explain why the field H2S analyzer detected H2S but it was not found in the bag sample. The carbon filters demonstrated good removal of odor and reduced sulfur species by showing very low odor levels in both outlets tested (69 DT-to-75 DT) and low reduced sulfur species concentrations as well (non-detect for sulfur species except for low levels of dimethyl sulfide and dimethyl disulfide in both outlets). Control efficiencies can be calculated along with emission rate data for odor and species knowing the flow from the carbon filters.

The highest levels of odor from the plant processes was from the headworks influent lift station

under the well grate on the outdoor platform which showed an odor level of 8,313 DT and detectable levels of hydrogen sulfide, methyl mercaptan, and dimethyl disulfide in the air Tedlar bag sample.

Again, it should be noted that when ammonia and amines are present in a Tedlar bag sample with hydrogen sulfide, hydrogen sulfide can be scavenged thus resulting in lower readings from the lab sample as compared to the field instrument. Likewise, Tedlar bag odor samples can also be affected when these odorous compounds react and are thus not detected by the odor panel. If a choice needs to be made using a value for hydrogen sulfide, the conservative approach would be to use the hydrogen sulfide value from the field instrument over the lab data if the field value is higher. As such, these odor and concentration or flux data should be used conservatively when conducting an odor assessment or apportionment of the facility. However, when using these data in comparison to other sources where the samples are subject to the same matrix affects, the relative use of these data can be viewed with higher certainty.

V. SUMMARY

A summer season testing event was conducted at that City of Ann Arbor WWTP on July 31 and August 1, 2019. Odor sources were investigated by collecting ambient air, process air, room air, and flux chamber gas samples where both field and laboratory methods were used to assess odor and odor species levels. Testing was conducted for the purpose of generating a data base for understanding odor sources, potential ambient air impacts from odor sources, and for projecting off site odors to the neighborhood. The following is a summary of activities and results associated with this objective:

- Ambient air, process air, room air, and flux chamber sampling was conducted using standard sampling methods and laboratory methods to better understand odor sources and their potential impacts off site in the surrounding community.
- Field and laboratory quality control data indicate acceptable data quality for ASTM E679 (olfactory odor) and USEPA Method TO-15 for speciated reduced sulfur compounds. The method blank level for the odor sample was typical for the method blank level (10 DT). No compounds were detected above MDL for the speciated sulfur blank sample.
- These summer season testing results (field grab samples and flux chamber samples) can be used to satisfy the program objectives. Emission rate data using these process exhaust concentration data are reported elsewhere.

REFERENCES

- 1) Chris Easter, HDR, Inc. Air Sampling Investigation Work Plan, City of Ann Arbor Area Odor Study, July 23, 2019.
- 2) USEPA. 1986. "Measurement of Gaseous Emission Rates From Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide." EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA Contract No. 68-02-3889, Work Assignment No. 18, Radian Corporation, February 1986. NTIS # PB 86-223161.

ATTACHMENT A

EMISSION MEASUREMENT DATA SHEETS

Table 1. Summer Sampling Event; Ann Arbor WWTP, July 31 and August 1, 2019.

DATE	TIME	SOURCE	Sample Type	NH3 T	Amine T	H2S	Odor	TRS	ODOR	ODOR	ODOR	ODOR CHARACTER	COMMENT
		Summer Testing Event		(ppmv)	(ppmv)	(ppmv)	ID	ID	DT	SL a	SL a		
7/31/2019	834	Secondary Clarifier SC-3, Quiescent Zone	Surface Flux	ND	ND	0.001	O-100	S-100	11	too low	to low	sour, sewage, gassy, sulfur, rotten, plastic, cleanin products	Center of quiescent zone
7/31/2019	933	Aerated Zone 3 at End of Basin	Surface Flux	ND	ND	0.0097	O-101	S-101	11	too low	to low	sulfur, H2S, gassy,swampy, earthy, cleaning products, plastic	Fine bubble aeration, flow at 630 scfm
7/31/2019	915	Downwind Ambient Air, SE Corner	Ambient Air (Grab)	NA	NA	0.0	O-102	S-102	10	too low	to low	sour, plastic,stale, exhaust	SE wind bring air mass from the WWT to the sampling location
7/31/2019	950	Dewatering Truck Bay, Truck Loading	Room Air (Grab)	ND	ND	0.0017	O-103	S-103	11	too low	to low	sour, sulfur, sewage, rotten garbage, urine, outhouse, feces, fishy, plastic	Truck loading, slight east wind
7/31/2019	1018	Aerated Zone 1 Aeraton Basin	Surface Flux	ND	ND	0.014	O-104	S-104	21	0.59	0.83	sour H2S, sewage, rotten eggs/garbage/vegetables, skunk, mercaptan	Fine bubble aeration, flow at 1800 scfm
7/31/2019	1101	Aeration Basin Anoxic/Anaerobic Zone	Surface Flux	ND	ND	0.045	O-105	S-105	21	0.63	0.86	sour, H2S, sewage, rottne sludge/garbage/vegetables, skunk mercaptan, vomitus	Not aerated
7/31/2019	1010	Upwind Ambient Air, NE Corner	Ambient Air (Grab)	NA	NA	0.0	O-106	S-106	19	0.37	0.98	sour, sulfur, vegetation, wet grass, plastic, exhaust	NE corner inside front gate, calm wind
7/31/2019	1203	Primary E-3, Quiescent Zone	Surface Flux	0.1	0.2	0.029	O-107	S-107	163	0.51	0.81	skunk, mercaptan, rotten garbage/sludge, feces	Center of quiescent zone
7/31/2019	1`257	Primary E-3, Weir Zone	Surface Flux	ND	0.1	1.0	O-108	S-108	1507	0.40	0.79	sour, sewage, sulfur, H2S, rotten garbage/eggs/sludge, feces	Fine bubble transport by wastewater falling through weir into trough
7/31/2019	1154	Tertiary Filter Exhaust Fan	Room Air (Grab)	NA	NA	0.0	O-109	S-109	10	too low	to low	sour, H2S, rotten, sewage, plastic, rubber	Collected at the center of the exhaust fan
7/31/2019	1235	Headspace of Overflow Structure	Room Air (Grab)	0.5	ND	0.002	O-110	NA	250	0.53	0.89	rotten sewage/cabbage/garbage, feces, manure, outhouse, sulfur, urine	Structure just outside gate
7/31/2019	1352	Screen/Grit Building Effluent; Splitter Box	Surface Flux	0.1	0.2	1.9	O-111	S-111	1451	0.63	0.77	sour, rotten eggs/garbage, sewage, sulfur, H2S	Coarse bubble aeration, well mixed
8/1/2019	759	Dewatering Centrifuge Room Exhaust	Room Air (Grab)	ND	ND	0.001	O-200	S-200	11	too low	to low	sour, light sewage, rubber, plastic, cleaning chemicals	Center of room
8/1/2019	825	Outlet of Carbon Filter Vent #2, Biosolids Bldg	Process Vent (Grab)	2	2	0.055	O-201	S-201	75	0.44	0.80	sulfur, sewage, rotten vegetables, dead animals	Center of exhaust stack
8/1/2019	833	Outlet of Carbon Filter Vent #3, Biosolids Bldg	Process Vent (Grab)	1.5	4	0.050	O-202	S-202	69	0.49	0.80	sulfur, sewage, rotten vegetables, garbage	Center of exhaust stack
8/1/2019	909	Cake Hopper Level Exhaust Air	Room Air (Grab)	1.5	ND	0.01	O-203	S-203	12	too low	to low	sour, rotten eggs/garbage/vegetables, sewage, old urine, Cl2, earthy dirt, plastic	Center of room
8/1/2019	920	Dewatering Centrifuge (Lower) Room	Room Air (Grab)	ND	0.2	0.006	O-204	S-204	8	too low	to low	sulfur, sewage, plastic, cleaning chemicals, Cl2, new vinyl	Center of room
8/1/2019	943	Gravity Belt Thickener Room Exhaust	Room Air (Grab)	ND	ND	0.005	O-205	S-205	11	too low	to low	sour, sewage, sulfur, wet cardboard, earthy, dirt, Cl2, plastic	Center of room
8/1/2019	956	Inlet To Carbon Filters; Common Line	Process Vent (Grab)	1.3	ND	0.15	O-206	S-206	620	0.73	0.87	sewage, sulfur, sludge, rotten vegetables,/garbage, outhouse, earthy, dirt	Common inlet to carbon scrubbers
8/1/2019	1010	Inlet to Ammonia Scrubber	Process Vent (Grab)	21	>20	NA	None	None	None	None	None	No odor sample	No odor or sulfur sample was collected
8/1/2019	1013	Outlet to Ammonia Scrubber	Process Vent (Grab)	ND	ND	NA	None	None	None	None	None	No odor sample	No odor or sulfur sample was collected
8/1/2019	1057	Grit Tank Room	Room Air (Grab)	ND	ND	0.13	O-207	S-207	298	0.47	0.77	rotten sewage, sulfur, sulfides, rotten eggs, H2S, rotten garbage	Center of room
8/1/2019	1111	Screen/Grit Building Exhaust	Room Air (Grab)	ND	ND	0.27	O-208	S-208	211	0.69	0.79	H2S, rotten sewage, sulfur, rotten eggs	Center of room
8/1/2019	1133	Headworks Influent Lift Station	Well Air Under Grate (Grab)	NA	NA	16.5	O-209	S-209	8313	0.60	0.83	H2S, rotten sewage, sulfur, rotten eggs/garbage	Sample taken throug grate representing air vented to atmosphere
8/1/2019	1155	Equalization Basin Exhaust	Room Air (Grab)	NA	NA	0.006	O-210	S-210	75	0.64	0.77	sour, sewage, sulfur, rotten vegetables,/garbage/sludge, sour milk, earthy, dirt	Basin was being filled as the basin room air was sampled
8/1/2019	1226	Media Blank	QC	NA	NA	NA	O-211	S-211	10	too low	to low	sour, sewage, sulfur, H2S, plastic, Cl2, bleach, chemicals	Ultra hight purity air in sampling media
		Spring Screening Event											
4/17/2019	721	Truck Loading Bay- No Truck	Room Air (Grab)	0.1	ND	0.002/0.004	O-001	S-001	19	0.63	0.77	sour, stale, plastic, vegetation, swampy	Truck Bay unused for 24 hours
4/17/2019	832	Ammonia Scrubber Exhaust	Process Vent (Grab)	ND	ND	NA	NA	NA	NA	NA	NA	NA	
4/17/2019	835	Ammonia Scrubber Inlet- N3 Only	Process Vent (Grab)	2	NA	NA	NA	NA	NA	NA	NA	NA	
4/17/2019	837	Ammonia Scrubber Inlet- Amines Only	Process Vent (Grab)	NA	1.5	NA	NA	NA	NA	NA	NA	NA	
4/17/2019	939	Ambient Air Downwind of WWTP	Ambient Air (Grab)	NA	NA	0.002/0.002	O-002	S-002	17	0.59	0.86	sour, stale, plastic, vegetation, candle wax	Half way between front gate and pump shed, 2-5 mph; easterly flow
4/17/2019	958	Truck Loading Bay- Truck Loading	Room Air (Grab)	ND	ND	5.3	O-003	S-003	16,575	0.60	0.71	sewage, sulfur, garbage, manure, fecal, rotten sludge	H2S at 2.5 ppmv soon after start, 6.9 max, 4.4 ppmv as sample collected
4/17/2019	1016	Ambient Air Upwind of WWTP	Ambient Air (Grab)	NA	NA	0.002/0.002	O-004	S-004	10	LOW	LOW	sour, stale, plastic, burnt plastic, vegetation mushrooms, salty	East end of WWTP at tree line near river, 1-2 mph; easterly flow
4/17/2019	1046	Inlet To Carbon Filters; Common Line	Process Vent (Grab)	ND	ND	3.9/3.7	O-005	S-005	11,730	0.51	0.78	feces, rotten sludge, sewage, dirty toilet, outhouse, fecal	
4/17/2019	1106	Carbon Filter Outlet Unit 1, South	Process Vent (Grab)	0.1	0.2/0.3	0.023/0.022	O-006	S-006	82	0.59	0.72	sour, rotten manure, garbage, sewage, rotten sludge, mercaptan	
4/17/2019	1133	Carbon Filter Outlet Unit 2, Middle	Process Vent (Grab)	ND	ND	0.016/0.016	O-007	S-007	45	0.67	0.73	sour, feces, manure, rotten vegetable garbage, rotten mercaptan, rotten spinach, dirty toilet, outhouse	
4/17/2019	1150	Centrifuge Room Exhaust	Room Air (Grab)	ND	ND	0.003/0.003	O-008	S-008	19	0.63	0.73	sour, stale, vegetation, salty, plastic, burning plastic, smoky, burnt	Center of retangular exhaust screen
4/17/2019	1215	Media Blank	QC	NA	NA	NA	O-009	S-009	23	0.55	0.78	fresh cut wood, wood chips, pencil lead, plastic, musty, vegetation	Ultra high purity air; <0.01 ppmv hydrocarbon content

ND- Not detected
NA- not applicable
NH3 T- ammonia tube
Amine T- amine tube
H2S- hydrogen sulfide by Jerone 631X instrument
SlA/SLb- Steven's Law Contants

Table 2. Summary of Reduced Sulfur Species Concentration Data

SOURCE	Sample Type	H2S-F (ppmv)	TRS ID	H2S (ppbv)	H2S (ug/m3)	CS (ppbv)	CS (ug/m3)	MM (ppbv)	MM (ug/m3)	EM (ppbv)	EM (ug/m3)	DMS (ppbv)	DMS (ug/m3)	CDS (ppbv)	CDS (ug/m3)	iPM (ppbv)
Summer Testing Event																
Secondary Clarifier SC-3, Quiescent Zone	Surface Flux	0.001	O-100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aerated Zone 3 at End of Basin	Surface Flux	0.0097	O-101	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Downwind Ambient Air, SE Corner	Ambient Air (Grab)	0.0	O-102	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dewatering Truck Bay, Truck Loading	Room Air (Grab)	0.0017	O-103	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aerated Zone 1 Aeraton Basin	Surface Flux	0.014	O-104	13.8	19.2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aeration Basin Anoxic/Anaerobic Zone	Surface Flux	0.045	O-105	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Upwind Ambient Air, NE Corner	Ambient Air (Grab)	0.0	O-106	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Primary E-3, Quiescent Zone	Surface Flux	0.029	O-107	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Primary E-3, Weir Zone	Surface Flux	1.0	O-108	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tertiary Filter Exhaust Fan	Room Air (Grab)	0.0	O-109	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Headspace of Overflow Structure	Room Air (Grab)	0.002	O-110	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Screen/Grit Building Effluent, Splitter Box	Surface Flux	1.9	O-111	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dewatering Centrifuge Room Exhaust	Room Air (Grab)	0.001	O-200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Outlet of Carbon Filter Vent #2, Biosolids Bldg	Process Vent (Grab)	0.055	O-201	ND	ND	ND	ND	ND	ND	ND	ND	112.3	285.9	ND	ND	ND
Outlet of Carbon Filter Vent #3, Biosolids Bldg	Process Vent (Grab)	0.050	O-202	ND	ND	ND	ND	ND	ND	ND	ND	100.1	254.8	ND	ND	ND
Cake Hopper Level Exhaust Air	Room Air (Grab)	0.01	O-203	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dewatering Centrifuge (Lower) Room	Room Air (Grab)	0.006	O-204	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gravity Belt Thickener Room Exhaust	Room Air (Grab)	0.005	O-205	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inlet To Carbon Filters; Common Line	Process Vent (Grab)	0.15	O-206	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inlet to Ammonia Scrubber	Process Vent (Grab)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Outlet to Ammonia Scrubber	Process Vent (Grab)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Grit Tank Room	Room Air (Grab)	0.13	O-207	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Screen/Grit Building Exhaust	Room Air (Grab)	0.27	O-208	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Headworks Influent Lift Station	Well Air Under Grate (Grab)	16.5	O-209	5,120.40	7,151.7	ND	ND	175.0	345.1	ND	ND	ND	ND	ND	ND	ND
Equalization Basin Exhaust	Room Air (Grab)	0.006	O-210	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Media Blank	QC	NA	O-211	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lab Blank		NA	Lab	<16.2	<22.6	<9.7	<23.9	<16.2	<31.9	<17.1	<43.2	<17.8	<45.3	<18.4	<57.3	<17.1
Spring Screening Event																
Truck Loading Bay- No Truck	Room Air (Grab)	0.002/0.004	S-001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ammonia Scrubber Exhaust	Process Vent (Grab)	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonia Scrubber Inlet- N3 Only	Process Vent (Grab)	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ammonia Scrubber Inlet- Amines Only	Process Vent (Grab)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ambient Air Downwind of WWTP	Ambient Air (Grab)	0.002/0.002	S-002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Truck Loading Bay- Truck Loading	Room Air (Grab)	5.3	S-003	3,356.3	4,687.8	117.1	288.4	794.5	1,566.6	ND	ND	585.6	1,491.0	ND	ND	ND
Ambient Air Upwind of WWTP	Ambient Air (Grab)	0.002/0.002	S-004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inlet To Carbon Filters; Common Line	Process Vent (Grab)	3.9/3.7	S-005	962.4	1,344.20	28.3 J	69.6 J	249.9	492.7	ND	ND	262.1	667.3	ND	ND	ND
Carbon Filter Outlet Unit 1, South	Process Vent (Grab)	0.023/0.022	S-006	ND	ND	ND	ND	ND	ND	ND	ND	122.5	312.0	ND	ND	ND
Carbon Filter Outlet Unit 2, Middle	Process Vent (Grab)	0.016/0.016	S-007	ND	ND	ND	ND	ND	ND	ND	ND	69.1	175.9	ND	ND	ND
Centrifuge Room Exhaust	Room Air (Grab)	0.003/0.003	S-008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Media Blank	QC	NA	S-009	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lab Blank		NA	Lab	<16.2	<22.6	<9.7	<23.9	<16.2	<31.9	<17.1	<43.2	<17.8	<45.3	<18.4	<57.3	<17.1

H2S-F- Hydrogen sulfide measured with field analyzer

H2S- Hydrogen sulfide

CS- Carbonyl sulfide

MM- Methyl mercaptan

EM- Ethyl mercaptan

DMS- Dimethyl sulfide

CDS- Carbon disulfide

iPM- i-Propyl Mercaptan

EMS- Ethyl methyl sulfide

nPM- n-Propyl mercaptan

Thio- Thiophene

IBM- Isobutyl mercaptan

DES- Diethyl sulfide

tBM- t-Butyl mercaptan

nBM- n-Butyl mercaptan

DMDS- Dimethyldisulfide

3MT- 3-Methylthiophene

THT- Tetrahydrothiophene

2,5-DMT- 2,5-Dimethylthiophene

DEDS- Diethyldisulfide

2ET- 2-Ethylthiophene

J- value estimated, below reporting limit

Table 2. Summary of Reduced Sulfur Species Concentration Data

[illegible]

Table 2. Summary of Reduced Sulfur Species Concentration Data

2,5-DMT (ug/m3)	DEDS (ppbv)	DEDS (ug/m3)	2ET (ppbv)	2ET (ug/m3)
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
<87.3	<17.6	<80.9	<17.3	<86.6
ND	ND	ND	ND	ND
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
ND	ND	ND	ND	ND
<87.3	<17.6	<80.9	<17.3	<86.6

Table 3. Summary of Summer Flux Sampling Data

DATE	TIME	SOURCE	Sample Type	NH3 F	NH3 F	Amine F	Amine F	H2S F	H2S F	Odor	TRS	ODOR	ODOR	TRS	H2S	H2S	DES	DES	COMMENT
		Summer Testing Event		(ppmv)	(mg/m2,min)	(ppmv)	(mg/m2,min)	(ppmv)	(mg/m2,min)	ID	ID	DT	(DT/m2,min)	ID	(ug/m3)	(mg/m2,min))	(mg/m3)	(mg/m2,min))	
7/31/2019	834	Secondary Clarifier SC-3, Quiescent Zone	Surface Flux	ND	ND	ND	ND	0.001	0.0000523	O-100	S-100	11	0.424	S-100	ND	DN	ND	ND	Center of quiescent zone
7/31/2019	933	Aerated Zone 3 at End of Basin	Surface Flux	ND	ND	ND	ND	0.0097	0.000507	O-101	S-101	11	0.424	S-101	ND	ND	ND	ND	Fine bubble aeration, flow at 630 scfm
7/31/2019	1018	Aerated Zone 1 Aeraton Basin	Surface Flux	ND	ND	ND	ND	0.014	0.000732	O-104	S-104	21	0.809	S-104	0.0192	0.0007392	0.1608	0.0061908	Fine bubble aeration, flow at 1800 scfm
7/31/2019	1101	Aeration Basin Anoxic/Anaerobic Zone	Surface Flux	ND	ND	ND	ND	0.045	0.00235	O-105	S-105	21	0.809	S-105	ND	ND	ND	ND	Not aerated
7/31/2019	1203	Primary E-3, Quiescent Zone	Surface Flux	0.1	0.00262	0.2	0.00954	0.029	0.00152	O-107	S-107	163	6.28	S-107	ND	ND	ND	ND	Center of quiescent zone
7/31/2019	1`257	Primary E-3, Weir Zone	Surface Flux	ND	ND	0.1	0.00477	1.0	0.0539	O-108	S-108	1507	58.0	S-108	ND	ND	ND	ND	Fine bubble transport by wastewater falling through weir into trough
7/31/2019	1352	Screen/Grit Building Effluent; Splitter Box	Surface Flux	0.1	0.00262	0.2	0.00954	1.9	0.0994	O-111	S-111	1451	55.9	S-111	ND	ND	ND	ND	Coarse bubble aeration, well mixed
8/1/2019	1226	Media Blank	QC	NA	NA	NA	NA	NA	NA	O-211	S-211	10	0.385	S-211	ND	ND	ND	ND	Ultra hight purity air in sampling media

QC- quality control
NH3 F- field detection by color tube
Ammine F- field detection by color tube
H2S F- field detection by Jerome 631 instrument
Flux NH3= (17 ppmv NH3/25 gas constant)*(0.005 m3/min/0.013 m2)= mg/m2,min
Flux Methylamine= (31 ppmv NH3/25 gas constant)*(0.005 m3/min/0.013 m2)= mg/m2,min
Flux H2S F= (34 ppmv H2S/25 gas constant)*(0.005 m3/min/0.013 m2)= mg/m2,min
H2S-F- Hydrogen sulfide measured with field analyzer
H2S- Hydrogen sulfide lab analysis
DES- Diethyl sulfide lab analysis
Flux H2S mg/m3 = (H2S mg/m3)*(0.005 m3/min/0.013 m2)= mg/m2,min
Flux DES mg/m3 = (DES mg/m3)*(0.005 m3/min/0.013 m2)= mg/m2,min

ATTACHMENT B

CHAIN OF CUSTODY
CALIBRATION DATA
CERTIFICATIONS

ENVIRONMENTAL

Analytical Service, Inc.

053E

050K

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

CHAIN OF CUSTODY RECORD

Project Number		Project Name		Quote		Requested TAT					
REPORT TO:		1198-44-018				Analytical Tests					
Attention	125/11/10	Matrix		SDG		Comments					
Company	CE SCIMM/DT	A - Ambient Air									
Address	1900 LIVE OAK RD	SG - Soil Gas									
City, State, Zip	RED BLUFF CA 96001	S - Source									
Phone/Fax	530 8791750	I - Indoor Air									
e-mail	clawm105@ce-scim.com										
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Matrix	Initial Pressure	Final Pressure	Laboratory ID	Comments
0-100	7/21/9	0934									
0-101	"	0933									
0-102	"	0915									
0-103	"	0950									
0-104	"	1015									
0-105	"	101									
0-106	"	1010									
0-107	"	1203									
Comments 0-105 " 1254 0-11 7/21/9 1352											
0-107 " 1154											
0-110 " 1235											
BILLING INFORMATION:		SAMPLED BY		Date/Time							
ATTENTION		125/11/10		7/21/9							
Company		CE SCIMM/DT		1300							
Address											
City, State, Zip											
Purchase Order											

Analytical Service, Inc.

CHAIN OF CUSTODY RECORD

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

Project Number		Project Name		Quote		Requested TAT							
REPORT TO:						Analytical Tests							
Attention		Matrix											
Company		A - Ambient Air											
Address		SG - Soil Gas											
City, State, Zip		S - Source											
Phone/Fax		I - Indoor Air											
e-mail													
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Matrix	Initial Pressure	Final Pressure	Laboratory ID	SDG		Comments
S-100	7/2/19	0931											
S-101	"	0933											
S-102	"	0940											
S-103	"	0943											
S-104	"	1018											
S-105	"	1105											
S-106	"	1211											
S-107	"	1203											
Comments: S-109 11 1231 1235-111 7/2/19 1332													
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S-173 11 1231 1235-111 7/2/19 1332													

054E

CHAIN OF CUSTODY RECORD

Project Number		Project Name		Quote		Requested TAT	
REPORT TO:		HAR- A-101P				Analytical Tests	
Attention	02/11/19			Matrix		SDG	
Company	1020111P COM RD			A - Ambient Air			
Address	1020111P COM RD			SG - Soil Gas			
City, State, Zip	1020111P COM RD			S - Source			
Phone/Fax				I - Indoor Air			
e-mail	summit@pco.net						
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Matrix
0-200	01/19	0759					
0-201		0821					
0-202		0833					
0-203		0909					
0-204		0920					
0-205		0943					
0-206		0946					
0-207		1057					
Comments: 0-208 1111 0-211 1224							
0-209 1133							
0-210 1155							
BILLING INFORMATION:				SAMPLED BY		Date/Time	
ATTENTION				02/11/19		02/19	
Company				1020111P		1300	
Address				1020111P			
City, State, Zip				RECEIVED FOR LAB			
Purchase Order							

Analytical Service, Inc.

CHAIN OF CUSTODY RECORD

173 Cross Street
San Luis Obispo, CA
93401 - 7597
805.781.3585
Fax 805.541.4550

Fax 805.541.4550

Project Number		Project Name		Quote Number	
REPORT TO:		HDA - AWP			
Company		PSC/MMA/DT		MATRIX LEGEND	
Address		19100 LIOU CRT RD		A - Ambient Air Low Level	
City/State/Zip		RR 1A 96030		I - Indoor Air	
Phone		5305294316 (FAX)		S - Source Air High Level	
ATTENTION		LFS		G - Gas/Product	
SAMPLE DESCRIPTION		SAMPLE DATE	SAMPLE TIME	CANISTER NUMBER	C O M P G R A B
S-200		09/19	0804		X
S-201			0837		
S-202			0842		
S-203			0915		
S-204			0926		
S-205			0930		
S-206			1000		
S-207			1107		
COMMENTS		S-208 N 1118 S-210 1202			
S-209 V 1139		S-211 1229			
BILLING INFORMATION		SAMPLED BY: PSC/MMA/DT			
Company		Relinquished By: PSC/MMA/DT			
Address		Relinquished By: PSC/MMA/DT			
City/State/Zip		Relinquished By: PSC/MMA/DT			
ATTENTION		Relinquished By: PSC/MMA/DT			
Purchase Order/Billing Reference		REMARKS			

ATTACHMENT C

LABORATORY REPORTS



Wednesday, August 07, 2019

Sample Delivery Group (SDG) 219346
EAS Project Number: 17424

Chuck Schmidt
C.E. Schmidt
19200 Live Oak Road
Red Bluff, CA 96080

Chuck ,

Enclosed is the analytical report for the samples received and analyzed by Environmental Analytical Service, Inc. for the following Project.

Client Project Name: HDR-AAWTP
PO Number: None Given
Client Project Number None Given
Sample Event Date: 7/31/19

If you have any questions on the report or the analytical data please contact me at (805) 781-3585.

Sincerely

Steven D. Hoyt Ph.D.
Laboratory Director

SDH/LIMS

Laboratory Report

Project Name:

HDR-AAWTP

EAS SDG Number: **219346**

Client Project Manager: Chuck Schmidt

Prepared For:

C.E. Schmidt

19200 Live Oak Road

Red Bluff

CA 96080

Project Number: 17424

Sample Event Date: 7/31/19

Received Date: 8/1/2019

Report Date: 8/7/2019

Project Number: None Given

PO Number: None Given

This is the Laboratory Report for the samples in the indicated Sample Delivery Group (SDG). Each sample received in the group is assigned a Laboratory ID number. The combination of the SDG number and the Lab ID number is a unique identifier for the sample.

This Report Contains:

Laboratory Work Order

Project Sample Media

Laboratory Case Narrative and Chain of Custody

Method Description (when applicable)

Quality Control Reports

Analytical Reports

NELAC Certification: Florida E871125

173 Cross Street, San Luis Obispo, CA 93401 (805) 781-3585

Laboratory Work Order

SDG Number: 219346

Project Number: 17424

Client: Chuck Schmidt

Received: 8/1/2019

C.E. Schmidt

SAMPLE DESCRIPTION AND ANALYSIS REQUESTED

Client Sample ID	EAS Lab No.	Analysis Requested	Date Sampled
S-100	219346 1	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-101	219346 2	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-102	219346 3	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-103	219346 4	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-104	219346 5	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-105	219346 6	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-106	219346 7	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-107	219346 8	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-108	219346 9	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-109	219346 10	EPA 15 M Reduced Sulfur Gases	7/31/2019
S-111	219346 11	EPA 15 M Reduced Sulfur Gases	7/31/2019

Project Sample Media

SDG Number: 219346

The following sample media was used for this Sample Delivery Group (SDG). The Sample Media column identifies the type of media. For canisters, the Sample Media Batch gives the canister number followed by the cleaning batch number, which is a unique identification. Canisters that are received with sub-ambient pressures are pressurized to about 5 psig. The initial pressure of the canister when it is received is recorded along with the final pressure after pressurization. The canister dilution factor is the ratio of the final to initial pressure. The results are adjusted for the can dilution factor.

SDG	Lab ID	Client Sample No.	Sample Media	Batch	Pressure, torr Initial	Final	Can Factor
219346	1	S-100		100			
219346	2	S-101		100			
219346	3	S-102		100			
219346	4	S-103		100			
219346	5	S-104		100			
219346	6	S-105		100			
219346	7	S-106		100			
219346	8	S-107		100			
219346	9	S-108		100			
219346	10	S-109		100			
219346	11	S-111		100			

Laboratory Case Narrative

EAS SDG Number: 219346

Project Number: 17424

Client: C.E. Schmidt

The Laboratory Case Narrative for the SDG is below. The Chain of Custody form(s) follow the Laboratory Case Narrative.

Sample Control Narrative

The samples were all received in good condition and with proper preservation.

Analytical Methods

The methods used for sample analysis are listed on the Analytical Report header, and have been modified as described in the EAS Quality Manual..

Case Narrative

QC Narrative

All analyses met EAS method criteria as defined in the Quality Manual, except as noted in the report or QC reports with data qualifiers.

Subcontract Narrative

No sample analysis was subcontracted for this project

Laboratory Certification

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness other than the condition(s) noted above. The Laboratory Report is property of EAS and its client. The entire report has been reviewed and approved.



Date Approved: 8/7/2019

Steven D. Hoyt, Ph.D.
Environmental Analytical Service
Laboratory Director

ENVIRONMENTAL

Analytical Service, Inc.

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

CHAIN OF CUSTODY RECORD

Project Number		Project Name		Quote		Requested TAT	
REPORT TO:		Matrix		SDG		Analytical Tests	
Attention	Company	Address	City, State, Zip	Phone/Fax	e-mail	Flow Reg Number	Canister Number
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Matrix	Initial Pressure	Final Pressure
Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Matrix	Initial Pressure	Final Pressure
✓ S-100	7/31/19	0834			A - Ambient Air		
✓ S-101	"	0933			SG - Soil Gas		
✓ S-102	"	0920			S - Source		
✓ S-103	"	0953			I - Indoor Air		
✓ S-104	"	1018					
✓ S-105	"	1005					
✓ S-106	"	1015					
✓ S-107	"	1203					
Comments: S-100 11 1257 09 S-111 7/31/19 1352 1211 SB							
✓ S-109	"	1155		10			
S-110 NONE KTB							
BILLING INFORMATION:				SAMPLED BY			
ATTENTION				Date/Time			
Company				7/31/19			
Address				1300			
City, State, Zip				RECEIVED FOR LAB			
Purchase Order				8/1/19 10:00			

Quality Control Report

EAS SDG Number 219346

Project Number: 17424

QC Narrative

Samples were analyzed in a daily analytical batch (DAB) designated by a QC batch number, and were analyzed using EAS standard laboratory QC specified in the EAS Quality Manual which may be different than the referenced agency method. Any deviations from the EAS QC criteria are flagged in the Laboratory Control Reports or in the sample Analytical Reports.

Standard Laboratory QC Report

Unless project specific QC was requested, this Section containing the standard laboratory QC (Level 2) supplied with the Analytical Reports. Each sample is analyzed in a Daily Analytical Batch (DAB) which includes the method blank, a laboratory control spike (LCS) and a laboratory control duplicate (LCD). A Daily Analytical Batch QC report is supplied for each method requested.

Method Blank

The method blank is a laboratory generated sample which assesses the degree to which laboratory operations cause a false positive. The target analytes in the analytical reports for a daily analytical batch are "B" flagged if their concentrations are present in the Method Blank above the RL, unless the result is greater than ten times the blank value..

Laboratory Control Spike

A laboratory control spike is a well characterized matrix similar to the sample which is spiked and run in duplicate with each Daily Analytical Batch. The laboratory control spike results are reported as a percent recovery. The QC Criteria for the control spike is listed in the Laboratory Control Report. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report. The control spike contains an abbreviated list of compounds in the method, and may contain compounds not on the target list for the specified report.

Laboratory Control Duplicate

The laboratory control duplicate is a duplicate analysis of the laboratory control spike, a standard, or a sample depending on the method. The results are reported as a relative percent difference (RPD). The criteria for the duplicate is in the Laboratory Control Report for the Daily Analytical Batch. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report.

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: LABQC

Laboratory ID: B08019

File Name: B08019A
Sample ID: METHOD BALNK
Can/Tube#:
QC_Batch: 080119-GCP

Date Sampled:
Date Analyzed: 08/01/19
Can Dilution Factor: 1.00
Air Volume: 10.00 ml
Time: 15:43

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-14 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA TO-14

Date: 08/01/19

QC_Batch: 080119-GCP

CAS#	Compound	Standard Recovery	Standard Recovery	LCL %	UCL %	RSD %	RSD Limit
7783-06-4	Hydrogen Sulfide	95	106	80	120	6	15
463-58-1	Carbonyl Sulfide	91	112	80	120	10	15
74-93-1	Methyl Mercaptan	98	102	80	120	2	15
75-08-1	Ethyl Mercaptan	98	103	80	120	2	15
75-18-3	Dimethyl Sulfide	102	102	80	120	4	15
75-15-0	Carbon Disulfide	98	111	80	120	10	15
75-33-2	i-Propyl Mercaptan	102	103	80	120	4	15
624-89-5	Ethyl Methyl Sulfide	101	96	80	120	4	15
107-03-9	n-Propyl Mercaptan	103	105	80	120	7	15
110-02-1	Thiophene	98	111	80	120	10	15
513-44-0	Isobutyl Mercaptan	95	109	80	120	8	15
352-93-2	Diethyl Sulfide	102	108	80	120	9	15
75-66-1	t-Butyl Mercaptan	82	92	80	120	23	30
109-79-5	n-Butyl Mercaptan	100	104	80	120	4	30
624-92-0	Dimethyl Disulfide	98	113	80	120	12	30
616-44-4	3-Methylthiophene	97	118	80	120	17	30
110-01-0	Tetrahydrothiophene	107	106	80	120	11	30
638-02-8	2,5-Dimethylthiophene	104	125	70	130	27	30
110-81-6	Diethyl Disulfide	103	125	70	130	26	30
872-55-9	2-Ethylthiophene	104	122	70	130	24	30

RSD = Relative standard deviation of triplicate standard analysis

Limits are based on fixed laboratory analysis by GC/FPD

Analytical Reports

EAS SDG Number 219346

Project Number: 17424

The following pages contain the certified Analytical Reports for the samples submitted in the Sample Delivery Group (SDG) and are in order of the EAS Lab ID number. All of the analytical methods used are modifications of the published methods. Procedural method modifications, QC modifications, QC Criteria modifications, target lists, definitions of detection limits, and flags are all explained in detail in the EAS Quality Manual.

The Analytical Report has columns for the method detection limit (MDL), the reporting limit (RL), and the Amount. The Amount is the concentration of the compound in the sample. The report usually has the results reported with two commonly used units. The MDL, RL, and Amount are adjusted for the canister dilution factor and any dilution caused by sample matrix effects.

NELAC CERTIFICATION

EAS is accredited by the National Environmental Laboratory Accreditation (NELAC) with the Florida Department of Health, one of the NELAC certifying states. EAS is certified for the EPA TO-15, EPA TO-11 and EPA TO-4 methods. A list of accredited compounds is available on request.

DETECTION LIMITS

MDL: The MDL is lowest concentration that can be measured to be statistically above the noise level and is determined using the EPA 2016 method which uses the standard deviation of replicate measurements made over time. The method also incorporates systematic instrumentation blank levels. See Quality Manual for detailed explanation.

RL: The reporting limit (RL) is the lowest concentration that can be reliably reported for each compound that meets the QC Criteria for the method, background levels, or project specific considerations. The QC criteria level for the method blank is to be less than the RL. See Quality Manual for more information.

DATA FLAGS

In the standard report, if a compound is not detected above the method detection limit, a "ND" is in the Amount column. The flag column is used for both the not detect flag and for any data flags.

B - This compound was detected in the batch method blank above the reporting limit and is greater than one tenth the amount in the sample.

E - This compound exceeds the calibration range for this sample volume.

J - The amount reported is estimated because it was below the RL and could be below the lowest calibration point, have higher uncertainty, or could be the result of system background

UNITS

PPBV or PPMV: Parts-per-billion (or million) by volume is a mole (volume) ratio of the moles of analyte divided by the moles of air (gas). This is the primary unit used to report air or gas concentrations and is independent of temperature and pressure.

UG/M3 OR MG/M3: The reported result was calculated based on 1 atm pressure and a temperature of 25C. The conversion from PPBV is: $UG/M3 = PPBV \times MW/24.46$ where 24.46 is the gas constant and MW is the Compound's Molecular Weight (sometimes called Formula Weight)

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219346

Laboratory ID: 1

File Name: 1934601A
Sample ID: S-100
Can/Tube#: TBAG
QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 8:34
Date Analyzed: 08/01/19 Time: 16:18
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219346

Laboratory ID: 2

File Name: 1934602A
Sample ID: S-101
Can/Tube#: TBAG
QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 9:33
Date Analyzed: 08/01/19 Time: 16:51
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

SDG: 219346

Analytical Method: EPA 15

Laboratory ID: 3

File Name: 1934603A
Sample ID: S-102
Can/Tube#: TBAG
QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 9:20
Date Analyzed: 08/01/19 Time: 17:18
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219346

Laboratory ID: 4

File Name: 1934604A
Sample ID: S-103
Can/Tube#: TBAG
QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 9:55
Date Analyzed: 08/01/19 Time: 17:45
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219346

Laboratory ID:

5

File Name: 1934605B

Date Sampled: 07/31/19

Time: 10:18

Sample ID S-104

Date Analyzed: 08/01/19

Time: 21:33

Can/Tube#: TBAG

Can Dilution Factor: 1.00

QC_Batch: 080119-GCP

Air Volume: 20.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	8.1	24.3	13.8	11.3	33.9	19.2	J
463-58-1	Carbonyl Sulfide	4.9	14.6	ND	11.9	35.8	ND	
74-93-1	Methyl Mercaptan	8.1	24.3	ND	15.9	47.8	ND	
75-08-1	Ethyl Mercaptan	8.6	25.7	ND	21.8	65.4	ND	
75-18-3	Dimethyl Sulfide	8.9	26.7	ND	22.7	68.0	ND	
75-15-0	Carbon Disulfide	9.2	27.6	ND	28.7	86.0	ND	
75-33-2	i-Propyl Mercaptan	8.6	25.7	ND	26.7	80.2	ND	
624-89-5	Ethyl Methyl Sulfide	8.6	25.7	ND	31.7	95.0	ND	
107-03-9	n-Propyl Mercaptan	8.6	25.8	ND	26.8	80.4	ND	
110-02-1	Thiophene	9.1	27.4	ND	31.5	94.6	ND	
513-44-0	Isobutyl Mercaptan	8.9	26.6	ND	32.8	98.3	ND	
352-93-2	Diethyl Sulfide	8.4	25.2	43.5	31.0	93.1	160.8	
75-66-1	t-Butyl Mercaptan	8.6	25.8	ND	31.7	95.2	ND	
109-79-5	n-Butyl Mercaptan	8.6	25.8	ND	31.7	95.2	ND	
624-92-0	Dimethyl Disulfide	9.0	27.1	ND	34.9	104.7	ND	
616-44-4	3-Methylthiophene	8.8	26.4	ND	35.4	106.1	ND	
110-01-0	Tetrahydrothiophene	8.6	25.8	ND	31.1	93.3	ND	
638-02-8	2,5-Dimethylthiophene	9.5	28.5	ND	43.6	130.9	ND	
110-81-6	Diethyl Disulfide	8.8	26.4	ND	40.4	121.3	ND	
872-55-9	2-Ethylthiophene	8.6	25.9	ND	43.3	129.9	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219346

Laboratory ID: 6

File Name: 1934606A

Sample ID S-105

Can/Tube#: TBAG

QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 11:05

Date Analyzed: 08/01/19 Time: 18:42

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219346

Laboratory ID: 7

File Name: 1934607A

Sample ID S-106

Can/Tube#: TBAG

QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 10:15

Date Analyzed: 08/01/19 Time: 19:08

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219346

Laboratory ID: 8

File Name: 1934608A
Sample ID: S-107
Can/Tube#: TBAG
QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 12:03
Date Analyzed: 08/01/19 Time: 19:34
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219346

Laboratory ID: 9

File Name: 1934609A

Sample ID: S-108

Can/Tube#: TBAG

QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 12:57

Date Analyzed: 08/01/19 Time: 20:03

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219346

Laboratory ID: 10

File Name: 1934610A

Sample ID: S-109

Can/Tube#: TBAG

QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 11:55

Date Analyzed: 08/01/19 Time: 20:29

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219346

Laboratory ID: 11

File Name: 1934611A
Sample ID: S-111
Can/Tube#: TBAG
QC_Batch: 080119-GCP

Date Sampled: 07/31/19 Time: 13:52
Date Analyzed: 08/01/19 Time: 20:56
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	



Wednesday, August 07, 2019

Sample Delivery Group (SDG) 219347
EAS Project Number: 17424

Chuck Schmidt
C.E. Schmidt
19200 Live Oak Road
Red Bluff, CA 96080

Chuck ,

Enclosed is the analytical report for the samples received and analyzed by Environmental Analytical Service, Inc. for the following Project.

Client Project Name: HDR-AAWTP
PO Number: None Given
Client Project Number: None Given
Sample Event Date: 8/1/19

If you have any questions on the report or the analytical data please contact me at (805) 781-3585.

Sincerely,

Steven D. Hoyt Ph.D.
Laboratory Director

SDH/LIMS

Laboratory Report

Project Name:

HDR-AAWTP

EAS SDG Number: **219347**

Client Project Manager: Chuck Schmidt

Prepared For:

C.E. Schmidt

19200 Live Oak Road

Red Bluff

CA 96080

Project Number: 17424

Sample Event Date: 8/1/19

Received Date: 8/2/2019

Report Date: 8/7/2019

Project Number: None Given

PO Number: None Given

This is the Laboratory Report for the samples in the indicated Sample Delivery Group (SDG). Each sample received in the group is assigned a Laboratory ID number. The combination of the SDG number and the Lab ID number is a unique identifier for the sample.

This Report Contains:

Laboratory Work Order

Project Sample Media

Laboratory Case Narrative and Chain of Custody

Method Description (when applicable)

Quality Control Reports

Analytical Reports

NELAC Certification: Florida E871125

173 Cross Street, San Luis Obispo, CA 93401 (805) 781-3585

Laboratory Work Order

SDG Number: 219347

Project Number: 17424

Client: Chuck Schmidt

Received: 8/2/2019

C.E. Schmidt

SAMPLE DESCRIPTION AND ANALYSIS REQUESTED

Client Sample ID	EAS Lab No.	Analysis Requested	Date Sampled
S-200	219347 1	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-201	219347 2	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-202	219347 3	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-203	219347 4	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-204	219347 5	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-205	219347 6	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-206	219347 7	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-207	219347 8	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-208	219347 9	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-209	219347 10	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-210	219347 11	EPA 15 M Reduced Sulfur Gases	8/1/2019
S-211	219347 12	EPA 15 M Reduced Sulfur Gases	8/1/2019

Project Sample Media

SDG Number: 219347

The following sample media was used for this Sample Delivery Group (SDG). The Sample Media column identifies the type of media. For canisters, the Sample Media Batch gives the canister number followed by the cleaning batch number, which is a unique identification. Canisters that are received with sub-ambient pressures are pressurized to about 5 psig. The initial pressure of the canister when it is received is recorded along with the final pressure after pressurization. The canister dilution factor is the ratio of the final to initial pressure. The results are adjusted for the can dilution factor.

SDG	Lab ID	Client Sample No.	Sample Media	Batch	Pressure, torr		Can Factor
					Initial	Final	
219347	1	S-200		100			
219347	2	S-201		100			
219347	3	S-202		100			
219347	4	S-203		100			
219347	5	S-204		100			
219347	6	S-205		100			
219347	7	S-206		100			
219347	8	S-207		100			
219347	9	S-208		100			
219347	10	S-209		100			
219347	11	S-210		100			
219347	12	S-211		100			

Laboratory Case Narrative

EAS SDG Number: 219347

Project Number: 17424

Client: C.E. Schmidt

The Laboratory Case Narrative for the SDG is below. The Chain of Custody form(s) follow the Laboratory Case Narrative.

Sample Control Narrative

The samples were all received in good condition and with proper preservation.

Analytical Methods

The methods used for sample analysis are listed on the Analytical Report header, and have been modified as described in the EAS Quality Manual..

Case Narrative

QC Narrative

All analyses met EAS method criteria as defined in the Quality Manual, except as noted in the report or QC reports with data qualifiers.

Subcontract Narrative

No sample analysis was subcontracted for this project

Laboratory Certification

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness other than the condition(s) noted above. The Laboratory Report is property of EAS and its client. The entire report has been reviewed and approved.



Date Approved: 8/7/2019

Steven D. Hoyt, Ph.D.
Environmental Analytical Service
Laboratory Director

CHAIN OF CUSTODY RECORD

Project Number		Project Name: HDR - ATWTP		Quote Number:		ANALYTICAL TESTS		REMARKS	
REPORT TO:									
Company		CE SCHMIDT		MATRIX LEGEND		INITIAL PRESSURE		FINAL PRESSURE	
Address		19200 WEBER RD		A - Ambient Air, Low Level					
City/State/Zip		Paso, CA 94680		I - Indoor Air					
Phone		530 529 4236 (FAX)		S - Source Air, High Level					
ATTENTION		CES		G - Gas/Product					
SAMPLE DESCRIPTION		SAMPLE DATE		SAMPLE TIME		CANISTER NUMBER		MATRIX	
								G R A B A I S G	
VS-200		8/1/9		0801				NA	
VS-201				0827				NA	
VS-202				0842				NA	
VS-203				0915				NA	
VS-204				0926				NA	
VS-205				0950				NA	
VS-206				1000				NA	
VS-207				1107				NA	
VS-208				1118				NA	
VS-209				1139				NA	
VS-210				1202				NA	
VS-211				1229				NA	
BILLING INFORMATION									
Company		CE SCHMIDT		SAMPLED BY: CESCHMIDT		Date: 8/1/9		Time: 1300	
Address		SAME		Relinquished By:		Date: 8/1/9		Time: 1400	
City/State/Zip				Relinquished By:		Date: 8/1/9		Time: 1400	
ATTENTION				Relinquished By:		Date: 8/1/9		Time: 1400	
Purchase Order/Billing Reference				Relinquished By:		Date: 8/1/9		Time: 1400	

Quality Control Report

EAS SDG Number 219347

Project Number: 17424

QC Narrative

Samples were analyzed in a daily analytical batch (DAB) designated by a QC batch number, and were analyzed using EAS standard laboratory QC specified in the EAS Quality Manual which may be different than the referenced agency method. Any deviations from the EAS QC criteria are flagged in the Laboratory Control Reports or in the sample Analytical Reports.

Standard Laboratory QC Report

Unless project specific QC was requested, this Section containing the standard laboratory QC (Level 2) supplied with the Analytical Reports. Each sample is analyzed in a Daily Analytical Batch (DAB) which includes the method blank, a laboratory control spike (LCS) and a laboratory control duplicate (LCD). A Daily Analytical Batch QC report is supplied for each method requested.

Method Blank

The method blank is a laboratory generated sample which assesses the degree to which laboratory operations cause a false positive. The target analytes in the analytical reports for a daily analytical batch are "B" flagged if their concentrations are present in the Method Blank above the RL, unless the result is greater than ten times the blank value..

Laboratory Control Spike

A laboratory control spike is a well characterized matrix similar to the sample which is spiked and run in duplicate with each Daily Analytical Batch. The laboratory control spike results are reported as a percent recovery. The QC Criteria for the control spike is listed in the Laboratory Control Report. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report. The control spike contains an abbreviated list of compounds in the method, and may contain compounds not on the target list for the specified report.

Laboratory Control Duplicate

The laboratory control duplicate is a duplicate analysis of the laboratory control spike, a standard, or a sample depending on the method. The results are reported as a relative percent difference (RPD). The criteria for the duplicate is in the Laboratory Control Report for the Daily Analytical Batch. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report.

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: LABQC
Laboratory ID: B08029

File Name: B08029A
Sample ID: METHOD BALNK
Can/Tube#:
QC_Batch: 080219-GCP

Date Sampled:
Date Analyzed: 08/02/19
Can Dilution Factor: 1.00
Air Volume: 10.00 ml
Time: 10:34

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

Date: 08/02/19

QC_Batch: 080219-GCP

CAS#	Compound	Standard Recovery	Standard Recovery	LCL %	UCL %	RSD %	RSD Limit
7783-06-4	Hydrogen Sulfide	98	91	80	120	11	15
463-58-1	Carbonyl Sulfide	98	94	80	120	7	15
74-93-1	Methyl Mercaptan	105	93	80	120	6	15
75-08-1	Ethyl Mercaptan	102	96	80	120	3	15
75-18-3	Dimethyl Sulfide	102	98	80	120	2	15
75-15-0	Carbon Disulfide	95	107	80	120	6	15
75-33-2	i-Propyl Mercaptan	94	96	80	120	9	15
624-89-5	Ethyl Methyl Sulfide	101	102	80	120	2	15
107-03-9	n-Propyl Mercaptan	98	105	80	120	4	15
110-02-1	Thiophene	93	114	80	120	12	15
513-44-0	Isobutyl Mercaptan	89	109	80	120	10	15
352-93-2	Diethyl Sulfide	92	107	80	120	8	15
75-66-1	t-Butyl Mercaptan	97	103	80	120	3	20
109-79-5	n-Butyl Mercaptan	92	103	80	120	7	20
624-92-0	Dimethyl Disulfide	88	104	80	120	10	20
616-44-4	3-Methylthiophene	80	123	70	130	21	30
110-01-0	Tetrahydrothiophene	96	107	70	130	6	30
638-02-8	2,5-Dimethylthiophene	71	127	70	130	28	30
110-81-6	Diethyl Disulfide	71	126	70	130	27	30
872-55-9	2-Ethylthiophene	81	116	70	130	18	30

RSD = Relative standard deviation of triplicate standard analysis

Limits are based on fixed laboratory analysis by GC/FPD

Analytical Reports

EAS SDG Number 219347

Project Number: 17424

The following pages contain the certified Analytical Reports for the samples submitted in the Sample Delivery Group (SDG) and are in order of the EAS Lab ID number. All of the analytical methods used are modifications of the published methods. Procedural method modifications, QC modifications, QC Criteria modifications, target lists, definitions of detection limits, and flags are all explained in detail in the EAS Quality Manual.

The Analytical Report has columns for the method detection limit (MDL), the reporting limit (RL), and the Amount. The Amount is the concentration of the compound in the sample. The report usually has the results reported with two commonly used units. The MDL, RL, and Amount are adjusted for the canister dilution factor and any dilution caused by sample matrix effects.

NELAC CERTIFICATION

EAS is accredited by the National Environmental Laboratory Accreditation (NELAC) with the Florida Department of Health, one of the NELAC certifying states. EAS is certified for the EPA TO-15, EPA TO-11 and EPA TO-4 methods. A list of accredited compounds is available on request.

DETECTION LIMITS

MDL: The MDL is lowest concentration that can be measured to be statistically above the noise level and is determined using the EPA 2016 method which uses the standard deviation of replicate measurements made over time. The method also incorporates systematic instrumentation blank levels. See Quality Manual for detailed explanation.

RL: The reporting limit (RL) is the lowest concentration that can be reliably reported for each compound that meets the QC Criteria for the method, background levels, or project specific considerations. The QC criteria level for the method blank is to be less than the RL. See Quality Manual for more information.

DATA FLAGS

In the standard report, if a compound is not detected above the method detection limit, a "ND" is in the Amount column. The flag column is used for both the not detect flag and for any data flags.

B - This compound was detected in the batch method blank above the reporting limit and is greater than one tenth the amount in the sample.

E - This compound exceeds the calibration range for this sample volume.

J - The amount reported is estimated because it was below the RL and could be below the lowest calibration point, have higher uncertainty, or could be the result of system background

UNITS

PPBV or PPMV: Parts-per-billion (or million) by volume is a mole (volume) ratio of the moles of analyte divided by the moles of air (gas). This is the primary unit used to report air or gas concentrations and is independent of temperature and pressure.

UG/M3 OR MG/M3: The reported result was calculated based on 1 atm pressure and a temperature of 25C. The conversion from PPBV is: $UG/M3 = PPBV \times MW/24.46$ where 24.26 is the gas constant and MW is the Compounds Molecular Weight (sometimes called Formula Weight)

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219347

Laboratory ID: 1

File Name: 1934701A

Sample ID: S-200

Can/Tube#: TBAG

QC_Batch: 080219-GCP

Date Sampled: 08/01/19

Time: 8:04

Date Analyzed: 08/02/19

Time: 11:38

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347

Laboratory ID: 2

File Name: 1934702A
Sample ID: S-201
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 8:27
Date Analyzed: 08/02/19 Time: 12:04
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	112.3	45.3	135.9	285.9	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	136.1	69.8	209.5	525.5	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347

Laboratory ID: 3

File Name: 1934703A
Sample ID: S-202
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 8:42
Date Analyzed: 08/02/19 Time: 12:29
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	100.1	45.3	135.9	254.8	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	116.5	69.8	209.5	449.9	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347

Laboratory ID: 4

File Name: 1934704A
Sample ID: S-203
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 9:15
Date Analyzed: 08/02/19 Time: 13:08
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347
Laboratory ID: 5

File Name: 1934705A
Sample ID: S-204
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 9:26
Date Analyzed: 08/02/19 Time: 13:36
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219347

Laboratory ID:

6

File Name: 1934706A

Date Sampled: 08/01/19

Time: 9:50

Sample ID: S-205

Date Analyzed: 08/02/19

Time: 14:05

Can/Tube#: TBAG

Can Dilution Factor: 1.00

QC_Batch: 080219-GCP

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219347

Laboratory ID:

7

File Name: 1934707A

Sample ID S-206

Can/Tube#: TBAG

QC_Batch: 080219-GCP

Date Sampled: 08/01/19

Time: 10:00

Date Analyzed: 08/02/19

Time: 14:29

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219347

Laboratory ID:

8

File Name: 1934708A

Sample ID: S-207

Can/Tube#: TBAG

QC_Batch: 080219-GCP

Date Sampled: 08/01/19

Time: 11:07

Date Analyzed: 08/02/19

Time: 15:01

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method:

EPA 15

SDG: 219347

Laboratory ID: 9

File Name: 1934709A

Sample ID: S-208

Can/Tube#: TBAG

QC_Batch: 080219-GCP

Date Sampled: 08/01/19

Time: 11:18

Date Analyzed: 08/02/19

Time: 15:27

Can Dilution Factor: 1.00

Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347

Laboratory ID: 10

File Name: 1934710A
Sample ID: S-209
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 11:39
Date Analyzed: 08/02/19 Time: 15:53
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	5,120.4	22.6	67.7	7,151.7	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	175.0	31.9	95.6	345.1	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	146.9	69.8	209.5	567.2	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347

Laboratory ID: 11

File Name: 1934711A
Sample ID: S-210
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 12:02
Date Analyzed: 08/02/19 Time: 16:17
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA 15 Modified Reduced Sulfur GC/FPD

Analytical Method: EPA 15

SDG: 219347

Laboratory ID: 12

File Name: 1934712A
Sample ID: S-211
Can/Tube#: TBAG
QC_Batch: 080219-GCP

Date Sampled: 08/01/19 Time: 12:29
Date Analyzed: 08/02/19 Time: 16:47
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	16.2	48.5	ND	22.6	67.7	ND	
463-58-1	Carbonyl Sulfide	9.7	29.1	ND	23.9	71.7	ND	
74-93-1	Methyl Mercaptan	16.2	48.5	ND	31.9	95.6	ND	
75-08-1	Ethyl Mercaptan	17.1	51.4	ND	43.6	130.9	ND	
75-18-3	Dimethyl Sulfide	17.8	53.4	ND	45.3	135.9	ND	
75-15-0	Carbon Disulfide	18.4	55.1	ND	57.3	172.0	ND	
75-33-2	i-Propyl Mercaptan	17.1	51.4	ND	53.5	160.4	ND	
624-89-5	Ethyl Methyl Sulfide	17.1	51.4	ND	63.4	190.1	ND	
107-03-9	n-Propyl Mercaptan	17.2	51.5	ND	53.6	160.8	ND	
110-02-1	Thiophene	18.3	54.9	ND	63.1	189.2	ND	
513-44-0	Isobutyl Mercaptan	17.7	53.2	ND	65.5	196.6	ND	
352-93-2	Diethyl Sulfide	16.8	50.4	ND	62.1	186.2	ND	
75-66-1	t-Butyl Mercaptan	17.2	51.5	ND	63.5	190.5	ND	
109-79-5	n-Butyl Mercaptan	17.2	51.5	ND	63.5	190.4	ND	
624-92-0	Dimethyl Disulfide	18.1	54.3	ND	69.8	209.5	ND	
616-44-4	3-Methylthiophene	17.6	52.7	ND	70.7	212.1	ND	
110-01-0	Tetrahydrothiophene	17.2	51.7	ND	62.2	186.6	ND	
638-02-8	2,5-Dimethylthiophene	19.0	57.0	ND	87.3	261.9	ND	
110-81-6	Diethyl Disulfide	17.6	52.8	ND	80.9	242.6	ND	
872-55-9	2-Ethylthiophene	17.3	51.9	ND	86.6	259.8	ND	



Odor Science & Engineering, Inc.
105 Filley Street, Bloomfield, CT 06002
(860) 243-9380 Fax: (860) 243-9431

August 7, 2019

Chuck E. Schmidt
19200 Live Oak Road
Red Bluff, CA 96080

schmidtce@aol.com

RE: Odor Panel Analysis
OS&E Project No. 2150-M-00
Project Name: HDR/Ann Arbor WWTP

Dear Chuck:

This letter presents the results of the recent odor panel analyses conducted by Odor Science & Engineering, Inc. (OS&E) for your continuing HDR/Ann Arbor sampling project. A total of twenty-four (24) samples were collected over a two-day period (12 on July 31st & 12 on August 1st, 2019) by on-site personnel. The odor samples were collected into 12 liter Tedlar gas sampling bags provided by OS&E. Immediately following sample collection, the bags were shipped via priority overnight a.m. delivery service to OS&E's Olfactory Laboratory in Bloomfield, CT for sensory analysis. All of the samples arrived intact under chain of custody.

Upon arrival the samples were analyzed by dynamic dilution olfactometry using a trained and screened odor panel of 8 members. The odor panelists were chosen from OS&E's pool of panelists from the Greater Hartford area who actively participate in ongoing olfactory research and represent an average to above average sensitivity when compared to a large population. The samples were quantified in terms of dilution-to-threshold (D/T) ratio and odor intensity in accordance with ASTM Methods E-679-04 and E-544-10, respectively. The odor panelists were also asked to describe the odor character of the samples at varying dilution levels. The odor panel methodology is further described in Attachment A.

The results of the odor panel test are presented in the attached Table 1.

We appreciate the opportunity to assist you on this project. Please feel free to call Martha O'Brien or me if you have any questions concerning these results.

Sincerely,
ODOR SCIENCE & ENGINEERING, INC.

Gary K. Grumley
Associate Scientist

Table 1. Results of dynamic dilution olfactometry analysis – August 1st, 2019**Chuck E. Schmidt: Ann Arbor/HDR****OS&E Project No. 2150-M-00**

Sampling Information			Odor Conc. D/T ⁽¹⁾	Stevens' Law Constants ⁽²⁾		Odor Character ⁽³⁾
				a	b	
7/31/19	08:34	0-100	11	--	--	sour, sewage, gassy, sulfur, rotten, plastic, cleaning products
7/31/19	09:33	0-101	11	--	--	sulfur, H ₂ S, gassy, swampy, earthy, cleaning products, plastic
7/31/19	09:15	0-102	10	--	--	sour, plastic, stale, exhaust
7/31/19	09:50	0-103	11	--	--	sour, sulfur, sewage, rotten garbage, urine, outhouse, feces, fishy, plastic
7/31/19	10:18	0-104	21	.59	.83	sour, H ₂ S, sewage, rotten eggs/garbage/vegetables, skunk, mercaptan
7/31/19	11:05	0-105	21	.63	.86	sour, H ₂ S, sewage, rotten sludge/garbage/vegetables, skunk, mercaptan, vomitus
7/31/19	10:10	0-106	19	.37	.98	sour, sulfur, vegetation, wet grass, plastic, exhaust
7/31/19	12:03	0-107	163	.51	.81	skunk, mercaptan, rotten garbage/sludge, feces
7/31/19	12:57	0-108	1,507	.40	.79	sour, sewage, sulfur, H ₂ S, rotten garbage/eggs/sludge, feces
7/31/19	11:54	0-109	10	--	--	sour, H ₂ S, rotten, sewage, plastic, rubber
7/31/19	12:35	0-110	250	.53	.89	rotten sewage/cabbage/garbage, feces, manure, outhouse, sulfur, urine
7/31/19	13:52	0-111	1,451	.63	.77	sour, rotten eggs/garbage, sewage, sulfur, H ₂ S

1. D/T = dilutions-to-threshold
 2. Stevens' Law correlates odor concentration (C) and odor intensity (I): $I = aC^b$. The constants a and b were determined by regression analysis based on the intensity ratings of the odor panel at varying dilution levels. I = 0-8 (based on the n-butanol intensity scale), C = odor concentration (D/T) typical of ambient odor levels.
 3. Summary of all odor character descriptors used by the odor panelists at varying dilution levels.
- Sample too low for Dose Response calculation

Table 1 (cont'd). Results of dynamic dilution olfactometry analysis – August 2nd, 2019

Chuck E. Schmidt: Ann Arbor/HDR

OS&E Project No. 2150-M-00

Sampling Information			Odor Conc. D/T ⁽¹⁾	Stevens' Law Constants ⁽²⁾		Odor Character ⁽³⁾
Date	Time	ID		a	b	
08/01/19	07:59	0-200	11	--	--	sour, light sewage, rubber, plastic, cleaning chemicals
08/01/19	08:25	0-201	75	.44	.80	sulfur, sewage, rotten vegetables, dead animals
08/01/19	08:33	0-202	69	.49	.80	sulfur, sewage, rotten vegetables, garbage
08/01/19	09:09	0-203	12	--	--	sour, rotten eggs/garbage/vegetables, sewage, old urine, Cl ₂ , earthy dirt, plastic
08/01/19	09:20	0-204	8	--	--	sulfur, sewage, plastic, cleaning chemicals, Cl ₂ , new vinyl
08/01/19	09:43	0-205	11	--	--	sour, sewage, sulfur, wet cardboard, earthy, dirt, Cl ₂ , plastic
08/01/19	09:56	0-206	620	.73	.87	sewage, sulfur, sludge, rotten vegetables/garbage, outhouse, earthy, dirt
08/01/19	10:57	0-207	298	.47	.77	rotten sewage, sulfur, sulfides, rotten eggs, H ₂ S, rotten garbage
08/01/19	11:11	0-208	211	.69	.79	H ₂ S, rotten sewage, sulfur, rotten eggs
08/01/19	11:33	0-209	8,313	.60	.83	H ₂ S, rotten sewage, sulfur, rotten eggs/garbage
08/01/19	11:55	0-210	75	.64	.77	sour, sewage, sulfur, rotten vegetables/garbage/sludge, sour milk, earthy, dirt
08/01/19	12:26	0-211	10	--	--	sour, sewage, sulfur, H ₂ S, plastic, Cl ₂ , bleach, chemicals

1. D/T = dilutions-to-threshold
 2. Stevens' Law correlates odor concentration (C) and odor intensity (I): $I = aC^b$. The constants a and b were determined by regression analysis based on the intensity ratings of the odor panel at varying dilution levels. I = 0-8 (based on the n-butanol intensity scale), C = odor concentration (D/T) typical of ambient odor levels.
 3. Summary of all odor character descriptors used by the odor panelists at varying dilution levels.
- Sample too low for Dose Response calculation

Odor Science & Engineering, Inc. 105 Filley Street Bloomfield, CT 06002
Phone (860) 243-9380 Fax (860) 243-9431 www.odorscience.com

ATTACHMENT A
Odor Science & Engineering, Inc.
Odor Panel Methodology

Measurement of Odor Levels by Dynamic Dilution Olfactometry

Odor concentration is defined as the dilution of an odor sample with odor-free air, at which only a specified percent of an odor panel, typically 50%, will detect the odor. This point represents odor threshold and is expressed in terms of “dilutions-to-threshold” (D/T).

Odor concentration was determined by means of OS&E's forced choice dynamic dilution olfactometer. The members of the panel who have been screened for their olfactory sensitivity and their ability to match odor intensities, have participated in on-going olfactory research at OS&E for a number of years.

In olfactometry, known dilutions of the odor sample were prepared by mixing a stream of odor-free air with a stream of the odor sample. The odor-free air is generated in-situ by passing the air from a compressor pump through a bed of activated charcoal and a potassium permanganate medium for purification. A portion of the odor free air is diverted into two sniff ports for direct presentation to a panelist who compares them with the diluted odor sample.

Another portion of the odor-free air is mixed in a known ratio with the odor from the sample bag and is then introduced into the third sniff port. A panelist is thus presented with three identical sniff ports, two of which provide a stream of odor-free air and the third one a known dilution of the odor sample. Unaware of which is which, the panelist is asked to identify the sniff port which is different from the other two, i.e., which contains the odor. The flow rate at all three nose cups is maintained at 3 liters per minute.

The analysis starts at high odor dilutions. Odor concentration in each subsequent evaluation is increased by a factor of 2. Initially a panelist is unlikely to correctly identify the sniff port which contains an odor. As the concentration increases, the likelihood of error is reduced and at one point the response at every subsequently higher concentration becomes consistently correct. The lowest odor concentration at which this consistency is first noticed, represents the **detection odor threshold** for that panelist.

As the odor concentration is increased further in the subsequent steps, the panelist becomes aware of the odor character, i.e. becomes able to differentiate the analyzed odor from other odors. The lowest odor concentration at which odor differentiation first becomes possible, represent the **recognition odor threshold** for the panelist. Essentially all of OS&E's work is done with recognition odor threshold. By definition the threshold odor is equal to 1 D/T (i.e. the volume of odorous air after dilution divided by the volume before dilution equals one).

The panelists typically arrive at threshold values at different concentrations. To interpret the data statistically, the geometric mean of the individual panelist's thresholds is calculated.

The olfactometer and the odor presentation procedure meet the recommendations of ASTM Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits (ASTM E679-04). The analysis was carried out in the OS&E Olfactory Laboratory in Bloomfield, Connecticut.

Odor Intensity

Odor intensity is determined using reference sample method with n-butanol as the reference compound (ASTM Method E-544-10). The n-butanol odor intensity scale is based on n-butanol vapor as odorant at eight concentrations. The concentration increases by a factor of two at each intensity step, starting with approximately 15 ppm at step 1.

Odors of widely different types can be compared on that scale just like the intensities of the lights of different colors can be compared to the intensity of standard, e.g. white light. Odor character and hedonic tone are ignored in that comparison. Odor intensities are routinely measured as part of the dynamic dilution olfactometry measurements. The n-butanol vapor samples are presented to the panelists in closed jars containing the standard solutions of n-butanol in distilled water. The vapor pressure above the butanol solutions corresponds to the steps on the n-butanol scale. To observe the odor intensity, a panelist opens the jar and sniffs the air above the liquid. The panelist then closes the jar so that the equilibrium vapor pressure of butanol can be re-established before the next panelist uses the jar. The odor in the jar is compared with unknown odor present at the olfactometer sniff port.

The relationship between odor concentration and intensity can be expressed as a psychophysical power function also known as Steven's law (Dose-Response Function). The function is of the form:

$$I = aC^b$$

where:

I = odor intensity on the butanol scale

C = the odor level in dilution-to-threshold ratio (D/T)

a,b = constants specific for each odor

The major significance of the dose-response function in odor control work is that it determines the rate at which odor intensity decreases as the odor concentration is reduced (either by atmospheric dispersion or by an odor control device).

Odor emissions are used as input to an odor dispersion model, which predicts odor impacts downwind under a variety of meteorological conditions. Whether or not an odor is judged objectionable depends primarily in its intensity. The dose-response constants are used to convert predicted ambient odor concentration to intensity levels. OS&E experience has shown that odors are almost universally considered objectionable when their intensity is 3 or higher on the 8-point n-butanol scale. In general, the lower the intensity, the lower the probability of complaints.

Odor Character Description

Odor character refers to our ability to recognize the similarity of odors. It allows us to distinguish odors of different substances on the basis of experience. We use three types of descriptors, general such as “sweet”, “pungent”, “acrid”, etc. or specific references to its source such as “orange”, “skunk”, “paint”, “sewage”, etc., or to a specific chemical, e.g. “methyl mercaptan”, “butyric acid”, or “cyclohexane”. In the course of the dynamic dilution olfactometry measurements, the odor panelists are asked to describe the character of the odors they detect.



Appendix E. 10152084-0WW-M0006-Dispersion Modeling, Rev. 1



Technical Memorandum

Document Number: 10152084-0WW-M0006 (Rev. 1)

To: Chris Englert, City of Ann Arbor WWTP

From: Chris Easter, HDR
Josh Prusakiewicz, HDR

Date: January 3, 2020

Subject: Baseline Dispersion Modeling Results, Rev. 1
City of Ann Arbor WWTP Area Odor Study

Purpose and Introduction

This memorandum presents the odor dispersion modeling results representing the baseline odor conditions for the existing Ann Arbor Wastewater Treatment Plant (WWTP) and nearby collection system odor sources. Odor impact risk from the plant and the collection system related sources are considered out to a two-mile radius from the WWTP. The evaluation includes odor sources evaluated at the plant and the collection system locations near the plant, as presented in the spring and summer odor sampling technical memos listed below:

- TM 10152084-0WW-M0002 Spring Odor Source Sampling Summary, Rev. 0 dated July 10, 2019
- TM 10152084-0WW-M0004 Summer Odor Source Sampling Summary, Rev. 0 dated October 18, 2019

Odor Emission Rate Estimates for Dispersion Modeling

The odor detection threshold (DT) data from the summer odor sampling was used to create odor emission rate (OER) estimates presented in Table 1. The source data for this OER are discussed and presented in detail in Technical Memoranda M0002 and M0004 listed above. The table is repeated here as a summary of the input to the dispersion modeling.

The OER table lists the projected mass of odor emissions along with an indication of the percentage contribution to overall odor emissions by source. Table 1 presents all odor sources where samples were sent for odor panel laboratory evaluation to determine odor DT values. See Attachment A for an explanation of Odor Panel Methodology from Odor Science & Engineering, Inc which explains what DT means.

The OER in Table 1 is based on summer odor data but the dispersion model also includes the seasonal differences in how biosolids are processed differently between winter, when dewatered biosolids cake is loaded and hauled in covered but open bed tractor trailer trucks, and summer when liquid biosolids is loaded into sealed liquid hauling trucks for beneficial reuse land application.



Table 1: Wastewater Odor Emission Rate Summary Based on Summer Sampling Data from July 1 and August 1, 2019

Sampling Location	DT value	Surface Area (ft ²)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric cfm	Process air (cfm/ft ²)	Flux Chamber Rate Total (m ³ /s/m ²)	DT OU/Sec	% of Plant Total	Comments
Retention / EQ Building	75	3.3			325			12	0.15	Represents small cracks in the large access hatch on the northwest corner of the EQ Building and grating on the east end. Assume EQ fill rate of 3.5 MGD based on summer sampling as typical fill rate.
Raw Sewage Influent Lift Station	8313	21	1063	5		51	0.25907	4168	54.47	Represents open surface area above open channel gratings and edge cracks in the covers on the lift station Archimedes screw pumps. Archimedes screw pump discharge channel was shown to be positively exhausting at up to 200 fpm through grating.
Screen and Grit Building Exhaust Fans	211	24.9			12400			1235	16.14	Assumes 4 roof exhaust fans on screen and grit building at their rated cfm values.
Grit Tank Room	298	8.3			2500			352	4.59	Assumes roof exhaust fan running at rated value.
Flow Splitter Structure Primary Influent - West	1451	2458	240	5		0.098	0.00114	377	4.92	Includes open grating channels flowing into and out of the splitter box plus the open areas of the aerated structure.
Flow Splitter Structure Primary Influent - East	1451	1514	120	5		0.079	0.00104	213	2.78	Includes open channels and grating channels flowing into and out of the splitter box plus the open areas of the aerated structure.
Primary Clarifier Quiescent Zone – West Plant	163	5542	0	5		0.000	0.00064	54	.703	Single clarifier running on West Plant.
Primary Clarifier Quiescent Zone – East Plant	163	11084	0	5		0.000	0.00064	108	1.406	Two clarifiers running on East Plant.
Primary Clarifier Weir Zone – West Plant	1507	1257	0	5		0.000	0.00064	113	1.474	Assumed 4 feet wide launder (wall to weir) with 100 feet diameter. One online.
Primary Clarifier Weir Zone – East Plant	1507	2514	0	5		0.000	0.00064	226	2.948	Assumed 4 feet wide launder (wall to weir) with 100 feet diameter. Two online.
Anoxic/Anaerobic Zone of Aeration Basin – West Plant	21	3612	0	5		0.000	0.00064	5	0.059	Area from one west basin online.
Anoxic/Anaerobic Zone of Aeration Basin – East Plant	21	8295	0	5		0.000	0.00064	10	0.136	Area from two east basins online.



Sampling Location	DT value	Surface Area (ft2)	Process Air (cfm)	Flux Rate (L/min)	Point Source Volumetric cfm	Process air (cfm/ft2)	Flux Chamber Rate Total (m3/s/m2)	DT OU/Sec	% of Plant Total	Comments
Aerated Zone 1 Aeration Basin – West Plant	21	5419	2293	5		0.423	0.00279	29	0.385	Area from one west basin online. Splits aerated zones into front half.
Aerated Zone 1 Aeration Basins – East Plant	21	10838	4585	5		0.423	0.00279	59	0.771	Area from two east basins online. Split aerated zones into front half.
Aerated Zone 3 at end of Aeration Basin – West Plant	11	5419	1123	5		0.207	0.00169	9	0.123	Area from one west basin online. Splits aerated zones into back half.
Aerated Zone 3 at end of Aeration Basins – East Plant	11	10838	2245	5		0.207	0.00169	19	0.245	Area from two east basins online. Split aerated zones into back half.
Secondary Clarifier – West Plant	11	9693	0	5		0.000	0.00064	6	0.083	Area from one clarifier online.
Secondary Clarifiers – East Plant	11	19386	0	5		0.000	0.00064	13	0.166	Area from two clarifiers online.
Gravity Belt Thickener Room Exhaust	11	19.6			36000			187	2.442	18,000 cfm rating on one fan for winter conditions but two fans assumed in summer.
Centrifuge Room Exhaust	11	9			7000			36	0.475	Assumed two exhaust fans at rated value 3500 cfm each.
Cake Hopper Level Exhaust Air	12	9			5000			28	0.370	Assumed one fan running at rated value.
Centrifuge (Lower) Room Conveyor Floor Exhaust Fan	8	4.0			7000			26	0.345	Assumed one fan based on field observations. Largest fan rating.
Truck Loading Bay (During active truck loading)	11	8.6			7000			36	0.475	Assumed two fans running at rated value. DT value from summer data. Note that winter DT for tuck loading is much higher at 16575 DT. Both conditions will be modeled in AERMOD.
Tertiary Filter Room Exhaust	10	15.9			9200			43	0.567	Based on field measurements from 4 wall fans running.
Outlet of Carbon Filters	68	3.53			9000			289	3.774	Field cfm data from two stacks at 18 inch diameter each. DT is based on average of all data including spring and summer sampling which ranged from as low as 45 to as high as 82 depending on which carbon unit was sampled.
Overflow Splitter Structure Headspace at plant entrance	250	4		5		0.000	0.00064	0.05955	0.00	



During offsite collection system investigations and sampling, several small odor locations were identified where the sewer system headspace showed an intermittent tendency for positive pressurization and exhausting of collection system headspace odors. These included a manhole on Old Dixboro Road near the intersection of Deco Ct. and exhaust from a small passive carbon odor scrubber on the collection system headspace at the entrance road leading into the plant at the lower end of Old Dixboro Rd. Both were small impact sources but both are considered in the odor dispersion modeling because of their proximity to bridge commuter traffic on South Dixboro Road and a home near North Dixboro Road where odor complaints have been reported. Odor DT for these sources is based on hydrogen sulfide (H_2S) odor equivalents using H_2S data from Acrulog H_2S data loggers used to measure odors from the sewer in these locations. The DT equivalent assumes 1 DT = 0.0005 parts per million (ppm) per Water Environment Federation Manual of Practice 25: "Control of Odors and Emissions from Wastewater Treatment Plants".

Literature suggests DT ranges for H_2S are from 0.0005 ppm to as high as 0.009 ppm because of the somewhat subjective nature of odor panel evaluations involving peoples' sense of smell. The more conservative 0.0005 ppm ratio was used for this evaluation.

For air exhausting from the manhole pick hole cover exhaust on Old Dixboro Rd., this equated to 19,760 DT for the small amount of untreated air leaving the pick hole. For the exhaust from the passive vent carbon system, this equated to 150 DT based on the assumption that the carbon removed at least 90% of the odor from the raw air at 1,540 DT based on the average H_2S of 0.77 ppm seen on the inlet of the carbon odor scrubber.

Odorous air volumetric flow rates were measured directly in the field at these collection system locations in cubic feet per minute (cfm). Although these locations were only intermittently positively pressured, they were modeled as though they exhausted continuously as the most conservative assumption.

Odor DT and emission rates for the dispersion modeling were adjusted for winter months as follows based on early spring sampling data:

- During winter months (roughly November to May) the truck loading bay exhaust when trucks were not actively loading was set at 19 DT compared to 11 DT in summer. This represents normal operation without active biosolids cake truck loading.
 - Active truck loading during winter with open-top cake trucks is based on a measured 16,575 DT at the wall mounted exhaust louvers. This is a short term, unusual case, when trucks are actively loading but was also evaluated and is presented in the dispersion modeling evaluation. Trucks take only about 30 to 45 minutes to load and one or two trucks are loaded every weekday. Consequently, this impact is intermittent and typically short-term during winter months.
- Centrifuge room exhaust for winter, when centrifuge dewatering is operational, was set to a field measured value of 19 DT compared to summer when it was measured at 11 DT.
- Gravity belt thickener room exhaust rates were set at 18,000 cfm with one exhaust fan operating in winter but at 36,000 cfm with two 18,000 cfm exhaust fans in summer.



Dispersion Modeling

The OER table provides a sense of the overall odor contribution by source but does not consider how the odors might or might not disperse off site. Dispersion modeling provides an improved understanding of the relative risk of creating off-site impacts for each odor source because it considers how the odors migrate from the sources to the receptors (the community). It considers terrain conditions including elevation, building downwash effects, and weather patterns. Odor dispersion modeling should be thought of as a risk assessment evaluation to determine the highest risk odor sources with the greatest potential for negative odor impacts and an overall evaluation to understand the risk level of noticeable nuisance level odors.

The dispersion model uses mathematical equations that relate emissions from a source to predicted ambient air concentrations downwind. The AERMOD dispersion model was used for this analysis. This model is recommended by the EPA and has been widely used in odor impact assessments. AERMOD is designed to assess the individual and combined impacts from multiple sources and source types such as point or area sources.

The following subsections describe the inputs developed for the Ann Arbor WWTP baseline AERMOD modeling.

Source Data Inputs

Source data must be characterized to show the odor concentration of the source, the volumetric emission rate of the source, the resulting mass emission of the odor, and the type of source. The source concentrations could be based on a particular odor-causing compound, such as H_2S . However, if H_2S is not the only or even the primary odor-causing compound of concern, then it might not be a good indicator of what will cause risk of off-site odor complaints.

Source data from the spring and summer Ann Arbor odor sampling indicate that the odors from the plant are caused by a variety of compounds. These included H_2S as well as low levels of reduced sulfur organic odor compounds such as methyl mercaptan (MM), dimethyl sulfide (DMS), dimethyl disulfide (DMDS) and carbonyl sulfide (CS) as well as low level ammonia and amine based odors from several biosolids sources. As such, it is more appropriate to evaluate dispersion effects based on odors expressed as a DT level in order to consider all odorous compounds. For instance, if modeling was done solely on H_2S then sources where the reduced sulfur compounds or ammonia play a key role would not be fully considered in the dispersion impact projections. The detection threshold value DT provides an estimate of the broad spectrum odors as perceived by the odor panelist noses, regardless of which odor causing compounds are present. DT values were used to develop the OER table estimates.

Terrain, Building and Odor Source Characterization Inputs

Three types of odor sources were identified:

- Point sources, such as the exhaust from the existing carbon adsorption odor control system exhaust stacks in the Solids Handling Building (SHB).
- Area sources, such as the primary clarifiers, flow splitter channels and aeration basins.
- Volume sources, such as the building wall exhaust louvers and fans for building HVAC exhaust systems.



The dimensions and location of each of these sources are included in the modeling evaluation. AERMOD considers the differences in each of these types of physical odor sources.

The AERMOD dispersion model has two options for determining how the dispersion model considers the effects of land use: “urban” and “rural.” The rural option was used in this evaluation given the relatively limited degree of urbanization within three kilometers of the plant. The urban land use option is appropriate only if over half of the area within three kilometers of the source is considered to be in the urban land use category (i.e., include multi-story buildings, industrial areas, and older urban housing areas with closely spaced houses). Since this does not describe the plant area, the rural dispersion coefficients, mixing heights, and temperature gradient effects were used in the modeling analysis.

The “rural” land use option is also the more-conservative assumption, because dispersion (or dilution) of the odors is generally less under these conditions. In an urban setting, buildings promote turbulence and mixing, which enhances dispersion. Rural land use generally lacks these effects, resulting in relatively slower dispersion (and dilution) of the odors as they migrate away from the plant.

Terrain elevations and land cover type are all considered in the AERMOD set up files. This data is part of the input set up that defines the topographic elevations and land cover in the area of interest.

An aerial photograph was used as the base map to locate the individual sources when setting up the modeling input files. A receptor grid array was defined and superimposed on the site aerial map. Receptors are the locations where ambient concentrations are calculated by the dispersion model. The receptor grid used in this modeling analysis was rectangular, extending two miles from the plant with receptors located as follows:

- In general, odor receptor elevations were set at the approximate height of an average person to simulate the elevation of a person’s nose.
- The rectangular grid was established with receptors spaced every 10 meters on-site and out to $\frac{1}{4}$ kilometer, then every 50 meters out to $\frac{1}{2}$ kilometer, then 100 meter spacing out to just over two miles (3.5 kilometers or 2.17 miles).

Receptors were also established along the perimeter fence line of the WWTP and at the following “Sensitive Receptor” locations in the community:

- The location of a home off of North Dixboro Rd. where complaints have been reported.
- The location of a new retirement center, All Seasons Ann Arbor (All Seasons), under construction just northwest of the WWTP off of North Dixboro Rd.
- The Towsley community where odor complaints have been reported.
- The nearby St. Joseph Hospital parking lot southeast of the WWTP where odor complaints have been reported.
- The Washtenaw Community College (WCC) fitness center parking lot south of the plant where odors have been reported.
- The WCC area south of the plant where odors have been reported.

Overall, over 8,300 receptor locations were defined in the AERMOD model evaluation in order to evaluate potential odor impact risk as far as 2.17 miles from the WWTP. Figure 1 shows the

overall site along with the locations of the defined sensitive receptors. Figure 2 shows a more focused view of the WWTP odor sources. All of the highlighted zones of the plant were modeled. All blue zones were modeled as their actual structures in height, length, width and general shape so that AERMOD could do building and structure downwash effect calculations. All of the red zones represent the plant treatment processes that were assumed to be typically in service.

Figure 1: Overview with Sensitive Odor Receptors Locations Identified



Figure 2: Plan view of Ann Arbor WWTP structures and process emission sources



The plant was modeled assuming normal operation with the typical number of unit processes in service. This included:

- Normal loading to the Raw Sewage Influent Lift Station
- The Screenings and Grit Building in full service
- One of the two West Primary Clarifiers in service
- Two of the four East Primary Clarifiers in service
- One of the two West Aeration Basins in service
- Two of the four East Aeration Basins in service
- One of the two West Secondary Clarifiers in service
- Two of the four East Secondary Clarifiers in service
- Tertiary Filter Building in service
- Solids Handling Building in service
 - o In winter with centrifuge dewatering and biosolids cake production
 - o In summer without centrifuge dewatering and liquid biosolids hauling

The above was modeled as the normal baseline plant configuration in order to estimate the baseline odor impact potential. In addition to this, dewatered cake biosolids loading was also modeled in order to project the potential impact during periods when a biosolids cake truck is actively being loaded. Furthermore, several off site odor sources were modeled as previously discussed.

Several offsite sewer locations were not modeled because as part of the spring and summer sampling, it was determined that they either did not have any measureable H₂S odors or that they never pressurized creating potential for odorous air exhaust. These included:



- An access hatch to the wet well pump station in the green space at the WCC.
- A sealed manhole on East Huron River Dr. near the entrance to the WCC where H₂S was detected under the cover but the manhole was sealed without any pick hole openings.
- An access hatch to the pump station wet well near the WCC fitness center where H₂S odors were not detected and wet well pressurization was generally not observed.
- The Towsley neighborhood pump station where inspection did not indicate odor potential.

During the course of the winter kickoff meeting odor survey and the follow up spring, summer, and fall sampling events, no other odor sources were identified within two miles of the plant.

Metrological Data Inputs

The meteorological data used in this modeling analysis are from the Ann Arbor Municipal Airport. Five years of available meteorological data were used representing the years 2014 through 2018.

Three potential sources for meteorological (met) data were considered. These included the Ann Arbor Municipal Airport, the Willow Run Airport, and the North Campus Research Complex at the University of Michigan. Wind roses and the quality of the available met data were evaluated from all three. The wind roses were compared and showed all three had similar overall wind patterns. The Ann Arbor Municipal Airport data was selected because:

- It is a quality-controlled metrological data set from the local air permitting agency with data for the most recent five years.
- The North Campus Research Complex, although closer to the WWTP, had incomplete truncated met data that was not suitable for AERMOD.
- The Ann Arbor Municipal Airport was closer to the WWTP than the Willow Run Airport.

The dispersion model calculates odor dispersion effects every hour over the course of each year (8,760 data points, one for each hour of the year) for every receptor grid location. Using five years of meteorological data allows calculation of the potential dispersion risk for 43,800 hourly weather patterns defined by the local airport meteorological data. There were over 8,300 receptors in the model. By calculating the impact for each source, for every receptor location, for every hour of the five years, there is a high statistical probability of considering the worst-case conditions and thereby conservatively projecting the relative risk of a given odor source creating an off-site impact.

Modeling Approach

It should be noted that much of the odor source data was based on relatively warm weather odor generating conditions with relatively warm wastewater and sampling completed during summer weather. This sample timing was selected intentionally to attempt to capture higher odor-generating conditions representative of the higher odor threat times of the year. The sampling data may not represent the *absolute* highest peak odor concentration conditions that actually occur, but they are generally considered conservative.



The exception to this is for odor sources that change from summer to winter because of changes in how biosolids are processed in winter. This evaluation also considers those impacts by sampling completed in both conditions.

As such, for winter months, when odor levels from most sources may actually tend to be reduced, this assumption results in a conservative estimate of the off-site impact for sources such as the Raw Sewage Influent Lift Station, the Screenings and Grit Building, primary clarifiers, and aeration basins. As an example of this potential, the Screenings and Grit Building roof fans averaged near 0 ppm H₂S with peaks to 1 ppm during the week of May 8 through May 14, 2019, while averaging 1.03 ppm with peaks to 5 ppm during the week of July 31 to August 6, 2019. Odor DT data from August was used in the modeling which would tend to make the model projections in winter conservative. This will be discussed and considered when looking at odor impact plots in the following section of this memo.

Selecting an Odor Impact Criteria Goal

The selection of an odor impact criteria should consider all of the following:

- Odor concentration expressed as a DT value
- Odor impact duration
- Number of off-site exceedances allowed

While the acceptable DT impact level should also consider the relative offensiveness and character of the odor, the following general guidelines are offered in understanding the impacts of various DT levels from typical WWTP odor sources:

- Odor impacts in the range of at least 5 to 10 DT are typically required in order to be noticed above background community odor levels; longer duration or very frequent events at or above this level will create a risk of generating odor complaints.
- If impacts are significantly above 10 DT, then the likelihood of odor complaints rises.
- If the impacts are projected to be above 50 DT, then odor complaints are likely no matter how long the duration or how infrequently they occur.

Ann Arbor does not have a specific odor DT impact criterion set in local codes. WWTP staff should set a numeric odor impact goal that minimizes the risk of negatively impacting neighbors and develop a plan to work toward achieving this goal. Part of this effort may include looking at what other successful facilities have generally done.

Projected Odor Impacts Based on AERMOD

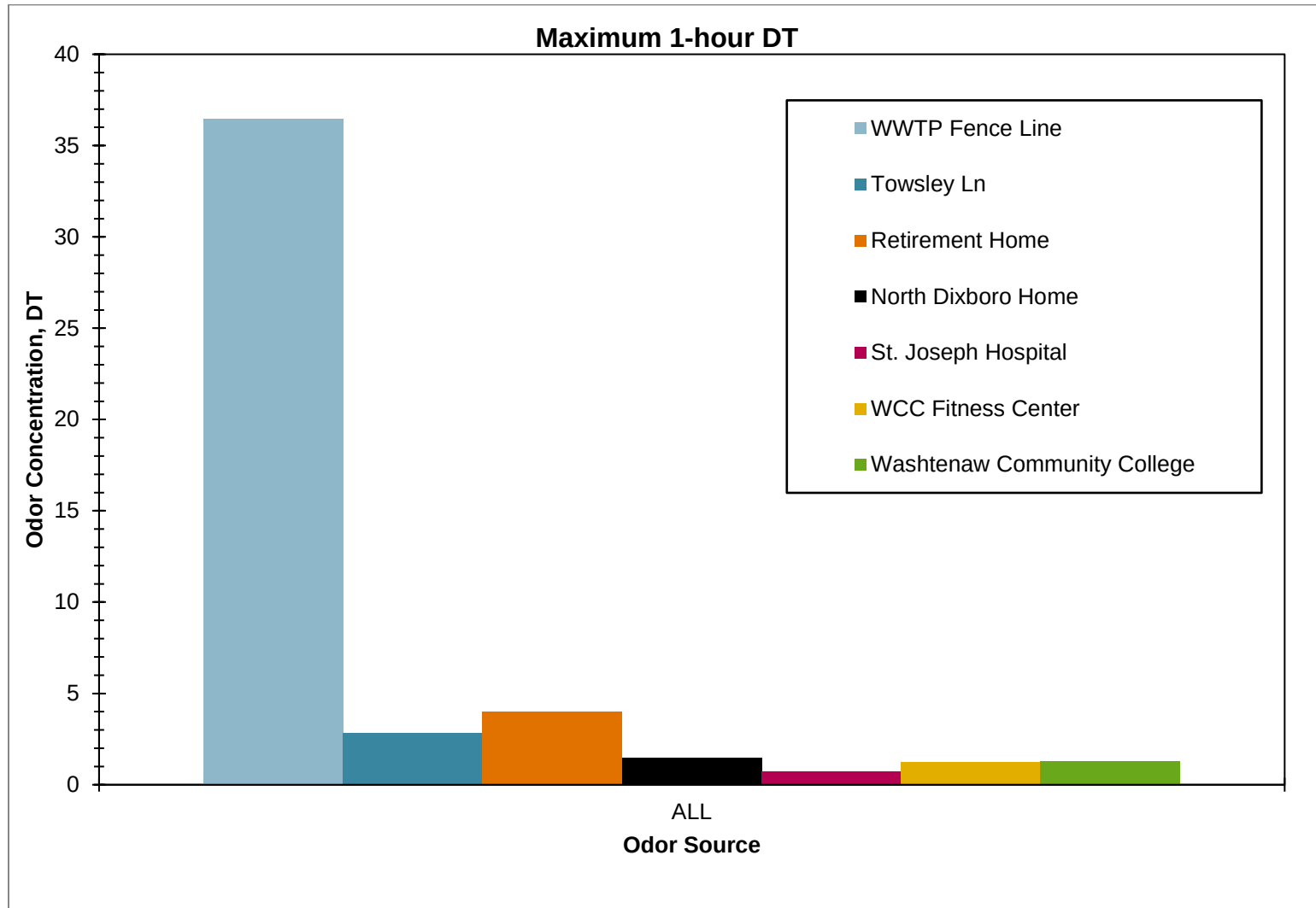
Projected odor impacts are presented in two ways. First, as a bar chart showing impacts of the individual sources at the various sensitive receptor locations and second, as odor impact contours (called odor isopleths) showing the maximum 1-hour average DT impact calculated by the dispersion model plotted onto an aerial view. The odor contours or odor isopleths are created by connecting calculated values for the 8,300 grid points that have the same projected DT impact. As such, the outer boundary of an odor isopleth line represents the projected maximum impact distance of a source that occurred at least one time during the five years of evaluated met data. This approach is therefore essentially projecting the maximum odor



footprint zone potential. By establishing the baseline odor condition this evaluation can help determine if any sources are problematic and may warrant odor mitigation.

Figures 3-1, 3-2, and 3-3 show the projected individual impacts of each source at the key sensitive receptor locations. The graphic is presented three ways: Figure 3-1 includes all odor sources together, except for the biosolids cake truck load outs in the winter, showing the composite effect on the offsite sensitive receptors and at the fence line; Figure 3-2 shows individual odor sources impacts; and Figure 3-3 shows only the sensitive community receptor locations included. The fence line location being impacted changes for each source, particularly since the fence line is close to many of the process basins. As such, the model predicts higher impact levels at the fence line locations than for the offsite sensitive receptors. These projected impacts will be shown more clearly in the odor isopleth plots in the next section.

Figure 3-1: All Odor Sources* Composite Impact on Offsite Sensitive Receptors and Fence Line



*Does not include biosolids cake truck loadouts in the winter

Figure 3-2: Individual Odor Sources Impact on Offsite Sensitive Receptors and Fence Line

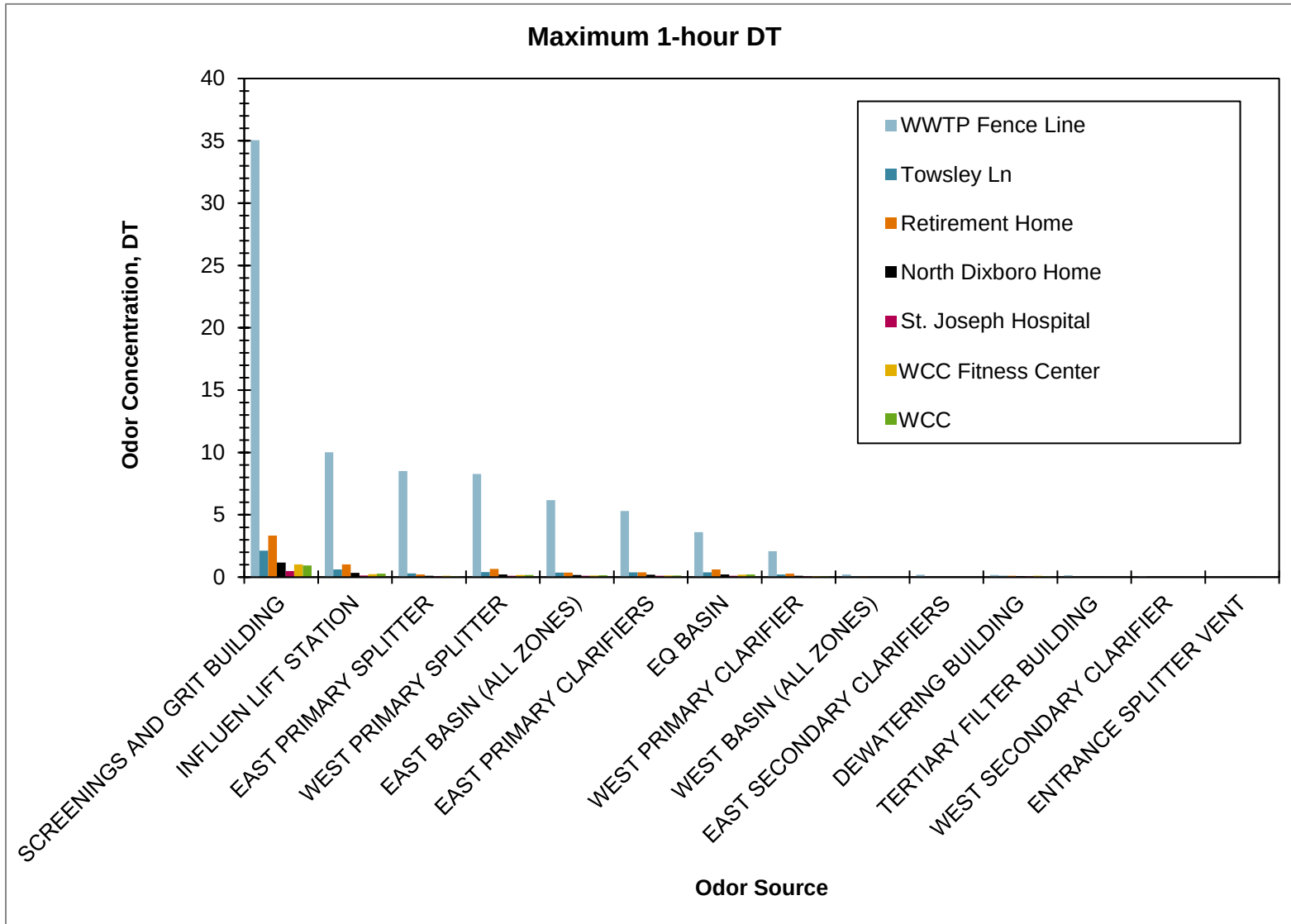


Figure 3-3: Offsite Sensitive Receptors and Fence Line Locations

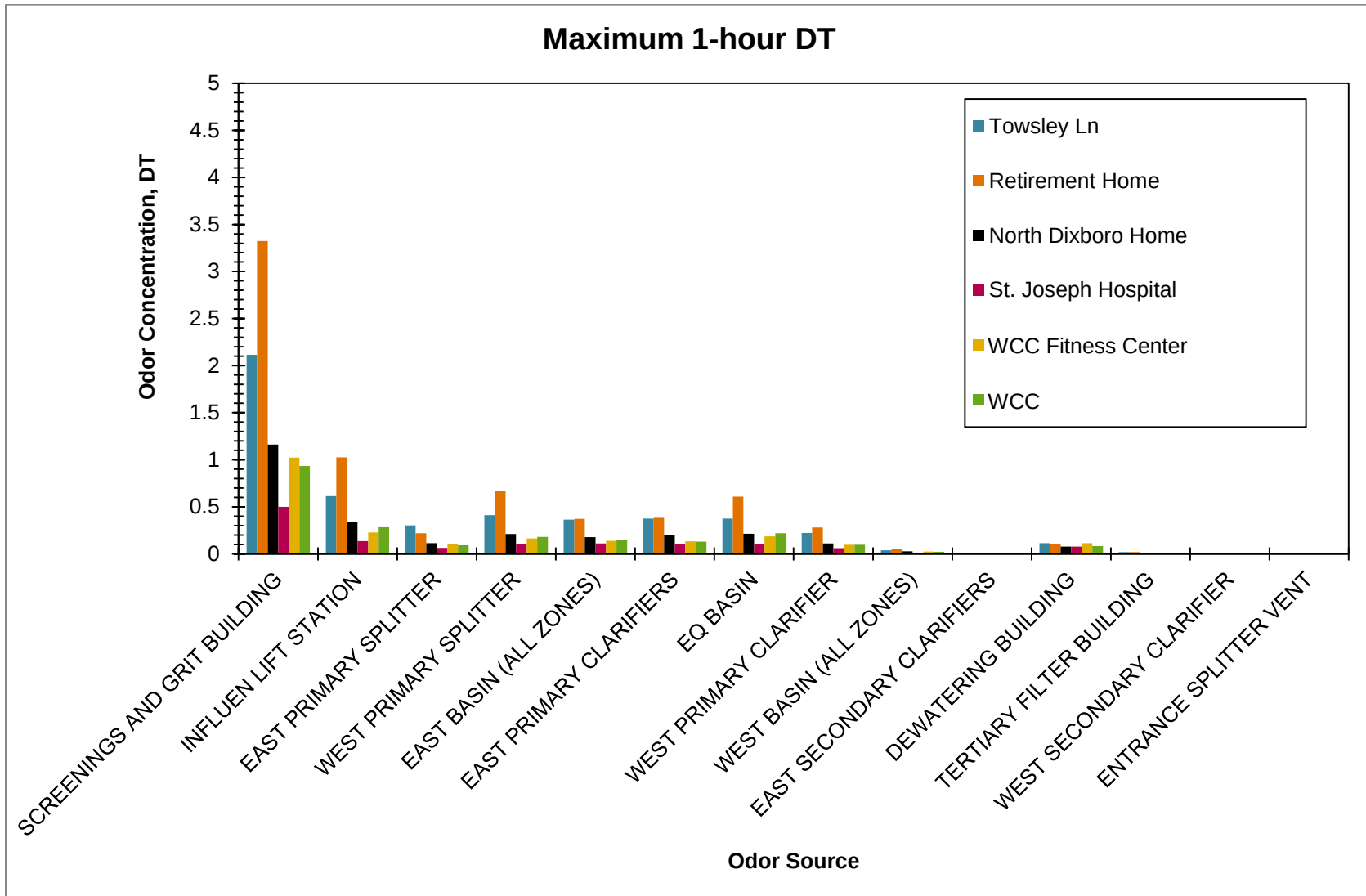
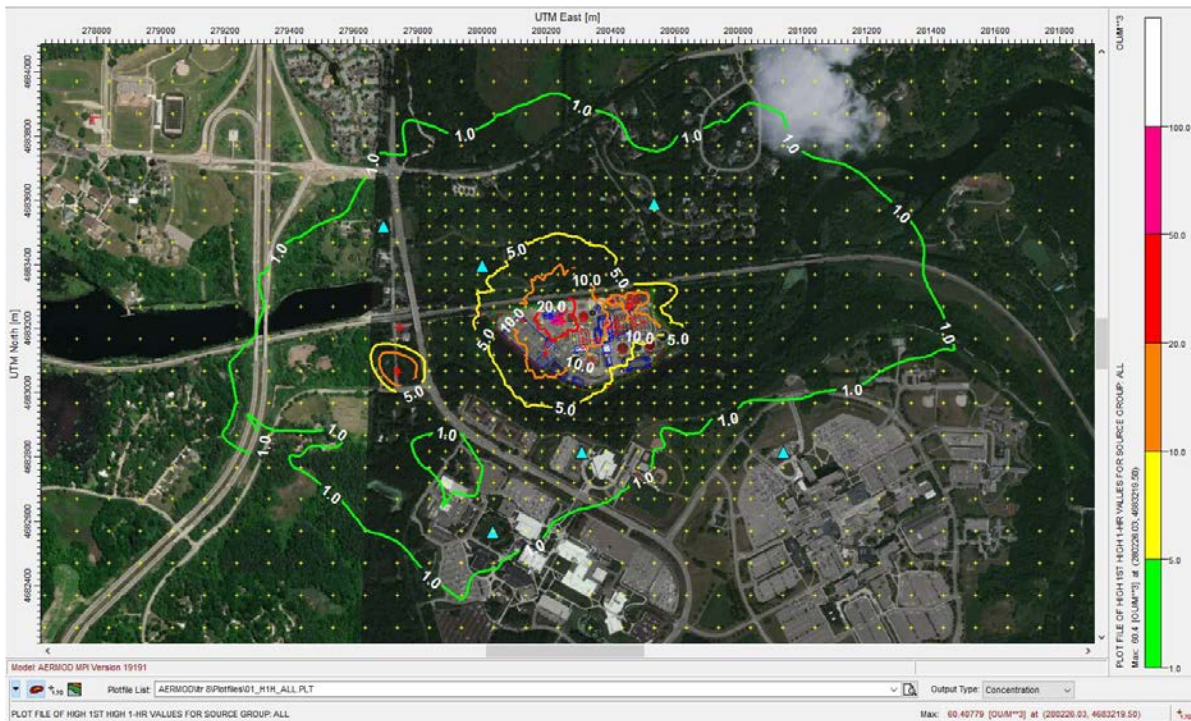
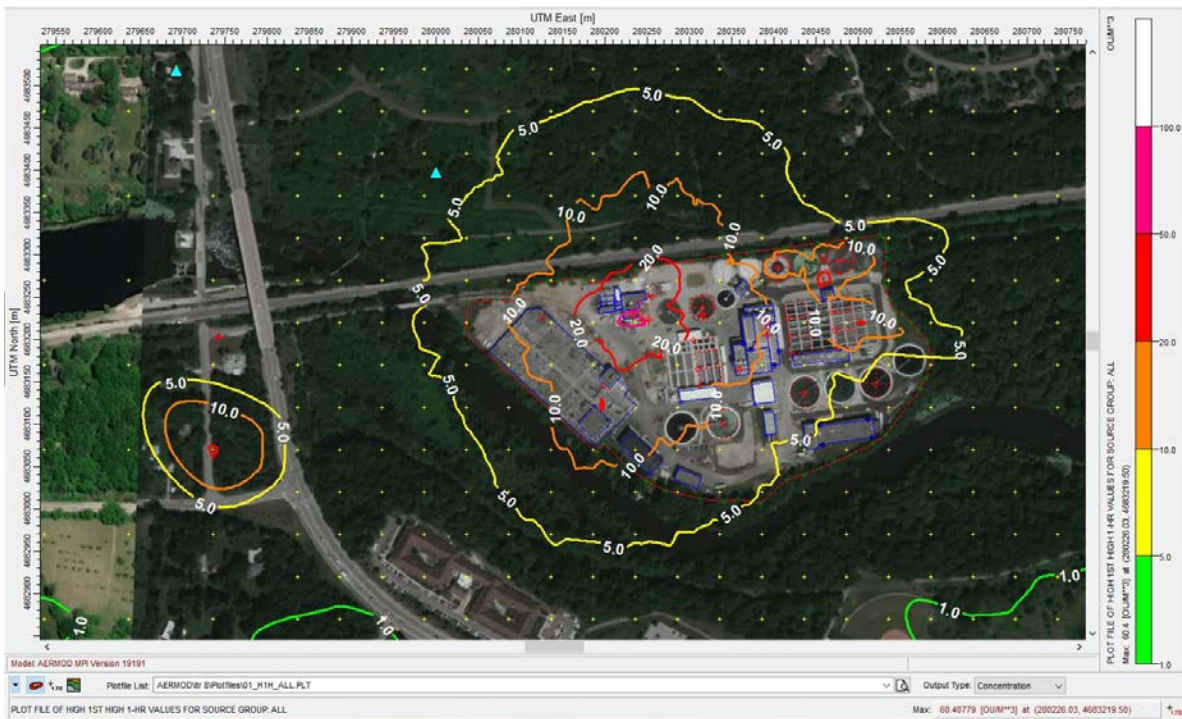




Figure 4 shows the composite impact of all of the sources, except the biosolids cake truck load outs in the winter, acting together based on the dispersion modeling for the baseline normal operating condition. Two scales are shown. The top graphic reaches further offsite to show the extent of the 1 DT impact potential. The bottom graphic zooms in closer to the plant boundary in order to show the extent of the 5 DT to 10 DT level of impact. This does not include the short-term higher odor impact during biosolids cake truck load outs in winter, which will be presented in a following section focused on the SHB.

For normal plant baseline conditions, the dispersion model projects the risk of a 5 DT impact on the Gallup Park walking trail located between the Towsley community and the new All Seasons community with as much as a 10 DT impact on the walking trail just north of the plant. Potential for up to 10 DT impacts on Old Dixboro are also projected from the manhole odor emissions along with a 5 DT potential to commuter traffic on the main roads.

Figure 4: Maximum 1-hour Odor DT Impact from all sources* (Top view: Expanded scale showing further from the plant. Bottom view: Zoomed showing more detail around the plant)



*Does not include biosolids cake truck loadouts in the winter

The following sections show the odor isopleth plots by individual source in order to better understand which sources contribute most to the overall risk of offsite odor potential.

Raw Sewage Influent Lift Station

Figure 5 shows the projected impact from the Raw Sewage Influent Lift Station. This includes emissions from open channel grating before and after the Archimedes screw lift pumps and spaces in the edges of the lift pump screw covers on top of the screw pumps.

Field investigation indicated that the grating immediately downstream of the channel carrying flow from the Archimedes screw pumps is actively exhausting air at approximately 100 to 200 feet per minute velocity. This would equate to over 1,000 cubic feet per minute (cfm) of relatively odorous air from the channel headspace. Essentially, it appears that the Archimedes screws and flowing wastewater drag odorous air which exhausts out the grating at the end of the screw pump effluent channel. The screw pumps create turbulent conditions stripping H_2S odors from the wastewater to the channel headspace. Some emissions also escape from the Archimedes conveyor covers which are not airtight along the edges. Figure 6 shows a view of the covers as well as the open grating in question.

The evaluation indicates a 5 DT impact potential on the rail tracks just north of the plant with the potential for 1 DT further out at the new retirement facility.

Figure 5: Raw Sewage Influent Lift Station Maximum 1-hour Odor DT

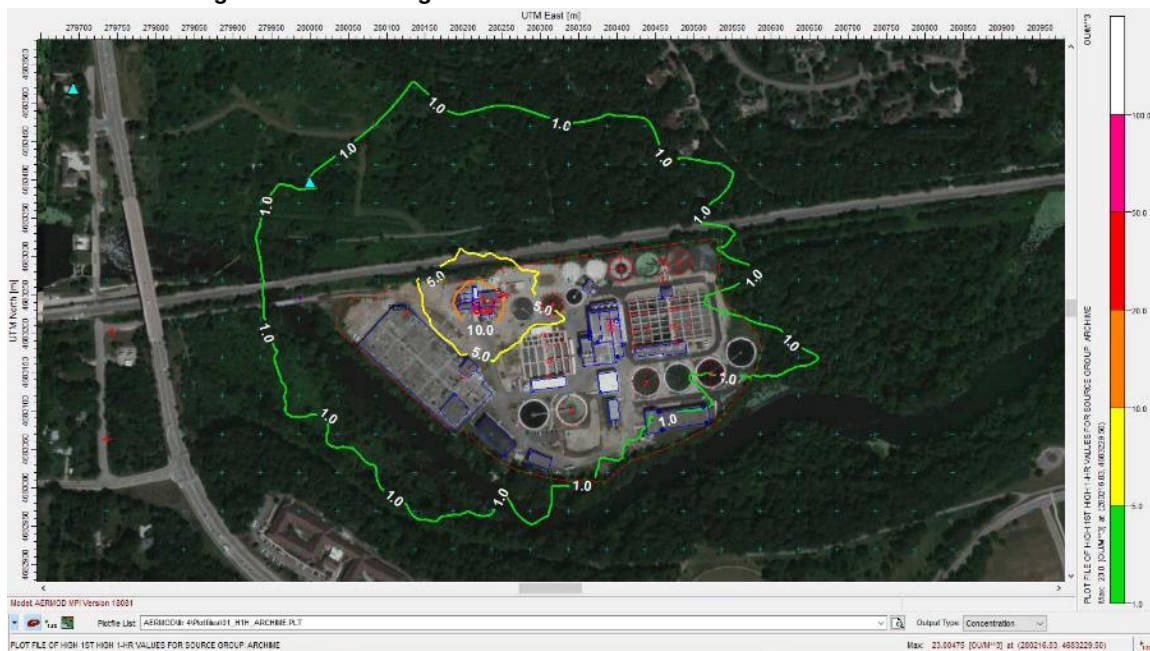


Figure 6: Photos of the Raw Sewage Influent Lift Station

(Left: Covered Archimedes screw pumps, Right: Open grating on lift station effluent channel)



Screenings and Grit Building Roof Exhaust Fans

Figure 7 shows the projected impact from roof mounted exhaust fans on the Screenings and Grit Building and the adjacent attached Grit Tank room. This includes multiple building exhaust fans on the roof. Figure 8 shows a portion of these exhaust fans. The evaluation indicates a 10 DT impact north past the railroad tracks and walking path with potential to reach 5 DT beyond the walking path and 1 DT out to the Dixboro bridge and into the Towsley neighborhood.

Figure 7: Screenings and Grit Building Roof Exhaust Maximum 1-hour Odor DT

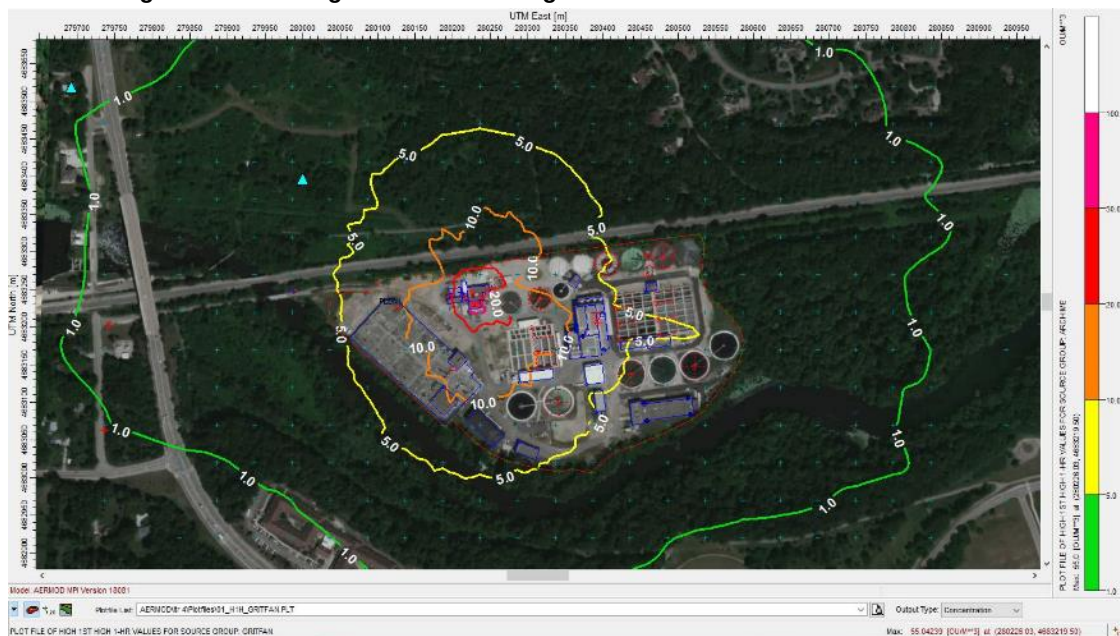


Figure 8 Roof Exhaust fans on the Screenings and Grit Building



This odor impact shown in Figure 7 from the Screenings and Grit Building fans may tend to over project winter impacts because the DT value used to calculate emission rate is from summertime sampling. H₂S data loggers in the Screenings and Grit Building measured early spring 2019 (late winter) data averaging below the detection limit of the AcruLog data logger with peaks to 1 ppm compared to August 2019 data averaging 1.03 ppm peaking to 5 ppm. Based solely on H₂S odors, the winter impacts may therefore be as much as 1/5th of the projected impacts based on the measured summer time DT.

Based solely on the dispersion plots, the influent pump station and Screenings and Grit Building roof exhaust fans are considered high risk sources, particularly during warmer wastewater months.

Flow Splitter Structures to Primary Clarifiers

Wastewater flow after screenings and grit removal are split between the East and West Plants. The West Plant has two parallel trains with two primary clarifiers followed by two aeration basins followed by two secondary clarifiers. The East Plant has four primary clarifiers, followed by four aeration basins followed by four secondary clarifiers. Flow splitting to the East and West Plants and into the various primary clarifiers is done by flow splitter channels. The Flow Splitter nearest the Screenings and Grit Building is shown in Figure 9. The channels into and out of the splitter structure are covered with open grating. Odors are present from the open splitter tanks and the grating with turbulence from aerators and weir gates causing H₂S odors to be stripped from the wastewater.

Figure 9: Flow Splitter Channels on the West Plant near the Screenings and Grit Building



Figure 10 shows the projected impact of the West Plant Flow Splitter. Figure 11 shows the projected impact of the East Plant Flow Splitter. Both odor isopleth plots indicate that the 5 DT impact level for the splitter odors reach as far as the railroad tracks just north of the plant with potential for 1 DT impact on the walking path, but do not reach further offsite to any of the sensitive odor receptor locations.

Figure 10: West Plant Flow Splitter channel Maximum 1-hour Odor DT

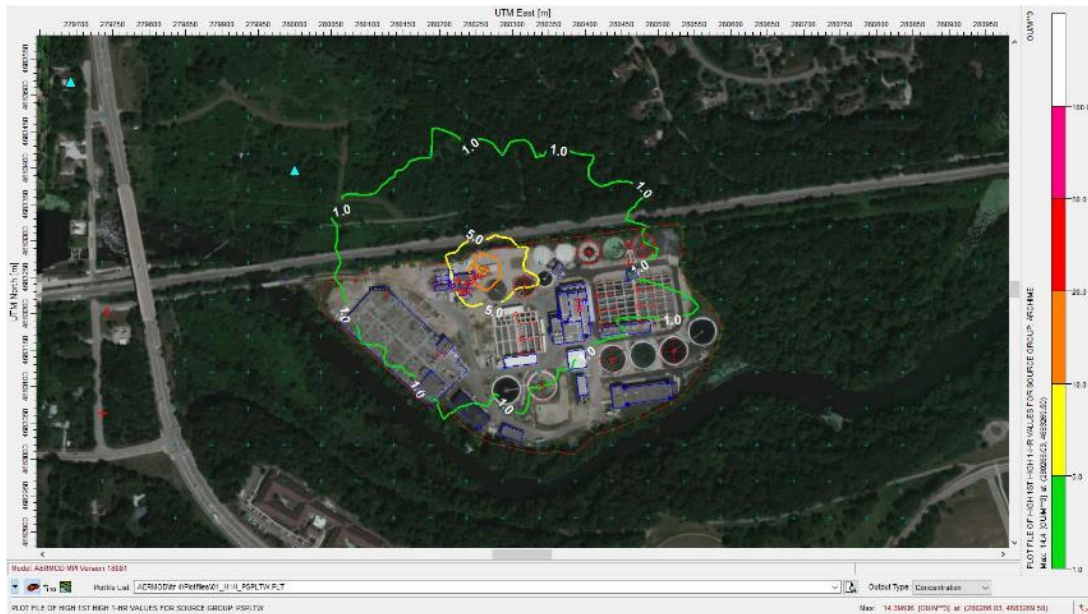
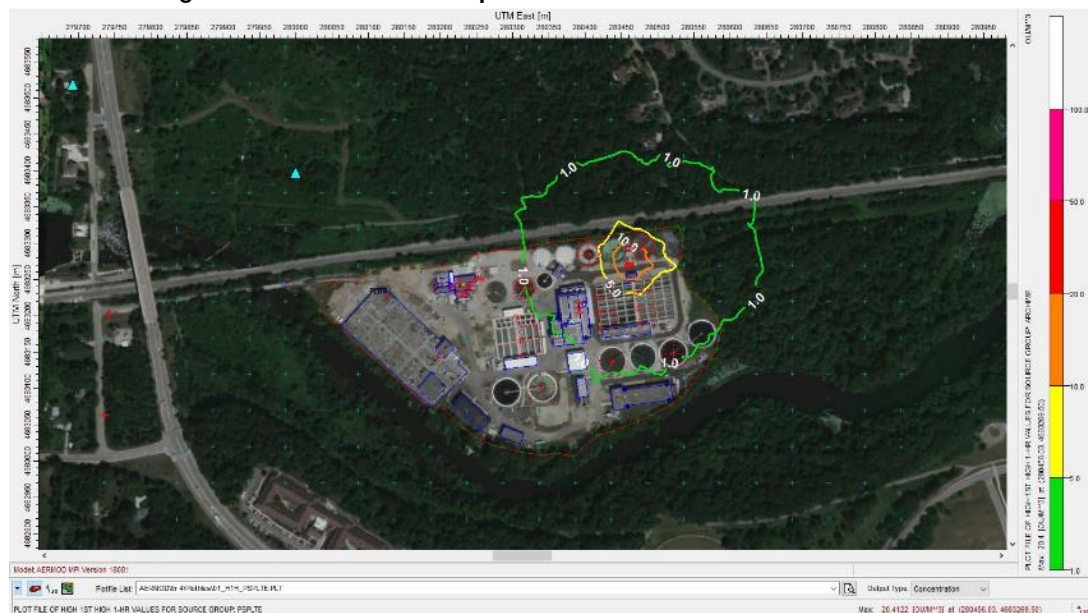


Figure 11: East Plant Flow Splitter channel Maximum 1-hour Odor DT



Primary Clarifiers

The primary clarifiers include two different zones of interest in terms of odor potential. These are the relatively low turbulence quiescent zone, which occupies most of the surface area, and the

outer launder and weir zones around the perimeter of the clarifiers which tend to be more turbulent with more concentrated odors. The quiescent zones for the primary clarifiers were shown to have a summertime DT value of 163 compared to the weir and launders at 1,507 DT. Figure 12 shows a photo of one of the primary clarifiers during sampling.

Figure 12: Primary Clarifier Photo

(Left: Quiescent zone of Primary Clarifier, Right: Launder and Weir zone)



Figure 13 shows the projected odor DT risk of the West Plant primary clarifier including the impact from both the quiescent and the weir zone. Figure 14 shows the projected odor DT risk of the two operating East Plant primary clarifiers including the impact from both the quiescent and the weir zones. Although the quiescent zone surface area is much greater than the launder and weir zone, most of the odor emission from the primary clarifier is projected from the launder and weirs. Based on the OER, the launder and weir zones represent 68% of the total odor emission from the primary clarifiers.

The projected odor isopleths do not predict greater than 5 DT offsite impacts from the primary clarifiers. Projected odor impacts are limited to 1 DT to the railroad tracks just north of the plant and to small portions of the walking path.

Figure 13: West Plant Primary Clarifier Maximum 1-hour Odor DT

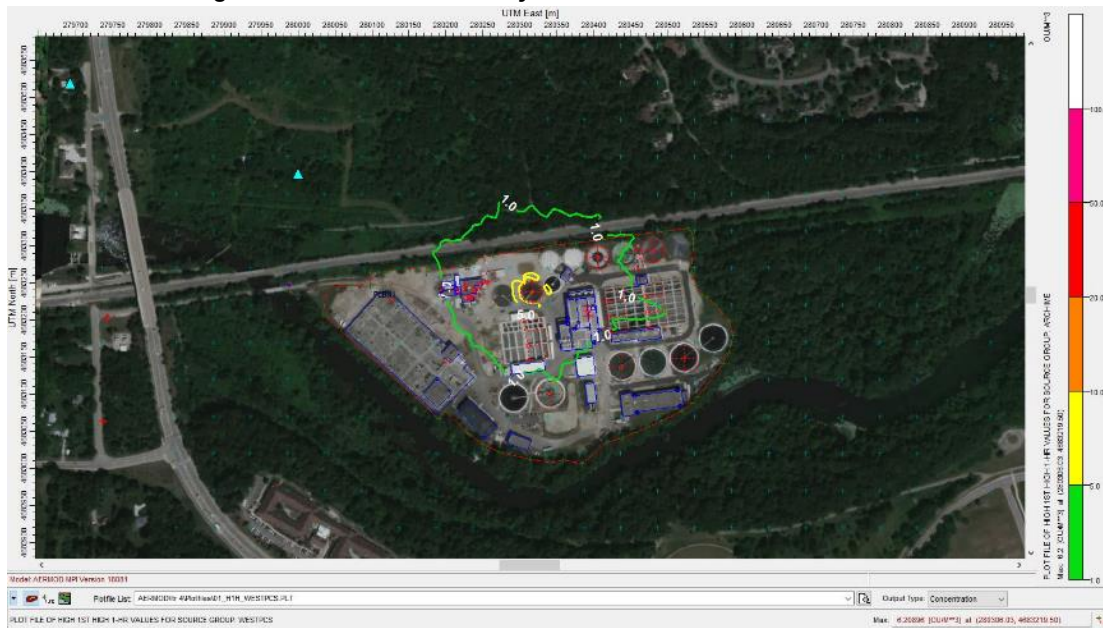
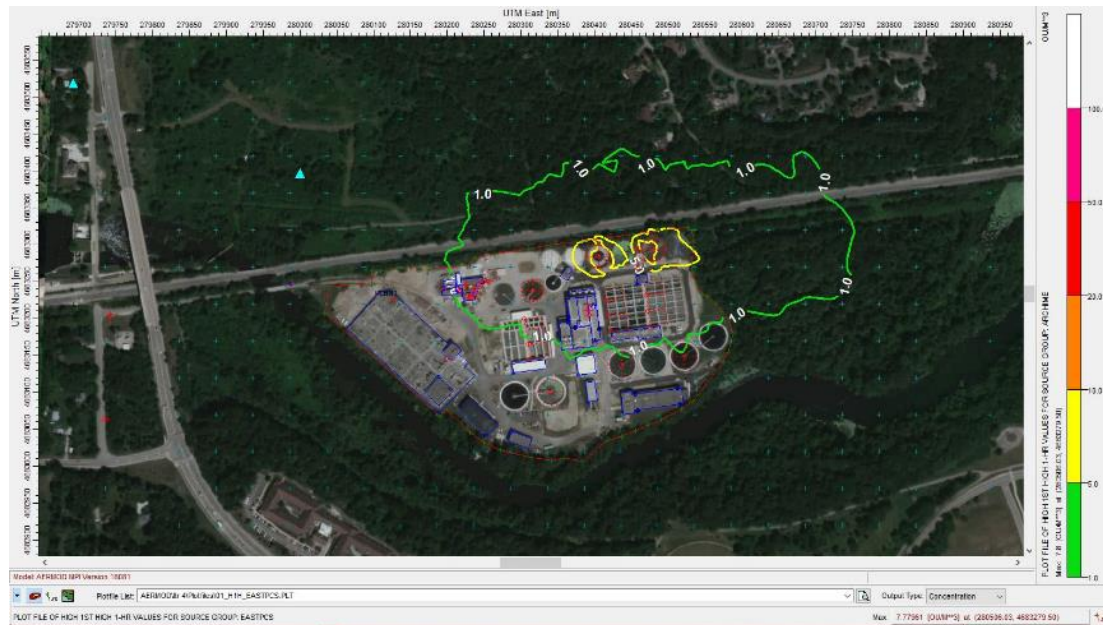


Figure 14: East Plant Primary Clarifiers Maximum 1-hour Odor DT



Aeration Basins

Aeration Basins were modeled in three pieces.

- The first approximately 1/3 of the basin which is an unaerated zone
- The first ½ of the aerated zone of the tanks
- The last ½ of the aerated zones of the tanks

This was done in recognition that typical odors from these zones can differ in intensity and the volumetric emission rate is different for each zone. The unaerated zones often have higher odor DT values but since there is no aeration to cause odor stripping, the volumetric emission is relatively low. The first portion of the aerated zones is often higher in DT because it is the first zone where aeration effects can strip residual odors. Further, this zone often has higher aeration rates at the front of the tank than the end due to tapered aeration process demands.

For the Ann Arbor WWTP, the DT values were 21 for the unaerated zone compared to 21 for the first ½ of the aerated zone compared to 11 DT for the last zone. All of these are relatively low compared to many other wastewater plants.

Figures 15 and 16 show the projected odor isopleth impacts from the West and East Aeration Basins. The aeration basin impacts are not projected to cause a 5 DT impact offsite. The East Basins do reach offsite just north to the railroad tracks at a 1 DT level, but do not cause a 5 DT impact. Further evaluation indicates that the majority of the aeration basin impact is from the first ½ of the aerated zone.

The dispersion modeling suggests the potential impact from the aeration basins is very low, well below a stringent 5 DT impact at all receptors except very near the fence line.

Figure 15: West Plant Aeration Basin Maximum 1-hour Odor DT

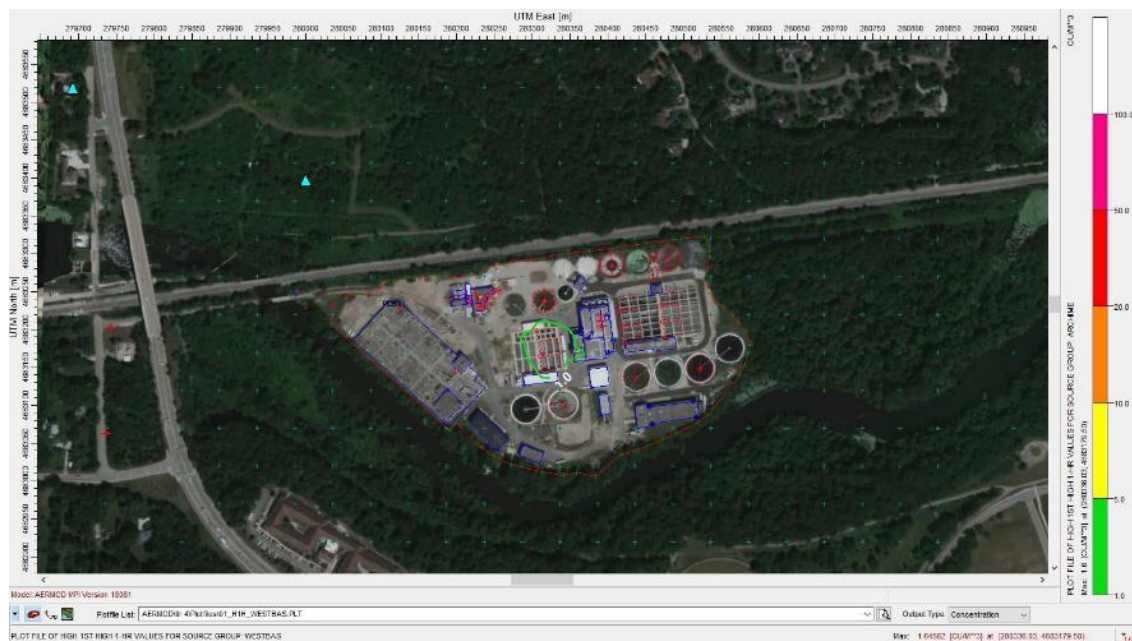
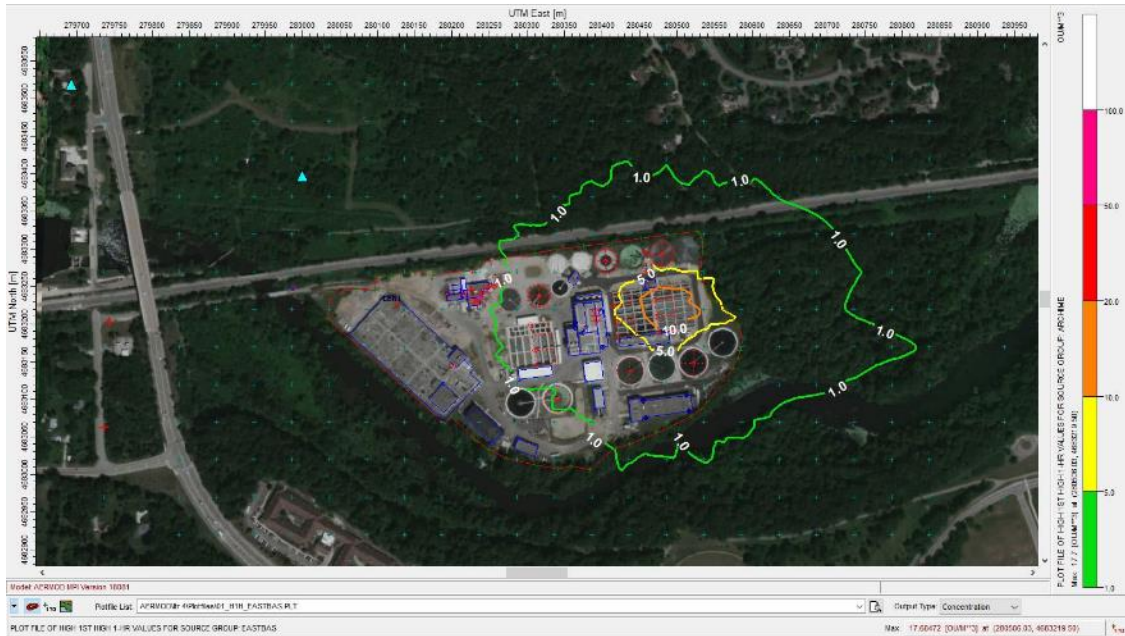


Figure 16: East Plant Aeration Basin Maximum 1-hour Odor DT



Secondary Clarifiers

Secondary clarifier weirs are covered with arched fiberglass reinforced plastic (FRP) covers in order to minimize algae growth on the weirs and launders. Figure 17 shows a photo of one of the secondary clarifiers during summer odor sampling.

Figure 17: Secondary Clarifier Photo





The side effect of the FRP covers is that odor emissions are contained from the turbulent launder and weir sections. As such odor emissions from the secondary clarifiers are limited to the quiescent zones. The odor levels from the secondary clarifiers are very low. The AERMOD evaluation indicated odor isopleth impacts above 1 DT are not projected to reach off site. Therefore, the secondary clarifier impacts are well below the stringent 5 DT impact. The secondary clarifiers are therefore considered a very low risk odor source that does not require further consideration.

Tertiary Filter Building Exhaust Fans

The Tertiary Filter Building has a total of four small exhaust fans located on the north and south walls that vent the filter room air. Odors from this source were low. As such, similar to the secondary clarifiers, the AERMOD evaluation indicated that isopleth impacts above 1 DT are not projected to reach off site. Therefore, the Tertiary Filter Building impacts are well below the stringent 5 DT impact. The Tertiary Filter Building is therefore considered a very low risk odor source that does not require further consideration.

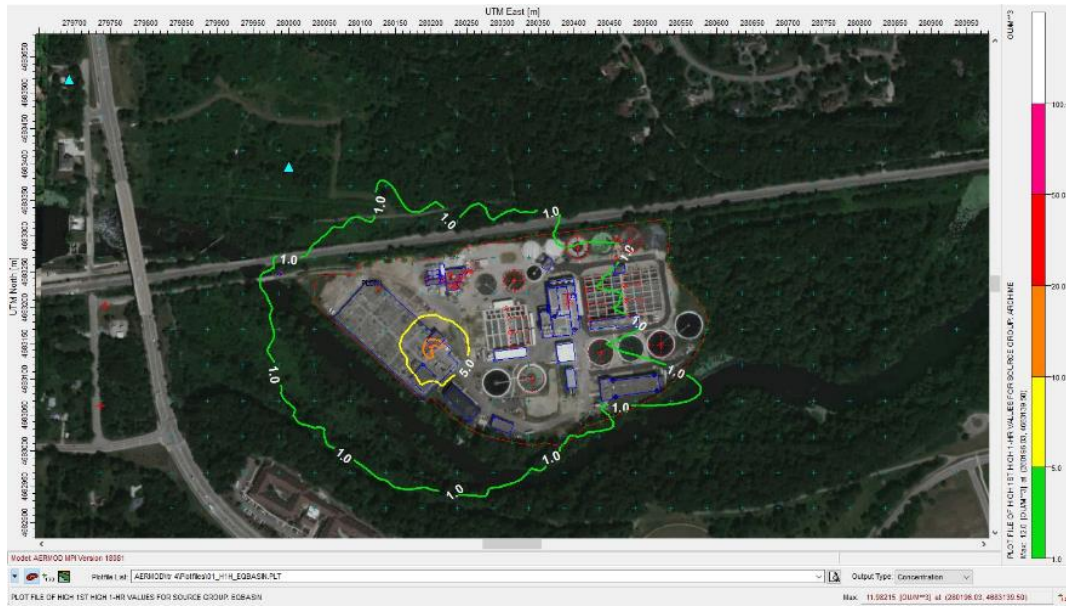
Flow Equalization Basin

Excess daily flow into the plant is diverted into the large, covered flow equalization basin (EQ) near the front gate of the plant. Generally, flow is diverted into the basin in the morning and day hours during high flow periods and then slowly emptied back into the plant during low flow periods, which provides steady loading to the wastewater processes in order to maximize treatment capabilities.

Potential odor emissions are from cracks in normally closed maintenance access hatches and small grating areas, both of which were modeled as though the odorous air flow volume was equal to the displacement caused by the rising wastewater as the tank is being filled. Filling does not occur 24 hours a day, but modeling made the conservative assumption that filling could happen any hour of the day and the EQ basin was modeled as a constant odor source.

Figure 18 shows the projected odor impact for the EQ basin. The AERMOD model does not project a 5 DT level impact offsite, but does project the potential for up to 1 DT on the railroad tracks just north of the plant and a small portion of the walking trail.

Figure 18: EQ Basin Maximum 1-hour Odor DT



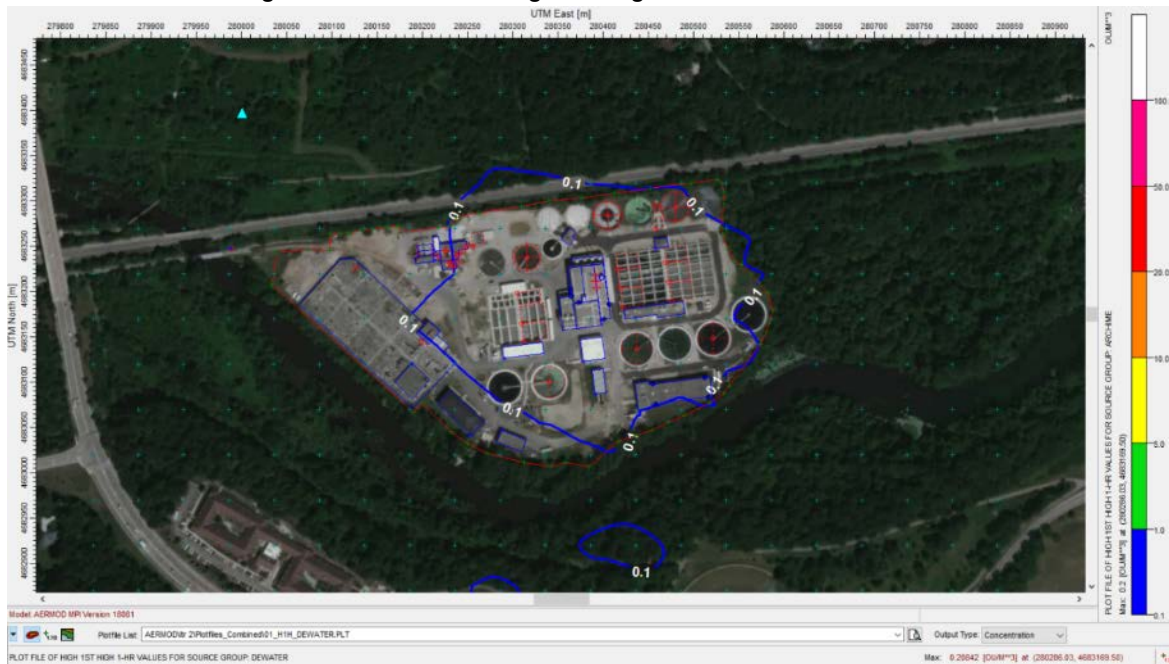
Solids Handling Building Impacts

The SHB includes multiple potential odor sources that were considered in the dispersion model. These included:

- Truck bay wall louver exhaust
- Gravity Belt Thickener room wall louver exhaust
- Centrifuge dewatering room wall louver exhaust
- Centrifuge conveyor room level wall exhaust
- Cake storage bin room roof exhaust
- Carbon Odor Control Scrubber system roof stack exhausts

Figure 19 shows a plot of the projected impact from the SHB sources under normal baseline conditions. No odor impacts over 1 DT were projected for normal building operation. In order to show a plot for consideration, odor isopleth lines less than 1 DT are plotted in Figure 19. The odor impacts around the SHB are from building downwash impacts but are normally projected to be very low. Some very low level plume landings are projected to the south, but all are well below the 5 DT impact and a minimum theoretically detectable 1 DT level.

Figure 19: Solids Handling Building Maximum 1-hour Odor DT



Odor projection shown in Figure 19 does not include biosolids cake truck loading, which occurs during winter months. Typically, one or two trucks are loaded with biosolids cake during the weekdays, which takes 30-45 minutes per truck. During non-winter months, liquid biosolids are loaded into sealed tanker trucks. The cake truck loading odor was 16,575 DT compared to 11 to 19 DT during sealed tanker truck bay operations. Figure 20 shows comparison photos of a cake truck being loaded in the winter to a liquid biosolids sealed tanker truck being loaded in the summer.

Figure 20: Biosolids Cake Truck Loading. (Left: Open Bed Biosolids Cake Truck loading during Winter, Right: Liquid Biosolids Sealed Tanker Truck loading in Summer)

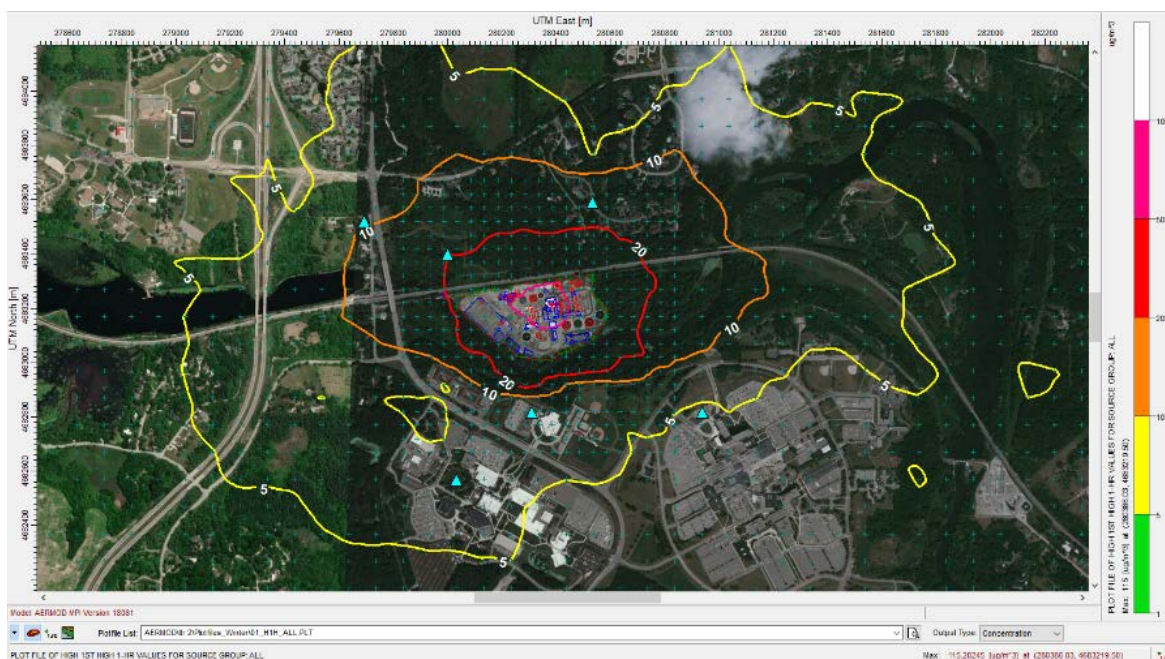


Cake trucks in winter are open bed with live bottom screw conveyors rapidly loading stored biosolids cake to the open bed. The stored biosolids cake sealed in the large storage bins has time to become septic and odorous. Cake odors are emitted into the room space as the cake falls into the truck bed. By contrast, in summer, liquid biosolids are discharged into a small

Figure 21 shows a comparison plot of the projected SHB impact with a truck loading, assuming 16,575 DT.

With the higher 16,575 DT measured during cake truck loading, the AERMOD model indicates the potential for distant 5 DT impacts to all of the defined sensitive odor receptors and up to 10 to 20 DT offsite to the north of the plant and out to Dixboro Road. While it should be clear that this is only possible during winter biosolids cake truck loading, the potential impact and odor footprint is large making this a high priority odor source.

Figure 21: Solids Handling Building Maximum 1-hour Odor DT with a Biosolids Cake Truck Loading In-Progress



A small overflow flow splitter structure exists on the WWTP entrance road. AERMOD dispersion projections for this source indicated only very localized impacts well below 5 DT at the structure with less than 1 DT impact to any of the sensitive receptor locations. Therefore, this represents a very low risk that does not require further consideration.

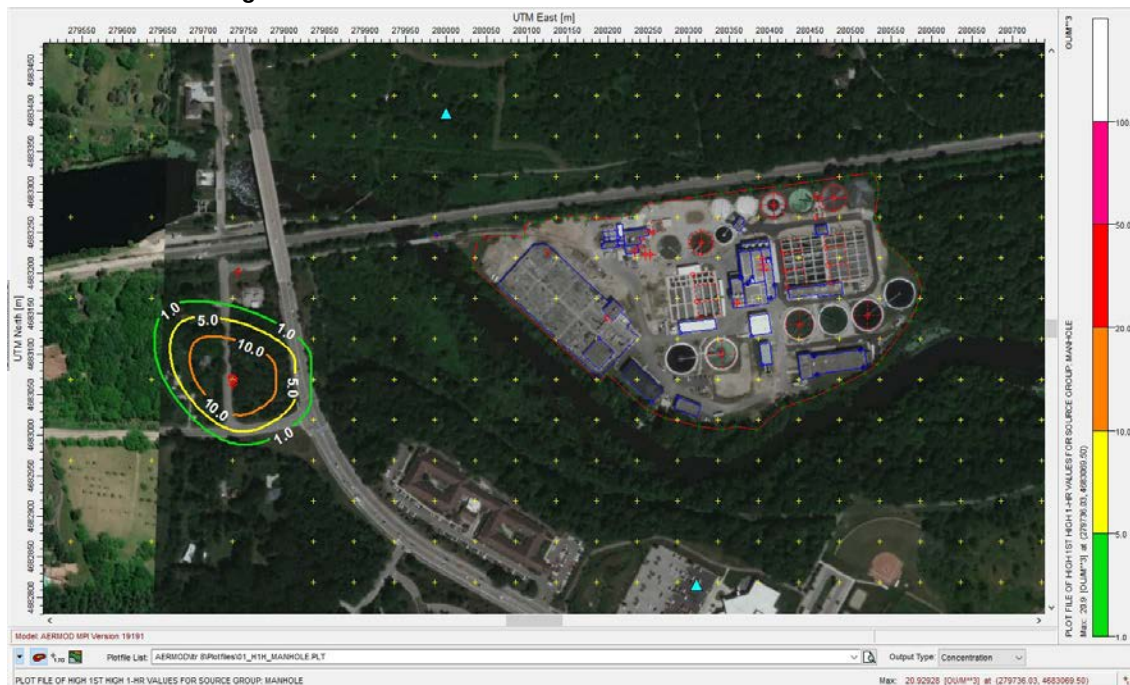
AERMOD projections for the existing passive carbon vent filter scrubber exhaust at the plant entrance location indicates impacts are always less than 1 DT. It should be reinforced that the treatment provided by the passive carbon filter is important in that the carbon is assumed to be removing over 90 percent of the raw odor from the sewer headspace. Otherwise, this location could cause odor issues because the pressurized untreated odorous air would be released.

Field observation by the carbon vent filter indicated no noticeable odor exhaust, but the raw odorous air from the sewer was odorous with an average of 0.77 ppm H₂S with peaks to 6 ppm.

Manhole Exhaust on Old Dixboro Road

Figure 22 shows the isopleth plot for the manhole exhaust near Old Dixboro Road. AERMOD projections for the exhaust from the Old Dixboro Rd. manhole pick hole indicates impacts up to 10 DT in the roadway next to the manhole on Old Dixboro and the potential for up to 5 DT impact on the main commuter roadways.

Figure 22: Old Dixboro Rd. Manhole Maximum 1-hour Odor DT



Conclusions and Recommendations

Odor impacts within two miles of the plant appear to be limited to several small collection system odor sources and several sources from the WWTP. Based on AERMOD dispersion modeling, the overall odor impact potential could exceed 5 DT under normal baseline operating conditions reaching offsite to the north of the WWTP to the walking path, the new retirement home location, and towards the Towsley community.

With the exception of winter biosolids truck loading, odor impacts are not projected to reach further offsite to the hospital or other locations, but winter biosolids loading is considered at risk further offsite from the WWTP.

The potential for this to occur is limited by hourly weather patterns and may not be frequent, but AERMOD evaluations indicate that impacts are possible. This evaluation determines the most conservative case projecting where odors are predicted to occur at least once during some portions of the five years of meteorological data used in the evaluation.



The priority odor sources having the most impact are:

- The Screenings and Grit Building roof exhaust fans
- The Raw Sewage Influent Lift Station
- The West and East Plants' Flow Splitter channels and structures
- The Primary Clarifiers' launder and weir zones

Of these, only the Screenings and Grit Building and Raw Influent Lift Station are considered high priority sources and should be considered as the first tier if odor mitigation actions are selected.

The most odorous impact potential is predicted for short term winter loadings of biosolids cake trucks. Although only one or two trucks are loaded during weekdays from November/December to April/May and it takes 30-45 minutes to load each truck, the loading process' potential for distant offsite odor impacts is significant. AERMOD projections show the ability to reach a 5 to 10 DT impact level for all of the sensitive odor receptors identified in this evaluation.



Appendix F. Cost Estimates for Odor Control Technology Options

Option 1 Packed Tower								
Preliminary Cost Estimate								
		Size/ Capacity/ Quantity						
	TYPE	Eng Units	LIFE	UNIT COST	CAPITAL COST	FUTURE REPL. COST	PW COST OF REPLACEMENT	
Structure Costs								
	packed tower 23 x 42 x 4; chemical building 25 x 20	217	cu yds	20	\$8	\$1,737	\$0	\$0
Excavation	75% of Excavation	163	cu yds	20	\$20	\$3,258	\$0	\$0
Backfill	25% of Excavation	54	cu yds	20	\$650	\$35,293	\$0	\$0
Concrete	25 x 20	500	sf	20	\$300	\$150,000	\$0	\$0
Building over Chem tanks								
Structure Costs Total					\$190,288	\$0	\$0	
Equipment Costs								
Insulated Chemical Scubber, fan, fan enclosure, initial media fill, recirculation pumps, grease eliminat	Parallel, Single Stage, Countercurrent	2	LS	20	\$370,971	\$741,942	\$0	\$0
Fan (Redundant)	FRP	1	each	20	\$50,000	\$50,000	\$0	\$0
Chemical Storage Tanks	FRP	2	Each	20	\$25,000	\$50,000	\$0	\$0
Chemical Feed Pumps (Duty/Spare for NaOH and NAOCL)	PD or Perisaltic	4	Each	20	\$10,000	\$40,000	\$0	\$0
Odor Control Collection Ductwork	FRP	500	LF of 30 to 60 inch	20	\$400	\$200,000	\$0	\$0
Odor Control Ductwork Fittings	FRP	20	each >24"	20	\$3,000	\$60,000	\$0	\$0
Ductwork Dampers	FRP	5	each >24"	20	\$3,000	\$15,000	\$0	\$0
Ductwork Supports	FRP	25	each	20	\$2,000	\$50,000	\$0	\$0
Equipment Cost Total						\$1,206,942	\$0	\$0
Total Equipment and Structure Costs						\$1,397,230	\$0	\$0
UNKNOWN COSTS								
GENERAL CONDITIONS	5%					\$93,149		
FIELD PAINTING/FINISHES	2%					\$37,259		
MECHANICAL	5%					\$93,149		
ELECTRICAL	7%					\$130,408		
INSTRUMENTATION	6%					\$111,778		
Known Cost Percentage	75%							
Unknown Cost Total						\$465,743		
SUBTOTAL (Unknown Costs + Equipment + Structures)						\$1,862,973		
Installation Markup	15%					\$279,446		
Subtotal Representing Capital Cost without Contingency						\$2,142,419		
Contractor OH	10%					\$214,242		
Contractor Profit	5%					\$117,833		
Contractor Mobilization and Bonds	5%					\$123,725		
Contingency	30%					\$779,466		
TOTAL PROJECT Construction COSTS						\$3,377,684		
PW COST OF FUTURE PURCHASES						\$0		
Engineering Design and Construction Phases	0%					\$0		
Client Administrative	0%					\$0		
Client Contingency	0%					\$0		
Total Project Costs						\$3,377,684		
ANNUAL COSTS								
PROCESS		FUEL \$/yr	ELECT \$/yr	Chemicals \$/yr	WATER \$/yr	MEDIA \$/yr	MAINT. PERS. \$/yr	TOTAL \$/yr
ODOR CONTROL SYSTEMS								
PROCESS COSTS		\$0	\$24,037	\$63,088	\$2,108	\$1,500	\$64,273	\$155,006
PERIODIC COSTS								
TOTAL ANNUAL COSTS		\$0	\$24,037	\$63,088	\$2,108	\$1,500	\$64,273	\$155,006
INTEREST RATE								
YEAR PROJECTED LIFE	6.000%							
	20							
PRESENT WORTH OF ANNUAL COSTS						\$1,777,906		
TOTAL CAPITAL COST						\$3,377,684		
PRESENT WORTH OF FUTURE PURCHASES						\$0		
TOTAL PROJECT PRESENT WORTH						\$5,155,591		

Option 2 Activated Carbon								
Preliminary Cost Estimate								
		Size/						
		Capacity/			UNIT	CAPITAL	FUTURE	PW COST OF
	TYPE	Quantity	Eng Units	LIFE	COST	COST	REPL. COST	REPLACEMENT
Structure Costs								
Excavation	22 x 44 x 4	143	cu yds	20	\$8	\$1,147.26	\$0	\$0
Backfill	75% of Excavation	108	cu yds	20	\$20	\$2,151.11	\$0	\$0
Concrete	25% of Excavation	36	cu yds	20	\$650	\$23,304	\$0	\$0
Structure Costs Total						\$26,602	\$0	\$0
Equipment Costs								
Insulated Carbon Vessel, fan, fan enclosure, initial media fill, prefilter, control panel	Dual Bed	2	LS	20	\$173,083	\$346,166	\$0	\$0
Fan (Redundant)	FRP	1	each	20	\$50,000	\$50,000	\$0	\$0
Odor Control Collection Ductwork	FRP	500	LF of 30 to 60 inch	20	\$400	\$200,000	\$0	\$0
Odor Control Ductwork Fittings	FRP	20	each >24"	20	\$3,000	\$60,000	\$0	\$0
Ductwork Dampers	FRP	5	each >24"	20	\$3,000	\$15,000	\$0	\$0
Ductwork Supports	FRP	25	each	20	\$2,000	\$50,000	\$0	\$0
Equipment Cost Total						\$721,166	\$0	\$0
Total Equipment and Structure Costs						\$747,768	\$0	\$0
UNKNOWN COSTS								
GENERAL CONDITIONS	5%					\$49,851		
FIELD PAINTING/FINISHES	2%					\$19,940		
MECHANICAL	5%					\$49,851		
ELECTRICAL	7%					\$69,792		
INSTRUMENTATION	6%					\$59,821		
Known Cost Percentage	75%							
Unknown Cost Total						\$249,256		
SUBTOTAL (Unknown Costs + Equipment + Structures)						\$997,023		
Installation Markup	15%					\$149,554		
Subtotal Representing Capital Cost without Contingency						\$1,146,577		
Contractor OH	10%					\$114,658		
Contractor Profit	5%					\$63,062		
Contractor Mobilization and Bonds	5%					\$66,215		
Contingency	30%					\$417,153		
TOTAL PROJECT Construction COSTS						\$1,807,665		
PW COST OF FUTURE PURCHASES						\$0		
Engineering Design and Construction Phases	0%					\$0		
Client Administrative	0%					\$0		
Client Contingency	0%					\$0		
Total Project Costs						\$1,807,665		
ANNUAL COSTS								
PROCESS		FUEL	ELECT	Nutrients	WATER	MEDIA	MAINT. PERS.	TOTAL
		\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr
ODOR CONTROL SYSTEMS								
PROCESS COSTS		\$0	\$18,499	\$0	\$0	\$28,260	\$22,932	\$69,691
PERIODIC COSTS								
TOTAL ANNUAL COSTS		\$0	\$18,499	\$0	\$0	\$28,260	\$22,932	\$69,691
INTEREST RATE								
YEAR PROJECTED LIFE	6.000%							
	20							
PRESENT WORTH OF ANNUAL COSTS						\$799,349		
TOTAL CAPITAL COST						\$1,807,665		
PRESENT WORTH OF FUTURE PURCHASES						\$0		
TOTAL PROJECT PRESENT WORTH						\$2,607,014		

Option 3 Biotower								
Preliminary Cost Estimate								
		Size/						
		Capacity/			UNIT	CAPITAL	FUTURE	PW COST OF
	TYPE	Quantity	Eng Units	LIFE	COST	COST	REPL. COST	REPLACEMENT
Structure Costs								
Excavation	biotower 19 x 24 x 4 (x2); water/nutrient building 15 x 15	143	cu yds	20	\$8	\$1,147.56	\$0	\$0
Backfill	75% of Excavation	108	cu yds	20	\$20	\$2,151.67	\$0	\$0
Concrete	25% of Excavation	36	cu yds	20	\$650	\$23,310	\$0	\$0
Building over water/nutrient	15 x 15	225	sf	20	\$300	\$67,500	\$0	\$0
Structure Costs Total						\$94,109	\$0	\$0
Equipment Costs								
Insulated Biotower, fan, fan enclosure, initial media fill, grease eliminator, recirc pumps, control panel	12' diameter	2	LS	20	\$629,054	\$1,258,107	\$0	\$0
Odor Control Collection Ductwork	FRP	500	LF of 30 to 60 inch	20	\$400	\$200,000	\$0	\$0
Odor Control Ductwork Fittings	FRP	20	each >24"	20	\$3,000	\$60,000	\$0	\$0
Ductwork Dampers	FRP	5	each >24"	20	\$3,000	\$15,000	\$0	\$0
Ductwork Supports	FRP	25	each	20	\$2,000	\$50,000	\$0	\$0
Equipment Cost Total						\$1,583,107	\$0	\$0
Total Equipment and Structure Costs						\$1,677,216	\$0	\$0
UNKNOWN COSTS								
GENERAL CONDITIONS	5%					\$111,814		
FIELD PAINTING/FINISHES	2%					\$44,726		
MECHANICAL	5%					\$111,814		
ELECTRICAL	7%					\$156,540		
INSTRUMENTATION	6%					\$134,177		
Known Cost Percentage	75%							
Unknown Cost Total						\$559,072		
SUBTOTAL (Unknown Costs + Equipment + Structures)						\$2,236,288		
Installation Markup	15%					\$335,443		
Subtotal Representing Capital Cost without Contingency						\$2,571,731		
Contractor OH	10%					\$257,173		
Contractor Profit	5%					\$141,445		
Contractor Mobilization and Bonds	5%					\$148,517		
Contingency	30%					\$935,660		
TOTAL PROJECT Construction COSTS						\$4,054,527		
PW COST OF FUTURE PURCHASES						\$0		
Engineering Design and Construction Phases	0%					\$0		
Client Administrative	0%					\$0		
Client Contingency	0%					\$0		
Total Project Costs						\$4,054,527		
ANNUAL COSTS								
PROCESS		FUEL	ELECT	Nutrients	WATER	MEDIA	MAINT. PERS.	TOTAL
		\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr
ODOR CONTROL SYSTEMS								
PROCESS COSTS		\$0	\$20,570	\$1,500	\$3,654	\$9,000	\$51,435	\$86,158
PERIODIC COSTS								
TOTAL ANNUAL COSTS		\$0	\$20,570	\$1,500	\$3,654	\$9,000	\$51,435	\$86,158
INTEREST RATE								
YEAR PROJECTED LIFE	6.000%							
	20							
PRESENT WORTH OF ANNUAL COSTS						\$988,229		
TOTAL CAPITAL COST						\$4,054,527		
PRESENT WORTH OF FUTURE PURCHASES						\$0		
TOTAL PROJECT PRESENT WORTH						\$5,042,756		

Option 4 Biofilter								
Preliminary Cost Estimate								
		Size/						
		Capacity/			UNIT	CAPITAL	FUTURE	PW COST OF
	TYPE	Quantity	Eng Units	LIFE	COST	COST	REPL. COST	REPLACEMENT
Structure Costs								
Excavation	94 x 34 x 6	710	cu yds	20	\$8	\$5,681.78	\$0	\$0
Backfill	25% of Excavation	178	cu yds	20	\$20	\$3,551.11	\$0	\$0
Concrete	Refer to Calcs	200	cu yds	20	\$650	\$130,000	\$0	\$0
Concrete Coating	Epoxy or Urethane corrosion coating	5,052	sf	20	\$20	\$101,040	\$0	\$0
Biofilter Cover	FRP or AL light duty	3,196	sf	20	\$30	\$95,880	\$0	\$0
Excavation (pre-humidification and fan pad)	28 x 28 x 4	116	cu yds	20	\$8	\$929.19	\$0	\$0
Backfill	75% of Excavation	87	cu yds	20	\$20	\$1,742.22	\$0	\$0
Concrete	25% of Excavation	29	cu yds	20	\$650	\$18,874	\$0	\$0
Structure Costs Total						\$357,698	\$0	\$0
Equipment Costs								
Packed Biofilter Media		13,500	cu ft	20	\$27	\$364,500	\$0	\$0
Floor System	Bac-T	2,700	sf	20	\$15	\$40,500	\$0	\$0
Prehumidification Tower (Chemical Scrubber)	Countercurrent	1	LS	20	\$195,000	\$195,000	\$0	\$0
Fans	FRP	2	each	20	\$50,000	\$100,000	\$0	\$0
Exhaust Stacks	Stainless	3	LS	20	\$5,000	\$15,000	\$0	\$0
Recirc Pumps	Horizontal end suction	2	each	20	\$10,000	\$20,000	\$0	\$0
Odor Control Collection Ductwork	FRP	650	LF of 30 to 60 inch	20	\$400	\$260,000	\$0	\$0
Odor Control Ductwork Fittings	FRP	26	each >24"	20	\$3,000	\$78,000	\$0	\$0
Ductwork Dampers	FRP	4	each >24"	20	\$3,000	\$12,000	\$0	\$0
Ductwork Supports	FRP	33	each	20	\$2,000	\$65,000	\$0	\$0
Equipment Cost Total						\$1,150,000	\$0	\$0
Total Equipment and Structure Costs						\$1,507,698	\$0	\$0
UNKNOWN COSTS								
GENERAL CONDITIONS	5%					\$100,513		
FIELD PAINTING/FINISHES	2%					\$40,205		
MECHANICAL	5%					\$100,513		
ELECTRICAL	7%					\$140,719		
INSTRUMENTATION	6%					\$120,616		
Known Cost Percentage	75%							
Unknown Cost Total						\$502,566		
SUBTOTAL (Unknown Costs + Equipment + Structures)						\$2,010,264		
Installation Markup	15%					\$301,540		
Subtotal Representing Capital Cost without Contingency						\$2,311,804		
Contractor OH	10%					\$231,180		
Contractor Profit	5%					\$127,149		
Contractor Mobilization and Bonds	5%					\$133,507		
Contingency	30%					\$841,092		
TOTAL PROJECT Construction COSTS						\$3,644,733		
PW COST OF FUTURE PURCHASES						\$0		
Engineering Design and Construction Phases	0%					\$0		
Client Administrative	0%					\$0		
Client Contingency	0%					\$0		
Total Project Costs						\$3,644,733		
ANNUAL COSTS								
PROCESS		FUEL	ELECT	Nutrients	WATER	MEDIA	MAINT. PERS.	TOTAL
		\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr
ODOR CONTROL SYSTEMS								
PROCESS COSTS		\$0	\$22,777	\$0	\$3,654	\$18,225	\$46,236	\$90,892
PERIODIC COSTS								
TOTAL ANNUAL COSTS		\$0	\$22,777	\$0	\$3,654	\$18,225	\$46,236	\$90,892
INTEREST RATE								
YEAR PROJECTED LIFE	6.000%							
	20							
PRESENT WORTH OF ANNUAL COSTS						\$1,042,526		
TOTAL CAPITAL COST						\$3,644,733		
PRESENT WORTH OF FUTURE PURCHASES						\$0		
TOTAL PROJECT PRESENT WORTH						\$4,687,259		

Solids Handling Building Truck Bay									
Preliminary Cost Estimate									
		Size/ Capacity/							
	TYPE	Quantity	Eng Units	LIFE	UNIT COST	CAPITAL COST	FUTURE REPL. COST	PW COST OF REPLACEMENT	
Structure Costs									
Excavation	14 x 14 x 4	29	cu yds	20	\$8	\$232.30	\$0	\$0	
Backfill	75% of Excavation	22	cu yds	20	\$20	\$435.56	\$0	\$0	
Concrete	25% of Excavation	7	cu yds	20	\$650	\$4,719	\$0	\$0	
Roof Decking Demo	Select	1	LS	20	\$5,000	\$5,000.00	\$0	\$0	
Structural Steel	Fan Support Structure	1	LS	20	\$225,000	\$225,000	\$0	\$0	
Structure Costs Total						\$235,386	\$0	\$0	
Equipment Costs									
Insulated Carbon Vessel, fan, fan enclosure, initial media fill, prefilter, control panel	Radial Bed	1	LS	20	\$323,917	\$323,917	\$0	\$0	
Odor Control Collection Ductwork	FRP	250	LF of 30 to 60 inch	20	\$400	\$100,000	\$0	\$0	
Odor Control Ductwork Fittings	FRP	10	each >24"	20	\$3,000	\$30,000	\$0	\$0	
Ductwork Dampers	FRP	3	each >24"	20	\$3,000	\$9,000	\$0	\$0	
Ductwork Supports	FRP	13	each	20	\$2,000	\$25,000	\$0	\$0	
Equipment Cost Total						\$487,917	\$0	\$0	
Total Equipment and Structure Costs						\$723,303	\$0	\$0	
UNKNOWN COSTS									
GENERAL CONDITIONS	5%					\$48,220			
FIELD PAINTING/FINISHES	2%					\$19,288			
MECHANICAL	5%					\$48,220			
ELECTRICAL	7%					\$67,508			
INSTRUMENTATION	6%					\$57,864			
Known Cost Percentage	75%								
Unknown Cost Total						\$241,101			
SUBTOTAL (Unknown Costs + Equipment + Structures)						\$964,404			
Installation Markup	15%					\$144,661			
Subtotal Representing Capital Cost without Contingency						\$1,109,065			
Contractor OH	10%					\$110,907			
Contractor Profit	5%					\$60,999			
Contractor Mobilization and Bonds	5%					\$64,049			
Contingency	30%					\$403,506			
TOTAL PROJECT Construction COSTS						\$1,748,524			
PW COST OF FUTURE PURCHASES						\$0			
Engineering Design and Construction Phases									
Client Administrative	0%					\$0			
Client Contingency	0%					\$0			
Total Project Costs						\$1,748,524			
ANNUAL COSTS									
PROCESS		FUEL	ELECT	Nutrients	WATER	MEDIA	MAINT. PERS.	TOTAL	
		\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	\$/yr	
ODOR CONTROL SYSTEMS									
PROCESS COSTS		\$0	\$20,555	\$0	\$0	\$33,660	\$22,181	\$76,396	
PERIODIC COSTS									
TOTAL ANNUAL COSTS		\$0	\$20,555	\$0	\$0	\$33,660	\$22,181	\$76,396	
INTEREST RATE									
YEAR PROJECTED LIFE	6.000%								
	20								
PRESENT WORTH OF ANNUAL COSTS						\$876,258			
TOTAL CAPITAL COST						\$1,748,524			
PRESENT WORTH OF FUTURE PURCHASES						\$0			
TOTAL PROJECT PRESENT WORTH						\$2,624,782			



Appendix G. Equipment Vendor Cutsheets



Daniel Company, Inc.

DANIEL COMPANY

1939 West 11th Street, Ste. E
Upland, CA 91786

Phone: (909) 982-1555

Fax: (909) 982-1855

Email: danmech@sbcglobal.net

Website: www.danielmechanical.com

DanADSORB

SKID-MOUNTED CARBON SYSTEMS



GENERAL INTRODUCTION

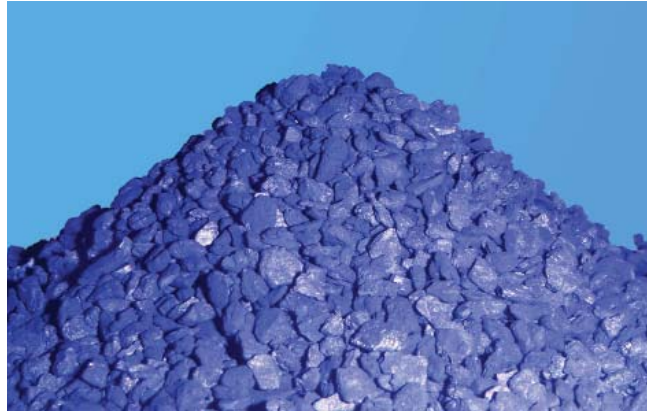
Hydrogen Sulfide, that nasty rotten egg smell that greets your workplace everyday, is a noxious killer! The National Institute for Occupational Safety and Health (NIOSH) recommends a limit of less than 10 parts per million (ppm) for a 5-day, 8-hour work week. Even smaller exposures can cause severe problems for asthmatics. Elimination of hydrogen sulfide and other volatile organic compounds should be considered critical to the maintenance of a safer and healthier work environment.



DANIEL COMPANY HAS YOUR SOLUTION!

SYSTEM DESCRIPTION

The **DanADSORB** Series by Daniel Company features skid-mounted, high capacity vapor phase carbon adsorber units. This series offers the user a fully integrated turnkey system that - by virtue of its modular and preassembled design - requires minimum installation and maintenance. The **DanADSORB** pre-engineered air-scrubbing system combines premium corrosion resistant construction with the latest in technology to solve a host of hazardous industrial air pollution control problems.



PRIMARY APPLICATION

The **DanADSORB**'s high degree of operational reliability and minimal requirements for maintenance and change outs make it ideal for usage at remote satellite facilities located along influent collection systems such as lift / pump stations. The **DanADSORB** system provides a cost-effective means by which noxious odors typically found at wastewater treatment plants are treated. It captures hydrogen sulfide and other fugitive emissions encountered at wastewater treatment plants' various process stages.

OUTSTANDING FEATURES AND BENEFITS

Reliability

- Corrosion and ultraviolet resistant materials of construction ensure long-life
- Engineered to delete problematic nutrients and chemical feed systems
- 1-year warranty comes standard

Simplicity

- Fully integrated, skid-mounted design facilitates effortless “bolt-down” and “plug-in” installation
- Automated process substantially reduces operator management
- High capacity carbon decreases frequency of media change out and related maintenance requirements

Safety

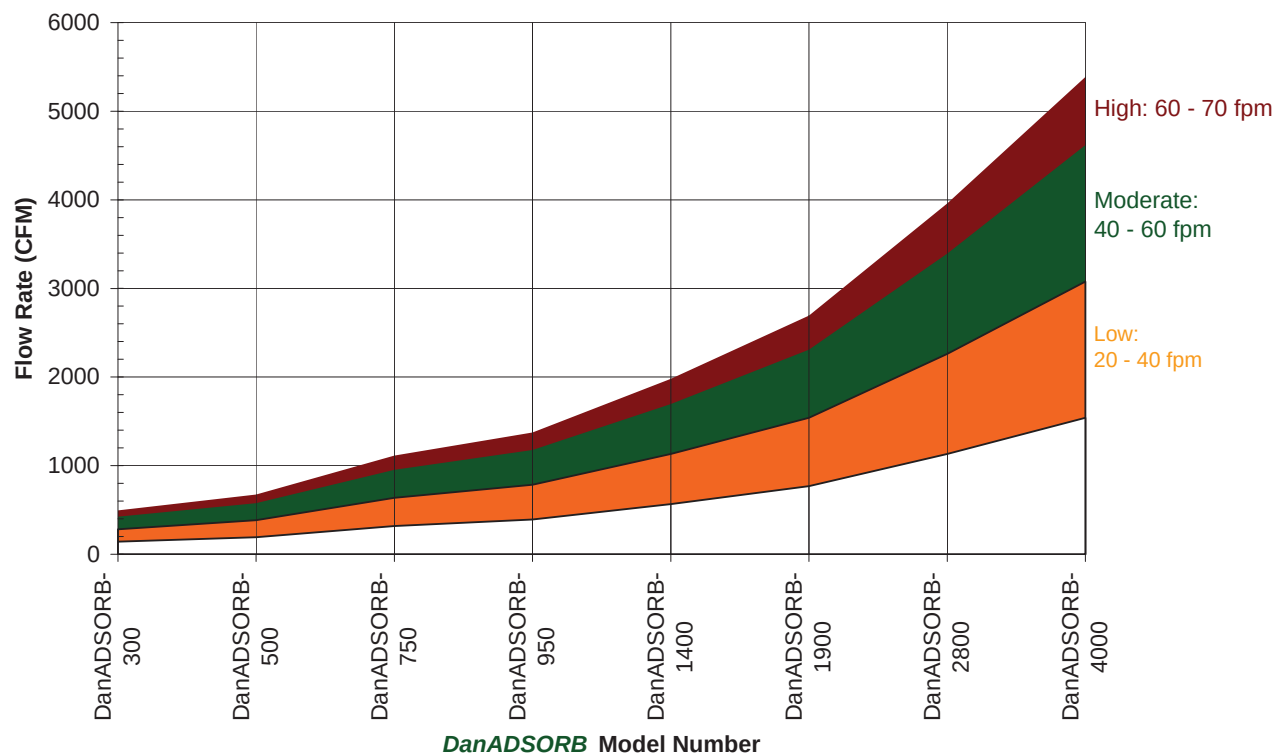
- Composite vessel construction is fire-retardant as defined by NFPA-91.
- Use of non-impregnated carbon eliminates the risk of caustic bed fires
- Zero leakage technology isolates system components

Efficiency and Economy

- Utilizing high capacity customized activated carbon achieves optimal contaminant removal efficiency
- Instantly adjusts to fluctuations in concentrations of influent pollutants
- Use of efficient blower design lowers electrical consumption

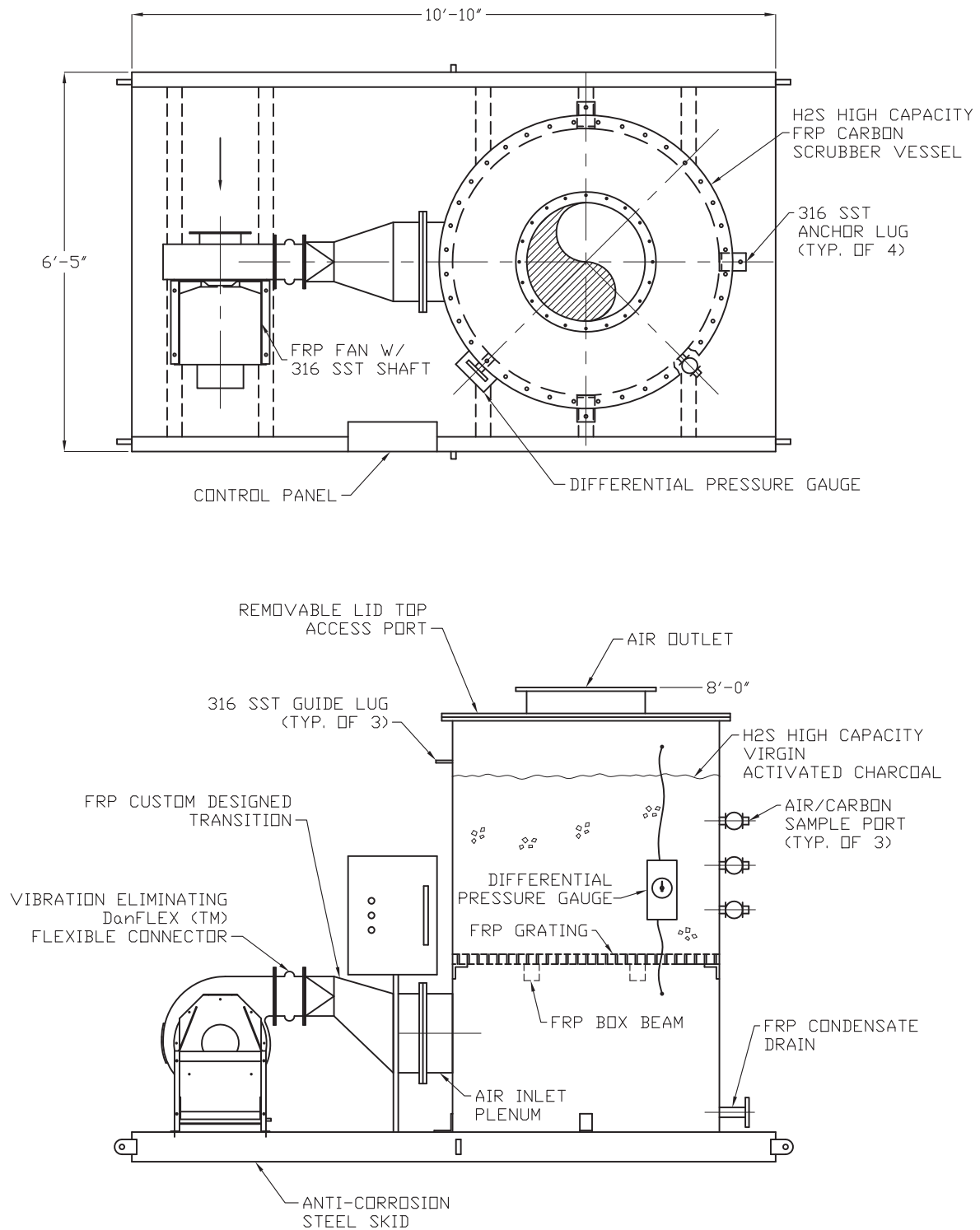


MODEL SELECTION GUIDE

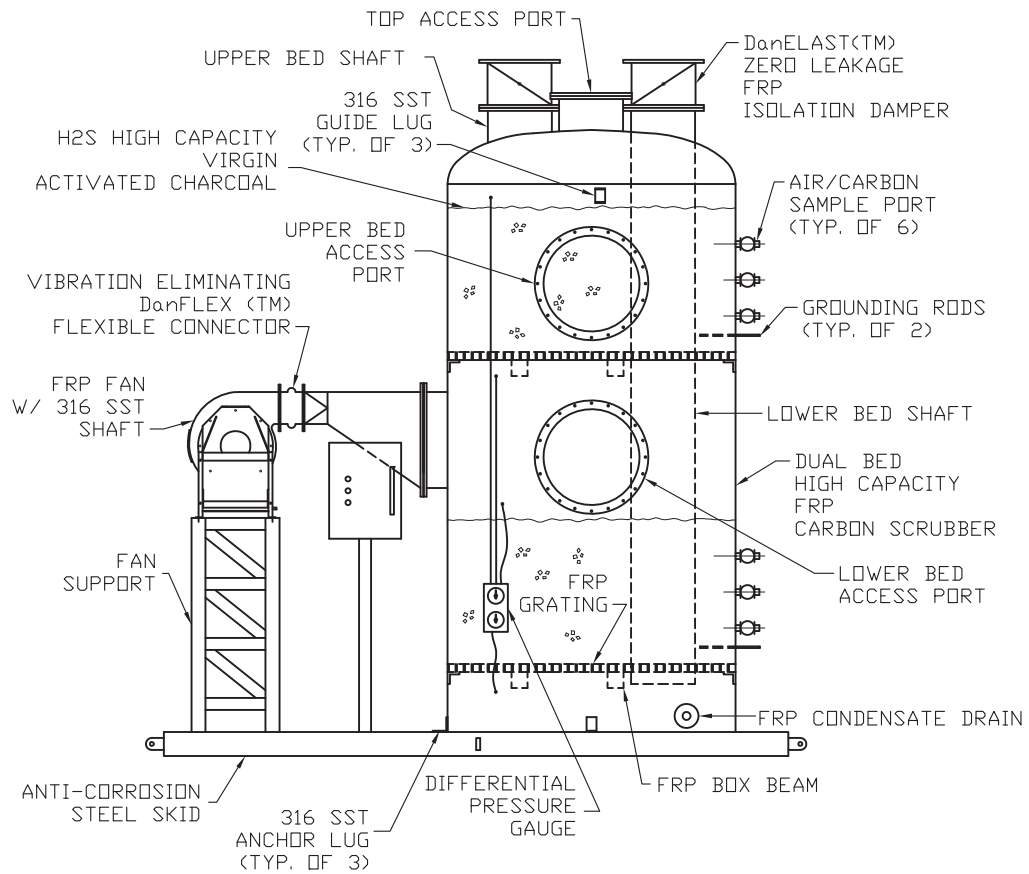
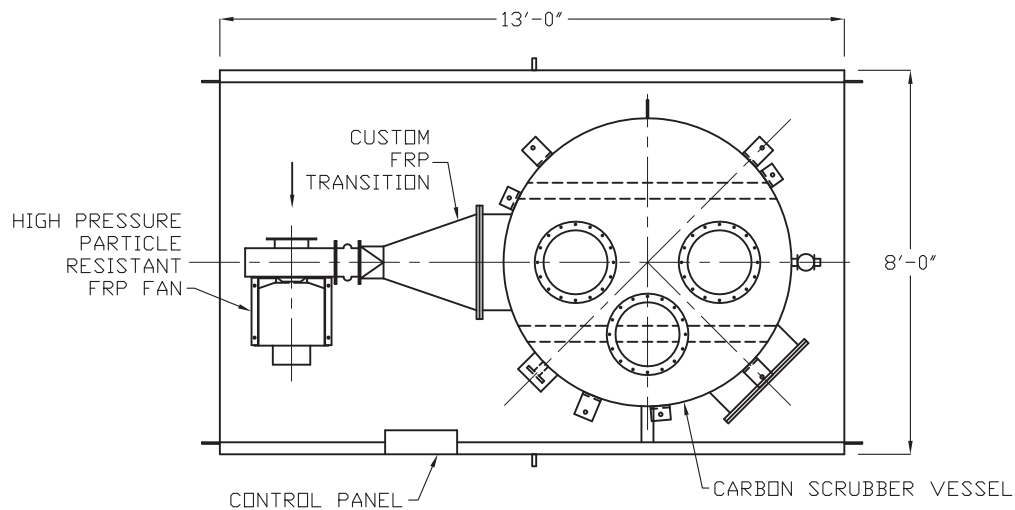


	MODEL	DIAMETER	CFM	L x W x H
SINGLE BED	DAS-300	3' - 0"	100-300	9' x 5' x 8'
	DAS-500	3' - 6"	300-500	10' x 5' x 8'
	DAS-750	4' - 6"	500-750	11' x 7' x 8'
	DAS-950	5' - 0"	750-1000	12' x 7' x 9'
	DAS-1400	6' - 0"	1000-1400	13' x 8' x 9'
	DAS-1900	7' - 0"	1400-1900	15' x 8' x 10'
DUAL BED	DAD-2800	6' - 0"	1900-2800	13' x 8' x 12'
	DAD-4000	7' - 0"	2800-4000	15' x 8' x 12'

* Vessel sizing above is based on a face velocity of 50 feet per minute (FPM) or less across the carbon bed(s). The exception is the 7' diameter dual-bed vessel at 4000 CFM, which has a face velocity of 52 FPM.



***DanADSORB* MODEL DAS-750**



DanADSORB MODEL DAD-2800

CONTACT US FOR MORE INFORMATION ON:

- Technical Support
- Suggested Specifications
- Detailed Drawings
- Engineering Design Data
- Material Data
- Packaged Radial Systems
- Custom Design Systems
- Pricing

DANIEL COMPANY

Fiberglass Air Pollution Control Systems

Corporate Office

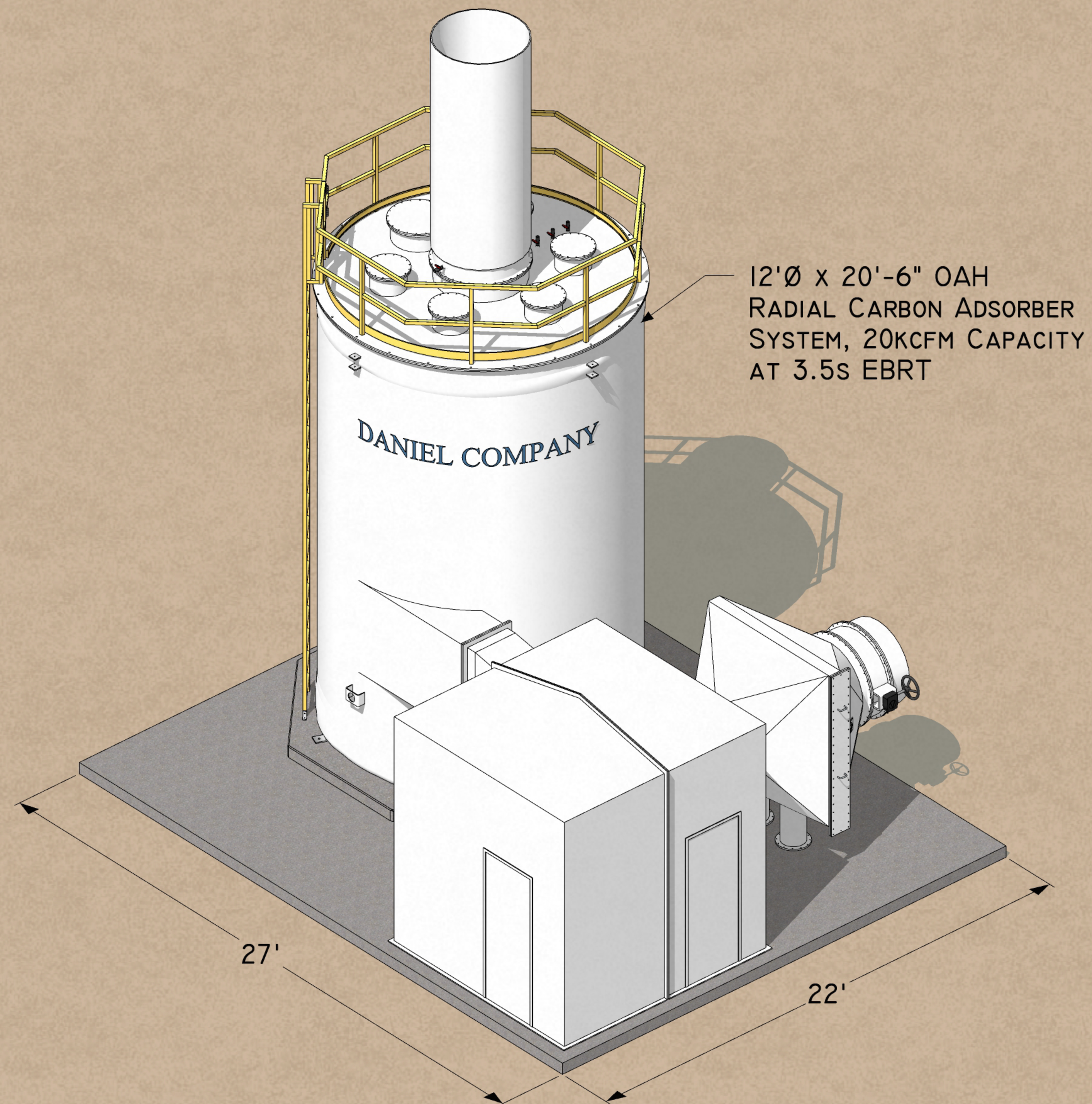
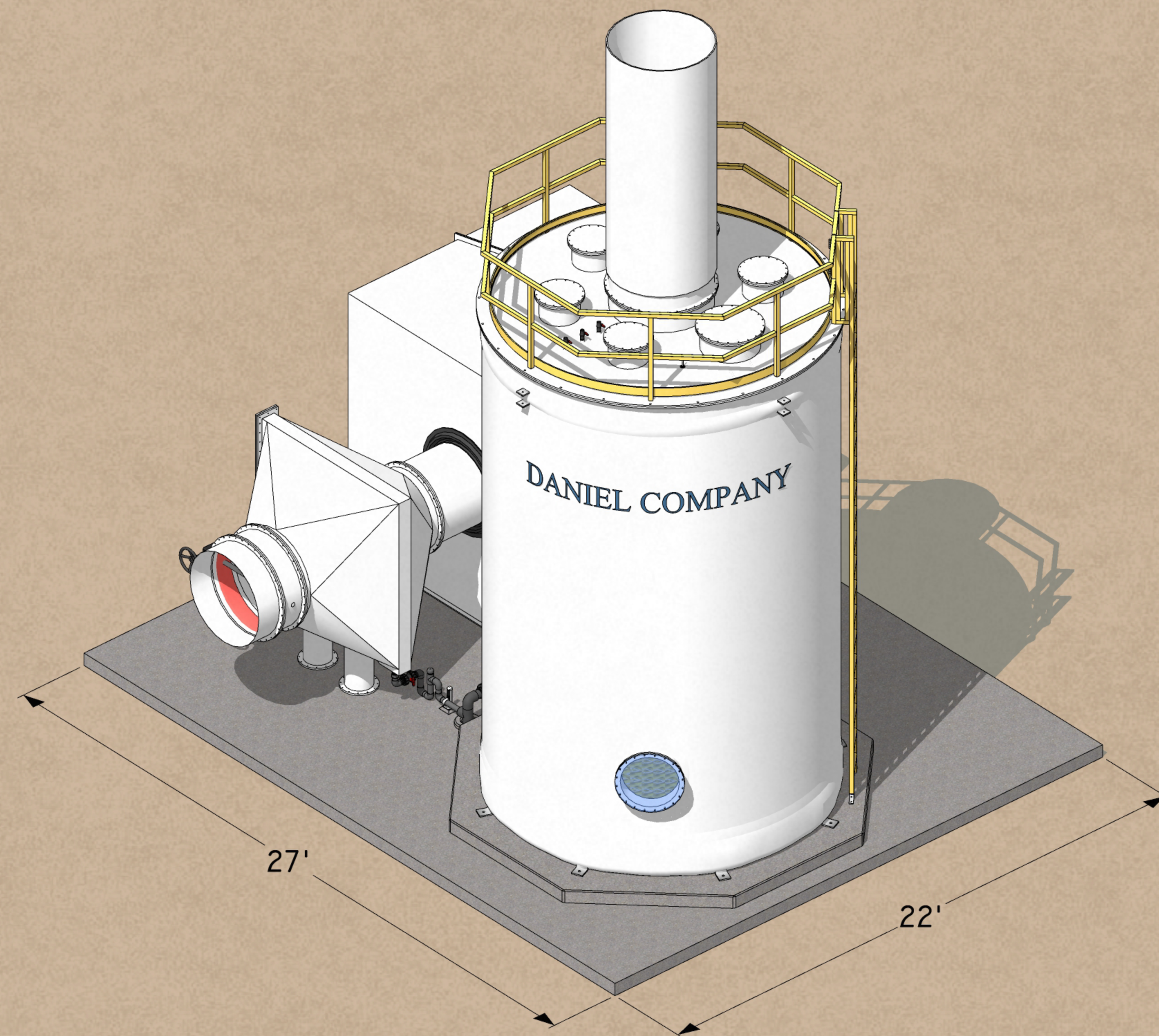
1939 West 11th Street, Ste E • Upland, CA 91786
Ph: (909) 982-1555 • Fax: (909) 982-1855

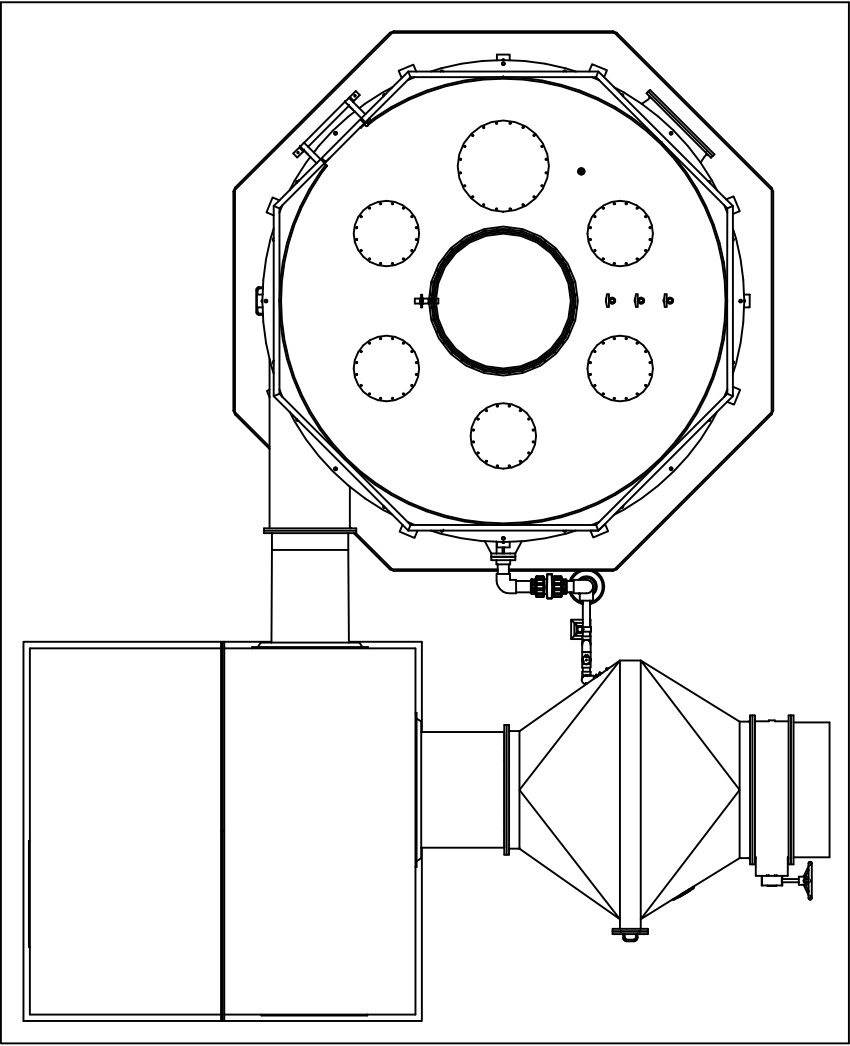
Manufacturing Facility

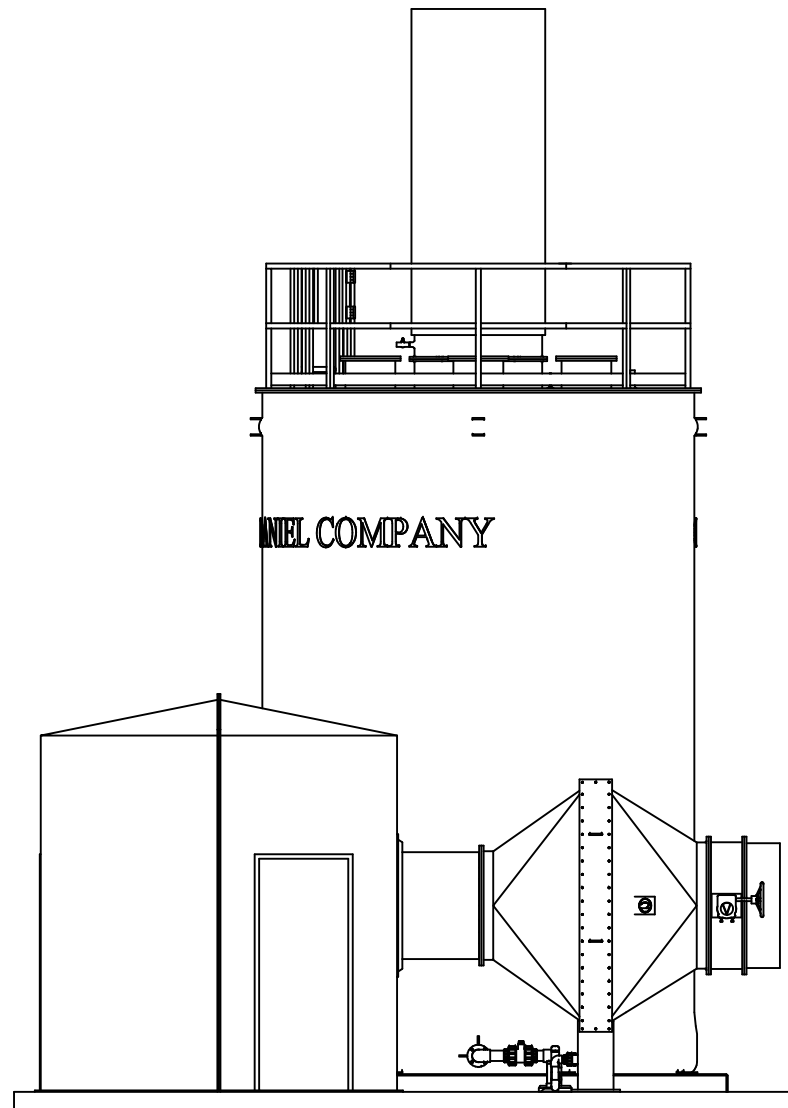
9972 Rancho Road • Adelanto, CA 92301
Ph: (760) 246-1100 • Fax: (760) 246-1161

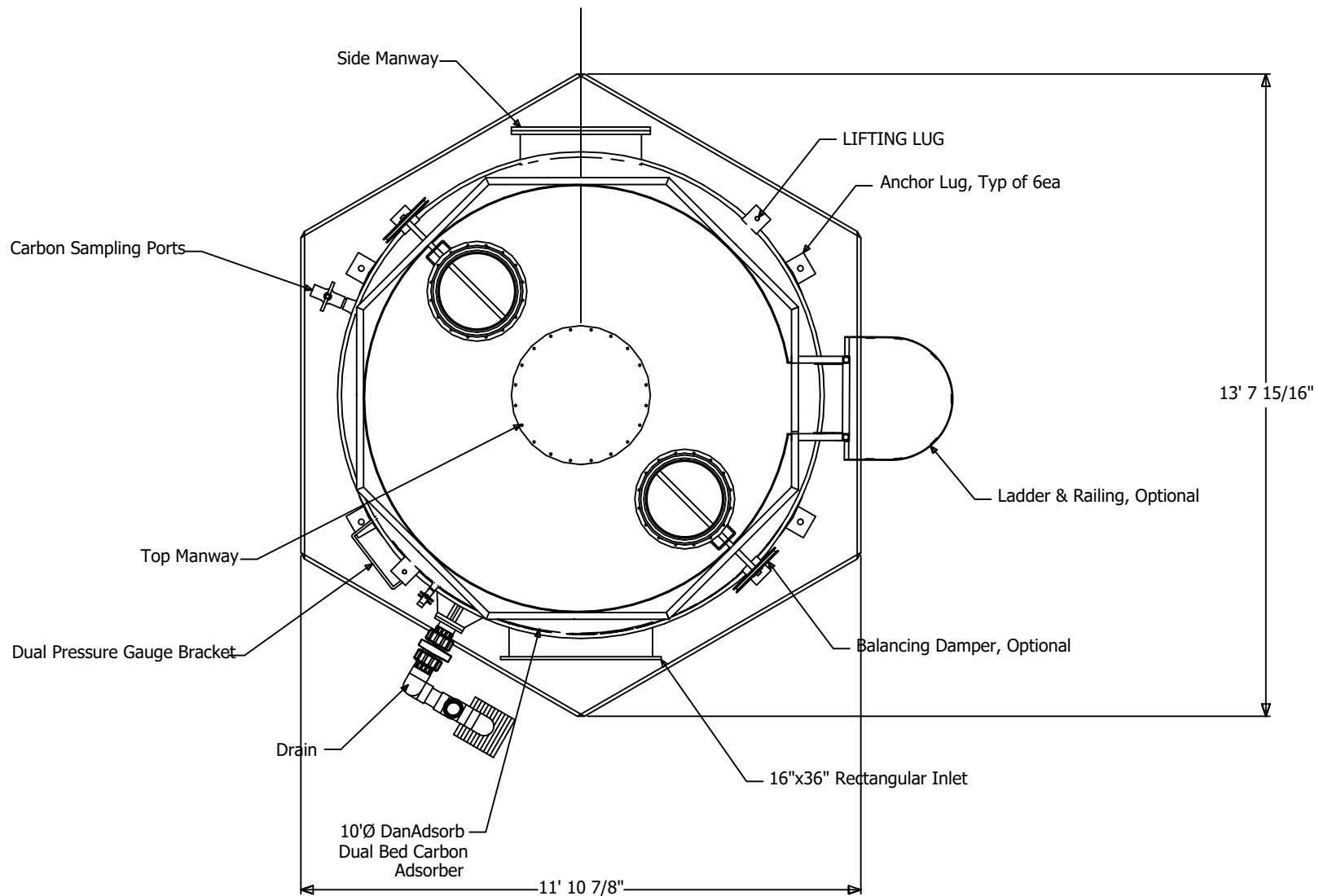
Website: www.danielmechanical.com

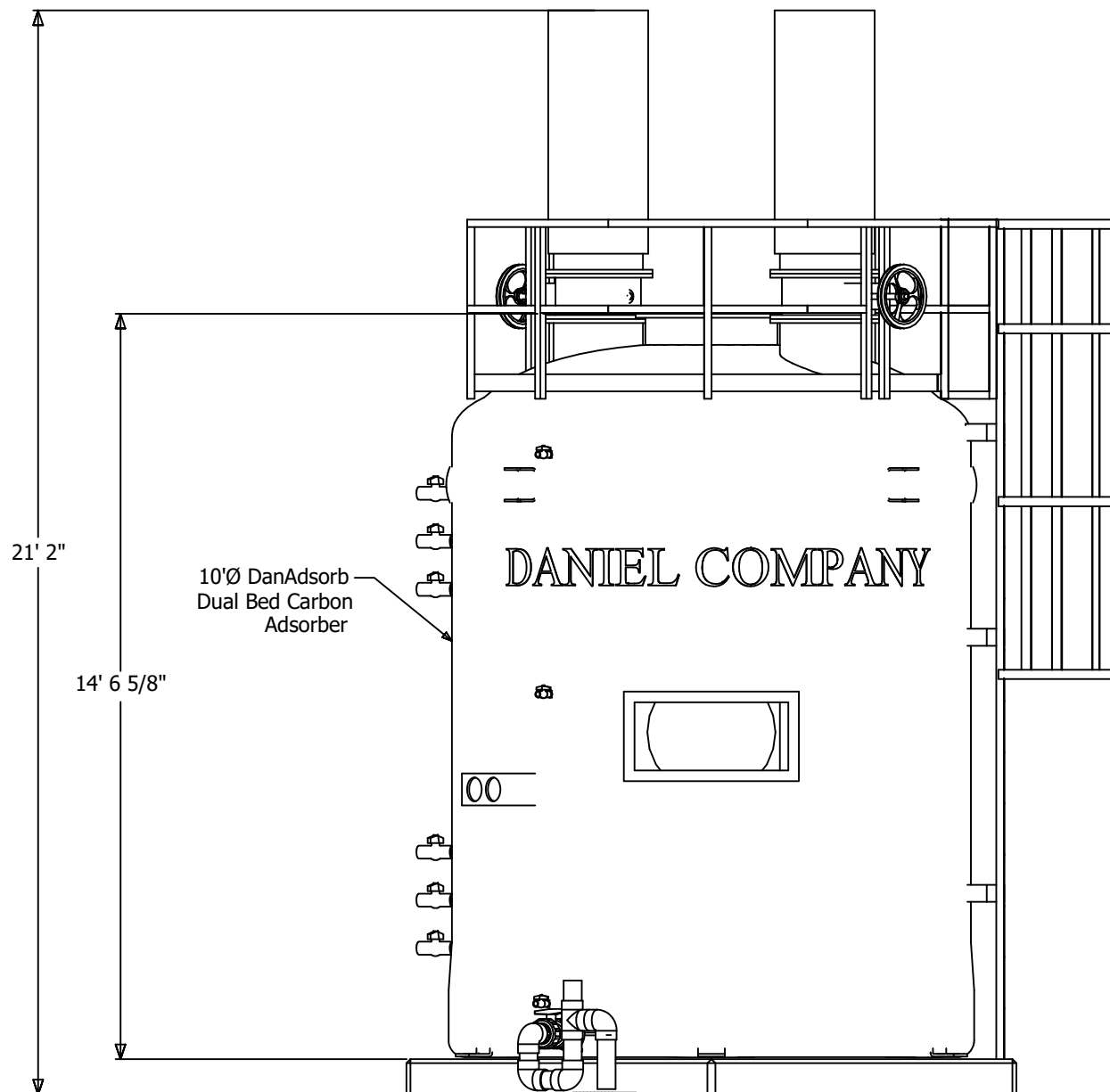
Email: Danmech@sbcglobal.net











Swartzbaugh, Zachary

From: Samuel Boswell <sboswell@danielmechanical.com>
Sent: Tuesday, October 29, 2019 8:09 PM
To: Swartzbaugh, Zachary
Cc: Jack Moser
Subject: RE: Ann Arbor Odor Control Study - Daniel Mechanical

Zach,

Here's my proposal, somewhat informal to put it all into an email I know, but I hope it will do for your odor control study. I believe I've included everything you asked for but if there's anything I've left out please let me know and I'll get it to you.

SOLIDS HANDLING BUILDING

20KCFM Radial Carbon Adsorber System Proposal:

Vessel Sizing:

36" Deep Bed Radial Carbon Vessel Details:		
Vessel Air Flowrate =	20000	ft ³ /min
Inner Basket Dia. (D1) =	4	ft
Outer Basket Dia. (D2) =	10	ft
Vessel Diameter * =	12	ft
Eff. Carbon Bed Height =	17.00	ft
Vessel Overall Height ** =	20.50	ft
Effective Carbon Volume =	1122	ft ³
Eff. Carbon Weight =	33650	lbs
Minimum Bed Velocity =	37.49	ft/min
Maximum Bed Velocity =	93.62	ft/min
Middle Bed Velocity =	53.58	ft/min
Average Bed Velocity =	57.24	ft/min
Empty Bed Retention Time (EBRT) =	3.36	seconds
4mm Pelletized Media ΔP =	3.64	in-H ₂ O
3mm Pelletized Media ΔP =	6.23	in-H ₂ O
4x6 Coco Granular Media ΔP =	7.12	in-H ₂ O
4x8 Darco H ₂ S Granular Media ΔP =	8.03	in-H ₂ O
4x8 Coco Granular Media ΔP =	8.27	in-H ₂ O

*Recommend Vessel Shell Inside Diameter larger than Outer Basket Dia. (D2) by 18" to 24" minimum for best airflow.

** Vessel overall height ~30" taller than effective bed height to account for top/bottom baffles and carbon fill ports.

20kcfm Radial

Drawings: <https://www.dropbox.com/sh/lmdkjiq9mgca2iy/AABK0NIJQMcuY6ulm0pYI79ka?dl=0>

Budgetary Pricing = \$290,000. Includes: 1ea 12'Ø x 20'-6" OAH 20kcfm FRP Radial Carbon Adsorber w/ Insulated Walls, minimum effective volume of 1122ft³ Carbon Media, Grease/mist eliminator, Fan, Fan Enclosure, Interconnecting ductwork, Control Panel. Excludes: Installation, Freight, Taxes, electrical/plumbing/concrete labor & materials.

20KCFM Dual Bed Carbon Adsorber System Proposal:

Vessel Sizing:

DanAdsorb Dual Bed Carbon Adsorber

Flowrate (CFM)	Diameter (ft)	# of Vessels	Flowrate per Vessel (CFM)	Bed Height (ft)	EBRT (sec)	Bed Surface Area (ft ²)	Outlet Stacks Ø (in)
10000	11	1	10000	3.00	3.33	95.03	20

11'Ø Dual Bed Carbon Adsorber

Drawings: <https://www.dropbox.com/sh/utkignewikd93kw/AABElwpF0ZDGYOUkeodXgodSa?dl=0>

Budgetary Pricing = \$320,000. Includes: 2ea 11'Ø x 14'-6" OAH 10kcfm FRP Dual Bed Carbon Adsorber w/ Insulated Walls, minimum effective volume of 556ft³ Carbon Media each, Grease/mist eliminator, Fan, Fan Enclosure, Interconnecting ductwork, Control Panel. Excludes: Installation, Freight, Taxes, electrical/plumbing/concrete labor & materials.

SCREENINGS AND GRIT BUILDING AREA

18KCFM Radial Carbon Adsorber System Proposal:

Vessel Sizing:

36" Deep Bed Radial Carbon Vessel Details:		
Vessel Air Flowrate =	18000	ft ³ /min
Inner Basket Dia. (D1) =	4	ft
Outer Basket Dia. (D2) =	10	ft
Vessel Diameter * =	12	ft
Eff. Carbon Bed Height =	15.30	ft
Vessel Overall Height ** =	18.67	ft
Effective Carbon Volume =	1010	ft ³
Eff. Carbon Weight =	30281.81	lbs
Minimum Bed Velocity =	37.49	ft/min
Maximum Bed Velocity =	93.62	ft/min
Middle Bed Velocity =	53.58	ft/min
Average Bed Velocity =	57.24	ft/min
Empty Bed Retention Time (EBRT) =	3.36	seconds
4mm Pelletized Media ΔP =	3.64	in-H ₂ O
3mm Pelletized Media ΔP =	4.97	in-H ₂ O
4x6 Coco Granular Media ΔP =	6.23	in-H ₂ O
4x8 Darco H ₂ S Granular Media ΔP =	7.12	in-H ₂ O
4x8 Coco Granular Media ΔP =	8.03	in-H ₂ O

*Recommend Vessel Shell Inside Diameter larger than Outer Basket Dia. (D2) by 18" to 24" minimum for best airflow.

** Vessel overall height ~30" taller than effective bed height to account for top/bottom baffles and carbon fill ports.

18kcfm Radial

Drawings: <https://www.dropbox.com/sh/83hz9kly3lqntlz/AABMsVhcRxsAIB7B2cTPHk2Ja?dl=0>

Budgetary Pricing = \$285,000. Includes: 1ea 12'Ø x 18'-8" OAH 18kcfm FRP Radial Carbon Adsorber w/ Insulated Walls, minimum effective volume of 1010ft³ Carbon Media, Grease/mist eliminator, Fan, Fan Enclosure, Interconnecting ductwork, Control Panel. Excludes: Installation, Freight, Taxes, electrical/plumbing/concrete labor & materials.

Adder: 1ea Redundant 18kcfm 12'Ø Radial Carbon Adsorber, media, and additional interconnecting ductwork/stacks. Budget cost = \$185,000.

18KCFM Dual Bed Carbon Adsorber System Proposal:

Vessel Sizing:

DanAdsorb Dual Bed Carbon Adsorber

Flowrate (CFM)	Diameter (ft)	# of Vessels	Flowrate per Vessel (CFM)	Bed Height (ft)	EBRT (sec)	Bed Surface Area (ft ²)	Outlet Stacks Ø (in)
9000	10	1	9000	3.00	3.05	78.54	20

10'Ø Dual Bed Carbon Adsorber

Drawings: https://www.dropbox.com/sh/g4nj3ldubgvlawx/AACZOIL8_3hPFNtpPwYk0mSXa?dl=0

Budgetary Pricing = \$300,000. Includes: 2ea 10'Ø x 14'-0" OAH 9kcfm FRP Dual Bed Carbon Adsorber w/ Insulated Walls, minimum effective volume of 457ft³ Carbon Media each, Grease/mist eliminator, Fan, Fan Enclosure, Interconnecting ductwork, Control Panel. Excludes: Installation, Freight, Taxes, electrical/plumbing/concrete labor & materials.

Adder: 1ea Redundant 9kcfm 10'Ø Dual Bed Carbon Adsorber, media, and additional interconnecting ductwork/stacks. Budget cost = \$155,000.

Alternative Technologies:

BioDan Biotrickling Filter System:

Vessel Sizing:

BioDan Biotrickling Filter

Flowrate (CFM)	Diameter (ft)	# of Vessels	Flowrate per Vessel (CFM)	Bed Height (ft)	Outlet with Demister (in, Ø)	EBRT (sec)	Bed Surface Area (ft ²)
18000	12	2	9000	19.89	54	15.00	113.10

12'Ø BioDan BTF Drawings: <https://www.dropbox.com/s/v5x64wflov95uk/BioDan-9000%2012ft%203%20Bed%20BTF.pdf?dl=0>

Budgetary Pricing = \$650,000. Includes: 2ea 12'Ø x 34'-0" OAH 9kcfm FRP Biotrickling Filter w/ Insulated Walls, minimum effective volume of 2550ft³ Bio-Media each, Grease eliminator, Recirculation Pumps, Fan, Fan Enclosure, Interconnecting ductwork, Control Panel. Excludes: Installation, Freight, Taxes, electrical/plumbing/concrete labor & materials.

Adder: 1ea Redundant 9kcfm 12'Ø BioDan BTF, media, recirculation pumps, and additional interconnecting ductwork/stack. Budget cost = \$215,000.

Wet Packed Chemical Scrubber System:

Vessel Sizing:

Chemical Scrubbing Tower

Flowrate (CFM)	Diameter (ft)	# of Vessels	Flowrate per Vessel (CFM)	Bed Height (ft)	EBRT (sec)	Bed Surface Area (ft ²)	Superficial Velocity (ft/min)
18000	7	1	18000	10.0	1.28	38.48	467.7

7'Ø Wet Packed Chemical Scrubber

Drawings: <https://www.dropbox.com/sh/k2jmfcox5awvrd/AABYXfli6PHV7X-pADGH4z05a?dl=0>

Budgetary Pricing = \$270,000. Includes: 1ea 7'Ø x 24'-0" OAH 18kcfm FRP Chemical Scrubber w/ Insulated Walls, minimum effective volume of 385ft³ Packing Media each, Grease eliminator, Recirculation Pumps, Fan, Fan Enclosure, Interconnecting ductwork, Control Panel. Excludes: Installation, Freight, Taxes, electrical/plumbing/concrete labor & materials, Chemical Storage & Feed System.

Adder: 1ea Redundant 18kcfm 7'Ø Chemical Scrubber, media, recirculation pumps, and additional interconnecting ductwork/stack. Budget cost = \$195,000.

Best Regards,

Sam Boswell, PE
Lead Process Designer
[Daniel Company, Inc.](#)
1939 W 11th Street, Suite E
Upland, CA 91786
Ph (909) 982-1555
Fax (909) 982-1855

From: Swartzbaugh, Zachary <Zachary.Swartzbaugh@hdrinc.com>
Sent: Tuesday, October 29, 2019 1:03 PM
To: Samuel Boswell <sboswell@danielmechanical.com>
Cc: Jack Moser <jmoser@danielmechanical.com>
Subject: RE: Ann Arbor Odor Control Study - Daniel Mechanical

A few other items to note, when quoting could you include the following:

- Enclosure on the fan
- Particulate filters
- Insulation on the carbon vessel

Zachary Swartzbaugh, PE
D 804.799.6868 M 717.487.3891

hdrinc.com/follow-us

From: Swartzbaugh, Zachary
Sent: Monday, October 28, 2019 2:21 PM
To: 'Samuel Boswell' <sboswell@danielmechanical.com>
Subject: RE: Ann Arbor Odor Control Study - Daniel Mechanical

Thanks Sam

Zachary Swartzbaugh, PE
D 804.799.6868 M 717.487.3891

hdrinc.com/follow-us

From: Samuel Boswell [<mailto:sboswell@danielmechanical.com>]
Sent: Monday, October 28, 2019 2:17 PM
To: Swartzbaugh, Zachary <Zachary.Swartzbaugh@hdrinc.com>
Cc: Jack Moser <jmoser@danielmechanical.com>
Subject: RE: Ann Arbor Odor Control Study - Daniel Mechanical

Hi Zach!

Thank you for reaching out! I should be able to get this to you in a few days, at the latest by Wednesday evening.

Best Regards,

Sam Boswell, PE

Lead Process Designer

[Daniel Company, Inc.](#)

1939 W 11th Street, Suite E
Upland, CA 91786
Ph (909) 982-1555
Fax (909) 982-1855

From: Swartzbaugh, Zachary <Zachary.Swartzbaugh@hdrinc.com>

Sent: Monday, October 28, 2019 7:46 AM

To: Samuel Boswell <sboswell@danielmechanical.com>

Cc: Jack Moser <jmoser@danielmechanical.com>

Subject: Ann Arbor Odor Control Study - Daniel Mechanical

Sam,

I hope all is well. I'm working on an Odor Control Study for the Wastewater Treatment Plant in Ann Arbor, Michigan to provide odor control for two areas. The first area is to provide odor control for the Screenings and Grit Building while the second area is for the Solids Handling Building.

Screenings and Grit Building

- Odorous air from screw lift station, screening channels, and within the building.
- Average concentration of H₂S ranging from 3-7 ppm.
- Ventilation rate of 18,000 cfm.

Solids Handling Building

- Odorous air from truck bay where dewatered cake (from centrifuges) will be loaded onto trucks.
 - Note that this odor control system will not run continuously, only when the trucks are being loaded. The loading of the trucks is seasonal.
- Average concentration of H₂S around 4 ppm and an average of 2 ppm for sulfur organics compounds.
- Ventilation rate of 20,000 cfm.

We are evaluating various odor control technologies for the Screenings and Grit Building area (carbon, packed tower, and bio tower) and carbon for the Solids Handling Building area. For the carbon applications, we would be interested in seeing both radial and dual bed flow sizing. For the odor control system, plan around achieving 99% hydrogen sulfide removal and approximately 85% removal for the other constituents.

Could you provide us with the following preliminary information for this application:

- Equipment cut sheets for the recommended carbon (radial and dual bed), packed tower, and bio tower equipment.
- Number of pieces of equipment to handle odor load and ventilation rate including redundancy (assuming the largest unit is offline). For the Solids Handling Building carbon unit, assume that redundancy is not required.
- Dimensional drawings of equipment.
- Budgetary cost estimate.

One other factor to consider, being that the project location is Ann Arbor we want to consider the ambient temperature and any additional equipment or provisions (heat tracing, wrapping, insulating, etc.) that may be required being that the major tank equipment will be stored outdoors in the elements. If you have any photos or example installations in similar climates, please provide for reference.

Feel free to reach out with any questions or to further discuss.

Regards,

Zach

Zachary Swartzbaugh, PE
Water/Wastewater Project Manager

HDR
4880 Sadler Road, Suite 100
Glen Allen, VA 23060-6164
D 804.799.6868 M 717.487.3891
Zachary.Swartzbaugh@hdrinc.com

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ECS Environmental Solutions



ENVIRONMENTAL SOLUTIONS

OFFERING A COMPLETE LINE OF
ODOR CONTROL PRODUCTS AND ACCESSORIES



VX CARBON ADSORBER

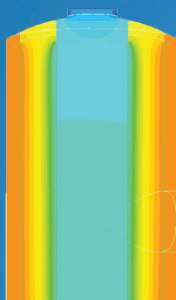
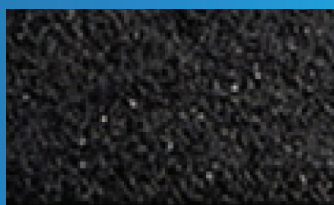
The VX radial flow is an efficient, highly effective system for removing H_2S and other compounds from municipal wastewater applications. These systems can utilize a wide variety of adsorbent media for specific treatment needs with lower capital and operating cost than Deep Bed or Up-Flow Systems all with a small footprint and low pressure drop requiring lower horsepower blowers.

- Lower capital cost and reduced operating costs
- High efficiencies of H_2S and organic odor removal
- Small foot-print and the ability to treat up to 40,000 cfm in a single 12' Diameter vessel
- High quality FRP construction manufactured to exceed industry standards
- Proprietary plug-flow air distribution system maximizing flow efficiency

WWW.ECS-ENV.COM

VX

SIMPLE, EASY, COST EFFECTIVE SOLUTION UP TO 3000 CFM



FEATURES

BENEFIT

Small Footprint

Up to 40,000 cfm can be treated in a single 12' Diameter vessel.

Proprietary Plenum Diffuser

Through extensive CFD and practical modeling the VX is designed with a special air diffuser system that creates even air distribution through the carbon bed.

High-Quality Construction

Vessel and internal components are manufactured using high quality, corrosion resistant materials to provide an indefinite service life.

Operator-Friendly

Besides fan components, the VX has no moving parts. Carbon is removed, filled and self-levels in the top access ports so man-entry is not required under normal circumstances.

High Quality Media

The ECS VX is available with a wide variety of media including Calgon Minotaur, one of only two A-Grade carbons with a .3 H₂S capacity and Calgon Centaur, a water regenerable carbon with ultimate H₂S capacity of .69

ECS Ring Cap

Simplifies removal of the vessel lid by reducing the number of fasteners. Special O-ring seal with built-in groove ensures a proper seal.

FRP Flanged Carbon Ports

High-quality FRP flanged ports providing a better seal and longevity.

ECS Offers the Following Complete Line of Odor Control Products

- V1 Single Bed
- V2 Dual-Bed
- VX Radial Flow
- X-Pac Chemical Scrubber
- BioPure Biofilter Media
- FRP Ductwork Systems
- AMCA Certified Dampers
- Grease Filter / Mist Eliminators
- Control Panels
- FRP Fans
- Activated Carbon Media
- FRP Chemical Storage Tanks
- FRP Hoods / Covers
- Sound Enclosures and Silencers
- Field Services



ECS is based out of a 100,000 sq/ft manufacturing / design facility located in central Texas.

We offer a complete line of odor control equipment and services including carbon adsorbers, wet scrubbers, biofilters with the unique capability to manufacture and supply system components.

P.O. BOX 127 / 2201 TAYLORS VALLEY RD / BELTON, TX 76513
P. 254.933.2270 / F. 254.933.2212

WWW.ECS-ENV.COM



Project Name: Ann Arbor Odor Control Study	Date: 30 October 2019
Local Representative:	Location: Ann Arbor, MI
Specification Section: N/A	Equipment: 18,000 cfm Odor Control Systems

System	Description	Budget
<p>ECS VX Odor Control System</p> 	<p>One, ECS VX-18000 Carbon Adsorber System, includes:</p> <ul style="list-style-type: none"> • 120" diameter Insulated, FRP, Radial Flow Vessel with SMACNA No-Loss Stack • 876 ft³ of high capacity carbon media • Vessel inlet balancing damper • One, FRP Centrifugal Fan rated for 18,000 cfm @ 10" w.c., 40 horsepower, 3-60-460v, Class 1 Div 2 Motor, with inlet and outlet flexible connectors and Sound Enclosure • One, NEMA 4X FRP Control Panel with fan motor/starter, on/off switch for fan control, run and alarm pilot lights, and dry contacts for fan run and fail status • One, ECS Grease/Mist Eliminator Pre-Filter, rated for 18,000 cfm in FRP housing with pre-filter pad 	<p>\$335,149 (includes freight to jobsite)</p>
<p>ECS V2 Odor Control System</p> 	<p>One, ECS V2-18000 Carbon Adsorber System, includes:</p> <ul style="list-style-type: none"> • Two, 120" diameter Insulated, FRP, Dual Deep Bed Vessels with SMACNA No-Loss Stacks • 942 ft³ of high capacity carbon media • Vessel inlet balancing dampers and interconnecting ductwork between fan and vessel inlets • One, FRP Centrifugal Fan rated for 18,000 cfm @ 10" w.c., 40 horsepower, 3-60-460v, Class 1 Div 2 Motor, with inlet and outlet flexible connectors and Sound Enclosure • One, NEMA 4X FRP Control Panel with fan motor/starter, on/off switch for fan control, run and 	<p>\$392,331 (includes freight to jobsite)</p>

	<p>alarm pilot lights, and dry contacts for fan run and fail status</p> <ul style="list-style-type: none"> One, ECS Grease/Mist Eliminator Pre-Filter, rated for 18,000 cfm in FRP housing with pre-filter pad 	
<p>ECS BioPac VTS Odor Control System</p> 	<p>One, 18,000 cfm BioPac VTS Odor Control System, includes:</p> <ul style="list-style-type: none"> Two, ECS BioPac VTS Towers with factory installed Structured Media, Insulated, rated for 9,000 cfm each One, ECS Grease/Particulate Filter with Poly Mesh Screen upstream of Odor Control Fan One, FRP Centrifugal Fan rated for 18,000 cfm @ 10" w.c., 40 horsepower, 3-60-460v, Class 1 Div 2 Motor, with inlet and outlet flexible connectors and Sound Enclosure One, NEMA 4X Control Panel to control Fan, and VTS Tower Two, FRP Coded Control Skid with Water Panels, Recirculation Pumps, and Nutrient Feed Systems, pre-mounted at Factory Interconnecting Ductwork between Odor Control Fan and BioPac VTS Towers 	<p>\$608,107 (includes freight to jobsite)</p>
<p>ECS X-Pac Odor Control System</p>	<p>One, ECS VX-18000 X-Pac Chemical Scrubber Odor Control System, includes:</p> <ul style="list-style-type: none"> One, ECS X-Pac Multi-Stage Packaged Scrubber Tower with factory installed Structured Media, with No-Loss Discharge Stack, rated for 99% H₂S removal efficiency Two, Recirculation pumps and all required instruments Four, Chemical metering Pumps Vessel inlet balancing damper One, FRP Centrifugal Fan rated for 18,000 cfm @ 10" w.c., 40 horsepower, 3-60-460v, Class 1 Div 2 Motor, 	<p>\$509,442 (includes freight to jobsite)</p>

	<p>with inlet and outlet flexible connectors and Sound Enclosure</p> <ul style="list-style-type: none"> • One, NEMA 4X FRP Control Panel with LCD Screen and PLC for Fan and Instrumentation control • One, ECS Grease/Particulate Filter with Poly Mesh Screen upstream of Odor Control Fan 	
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Additional items or services included:

- Design calculations, fabrication drawings, submittals and O&M manuals
- Warranty
- Start-up and Training

Items **NOT** included in the ECS scope of supply:

- Offloading, storage or installation
- Anchor bolts
- Ductwork supports or hangers
- Performance Testing



Project Name: Ann Arbor Odor Control Study	Date: 30 October 2019
Local Representative:	Location: Ann Arbor, MI
Specification Section: N/A	Equipment: 20,000 cfm Odor Control Systems

System	Description	Budget
<p>ECS VX Odor Control System</p> 	<p>One, ECS VX-20000 Carbon Adsorber System, includes:</p> <ul style="list-style-type: none"> • 120" diameter Insulated, FRP, Radial Flow Vessel with SMACNA No-Loss Stack • 973 ft³ of media, 65% high capacity carbon followed by 35% potassium permanganate polishing 8% media • Vessel inlet balancing damper • One, FRP Centrifugal Fan rated for 20,000 cfm @ 10" w.c., 50 horsepower, 3-60-460v, Class 1 Div 2 Motor, with inlet and outlet flexible connectors and Sound Enclosure • One, NEMA 4X FRP Control Panel with fan motor/starter, on/off switch for fan control, run and alarm pilot lights, and dry contacts for fan run and fail status • One, ECS Grease/Mist Eliminator Pre-Filter, rated for 20,000 cfm in FRP housing with pre-filter pad 	<p>\$357,834 (includes freight to jobsite)</p>
<p>ECS V2 Odor Control System</p> 	<p>One, ECS V2-20000 Carbon Adsorber System, includes:</p> <ul style="list-style-type: none"> • Two, 132" diameter Insulated, FRP, Dual Deep Bed Vessels with SMACNA No-Loss Stacks • 1,141 ft³ of media, each vessel bed to have 2' of high capacity carbon followed by 1' of potassium permanganate polishing 8% media • Vessel inlet balancing dampers and interconnecting ductwork between fan and vessel inlets • One, FRP Centrifugal Fan rated for 20,000 cfm @ 10" w.c., 50 horsepower, 3-60-460v, Class 1 Div 2 Motor, 	<p>\$434,175 (includes freight to jobsite)</p>



2201 Taylors Valley Road
Belton, Texas 76513
(254) 933-2270 office
(866) 928-1864 fax

	<p>with inlet and outlet flexible connectors and Sound Enclosure</p> <ul style="list-style-type: none">• One, NEMA 4X FRP Control Panel with fan motor/starter, on/off switch for fan control, run and alarm pilot lights, and dry contacts for fan run and fail status• One, ECS Grease/Mist Eliminator Pre-Filter, rated for 20,000 cfm in FRP housing with pre-filter pad	
--	---	--

Additional items or services included:

- Design calculations, fabrication drawings, submittals and O&M manuals
- Warranty
- Start-up and Training

Items **NOT** included in the ECS scope of supply:

- Offloading, storage or installation
- Anchor bolts
- Ductwork supports or hangers
- Performance Testing



Appendix H. Met Station Cutsheet

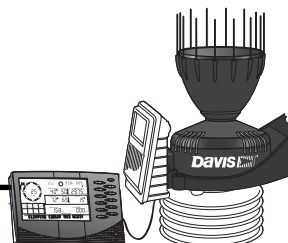
MET Station

- MET Station capable of measuring and monitoring weather data
- Station consists of a sensor and console
 - Sensors – rain, wind, temp, pressure, humidity, UV, etc.
 - Console – stores, collects data totals and averages, presents graphs of historic data
- Data can be transmitted via cabled or wireless
- Power source can be AC or battery and can be provided with battery backup
- Various mounting options available
- Field mounting location should be field verified with vendor
- Budgetary estimate of \$1,000 (dependent on selected features)



Cabled Vantage Pro2™ & Vantage Pro2 Plus™ Stations

6152C
6162C



Vantage Pro2™

The Vantage Pro2™ (# 6152C) and Vantage Pro2™ Plus (# 6162C) cabled weather stations include two components: the Integrated Sensor Suite (ISS) and the console. The ISS contains the sensor interface module (SIM), rain collector, an anemometer, and a passive radiation shield. The Vantage Pro2 console provides the user interface, data display, and calculations. The Vantage Pro2 Plus weather station includes two additional sensors that are optional on the Vantage Pro2 and purchased separately: the UV Sensor and the Solar Radiation Sensor. The console and ISS are powered by an AC-power adapter connected to the console. Batteries can be installed in the console to provide a backup power supply. Use WeatherLink® to let your weather station interface with a computer, log data, and upload weather information to the Internet. The 6152C and 6162C models rely on passive shielding to reduce solar-radiation induced temperature errors in the outside temperature sensor readings.

Integrated Sensor Suite (ISS)

Operating Temperature	-40° to +150°F (-40° to +65°C)
Non-operating Temperature	-40° to +158°F (-40° to +70°C)
Current Draw.	5 mA (average) at 4 to 6 VDC for ISS only. 10 mA average for both console and ISS
Connectors, Sensor.	Modular RJ-11
Cable Type	4-conductor, 26 AWG
Cable Length, Anemometer.	40' (12 m) (included); 240' (73 m) (maximum recommended)

Note: Maximum displayable wind decreases as the length of cable increases. at 140' (42 m) of cable, the maximum wind speed displayed is 135 mph (60 m/s); at 240' (73 m), the maximum wind speed displayed is 100 mph (34 m/s).

Wind Speed Sensor	Solid state magnetic sensor
Wind Direction Sensor	Wind vane with potentiometer
Rain Collector Type	Tipping bucket, 0.01" per tip (0.2 mm with metric rain adapter), 33.2 in ² (214 cm ²) collection area
Temperature Sensor Type.	PN Junction Silicon Diode
Relative Humidity Sensor Type	Film capacitor element
Housing Material	UV-resistant ABS, polypropylene
Sensor Inputs	
RF Filtering	RC low-pass filter on each signal line

ISS Dimensions(not including anemometer or bird spikes):

Vantage Pro2 with Standard Rad Shield	14.0" x 9.4" x 14.5" (356 mm x 239 mm x 368 mm)
Vantage Pro2 with Fan-Asprated Rad Shield	20.8" x 9.4" x 16.0" (528 mm x 239 mm x 406 mm)
Vantage Pro2 Plus with Standard Rad Shield	14.3" x 9.7" x 14.5" (363 mm x 246 mm x 368 mm)
Vantage Pro2 Plus with Fan-Aspirated Rad Shield	21.1" x 9.7" x 16.0" (536 mm x 246 mm x 406 mm)

Console

Console Operating Temperature	+32° to +140°F (0° to +60°C)
Non-Operating (Storage) Temperature	+14° to +158°F (-10° to +70°C)
Current Draw	5 mA average for console only, 10 mA average for both console and ISS
AC Power Adapter.	5 VDC, 300 mA, regulated
Battery Backup	3 C-cells
Battery Life (no AC power)	1 month (approximately)
Connectors	Modular RJ-11
Cable Type	4-conductor, 26 AWG
Cable Length, Console	100' (30 m) (included); 1000' (300 m) (maximum recommended)
Housing Material	UV-resistant ABS plastic
Console Display Type	LCD Transflective
Display Backlight.	LEDs
Dimensions (console: length x width x height, display length x height)	
Console	9.63" x 6.125" x 1.625" (245 mm x 156 mm x 41 mm)
Display	5.94" x 3.375" (151 mm x 86 mm)
Weight (with batteries).	1.88 lbs. (.85 kg)

Data Displayed on Console

Data display categories are listed with General first, then in alphabetical order.

General

Historical Graph Data	Includes the past 24 values listed unless otherwise noted; all can be cleared and all totals reset
Daily Data	Includes the earliest time of occurrence of highs and lows; period begins/ends at 12:00 am
Monthly Data.	Period begins/ends at 12:00 am on the first of the month
Yearly Data	Period begins/ends at 12:00 am on the first of January unless otherwise noted
Current Display Data.	Current display data describes the current reading for each weather variable. In most cases, the variable lists the most recently updated reading or calculation. Some current variable displays can be adjusted so there is an offset for the reading.
Current Graph Data.	Current data appears in the right most column in the console graph and represents the latest value within the last period on the graph; totals can be set or reset. Display intervals vary. Examples include: Instant, 15-min., and Hourly Reading; Daily, Monthly, High and Low
Graph Time Interval	1 min., 10 min., 15 min., 1 hour, 1 day, 1 month, 1 year (user-selectable, availability depends upon variable selected)
Graph Time Span	24 Intervals + Current Interval (see Graph Intervals to determine time span)
Graph Variable Span (Vertical Scale)	Automatic (varies depending upon data range); Maximum and Minimum value in range appear in ticker
Alarm Indication	Alarms sound for only 2 minutes (time alarm is always 1 minute) if operating on battery power. Alarm message is displayed in ticker as long as threshold is met or exceeded. Alarms can be silenced (but not cleared) by pressing the DONE key.
Update Interval	Varies with sensor - see individual sensor specifications

Barometric Pressure

Resolution and Units	0.01" Hg, 0.1 mm Hg, 0.1 hPa/mb (user-selectable)
Range	16.00" to 32.50" Hg, 410 to 820 mm Hg, 540 to 1100 hPa/mb
Elevation Range	-999' to +15,000' (-600 m to 4570 m) (Note that console screen limits entry of lower elevation to -999' when using feet as elevation unit.)
Uncorrected Reading Accuracy	±0.03" Hg (±0.8 mm Hg, ±1.0 hPa/mb) (at room temperature)
Sea-Level Reduction Equation Used	United States Method employed prior to use of current "R Factor" method
Equation Source	Smithsonian Meteorological Tables
Equation Accuracy	±0.01" Hg (±0.3 mm Hg, ±0.3 hPa/mb)
Elevation Accuracy Required	±10' (3m) to meet equation accuracy specification
Overall Accuracy	±0.03" Hg (±0.8 mm Hg, ±1.0 hPa/mb)
Trend (change in 3 hours)	Change 0.06" (2 hPa/mb, 1.5 mm Hg) = Rapidly Change 0.02" (.7hPa/mb,.5 mm Hg)= Slowly
Trend Indication	5 position arrow: Rising (rapidly or slowly), Steady, or Falling (rapidly or slowly)
Update Interval	1 minute or when console BAR key is pressed twice
Current Display Data	Instant
Current Graph Data	Instant, 15-min., and Hourly Reading; Daily, Monthly, High and Low
Historical Graph Data	15-min. and Hourly Reading; Daily, Monthly Highs and Lows
Alarms	High Threshold from Current Trend for Storm Clearing (Rising Trend) Low Threshold from Current Trend for Storm Warning (Falling Trend)
Range for Rising and Falling Trend Alarms	0.01 to 0.25" Hg (0.1 to 6.4 mm Hg, 0.1 to 8.5 hPa/mb)

Clock

Resolution	1 minute
Units	Time: 12 or 24 hour format (user-selectable)
Date	US or International format (user-selectable)
Accuracy	±8 seconds/month
Adjustments	Time: Automatic Daylight Savings Time (for users in North America and Europe that observe it in AUTO mode, MANUAL setting available for all other areas) Date: Automatic Leap Year
Alarms	Once per day at set time when active

Dewpoint (calculated)

Resolution and Units	1°F or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C
Range	-105° to +130°F (-76° to +54°C)
Accuracy	±2°F (±1°C) (typical)
Update Interval	10 to 12 seconds
Source	World Meteorological Organization (WMO)
Equation Used	WMO Equation with respect to saturation of moist air over water
Variables Used	Instant Outside Temperature and Instant Outside Relative Humidity
Current Display Data	Instant Calculation
Current Graph Data	Instant Calculation; Daily, Monthly High and Low
Historical Graph Data	Hourly Calculations; Daily, Monthly Highs and Lows
Alarms	High and Low Threshold from Instant Calculation

Vantage Pro2™**Evapotranspiration (calculated, requires solar radiation sensor)**

Resolution and Units	0.01" or 0.1 mm (user-selectable) °C is converted from °F rounded to nearest 1°C
Range	Daily to 32.67" (832.2 mm); Monthly & Yearly to 199.99" (1999.9 mm)
Accuracy	Greater of 0.01" (0.25 mm) or ±5%, Reference: side-by-side comparison against a CIMIS ET weather station
Update Interval	1 hour
Calculation and Source	Modified Penman Equation as implemented by CIMIS (California Irrigation Management Information System) including Net Radiation calculation
Current Display Data	Latest Hourly Total Calculation
Current Graph Data	Latest Hourly Total Calculation, Daily, Monthly, Yearly Total
Historical Graph Data	Hourly, Daily, Monthly, Yearly Totals
Alarm	High Threshold from Latest Daily Total Calculation

Forecast

Variables Used	Barometric Reading & Trend, Wind Speed & Direction, Rainfall, Temperature, Humidity, Latitude & Longitude, Time of Year
Update Interval	1 hour
Display Format	Icons on top center of display; detailed message in ticker at bottom
Variables Predicted	Sky Condition, Precipitation, Temperature Changes, Wind Direction and Speed

Heat Index (calculated)

Resolution and Units	1°F or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C
Range	-40° to +165°F (-40° to +74°C)
Accuracy	±2°F (±1°C) (typical)
Update Interval	10 to 12 seconds
Source	United States National Weather Service (NWS)/NOAA
Formulation Used	Steadman (1979) modified by US NWS/NOAA and Davis Instruments to increase range of use
Variables Used	Instant Outside Temperature and Instant Outside Relative Humidity
Current Display Data	Instant Calculation
Current Graph Data	Instant Calculation; Daily, Monthly High
Historical Graph Data	Hourly Calculations; Daily, Monthly Highs
Alarm	High Threshold from Instant Calculation

Humidity

Inside Relative Humidity (sensor located in console)

Resolution and Units	1%
Range	1 to 100% RH
Accuracy	±2%
Update Interval	1 minute
Current Display Data	Instant (user-adjustable offset available)
Current Graph Data	Instant; Hourly Reading; Daily, Monthly High and Low
Historical Graph Data	Hourly Readings; Daily, Monthly Highs and Lows
Alarms	High and Low Threshold from Instant Reading

Outside Relative Humidity (sensor located in ISS)

Resolution and Units	1%
Range	1 to 100% RH
Accuracy	±2%
Drift	<0.25% per year
Update Interval	50 seconds to 1 minute
Current Display Data	Instant (user-adjustable offset available)
Current Graph Data	Instant and Hourly Reading; Daily, Monthly High and Low
Historical Graph Data	Hourly Readings; Daily, Monthly Highs and Lows
Alarms	High and Low Threshold from Instant Reading

Moon Phase

Console Resolution	1/8 (12.5%) of a lunar cycle, 1/4 (25%) of lighted face on console
WeatherLink Resolution	0.09% of a lunar cycle, 0.18% of lighted face maximum (depends on screen resolution)
Range	New Moon, Waxing Crescent, First Quarter, Waxing Gibbous, Full Moon, Waning Gibbous, Last Quarter, Waning Crescent
Accuracy	±38 minutes

Rainfall

Resolution and Units	0.01" or 0.2 mm (user-selectable) (1 mm at totals ≥ 2000 mm)
Daily/Storm Rainfall Range	0 to 99.99" (0 to 999.8 mm)
Monthly/Yearly/Total Rainfall Range	0 to 199.99" (0 to 6553 mm)
Accuracy	For rain rates up to 4"/hr (100 mm/hr): ±4% of total or ± one tip of the bucket (0.01" /0.2 mm), whichever is greater.
Update Interval	20 to 24 seconds
Storm Determination Method	0.02" (0.5 mm) begins a storm event, 24 hours without further accumulation ends a storm event
Current Display Data	Totals for Past 15-min
Current Graph Data	Totals for Past 15-min, Past 24-hour, Daily, Monthly, Yearly (start date user-selectable) and Storm (with begin date); Umbrella is displayed when 15-minute total exceeds zero
Historical Graph Data	Totals for 15-min, Daily, Monthly, Yearly (start date user-selectable) and Storm (with begin and end dates)
Alarms	High Threshold from Latest Flash Flood (15-min. total, default is 0.50", 12.7 mm), 24-Hour Total, Storm Total,
Range for Rain Alarms	0 to 99.99" (0 to 999.7 mm)

Rain Rate

Resolution and Units	0.01" or 0.1mm (user-selectable) at typical rates (see Fig. 1 and 2)
Range	0, 0.04"/hr (1 mm/hr) to 82"/hr (0 to 2090 mm/hr)
Accuracy	±5% for rates less than 5" per hour (127 mm/hr)
Update Interval	20 to 24 seconds
Calculation Method	Measures time between successive tips of rain collector. Elapsed time greater than 15 minutes or only one tip of the rain collector constitutes a rain rate of zero.
Current Display Data	Instant
Current Graph Data	Instant and 1-min. Reading; Hourly, Daily, Monthly and Yearly High
Historical Graph Data	1-min Reading; Hourly, Daily, Monthly and Yearly Highs
Alarm	High Threshold from Instant Reading

Solar Radiation (requires solar radiation sensor)

Resolution and Units	1 W/m ²
Range	0 to 1800 W/m ²
Accuracy	±5% of full scale (Reference: Eppley PSP at 1000 W/m ²)
Drift	up to ±2% per year
Cosine Response	±3% for angle of incidence from 0° to 75°
Temperature Coefficient	-0.067% per °F (-0.12% per °C); reference temperature = 77°F (25 °C)
Update Interval	50 seconds to 1 minute (5 minutes when dark)
Current Graph Data	Instant Reading and Hourly Average; Daily, Monthly High
Historical Graph Data	Hourly Average, Daily, Monthly Highs
Alarm	High Threshold from Instant Reading

Sunrise and Sunset

Resolution	1 minute
Accuracy	±1 minute
Reference	United States Naval Observatory

Temperature

Inside Temperature (sensor located in console)

Resolution and Units	Current Data: 0.1°F or 1°F or 0.1°C or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C Historical Data and Alarms: 1°F or 1°C (user-selectable)
Range	+32° to +140°F (0° to +60°C)
Sensor Accuracy	±0.5°F (±0.3°C) (typical)
Update Interval	1 minute
Current Display Data	Instant (user-adjustable offset available)
Current Graph Data	Instant Reading; Daily and Monthly High and Low
Historical Graph Data	Hourly Readings; Daily and Monthly Highs and Lows
Alarms	High and Low Thresholds from Instant Reading

Outside Temperature (sensor located in ISS)

Resolution and Units	Current Data: 0.1°F or 1°F or 0.1°C or 1°C (user-selectable) nominal °C is converted from °F rounded to nearest 1°C Historical Data and Alarms: 1°F or 1°C (user-selectable)
Range	-40° to +150°F (-40° to +65°C)
Sensor Accuracy	±0.5°F (±0.3°C) (typical)
Radiation Induced Error (Passive Shield)	+4°F (2°C) at solar noon (insolation = 1040 W/m ² , avg. wind speed ≤ 2 mph (1 m/s)) (reference: RM Young Model 43408 Fan-Aspirated Radiation Shield)
Update Interval	10 to 12 seconds
Current Display Data	Instant (user-adjustable offset available)
Current Graph Data	Instant; Daily, Monthly, Yearly High and Low
Historical Graph Data	Hourly Readings; Daily, Monthly, Yearly Highs and Lows
Alarms	High and Low Thresholds from Instant Reading

Temperature Humidity Sun Wind Index (requires solar radiation sensor)

Resolution and Units	1°F or 1°C (user-selectable) °C is converted from °F rounded to nearest 1°C
Range	-90° to +165°F (-68° to +74°C)
Accuracy	±4°F (±2°C) (typical)
Update Interval	10 to 12 seconds
Sources and Formulation Used	United States National Weather Service (NWS)/NOAA Steadman (1979) modified by US NWS/NOAA and Davis Instruments to increase range of use and allow for cold weather use
Variables Used	Instant Outside Temperature, Instant Outside Relative Humidity, 10-minute Average Wind Speed, 10-minute Average Solar Radiation
Formulation Description	Uses Heat Index as base temperature, affects of wind and solar radiation are either added or subtracted from this base to give an overall effective temperature
Current Graph Data	Instant and Hourly Calculation; Daily, Monthly High
Historical Graph Data	Hourly Calculation; Daily, Monthly Highs
Alarm	High Threshold from Instant Reading

Ultra Violet (UV) Radiation Dose (requires UV sensor)

Resolution and Units	0.1 MEDs to 19.9 MEDs; 1 MED above 19.9 MEDs
Range	0 to 199 MEDs
Accuracy	±5% of daily total
Drift	up to ±2% per year
Update Interval	50 seconds to 1 minute (5 minutes when dark)
Current Graph Data	Latest Daily Total (user resettable at any time from Current Screen)
Historical Graph Data	Hourly, Daily Totals (user reset from Current Screen does not affect these values)
Alarm	High Threshold from Daily Total
Alarm Range	0 to 19.9 MEDs

Ultra Violet (UV) Radiation Index (requires UV sensor)

Resolution and Units	0.1 Index
Range	0 to 16 Index
Accuracy	±5% of full scale (Reference: Yankee UVB-1 at UV index 10 (Extremely High))
Cosine Response	±4% FS (0° to 90° zenith angle)
Update Interval	50 seconds to 1 minute (5 minutes when dark)
Current Graph Data	Instant Reading and Hourly Average; Daily, Monthly High
Historical Graph Data	Hourly Average, Daily, Monthly Highs
Alarm	High Threshold from Instant Calculation

Wind**Wind Chill (Calculated)**

Resolution and Units	1°F or 1°C (user-selectable); °C is converted from °F and rounded to the nearest 1°C
Range	-110° to +135°F (-79° to +57°C)
Accuracy	±2°F (±1°C) (typical)
Update Interval	10 to 12 seconds
Source	United States National Weather Service (NWS)/NOAA
Equation Used	Osczevski (1995) (adopted by US NWS in 2001)
Variables Used	Instant Outside Temperature and 10-min. Avg. Wind Speed
Current Display Data	Instant Calculation
Current Graph Data	Instant Calculation; Hourly, Daily and Monthly Low
Historical Graph Data	Hourly, Daily and Monthly Lows
Alarm	Low Threshold from Instant Calculation

Wind Direction

Range	1 - 360°
Display Resolution	16 points (22.5°) on compass rose, 1° in numeric display
Accuracy	±3°
Update Interval	2.5 to 3 seconds
Current Graph Data	Instant Reading (user adjustable); 10-min. Dominant; Hourly, Daily, Monthly Dominant
Historical Graph Data	Past 6 10-min. Dominants on compass rose only; Hourly, Daily, Monthly Dominants

Wind Speed

Resolution and Units	1 mph, 1 km/h, 0.4 m/s, or 1 knot (user-selectable) Measured in mph; other units are converted from mph and rounded to nearest 1 km/hr, 0.1 m/s, or 1 knot.
Range	0 to 200 mph, 0 to 173 knots, 0 to 89 m/s, 0 to 322 km/h
Update Interval	Instant Reading: 2.5 to 3 seconds, 10-minute Average: 1 minute
Accuracy	±2 mph (2 kts, 3.2 km/h, 0.9 m/s) or ±5%, whichever is greater
Maximum Cable Length	540' (165 m) (Note that maximum wind speed reading decreases as length of cable from anemometer to ISS increases.)
Current Display Data	Instant
Current Graph Data	Instant Reading; 10-minute and Hourly Average; Hourly High; Daily, Monthly and Yearly High with Direction of High
Historical Graph Data	10-min. and Hourly Averages; Hourly Highs; Daily, Monthly and Yearly Highs with Direction of Highs
Alarms	High Thresholds from Instant Reading and 10-minute Average

Sensor Charts

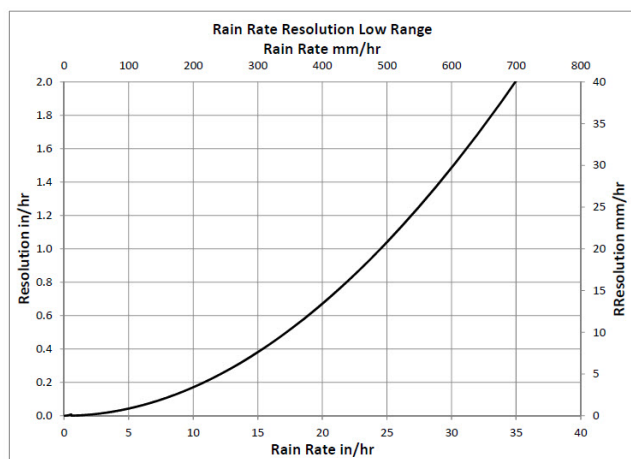


Figure 1. Low Range Rain Rate Resolution

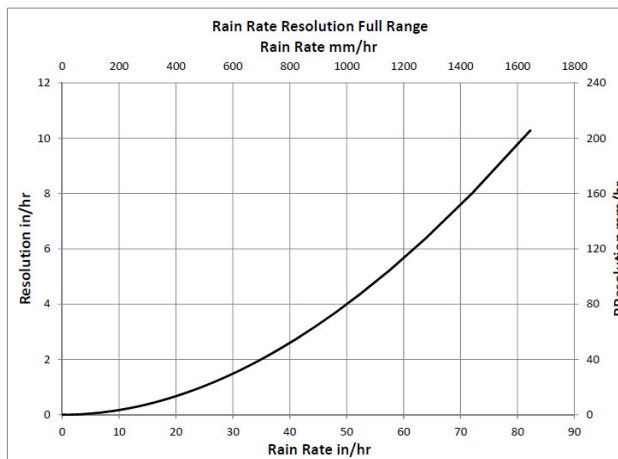


Figure 2. Full Range Rain Rate Resolution

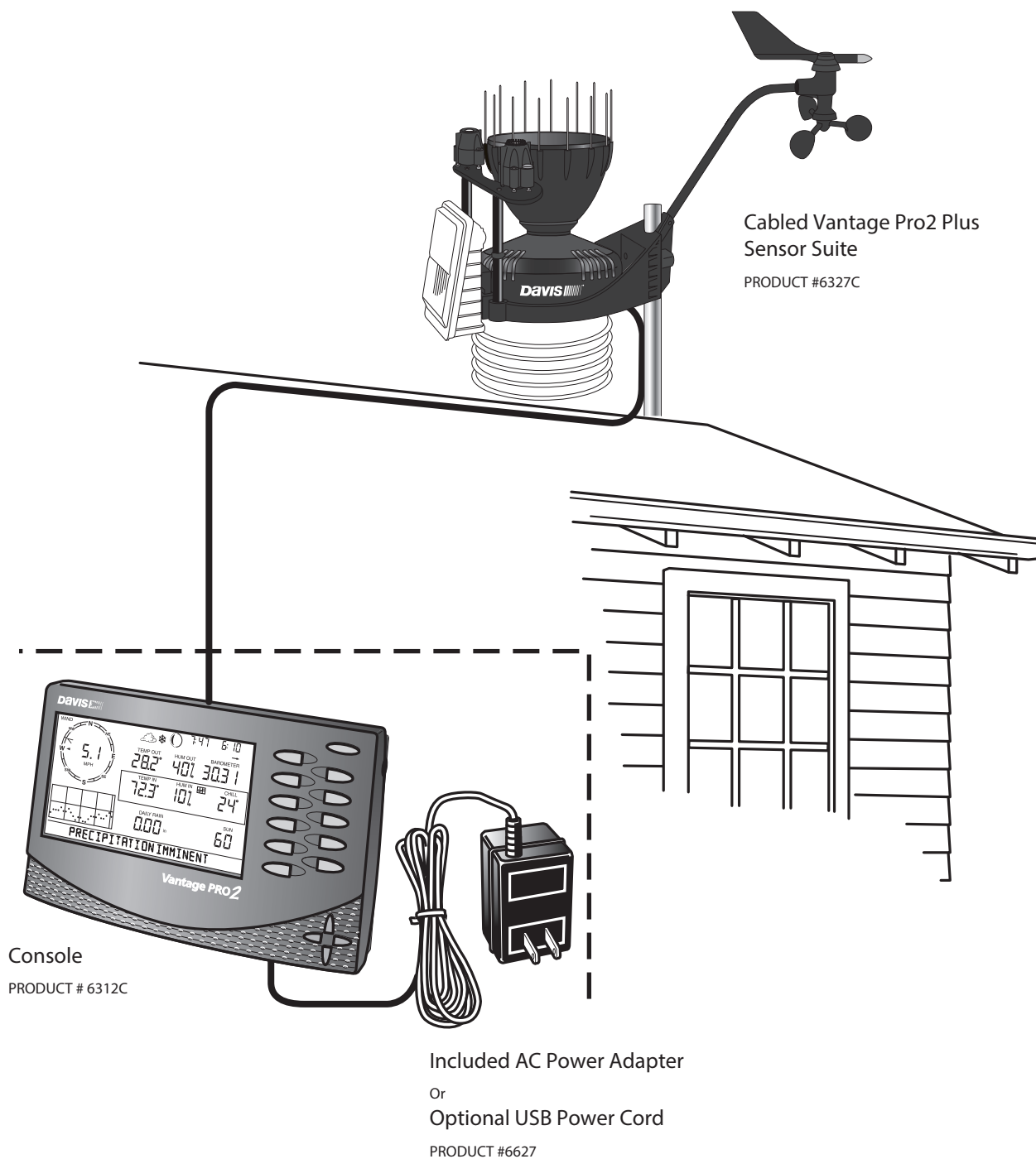
Package Dimensions

Product #	Package Dimensions (Length x Width x Height)	Package Weight	UPC Codes
6152C 6152CEU 6152CUK	17.50" x 10.4" x 16.0" (445 mm x 264 mm x 406 mm)	12 lbs. 15 oz. (5.9 kg)	011698 00755 4 011698 00772 1 011698 00773 8
6162C 6162CEU 6162CUK		13 lbs. 4 oz. (6.0 kg)	011698 00756 1 011698 00774 5 011698 00775 2
6322C 6322CM	17.50" x 10.4" x 16.0" (445 mm x 264 mm x 406 mm)	9 lbs.. 1 oz. (4.1 kg)	011698 00777 6 011698 01048 6
6327C 6327CM		11 lbs. 2 oz. (5.0 kg)	011698 00782 0 011698 01049 3

Vantage PRO2™ INSTALLATION DIAGRAM

Cabled Vantage Pro2™

This diagram shows a cabled Vantage Pro2 Plus sensor suite (which include UV and solar radiation sensors) connected to a cabled Vantage Pro2 console. A cabled Vantage Pro2 system allows for a cable connection of up to 100' (30 m). This connection can be extended up to 1000' (300 m) with optional extension cables. Please note that in a cabled system, the Vantage Pro2 console cannot receive data from any station except a cabled sensor suite.



When Weather Rules Your Life, Let Us Keep You Connected



Vantage Connect®

Vantage Connect from Davis Instruments provides the power to manage your environment, mitigate risk and make smarter decisions.

Have you ever wished that you had an extra pair of eyes and ears in a remote area of your property, workplace or vacation home to check weather conditions? **Davis Instruments has the solution: Vantage Connect.**

Vantage Connect allows you to track weather data from any remote location that has cellular coverage without leaving your home or office. Solar-powered and self-contained, Vantage Connect combines the function of a weather station receiver and cellular modem to report weather data from multiple Davis Weather Station configurations.

Vantage Connect installed with a Vantage Pro2 Sensor Suite (#6323) that includes a 24-Hour Fan-Aspirated Radiation Shield.



The **real-time information** is available online via smartphone, tablet or PC, allowing you to identify and manage potential problems, including those resulting from:

- **Frost or Freezing Conditions**
- **Extreme Heat**
- **High Winds**
- **Heavy Rain**
- **Pest or Disease Development***

*When paired with any Davis IPM software (PC only).

Remote Weather Data,

Vantage Connect allows you to view your weather data anywhere you have an internet connection in 5, 15 or 60-minute update intervals (depending on the service plan chosen). Whether you need to monitor erratic winds, unpredictable micro-climates or protect against a hard freeze, Vantage Connect can be programmed to send vital alarms via email or text in real time.

Specifically designed for locations with no additional power sources, Vantage Connect is equipped with a heavy-duty back-up battery that supplies ancillary power even in areas with little to no light. The wireless unit can listen to a combination of eight of the following Davis Weather Stations:

- 1 Vantage Vue ISS
- 2 Wireless Temperature/Humidity Stations
- 1 Vantage Pro2 ISS (any model)
- 3 Wireless Temperature Stations
- 1 Wireless Leaf & Soil Moisture/ Temperature Station
- 1 Anemometer/Sensor Transmitter Kit

Available in both wireless and cabled versions, Vantage Connect can either take the place of your console or work with your console to send weather data directly to the “cloud” using cellular technology. The wireless version of Vantage Connect is radio-compatible with Vantage Pro2 and Vantage Vue transmitters and repeaters for easy integration as a new remote station or into an existing weather station.



Battery backup and integrated data logger.

Free Mobile Apps

See your Vantage Connect station data on your smartphone. Scan the applicable QR code below or search for WeatherLink on iTunes or the Google Play Store.

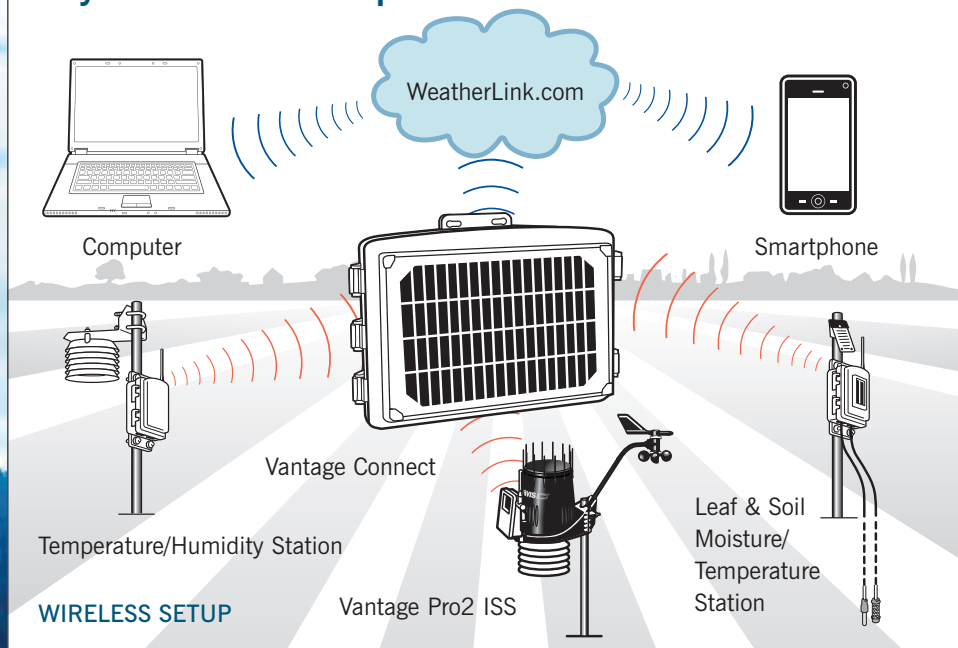


6556 WeatherLink iPhone App



6557 WeatherLink Android App

Vantage Connect moves data from multiple stations to your PC and smartphone



Versatile Integration

Vantage Connect is equipped with an integrated data logger and includes WeatherLink software. Your personal weather data is uploaded to a secure page on WeatherLink.com and can be viewed online or downloaded directly to your computer for analysis, archiving and reporting. You can choose to either manually download your data or set up automatic download times.*

WeatherLink.com is Davis' global weather network. Adding your weather station and Vantage Connect to the network is as simple as "plug-and-play".

*Automatic downloads to your PC only occur when the WeatherLink software is running.

Vantage Connect at a Glance		Wireless	Cabled
Can listen to up to 8 transmitters		Yes	No
Maximum number of integrated sensor suites (ISS)		1	1
Maximum number of Anemometer/Sensor Transmitter kits		1*	0
Maximum number of Wireless Leaf & Soil Moisture/ Temperature stations		1**	0
Maximum number of Temperature stations		3	0
Maximum number of Temperature/Humidity stations		2	0
Stored memory capacity:	5-Minute Update Interval	1 month	1 month
	15-Minute Update Interval	3 months	3 months
	60-Minute Update Interval	1 year	1 year
Compatible with repeaters		Yes	No
* When used to extend Vantage Pro2 anemometer from the ISS. Otherwise, 0.			
** Can use 2 only if one is leaf wetness and one is soil moisture.			





Your Remote Weather Data Solution

Vantage Connect is a self-contained, weather-resistant, solar-powered unit that comes with mounting hardware. Vantage Connect can be mounted on a Mounting Pole (#7717) or Mounting Tripod (#7716) and placed in areas where remote weather reporting is essential.

An annual service plan is required and hardware is subject to a one-time activation fee. Choose one of three update intervals.

INTEGRATED SENSOR SUITES



6322, 6323, 6327 and 6328 (shown)
Vantage Pro2 or Pro2 Plus
 (ISS only)
 \$405 – \$1050



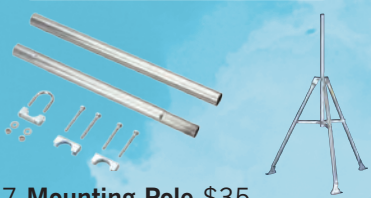
6357
Vantage Vue
 (ISS only)
 \$250

VANTAGE CONNECT



6620 **Vantage Connect** \$750
 6620C **Cabled Vantage Connect** \$750
 6645 **One-Time Activation Fee** \$25

INSTALLATION OPTIONS



7717 **Mounting Pole** \$35
 7716 **Mounting Tripod** \$85

CHOOSE YOUR PLAN (US ONLY)		
Update Interval	Product Number	Annual Service Charge
5 minutes	6632A	\$239.40
15 minutes	6634A	\$179.40
60 minutes	6636A	\$119.40

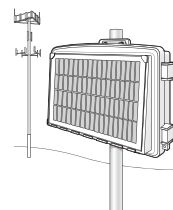
Computer system requirements:
 Windows XP and above. iPhone and Android compatible. Not compatible with Mac or Envoy 8X.



To place an order, or for additional information, please call us today at 800-678-3669.

View remote weather data from your home or office.

Vantage Connect®



6620, 6620C
6621, 6621C
6622, 6622C

Vantage Pro2™ Systems

Vantage Connect allows you to automatically upload data from a Davis Vantage Pro2™, Vantage Vue®, or other Vantage Pro2-compatible sensor suite to WeatherLink.com through the cellular network. With your own online account and a data plan, you can receive alarm e-mails when preset weather conditions occur, view data online or through a smart phone, or even download data into your PC with the WeatherLink® software. Vantage Connect must be mounted within cellular range and, if wireless, within radio transmission range of the transmitting station or retransmitting console.

Vantage Connect is available in both wireless and cabled versions, and in different packages depending on country of use. The data update interval is based on the purchased data plan. An annual data service plan is required. Select 5-minute, 15-minute, or 60-minute update plans. WeatherLink software is included.

General

Cellular Bands

GSM (6620, 6620C)	850, 900, 1800, 1900 MHz
CDMA (6621, 6621C)	800, 1900 MHz
3G UMTS (6622)	800, 850, 900, AWS1700, 1900, 2100 MHz

Operating Temperature -40° to +140°F; -40° to +60°C

Storage Temperature -40° to +140°F; -40° to +60°C

Average Current Draw 20 - 30 mA

Peak Current 2 A

Housing Material. Rugged ASA Plastic

Dimensions (width x length x height) 13.75 X 10 X 4.17 inches; 34.9 X 25.4 X 10.6 cm

Weight 8.14 lbs. (3.69 kg)

Solar Panel (@ 1000w/m²)

Nominal power	5 watt
Voc	21.6V
Isc	300mA
Vmp	18V
Imp	277mA

Battery

Replacement Part Number 7011.025

Battery Voltage. 6 volts

Battery Capacity. 12 Ah

Charging Temperature -4 to +120°F; -20 to +49°C

Estimated Battery Run Time (no solar charging, at 25°C)

Wireless 16 - 21 days

Cabled. 14 - 17 days

Charging Circuit

- High-efficiency switching charger
- Maximum-Peak-Power-Tracking (MPPT) at 18V - Typical for 12V solar-panel
- Charges 6V SLA battery @ 2A max
- Charging voltage temperature compensation
- Low- and high-temperature charging cut-out
- Low-battery load disconnect
- Reverse battery protection
- Designed to have multiple batteries and/or solar-panels added in parallel to extend capacities

Certifications

- FCC
- PTCRB
- CE
- Carrier

Sensor Data (internal sensors)

Barometric Pressure

Resolution and Units	0.01" Hg, 0.1 mm, 0.1 hPa, 0.1mb. (user selectable)
Range	16.00" to 32.50" Hg, 410 to 820 mm Hg, 540 to 1100 hPa or mb
Elevation Range	-1500' to +15,300' (-460 m to 4670 m)
Accuracy	
At -40° to +32°F (-40° to 0°C)	-0.06/+0.15" Hg (-1.5 /+3.8 mmHg; -2/+5 hPa/mb)
At +32° to +122°F (0° to +50°C)	±0.03" Hg (±0.8 mm Hg, ±1 hPa/mb)
At +122° to +140°F (+50° to +60°C)	-0.06/+0.15" Hg (-1.5 /+3.8 mmHg; -2/+5 hPa/mb)
Sea-Level Reduction Equation Used	United States Method employed prior to use of current "R Factor" method
Equation Source	Smithsonian Meteorological Tables
Equation Accuracy	±0.01" Hg (±0.3 mm Hg, ±0.3 hPa/mb)
Elevation Accuracy Required	±10' (3m) to meet equation accuracy specification
Trend (change in 3 hours)	Change ±0.06" (2.0 hPa/mb, 1.5 mm Hg) = Rapidly Change ±0.02" (0.7hPa/mb, 0.5 mm Hg) = Slowly
Trend Indication	5 position arrow: Rising (rapidly or slowly), Steady, or Falling (rapidly or slowly)
Update Interval	Based on data plan
Alarms	High Threshold from Current Trend for Storm Clearing (Rising Trend) Low Threshold from Current Trend for Storm Warning (Falling Trend)
Range for Rising and Falling Trend Alarms	0.01 to 0.25" Hg (0.1 to 6.4 mm Hg, 0.1 to 8.5 hPa/mb)

Inside Relative Humidity

Resolution and Units	1%
Range	1 to 100% RH
Accuracy	±3% from 1% to 90%; ±5% from 90% to 100%
Update Interval	Based on data plan
Alarms	High and Low Threshold from Instant Reading

Inside Temperature (or optional external temperature probe)

Resolution and Units	Current Data: 0.1°; °C is converted from °F and rounded to the nearest 0.1°C. Alarms: 1°; °C is converted from °F and rounded to the nearest 1°C.
Range	
Inside	-40° to +140°F (-40° to +60°C)
External Temperature Probe	-40° to +150°F (-40° to +65°C)
Sensor Accuracy	±1°F (±0.5°C) typical
Update Interval	Based on data plan
Alarms	High and Low Thresholds from Instant Reading

Weather Station Wireless Communications

Transmit/Receive Frequency

US Models	902.0 - 928.0 MHz FHSS
EU Models	868.0 - 868.6 MHz FHSS
Australia/Brazil Models	918.0 - 926.0 MHz FHSS
New Zealand Models	921.0 - 928.0 MHz FHSS
Japan Models	928.15 - 929.65 MHz FHSS
India Models	865.0 - 867.0 MHz FHSS

ID Codes Available 8

Range

Line of Sight	up to 1000 feet (300 m)
Through Walls	200 to 400 feet (60 to 120 m)

Package Dimensions

Product #	Package Dimensions (Length x Width x Height)	Package Weight	UPC Code
6620	15.0" x 11.5" x 5.5" 38.1 x 29.2 x 14.0 cm	10 lb. 10 oz 4.8 kg	011698 00989 3
6620C			011698 00995 4
6621			011698 01140 7
6621C			011698 01156 8
6622			011698 01167 4
6622C			011698 01248 0

**ATTACHMENT B
LEGAL STATUS OF OFFEROR**

(The Respondent shall fill out the provision and strike out the remaining ones.)

The Respondent is:

- A corporation organized and doing business under the laws of the state of _____, for whom _____ bearing the office title of _____, whose signature is affixed to this proposal, is authorized to execute contracts on behalf of respondent.*

*If not incorporated in Michigan, please attach the corporation's Certificate of Authority

- A limited liability company doing business under the laws of the State of _____, whom _____ bearing the title of _____ whose signature is affixed to this proposal, is authorized to execute contract on behalf of the LLC.
- A partnership organized under the laws of the State of _____ and _____ filed with the County of _____, whose members are (attach list including street and mailing address for each.)
- An individual, whose signature with address, is affixed to this RFP.

Respondent has examined the basic requirements of this RFP and its scope of services, including all Addendum (if applicable) and hereby agrees to offer the services as specified in the RFP.

_____, Date: _____,
Signature

(Print) Name _____ Title _____

Firm: _____

Address: _____

Contact Phone _____ Fax _____

Email _____

ATTACHMENT C
CITY OF ANN ARBOR DECLARATION OF COMPLIANCE

Non-Discrimination Ordinance

The "non discrimination by city contractors" provision of the City of Ann Arbor Non-Discrimination Ordinance (Ann Arbor City Code Chapter 112, Section 9:158) requires all contractors proposing to do business with the City to treat employees in a manner which provides equal employment opportunity and does not discriminate against any of their employees, any City employee working with them, or any applicant for employment on the basis of actual or perceived age, arrest record, color, disability, educational association, familial status, family responsibilities, gender expression, gender identity, genetic information, height, HIV status, marital status, national origin, political beliefs, race, religion, sex, sexual orientation, source of income, veteran status, victim of domestic violence or stalking, or weight. It also requires that the contractors include a similar provision in all subcontracts that they execute for City work or programs.

In addition the City Non-Discrimination Ordinance requires that all contractors proposing to do business with the City of Ann Arbor must satisfy the contract compliance administrative policy adopted by the City Administrator. A copy of that policy may be obtained from the Purchasing Manager

The Contractor agrees:

- (a) To comply with the terms of the City of Ann Arbor's Non-Discrimination Ordinance and contract compliance administrative policy.
- (b) To post the City of Ann Arbor's Non-Discrimination Ordinance Notice in every work place or other location in which employees or other persons are contracted to provide services under a contract with the City.
- (c) To provide documentation within the specified time frame in connection with any workforce verification, compliance review or complaint investigation.
- (d) To permit access to employees and work sites to City representatives for the purposes of monitoring compliance, or investigating complaints of non-compliance.

The undersigned states that he/she has the requisite authority to act on behalf of his/her employer in these matters and has offered to provide the services in accordance with the terms of the Ann Arbor Non-Discrimination Ordinance. The undersigned certifies that he/she has read and is familiar with the terms of the Non-Discrimination Ordinance, obligates the Contractor to those terms and acknowledges that if his/her employer is found to be in violation of Ordinance it may be subject to civil penalties and termination of the awarded contract.

Company Name

Signature of Authorized Representative

Date

Print Name and Title

Address, City, State, Zip

Phone/Email address

Questions about the Notice or the City Administrative Policy, Please contact:

Procurement Office of the City of Ann Arbor
(734) 794-6500

Revised 3/31/15 Rev. 0

NDO-2

**ATTACHMENT D
CITY OF ANN ARBOR
LIVING WAGE ORDINANCE DECLARATION OF COMPLIANCE**

The Ann Arbor Living Wage Ordinance (Section 1:811-1:821 of Chapter 23 of Title I of the Code) requires that an employer who is (a) a contractor providing services to or for the City for a value greater than \$10,000 for any twelve-month contract term, or (b) a recipient of federal, state, or local grant funding administered by the City for a value greater than \$10,000, or (c) a recipient of financial assistance awarded by the City for a value greater than \$10,000, shall pay its employees a prescribed minimum level of compensation (i.e., Living Wage) for the time those employees perform work on the contract or in connection with the grant or financial assistance. The Living Wage must be paid to these employees for the length of the contract/program.

<i>Companies employing fewer than 5 persons and non-profits employing fewer than 10 persons are exempt from compliance with the Living Wage Ordinance. If this exemption applies to your company/non-profit agency please check here ☐ No. of employees _____</i>
--

The Contractor or Grantee agrees:

- (a) To pay each of its employees whose wage level is not required to comply with federal, state or local prevailing wage law, for work covered or funded by a contract with or grant from the City, no less than the Living Wage. The current Living Wage is defined as \$17.42/hour for those employers that provide employee health care (as defined in the Ordinance at Section 1:815 Sec. 1 (a)), or no less than \$19.42/hour for those employers that do not provide health care. The Contractor or Grantor understands that the Living Wage is adjusted and established annually on April 30 in accordance with the Ordinance and covered employers shall be required to pay the adjusted amount thereafter to be in compliance with Section 1:815(3).

Check the applicable box below which applies to your workforce

- | | |
|--------------------------|---|
| ☐ | Employees who are assigned to any covered City contract/grant will be paid at or above the applicable living wage without health benefits |
| ☐ | Employees who are assigned to any covered City contract/grant will be paid at or above the applicable living wage with health benefits |

- (b) To post a notice approved by the City regarding the applicability of the Living Wage Ordinance in every work place or other location in which employees or other persons contracting for employment are working.
- (c) To provide to the City payroll records or other documentation within ten (10) business days from the receipt of a request by the City.
- (d) To permit access to work sites to City representatives for the purposes of monitoring compliance, and investigating complaints or non-compliance.
- (e) To take no action that would reduce the compensation, wages, fringe benefits, or leave available to any employee covered by the Living Wage Ordinance or any person contracted for employment and covered by the Living Wage Ordinance in order to pay the living wage required by the Living Wage Ordinance.

The undersigned states that he/she has the requisite authority to act on behalf of his/her employer in these matters and has offered to provide the services or agrees to accept financial assistance in accordance with the terms of the Living Wage Ordinance. The undersigned certifies that he/she has read and is familiar with the terms of the Living Wage Ordinance, obligates the Employer/Grantee to those terms and acknowledges that if his/her employer is found to be in violation of Ordinance it may be subject to civil penalties and termination of the awarded contract or grant of financial assistance.

Company Name

Street Address

Signature of Authorized Representative

Date

City, State, Zip

Print Name and Title

Phone/Email address



ATTACHMENT E

VENDOR CONFLICT OF INTEREST DISCLOSURE FORM

All vendors interested in conducting business with the City of Ann Arbor must complete and return the Vendor Conflict of Interest Disclosure Form in order to be eligible to be awarded a contract. Please note that all vendors are subject to comply with the City of Ann Arbor's conflict of interest policies as stated within the certification section below.

If a vendor has a relationship with a City of Ann Arbor official or employee, an immediate family member of a City of Ann Arbor official or employee, the vendor shall disclose the information required below.

1. No City official or employee or City employee's immediate family member has an ownership interest in vendor's company or is deriving personal financial gain from this contract.
2. No retired or separated City official or employee who has been retired or separated from the City for less than one (1) year has an ownership interest in vendor's Company.
3. No City employee is contemporaneously employed or prospectively to be employed with the vendor.
4. Vendor hereby declares it has not and will not provide gifts or hospitality of any dollar value or any other gratuities to any City employee or elected official to obtain or maintain a contract.
5. Please note any exceptions below:

Conflict of Interest Disclosure*	
Name of City of Ann Arbor employees, elected officials or immediate family members with whom there may be a potential conflict of interest.	☐ Relationship to employee
	☐ Interest in vendor's company
	☐ Other (please describe in box below)

*Disclosing a potential conflict of interest does not disqualify vendors. In the event vendors do not disclose potential conflicts of interest and they are detected by the City, vendor will be exempt from doing business with the City.

I certify that this Conflict of Interest Disclosure has been examined by me and that its contents are true and correct to my knowledge and belief and I have the authority to so certify on behalf of the Vendor by my signature below:		
Vendor Name		Vendor Phone Number
Signature of Vendor Authorized Representative	Date	Printed Name of Vendor Authorized Representative

ATTACHMENT F
CITY OF ANN ARBOR NON-DISCRIMINATION ORDINANCE

Relevant provisions of Chapter 112, Nondiscrimination, of the Ann Arbor City Code are included below.
You can review the entire ordinance at www.a2gov.org/humanrights.

Intent: It is the intent of the city that no individual be denied equal protection of the laws; nor shall any individual be denied the enjoyment of his or her civil or political rights or be discriminated against because of actual or perceived age, arrest record, color, disability, educational association, familial status, family responsibilities, gender expression, gender identity, genetic information, height, HIV status, marital status, national origin, political beliefs, race, religion, sex, sexual orientation, source of income, veteran status, victim of domestic violence or stalking, or weight.

Discriminatory Employment Practices: No person shall discriminate in the hire, employment, compensation, work classifications, conditions or terms, promotion or demotion, or termination of employment of any individual. No person shall discriminate in limiting membership, conditions of membership or termination of membership in any labor union or apprenticeship program.

Discriminatory Effects: No person shall adopt, enforce or employ any policy or requirement which has the effect of creating unequal opportunities according to actual or perceived age, arrest record, color, disability, educational association, familial status, family responsibilities, gender expression, gender identity, genetic information, height, HIV status, marital status, national origin, political beliefs, race, religion, sex, sexual orientation, source of income, veteran status, victim of domestic violence or stalking, or weight for an individual to obtain housing, employment or public accommodation, except for a bona fide business necessity. Such a necessity does not arise due to a mere inconvenience or because of suspected objection to such a person by neighbors, customers or other persons.

Nondiscrimination by City Contractors: All contractors proposing to do business with the City of Ann Arbor shall satisfy the contract compliance administrative policy adopted by the City Administrator in accordance with the guidelines of this section. All city contractors shall ensure that applicants are employed and that employees are treated during employment in a manner which provides equal employment opportunity and tends to eliminate inequality based upon any classification protected by this chapter. All contractors shall agree not to discriminate against an employee or applicant for employment with respect to hire, tenure, terms, conditions, or privileges of employment, or a matter directly or indirectly related to employment, because of any applicable protected classification. All contractors shall be required to post a copy of Ann Arbor's Non-Discrimination Ordinance at all work locations where its employees provide services under a contract with the city.

Complaint Procedure: If any individual believes there has been a violation of this chapter, he/she may file a complaint with the City's Human Rights Commission. The complaint must be filed within 180 calendar days from the date of the individual's knowledge of the allegedly discriminatory action or 180 calendar days from the date when the individual should have known of the allegedly discriminatory action. A complaint that is not filed within this timeframe cannot be considered by the Human Rights Commission. To file a complaint, first complete the complaint form, which is available at www.a2gov.org/humanrights. Then submit it to the Human Rights Commission by e-mail (hrc@a2gov.org), by mail (Ann Arbor Human Rights Commission, PO Box 8647, Ann Arbor, MI 48107), or in person (City Clerk's Office). For further information, please call the commission at 734-794-6141 or e-mail the commission at hrc@a2gov.org.

Private Actions For Damages or Injunctive Relief: To the extent allowed by law, an individual who is the victim of discriminatory action in violation of this chapter may bring a civil action for appropriate injunctive relief or damages or both against the person(s) who acted in violation of this chapter.

**THIS IS AN OFFICIAL GOVERNMENT NOTICE AND
MUST BE DISPLAYED WHERE EMPLOYEES CAN READILY SEE IT.**

ATTACHMENT G

CITY OF ANN ARBOR LIVING WAGE ORDINANCE

RATE EFFECTIVE APRIL 30, 2026 - ENDING APRIL 29, 2027

\$17.42 per hour

If the employer provides health care benefits*

\$19.42 per hour

If the employer does **NOT** provide health care benefits*

Employers providing services to or for the City of Ann Arbor or recipients of grants or financial assistance from the City of Ann Arbor for a value of more than \$10,000 in a twelve-month period of time must pay those employees performing work on a City of Ann Arbor contract or grant, the above living wage.

ENFORCEMENT

The City of Ann Arbor may recover back wages either administratively or through court action for the employees that have been underpaid in violation of the law. Persons denied payment of the living wage have the right to bring a civil action for damages in addition to any action taken by the City.

Violation of this Ordinance is punishable by fines of not more than \$500/violation plus costs, with each day being considered a separate violation. Additionally, the City of Ann Arbor has the right to modify, terminate, cancel or suspend a contract in the event of a violation of the Ordinance.

* Health Care benefits include those paid for by the employer or making an employer contribution toward the purchase of health care. The employee contribution must not exceed \$.50 an hour for an average work week; and the employer cost or contribution must equal no less than \$1/hr for the average work week.

The Law Requires Employers to Display This Poster Where Employees Can Readily See It.

**For Additional Information or to File a Complaint contact
Colin Spencer at 734/794-6500 or cspencer@a2gov.org**

APPENDIX A - SAMPLE CONTRACT

PROFESSIONAL SERVICES AGREEMENT BETWEEN [TBD] AND THE CITY OF ANN ARBOR FOR [TBD]

This agreement ("Agreement") is between the City of Ann Arbor, a Michigan municipal corporation, 301 E. Huron St. Ann Arbor, Michigan 48104 ("City"), and [TBD], a(n) [TBD] _____, [TBD], [TBD], [TBD] [TBD] ("Contractor"). City and Contractor agree as follows:

1. DEFINITIONS

Administering Service Area/Unit means [TBD].

Contract Administrator means [TBD], acting personally or through any assistants authorized by the Administrator/Manager of the Administering Service Area/Unit.

Deliverables means all documents, plans, specifications, reports, recommendations, and other materials developed for and delivered to City by Contractor under this Agreement.

Effective Date means the date this Agreement is signed by the last party to sign it.

Project means [TBD].

Services means [TBD] as further described in Exhibit A.

2. DURATION

- A. The obligations of this Agreement shall apply beginning on the Effective Date and this Agreement shall remain in effect until satisfactory completion of the Services unless terminated as provided for in this Agreement.

3. SERVICES

- A. Contractor shall perform all Services in compliance with this Agreement. The City retains the right to make changes to the quantities of Services within the general scope of the Agreement at any time by a written order. If the changes add to or deduct from the extent of the Services, the compensation shall be adjusted accordingly. All such changes shall be executed under the conditions of the original Agreement.
- B. Quality of Services under this Agreement shall be of the level of quality performed by persons regularly rendering this type of service. Determination of acceptable quality shall be made solely by the Contract Administrator.
- C. Contractor shall perform Services in compliance with all applicable statutory, regulatory, and contractual requirements now or hereafter in effect. Contractor shall also comply with and be subject to City policies applicable to independent contractors.

- D. Contractor may rely upon the accuracy of reports and surveys provided by the City, except when a defect should have been apparent to a reasonably competent professional or when Contractor has actual notice of a defect.

4. INDEPENDENT CONTRACTOR

- A. The parties agree that at all times and for all purposes under the terms of this Agreement each party's relationship to any other party shall be that of an independent contractor. Each party is solely responsible for the acts of its own employees, agents, and servants. No liability, right, or benefit arising out of any employer-employee relationship, either express or implied, shall arise or accrue to any party as a result of this Agreement.
- B. Contractor does not have any authority to execute any contract or agreement on behalf of the City, and is not granted any authority to assume or create any obligation or liability on the City's behalf, or to bind the City in any way.

5. COMPENSATION OF CONTRACTOR

- A. The total amount of compensation paid to Contractor under this Agreement shall not exceed \$0.00, which shall be paid upon invoice by Contractor to the City for services rendered according to the schedule in Exhibit B. Compensation of Contractor includes all reimbursable expenses unless a schedule of reimbursable expenses is included in an attached Exhibit B. Expenses outside those identified in the attached schedule must be approved in advance by the Contract Administrator.
- B. Payment shall be made monthly following receipt of invoices submitted by Contractor and approved by the Contract Administrator, unless a different payment schedule is specified in Exhibit B.
- C. Contractor shall be compensated for additional work or Services beyond those specified in this Agreement only when the scope of and compensation for the additional work or Services have received prior written approval of the Contract Administrator.
- D. Contractor shall keep complete records of work performed (e.g. tasks performed, hours allocated, etc.) so that the City may verify invoices submitted by Contractor. Such records shall be made available to the City upon request and submitted in summary form with each invoice.

6. INSURANCE/INDEMNIFICATION

- A. Contractor shall procure and maintain from the Effective Date or Commencement Date of this Agreement (whichever is earlier) through the conclusion of this Agreement, such insurance policies, including those required by this Agreement, as will protect itself and the City from all claims for bodily injury, death, or property damage that may arise under this Agreement; whether the act(s) or omission(s) giving rise to the claim were made by Contractor, Contractor's subcontractor, or anyone employed by Contractor

or Contractor's subcontractor directly or indirectly. Prior to commencement of work under this Agreement, Contractor shall provide documentation to the City demonstrating Contractor has obtained the policies and endorsements required by this Agreement. Contractor shall provide such documentation in a form and manner satisfactory to the City. Currently, the City requires insurance to be submitted through its contractor, myCOI. Contractor shall add registration@mycoitracking.com to its safe sender's list so that it will receive necessary communication from myCOI. When requested, Contractor shall provide the same documentation for its subcontractors.

- B. All insurance providers of Contractor shall be authorized to do business in the State of Michigan and shall carry and maintain a minimum rating assigned by A.M. Best & Company's Key Rating Guide of "A-" Overall and a minimum Financial Size Category of "V". Insurance policies and certificates issued by non-authorized insurance companies are not acceptable unless approved in writing by the City.
- C. To the fullest extent permitted by law, Contractor shall indemnify, defend, and hold the City and its officers, employees, and agents harmless from all suits, claims, judgments, and expenses, including attorney's fees, resulting or alleged to result, from an act or omission by Contractor or Contractor's employees or agents occurring in the performance or breach of this Agreement, except to the extent that any suit, claim, judgment, or expense are finally judicially determined to have resulted from the City's negligence, willful misconduct, or failure to comply with a material obligation of this Agreement. The obligations of this paragraph shall survive the expiration or termination of this Agreement.
- D. Contractor is required to have the following minimum insurance coverage:
1. Professional Liability Insurance or Errors and Omissions Insurance protecting Contractor and its employees - \$1,000,000.
 2. Commercial General Liability Insurance equivalent to, as a minimum, Insurance Services Office form CG 00 01 04 13 or current equivalent. The City of Ann Arbor shall be an additional insured. There shall be no added exclusions or limiting endorsements that diminish the City's protections as an additional insured under the policy.

\$1,000,000	Each occurrence as respect Bodily Injury Liability or Property Damage Liability, or both combined
\$2,000,000	Per project General Aggregate
\$1,000,000	Personal and Advertising Injury
 3. Worker's Compensation Insurance in accordance with all applicable state and federal statutes; also, Employers Liability Coverage for:

Bodily Injury by Accident - \$500,000 each accident
Bodily Injury by Disease - \$500,000 each employee
Bodily Injury by Disease - \$500,000 each policy limit
 4. Motor Vehicle Liability Insurance equivalent to, as a minimum, Insurance Services Office form CA 00 01 10 13 or current equivalent. Coverage shall include all owned vehicles, all non-owned vehicles and all hired vehicles. The

City of Ann Arbor shall be an additional insured. There shall be no added exclusions or limiting endorsements that diminish the City's protections as an additional insured under the policy. The limits of liability shall be \$1,000,000 for each occurrence as respects Bodily Injury Liability or Property Damage Liability, or both combined.

5. Umbrella/Excess Liability Insurance shall be provided to apply in excess of the Commercial General Liability, Employers Liability and the Motor Vehicle coverage enumerated above, for each occurrence and for aggregate in the amount of \$1,000,000.
- E. Commercial General Liability Insurance and Motor Vehicle Liability Insurance (if required by this Agreement) shall be considered primary as respects any other valid or collectible insurance that the City may possess, including any self-insured retentions the City may have; and any other insurance the City does possess shall be considered excess insurance only and shall not be required to contribute with this insurance. Contractor agrees to waive any right of recovery by its insurer against the City for any insurance listed herein.
- F. Insurance companies and policy forms are subject to approval of the City Attorney, which approval shall not be unreasonably withheld. Documentation must provide and demonstrate an unconditional and unqualified 30-day written notice of cancellation in favor of the City of Ann Arbor. Further, the documentation must explicitly state the following: (a) the policy number(s); name of insurance company; name(s), email address(es), and address(es) of the agent or authorized representative; name and address of insured; project name; policy expiration date; and specific coverage amounts; (b) any deductibles or self-insured retentions, which may be approved by the City in its sole discretion; (c) that the policy conforms to the requirements specified. Contractor shall furnish the City with satisfactory certificates of insurance and endorsements prior to commencement of any work. If any of the above coverages expire by their terms during the term of this Agreement, Contractor shall deliver proof of renewal and/or new policies and endorsements to the Administering Service Area/Unit at least ten days prior to the expiration date.

7. WAGE AND NONDISCRIMINATION REQUIREMENTS

- A. Nondiscrimination. Contractor shall comply, and require its subcontractors to comply, with the nondiscrimination provisions of MCL 37.2209. Contractor shall comply with the provisions of Section 9:158 of Chapter 112 of Ann Arbor City Code and assure that Contractor's applicants for employment and employees are treated in a manner which provides equal employment opportunity.
- B. Living Wage. If Contractor is a "covered employer" as defined in Chapter 23 of Ann Arbor City Code, Contractor must comply with the living wage provisions of Chapter 23 of Ann Arbor City Code, which requires Contractor to pay those employees providing Services to the City under this Agreement a "living wage," as defined in Section 1:815 of the Ann Arbor City Code, as adjusted in accordance with Section 1:815(3); to post a notice approved by the City of the applicability of Chapter 23 in every location in which regular or contract employees providing services under this Agreement are working; to maintain records of compliance; if requested by the City, to provide documentation to verify compliance; to take no action that would reduce the

compensation, wages, fringe benefits, or leave available to any employee or person contracted for employment in order to pay the living wage required by Section 1:815; and otherwise to comply with the requirements of Chapter 23.

8. REPRESENTATIONS AND WARRANTIES BY CONTRACTOR

- A. Contractor warrants that the quality of Services shall conform to the level of quality performed by persons regularly rendering this type of service.
- B. Contractor warrants that it has all the skills, experience, and professional and other licenses necessary to perform the Services.
- C. Contractor warrants that it has available, or will engage at its own expense, sufficient trained employees to provide the Services.
- D. Contractor warrants that it has no personal or financial interest in this Agreement other than the fee it is to receive under this Agreement. Contractor certifies that it will not acquire any such interest, direct or indirect, which would conflict in any manner with the performance of the Services. Contractor certifies that it does not and will not employ or engage any person with a personal or financial interest in this Agreement.
- E. Contractor warrants that it is not, and shall not become overdue or in default to the City for any contract, debt, or any other obligation to the City, including real and personal property taxes. Further Contractor agrees that the City shall have the right to set off any such debt against compensation awarded for Services under this Agreement.
- F. Contractor warrants that its bid or proposal for services under this Agreement was made in good faith, that it arrived at the costs of its proposal independently, without consultation, communication, or agreement for the purpose of restricting competition as to any matter relating to such costs with any competitor for these services; and no attempt has been made or will be made by Contractor to induce any other person or entity to submit or not to submit a bid or proposal for the purpose of restricting competition.
- G. The person signing this Agreement on behalf of Contractor represents and warrants that they have express authority to sign this Agreement for Contractor and agrees to hold the City harmless for any costs or consequences of the absence of actual authority to sign.
- H. The obligations, representations, and warranties of this section 8 shall survive the expiration or termination of this Agreement.

9. OBLIGATIONS OF THE CITY

- A. The City shall give Contractor access to City properties and project areas as required to perform the Services.
- B. The City shall notify Contractor of any defect in the Services of which the Contract Administrator has actual notice.

10. ASSIGNMENT

- A. Contractor shall not subcontract or assign any portion of any right or obligation under this Agreement without prior written consent from the City. Notwithstanding any consent by the City to any assignment, Contractor shall at all times remain bound to all warranties, certifications, indemnifications, promises, and performances required of Contractor under the Agreement unless specifically released from the requirement in writing by the City.
- B. Contractor shall retain the right to pledge payments due and payable under this Agreement to third parties.

11. TERMINATION OF AGREEMENT

- A. If either party is in breach of this Agreement for a period of 15 days following receipt of notice from the non-breaching party with respect to the breach, the non-breaching party may pursue any remedies available against the breaching party under applicable law, including the right to terminate this Agreement without further notice. The waiver of any breach by any party to this Agreement shall not waive any subsequent breach by any party.
- B. The City may terminate this Agreement, on at least 30 days' advance notice, for any reason, including convenience, without incurring any penalty, expense, or liability to Contractor, except the obligation to pay for Services actually performed under the Agreement before the termination date.
- C. Contractor acknowledges that if this Agreement extends for several fiscal years, continuation of this Agreement is subject to appropriation of funds through the City budget process. If funds are not appropriated or otherwise made available, the City shall have the right to terminate this Agreement without penalty at the end of the last period for which funds have been appropriated or otherwise made available by giving written notice of termination to Contractor. The Contract Administrator shall give Contractor written notice of such non-appropriation within 30 days after the Contract Administrator has received notice of such non-appropriation.
- D. The expiration or termination of this Agreement shall not release either party from any obligation or liability to the other party that has accrued at the time of expiration or termination, including a payment obligation that has already accrued and Contractor's obligation to deliver all Deliverables due as of the date of termination of the Agreement.

12. REMEDIES

- A. This Agreement does not, and is not intended to, impair, divest, delegate, or contravene any constitutional, statutory, or other legal right, privilege, power, obligation, duty, or immunity of the parties.
- B. All rights and remedies provided in this Agreement are cumulative and not exclusive, and the exercise by either party of any right or remedy does not preclude the exercise

of any other rights or remedies that may now or subsequently be available at law, in equity, by statute, in any other agreement between the parties, or otherwise.

- C. Absent a written waiver, no act, failure, or delay by a party to pursue or enforce any right or remedy under this Agreement shall constitute a waiver of that right with regard to any existing or subsequent breach of this Agreement. No waiver of any term, condition, or provision of this Agreement, whether by conduct or otherwise, shall be deemed or construed as a continuing waiver of any term, condition, or provision of this Agreement. No waiver by either party shall subsequently affect the waiving party's right to require strict performance of this Agreement.

13. NOTICE

All notices and submissions required under this Agreement shall be delivered to the respective party in the manner described herein to the address stated below or such other address as either party may designate by prior written notice to the other. Notices given under this Agreement shall be in writing and shall be personally delivered, sent by next day express delivery service, certified mail, or first class U.S. mail postage prepaid, and addressed to the person listed below. Notice will be deemed given on the date when one of the following first occur: (1) the date of actual receipt; (2) the next business day when notice is sent next day express delivery service or personal delivery; or (3) three days after mailing first class or certified U.S. mail.

If Notice is sent to Contractor:

[TBD]
ATTN: [TBD]
[TBD]
[TBD], [TBD] [TBD]

If Notice is sent to the City:

City of Ann Arbor
ATTN: [TBD]
301 E. Huron St.
Ann Arbor, Michigan 48104

With a copy to: The City of Ann Arbor
ATTN: Office of the City Attorney
301 East Huron Street, 3rd Floor
Ann Arbor, Michigan 48104

14. CHOICE OF LAW AND FORUM

This Agreement will be governed and controlled in all respects by the laws of the State of Michigan, including interpretation, enforceability, validity and construction, excepting the principles of conflicts of law. The parties submit to the jurisdiction and venue of the Circuit Court for Washtenaw County, State of Michigan, or, if original jurisdiction can be established, the United States District Court for the Eastern District of Michigan, Southern Division, with respect to any action arising, directly or indirectly, out of this Agreement or the performance or breach of this Agreement. The parties stipulate that the venues referenced in this Agreement are convenient

and waive any claim of non-convenience.

15. OWNERSHIP OF DOCUMENTS

Upon completion or termination of this Agreement, all Deliverables prepared by or obtained by Contractor as provided under the terms of this Agreement shall be delivered to and become the property of the City. Original basic survey notes, sketches, charts, drawings, partially completed drawings, computations, quantities, and other data shall remain in the possession of Contractor as instruments of service unless specifically incorporated in a Deliverable, but shall be made available, upon request, to the City without restriction or limitation on their use. The City acknowledges that the documents are prepared only for the Services. Prior to completion of the Services the City shall have a recognized proprietary interest in the work product of Contractor.

16. CONFLICTS OF INTEREST OR REPRESENTATION

Contractor certifies it has no financial interest in the Services to be provided under this Agreement other than the compensation specified herein. Contractor further certifies that it presently has no personal or financial interest, and shall not acquire any such interest, direct or indirect, which would conflict in any manner with its performance of the Services under this Agreement.

Contractor agrees to advise the City if Contractor has been or is retained to handle any matter in which its representation is adverse to the City and to obtain the City's consent therefor. The City's prospective consent to Contractor's representation of a client in matters adverse to the City, as identified above, will not apply in any instance where, as the result of Contractor's representation, Contractor has obtained sensitive, proprietary, or otherwise confidential information of a non-public nature that, if known to another client of Contractor, could be used in any such other matter by the other client to the material disadvantage of the City. Each matter will be reviewed on a case by case basis.

17. SEVERABILITY OF PROVISIONS

Whenever possible, each provision of this Agreement will be interpreted in a manner as to be effective and valid under applicable law. However, if any provision of this Agreement or the application of any provision to any party or circumstance is prohibited by or invalid under applicable law, that provision will be ineffective to the extent of the prohibition or invalidity without invalidating the remainder of the provisions of this Agreement or the application of the provision to other parties and circumstances.

18. EXTENT OF AGREEMENT

This Agreement, together with all Exhibits constitutes the entire understanding between the City and Contractor with respect to the subject matter of the Agreement and it supersedes, unless otherwise incorporated by reference herein, all prior representations, negotiations, agreements, or understandings, whether written or oral. Neither party has relied on any prior representations in entering into this Agreement. No terms or conditions of either party's invoice, purchase order, or other administrative document shall modify the terms and conditions of this Agreement, regardless of the other party's failure to object to such terms or conditions. This Agreement shall be binding on and shall inure to the benefit of the parties to this Agreement and their permitted

successors and permitted assigns and nothing in this Agreement, express or implied, is intended to or shall confer on any other person or entity any legal or equitable right, benefit, or remedy of any nature whatsoever under or by reason of this Agreement. This Agreement may only be altered, amended, or modified by written amendment signed by Contractor and the City. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be deemed to be one and the same agreement.

19. ELECTRONIC TRANSACTION

The parties agree that signatures on this Agreement may be delivered electronically or by facsimile in lieu of an physical signature and agree to treat electronic or facsimile signatures as binding.

[REMAINDER OF PAGE INTENTIONALLY LEFT BLANK; SIGNATURE PAGES FOLLOW]

[TBD]

CITY OF ANN ARBOR

By: _____

Name: _____

Title: _____

Date: _____

By: _____

Name: Milton Dohoney Jr.

Title: City Administrator

Date: _____

Approved as to substance:

By: _____

Name: _____

Title: _____

Date: _____

Approved as to form:

By: _____

Name: Atleen Kaur

Title: City Attorney

Date: _____

EXHIBIT A
Scope of Services

EXHIBIT B
Compensation