MONITORING WASTEWATER TO INFORM COVID-19 PUBLIC HEALTH RESPONSE

A guide to methods and lessons learned from Healthy Davis Together's experience in Davis, CA

HEALTHY DAVIS TOGETHER

Davis California

UCDAVIS UNIVERSITY OF CALIFORNIA

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EXECUTIVE SUMMARY

Monitoring for the presence of SARS-CoV-2, the virus that causes COVID-19, in wastewater can inform our understanding of the environmental dynamics of SARS-CoV-2 with differing degrees of temporal and spatial resolution. Wastewater monitoring of SARS-CoV-2 serves as a complementary tool to clinical testing, with advantages that include reduced costs due to population-level testing and early detection of outbreaks. Trends in the viral load can be monitored at a citywide scale or at smaller, neighborhood scales by regularly testing samples from wastewater treatment plants and autosamplers placed within a sewage system.

This playbook provides on overview of:

- Wastewater monitoring as an effective public health tool to track trends and prevent the spread of the SARS-CoV-2 virus;
- How we are implementing wastewater monitoring as part of Healthy Davis Together;
- How communities can establish their own wastewater monitoring program; and,
- Additional wastewater monitoring research and resources.

It is intended to inform and guide city managers, county public health officials, public works directors, and other municipal leaders in their efforts to implement and activate a wastewater monitoring program.

HDT's publication, **Safer School Reopenings: A Guide to Returning to In-Person Learning During COVID-19**, details our work with air filter and surface monitoring.

How can wastewater help us manage the pandemic?

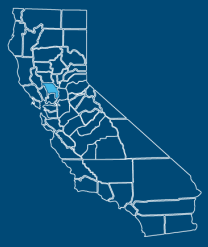
SCALE OF MONITORING	COMMUNICATIONS WHEN ACTION THRESHOLD IS REACHED
REGIONAL  Regional (e.g. Central Valley)  County	• Inform state public health departments
CITY  Wastewater treatment plant  Primary clarifier	• Local press release and media outreach • City-wide alert to all residents • Email, social media, website updates
SUB-CITY  Neighborhoods  University campus  Building complexes	• Neighborhood text or email alerts • Neighborhood listservs (e.g., Nextdoor) • Geo-targeted advertising
BUILDING  Schools  Dorms  Facility	• Door-to-door information drops (e.g. flyers, door hangers) • Deploy mobile/pop-up testing site

Figure 1. A summary of the relationship between monitoring scale and communications strategies

PART I: THE VALUE OF WASTEWATER MONITORING

Background

The idea of using wastewater as an information source for public health surveillance has been gaining popularity since the early 2000s. The concept builds on research and practices that examine wastewater for the presence of pathogens—the bacteria, viruses, and other microorganisms that cause disease—to assess the effectiveness of wastewater treatment processes. Advances in molecular biology techniques have made it easier to reliably detect pathogens of interest in wastewater, including several viruses responsible for **high-profile disease outbreaks.** In these cases, collected wastewater samples are concentrated and extracted in the laboratory. Analysis is accomplished using quantitative polymerase chain reaction (qPCR), where the presence and abundance of the genetic markers of pathogens are tested. Wastewater surveillance has demonstrated promise for monitoring hepatitis A, norovirus, and H1N1 (swine) flu in human populations and has become a **central component** of global efforts to eradicate polio.

In March of 2020, researchers in the Netherlands reported the **first detection of SARS-CoV-2** in municipal sewage. The potential of wastewater surveillance to inform COVID-19 response has since been widely recognized by scientists including public health experts, and government officials. Wastewater surveillance of COVID-19 offers **four key advantages**:

1. **Provides an early warning system.** SARS-CoV-2 can be detected in the excrement of at least half of people who have COVID-19 **three to seven days** in advance for pre-symptomatic and asymptomatic individuals. Approximately half of all COVID-19 infections have been attributed to **asymptomatic or pre-symptomatic transmission**. Escalating levels of SARS-CoV-2 in sewage therefore provides an early warning that COVID-19 may be spreading in a community.
2. **Generates population-wide data.** One wastewater sample can provide aggregated data for thousands or millions of people. These data are especially useful in regions with low individual testing rates (e.g., due to limited participation in testing, laboratory capacity, or supply constraints), and can provide complementary data when individual testing rates are high (e.g., to identify spikes in infection from asymptomatic cases).
3. **Is low-cost.** Collecting and testing a small number of wastewater samples is much less costly than individually testing thousands of patients to obtain population-wide data.
4. **Is less biased in capturing broad trends.** Individual testing data have an inherent selection bias: data exists only for those people who choose to get tested, participation is influenced by testing availability, and many people who do not show symptoms might not get tested. By contrast, wastewater surveillance provides data on the prevalence of SARS-CoV-2 in entire communities.

Differences Between Wastewater Monitoring Scales

Wastewater samples can be collected from different locations in a sewer network to generate aggregated data that represents city, sub-city, and building scales. Data collected at each scale offers a unique public health perspective. City-scale data can help officials prioritize resources and inform policy decisions. For example, a spike in the concentration of SARS-CoV-2 in a city's wastewater treatment plant (WWTP) could justify increasing clinical testing across the entire city and/or collecting additional wastewater samples from upstream collection sites (sub-city or building locations) to try to pinpoint specific neighborhoods where COVID-19 is spreading. By contrast, sustained low concentrations of SARS-CoV-2 in wastewater could justify looser restrictions on economic and social activities. Monitoring at the sub-city and building scales can be used to develop targeted messaging to neighborhoods or buildings with elevated concentrations. A summary of the advantages and limitations of applying wastewater monitoring at these three scales is presented in Table 1.

Table 1. Advantages and Limitations of Wastewater Monitoring At The City, Sub-city, and Building Scales

Scale	Description	Advantages	Limitations
City scale	Samples are collected from the influent or primary clarifier sludge of a wastewater treatment plant (WWTP) serving the city. to conduct large-scale testing	• Provides a low-cost way to capture aggregated, unbiased data on virus trends for a large geographic area. • WWTP influent and primary sludge are typically well mixed, meaning that the concentration of virus detected in samples is a more reliable indicator of the true concentration of the virus at the point of interest. • Removal of large solids and debris upstream of sampling points decreases potential for sampler clogging. • Almost all WWTPs routinely collect samples of influent and primary sludge for other purposes. Building on existing sampling infrastructure and workflows is an efficient use of resources and can facilitate high-frequency (e.g., daily) monitoring. • City-scale data is useful for informing broad monitoring, intervention, and reopening strategies.	• Potential for virus signal to degrade during the time that wastewater is in transit from point of outflow to WWTP. • In combined sewer systems, inflow from stormwater and industrial water may dilute virus signal to below detection limits. • Aggregated results provide limited opportunities for targeted follow-ups.

Scale	Description	Advantages	Limitations
Sub-city scale	Samples are collected from the city sewer system via maintenance holes. Collection points are strategically selected to isolate wastewater contributions from specific sub-regions or neighborhoods.	• Provides a low-cost way to capture unbiased data on virus trends within a city sub-region or neighborhood. • Comparing data collected from different parts of a city over time provides insight into dynamics of virus spread. • Monitoring can be targeted at high-priority areas, such as neighborhoods where testing and/or vaccination rates are low, or communities are especially vulnerable to infection. • Response strategies can be effectively tailored (e.g., working with community ambassadors to disseminate information, sending geographically targeted email/ text alerts, etc.).	• Potential for virus signal to degrade during the time that wastewater is in transit from point of outflow to WWTP. • In combined sewer systems, inflow from stormwater and industrial water may dilute virus signal to below detection limits. • Aggregated results provide limited opportunities for targeted follow-ups.
Building scale	Samples are collected from a maintenance hole or building cleanout to isolate individual buildings or facilities (e.g., university dorms, schools, skilled nursing facility, apartment complexes, prisons, etc.).	• Provides a low-cost way to capture unbiased data on virus trends for the users or inhabitants of a building. • If building-scale wastewater samples produce positive results, it is feasible to individually test most or all building users to identify and isolate infected individuals. • Communications strategies can be tailored to support different contexts.	• Costs of equipment (e.g., autosamplers) and personnel time required can be substantial. • • Interference from debris may clog autosamplers. Low flow from buildings may lead to inconsistent sampling. • At such a granular scale, data are likely to be noisy and impacted by small numbers of individuals. • Building-scale monitoring may raise privacy concerns.

Community Readiness Checklist

Each community should assess its readiness to implement a wastewater monitoring program, accounting for the scales of monitoring desired. After determining which scale or scales will be appropriate for the community, gaps in the current infrastructure should be identified as well as the investments required to update.

Table 2. The Implementation Requirements, Costs, and Considerations by Monitoring Scale

Scale of monitoring	Infrastructure Requirements	Associated Costs	Execution Considerations
City scale	Centralized wastewater treatment facility	Personnel time to collect and transport samples, laboratory expense to analyze samples, communications/web development team to share results publicly.	Appropriate buy-in from city, county, and other authorities with oversight of public health information, wastewater management, and the possible responses that may be implemented within the city or community served by the treatment plant.
Sub-city scale	Sanitary sewer system (septic systems are excluded). Sufficient autosamplers to collect samples from within the city/community and qualified personnel to access manholes and stop traffic as needed	Similar to city scale but with significantly greater costs due to increased sampling compared to collection from wastewater treatment plants.	Same as above, but with increased stakeholder engagement to target communications for specific regions being monitored.
Building scale	Sufficient autosamplers to collect samples at each building location	Similar to the sub-city scale.	Authority to intervene within the building (e.g. a university quarantining a dormitory based on strong positive testing).
Combination of scales	Infrastructure of at least two of the above scales	Same as above across scales.	Same as above across scales

PART II: WHAT WE ARE DOING IN DAVIS, CA

Healthy Davis Together (HDT), a joint project between UC Davis and the City of Davis, collects wastewater samples from "nodes" within the city's sewer system and monitors the City of Davis and the UC Davis Wastewater Treatment Plants (Figure 3). To date, HDT has collected and processed over 1,200 samples for SARS-CoV-2 analysis. Samples are collected three times per week at 24 sewer nodes in the city and seven days per week from wastewater influent at the City of Davis and UC Davis WWTPs. Samples are also collected weekly from 22 nodes within the UC Davis campus sewer system to monitor campus residence halls. The entire process from sample collection to final delivery of laboratory results typically takes about 24 hours. In addition, HDT is working with a **consortium** to monitor daily samples from the City of Davis WWTP primary sludge clarifier as part of a regional network of eight municipal wastewater treatment plants in northern California.

Several communications and response strategies have been implemented as part of HDT's wastewater monitoring program in the City of Davis (see Resources section for several examples). HDT formed a Wastewater Action Committee (WAC) to coordinate communications of all wastewater results between HDT scientists and City leadership on a weekly basis and to develop and implement responses to wastewater results. The WAC includes the Public Works Utilities and Operations Director, the Director of Business and Community Engagement, and the Chief of Police. Press releases have introduced the wastewater monitoring program, invited community members to opt into the Yolo Alert messaging system to receive notifications when elevations are detected, and detailed changes in the program through time. HDT posts results on its **website**, broken down by sampling region to keep the public informed each week (Figure 4). Virus levels in wastewater that exceed pre-defined action thresholds are reviewed by the WAC. For instance, in March 2021, a sustained increase in virus levels from a single sewer node indicated rising levels in a specific region of the city. The City of Davis used its opt-in text message alert system (Yolo Alert) to notify residents within the associated neighborhood. The City also posted information on virus detection in the neighborhood's wastewater via Nextdoor. Community members are encouraged to register through the Yolo Alert system to receive important wastewater updates of this kind.

Results from building scale monitoring on the UC Davis campus support the campus COVID-19 response. Results are communicated to campus leadership twice per week by email using a tiered action-level communications system (see Resources section). Virus levels that exceed action levels for wastewater from residence halls trigger campus representatives to evaluate student compliance with individual testing requirements on campus and to send email messages to residents of the impacted buildings if needed. Implementation and operation of wastewater monitoring is coordinated during bi-weekly meetings that include the Associate Vice Chancellor of Safety Services, the Director of Facility Services for Student Housing Administration, the Director of Utilities, the Wastewater Superintendent, the faculty director of the wastewater monitoring research team, and engineering and research staff.

Overall, the targeted responses to regions of the city and to campus are intended to encourage people living in the impacted areas to get tested for COVID-19 using HDT's free asymptomatic testing stations. HDT will continue wastewater monitoring at least through the end of 2021.

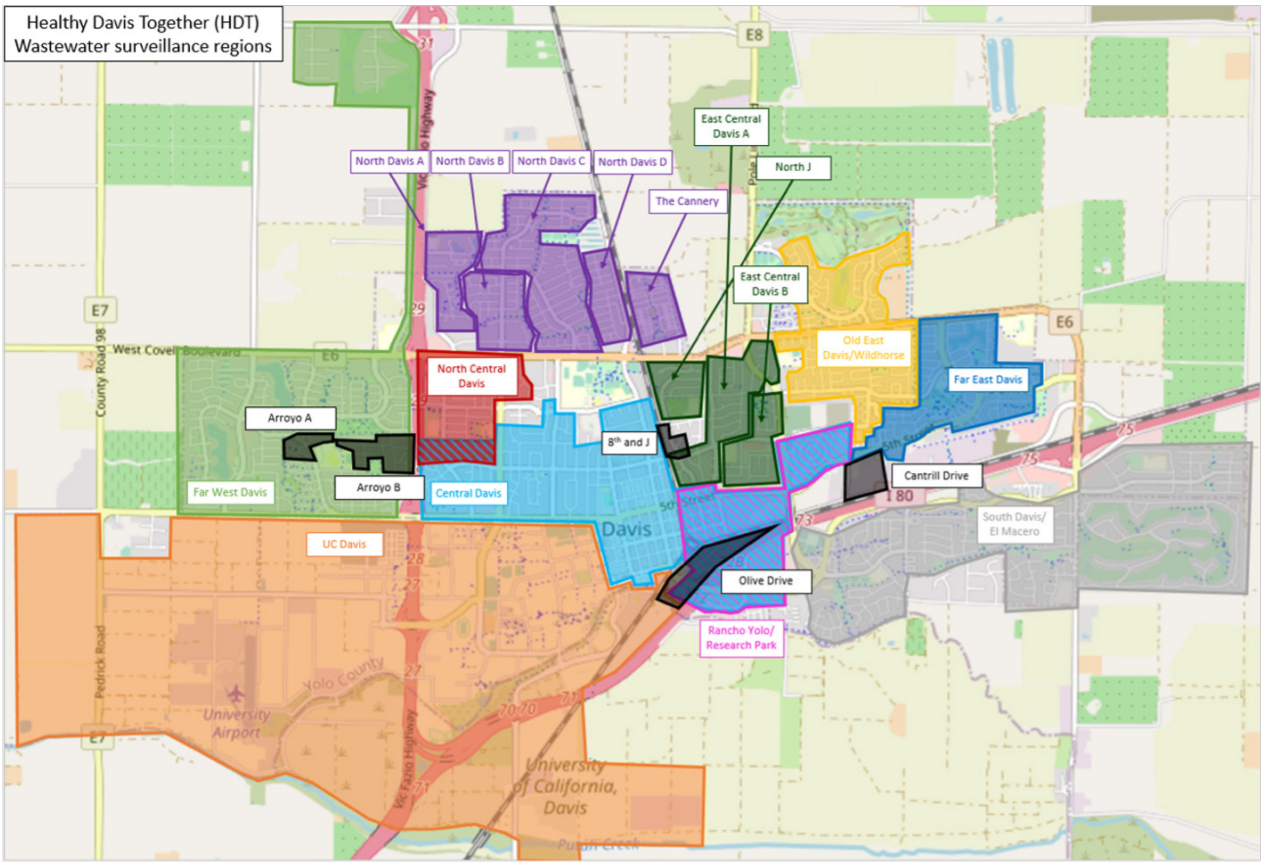


Figure 2. Map of the regions of the City of Davis monitored for SARS-CoV-2 with wastewater monitoring.

Lessons Learned

Communication is critical to realize the value of wastewater monitoring and mobilize the public to respond. Aligning on action thresholds and communication protocols early in the program will facilitate efficient information sharing through trusted channels (e.g., city government emails, websites, and newsletters). Prior to initiating targeted responses to wastewater signals, trusted public health experts can engage in community forums to explain the purpose of wastewater monitoring and answer questions from community members. News stories (print, radio, TV) and social media can then be used to alert the public and encourage testing in response to rising wastewater signals.

In developing action thresholds and response protocols, stakeholders should be aware of the variability and uncertainty inherent in environmental monitoring data. The complexity of the wastewater matrix introduces analytical challenges. Different methods of sample collection, concentration, extraction, analysis, and controls must be considered when comparing results from different regions. HDT has favored taking proactive measures in response to rising signals in wastewater, while recognizing that the science of wastewater monitoring is evolving. Limited availability of supplies and reagents necessary for wastewater monitoring can also delay the delivery of timely results and impact the capacity of a wastewater monitoring program. Additional lessons learned from wastewater surveillance on **college campuses** provide insights from efforts across the county.

HDT's experience points to three key planning needs for a wastewater monitoring program to facilitate effective decision-making and action in response to wastewater monitoring results:

1. **Determining thresholds for initiating responses to virus detection.** At the time of publication, guidance on setting action thresholds based on wastewater results has not been established nor standardized. Researchers are in the process of building greater statistical rigor into analyses of wastewater data to develop data-drive action strategies. The following strategies provide a glimpse into HDT's approaches for interpreting and acting upon data from wastewater monitoring. Currently, HDT is using three approaches to exercise flexibility and meet a range of threshold detection practices:

    a. **Start of Pandemic or Virus Reemergence:** In this approach, an action threshold is reached when virus concentrations at a sampling location are first detected above the limit of detection. In practice, the new detection should be observed over multiple sampling time points to provide evidence of a sustained increase over previously negative results. At a city-scale, the most applicable use of this approach is at the beginning of a pandemic, or in the event of a virus reemergence, to determine if the virus has entered a community. When wastewater viral detection changes from "nothing to something," local city governments and public health officials are immediately notified to begin mobilizing public health resources. HDT has also applied this approach throughout the pandemic at sub-city and building scales. Samples representing smaller populations more frequently yield non-detect results, and an increase in virus levels above the detection limit represents a significant and easily identifiable change in the data.

    b. **Slope Comparison:** When COVID-19 incidence is high enough in a sampling region to yield consistently positive wastewater results, changes in wastewater can be tracked over time to understand how viral infections are changing within the community. Typically, trends are evaluated using SARS-CoV-2 wastewater concentrations normalized by the concentration of a human fecal indicator. The human fecal indicator accounts for changes in wastewater dilution (e.g., due to showers or rain) and relative inputs of human waste (e.g., due to changes in population over the surveillance period). HDT currently applies this method to denote on the HDT website if levels in each sampling region are increasing, staying about the same, or decreasing. The slope of a two-week moving average (Figure 4) is evaluated to compare the current level of virus to the weeks prior. If resources allow, greater sampling frequency can provide increased resolution of the data and enables more reliable identification of changes.

    c. **Absolute Value:** An alternative to the slope comparison approach is to report and compare the highest absolute normalized values of detection. HDT has used this method to identify priority regions within the city to target communication interventions. This method helps interpret relative risk levels in different regions where testing and/or vaccination rates are low or where communities may be especially vulnerable to infection. One challenge with this approach is communicating the complexity and nuance of the calculated metric, which cannot be used to calculate the number of infections in a region. Communications must balance accuracy, clarity, and appropriateness for public consumption

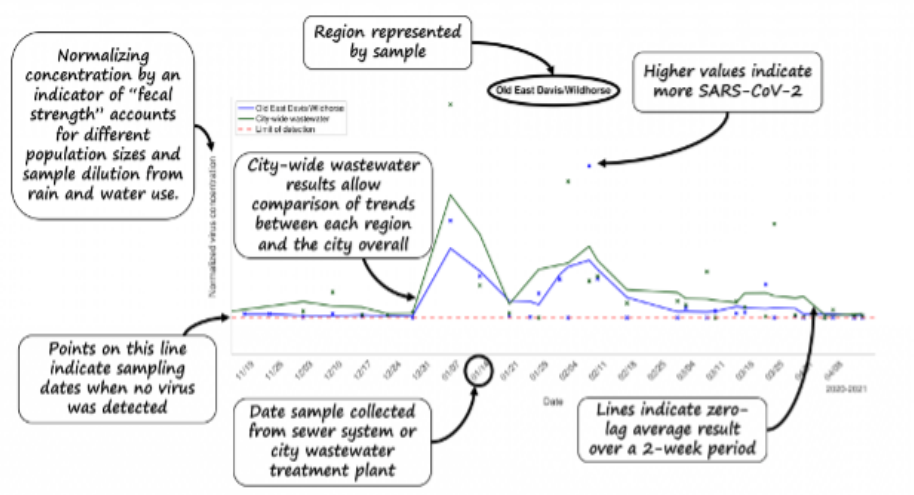


Figure 3. Example of the neighborhood wastewater monitoring results with instructions to aid in understanding.

2. **Developing action protocols.** Developing a portfolio of response strategies and implementation protocols facilitates readiness for when established wastewater action thresholds are reached at different monitoring scales. HDT views data from sampling within the city's sewer system and the City's WWTP together to evaluate potential explanations for the observed data in the context of other data sources (e.g., clinical testing capacity and usage, vaccination rates in different regions, and demographic data). Access to clinical testing for COVID-19 is a key component to an effective action protocol for wastewater monitoring. HDT's publication, **Blueprint for Community COVID-19 Testing** provides a guide to policies, procedures, and methods for developing a COVID-19 testing program. In addition to communications plans discussed in further detail below, clinical testing capacity and environmental monitoring sampling locations could be adjusted in response to wastewater data in the following ways:

    a. **In response to data from city wastewater treatment plants:** Consider increasing clinical testing capacity across town through increased hours and/or deploying mobile testing units. Additional autosamplers could be deployed throughout the sewer system or at key buildings to help locate the source of elevated signals or to rule out regions.

    b. **In response to data from one or a few nodes in the city:** In the case of a sustained increase in virus levels in the wastewater of a particular neighborhood relative to the WWTP, it is reasonable to conclude that infected individuals are present in the neighborhood(s) at a rate greater than the overall city. Depending on the size of the impacted area and the level of increase detected, consider increasing capacity for clinical testing through increased hours of operation or by deploying mobile testing units. Increasing sampling frequency in neighborhoods would increase resolution to locate source of increase.

    c. **In response to building-scale data:** For building-level monitoring, **point-of-care** diagnostic tests (e.g., at school health clinics) or **self-tests** provide options for rapid COVID-19 testing that could be deployed with relatively low infrastructure investments. Additional environmental monitoring (e.g., collection of air filters swabs) could also help identify the origin of the outbreak within a building.

3. **Establishing a plan for communications.** HDT built communications about wastewater monitoring into the program from its initiation. Clear messages about what wastewater sampling is, how it is done, and how it can serve as an early detection system help educate community members and generate interest in receiving regular wastewater updates. Equally important is establishing a review and approval process for City leaders and other stakeholders involved in the implementation of the wastewater monitoring program. If an action threshold is reached, the appropriate city officials are notified immediately and the agreed upon communications process activated. Depending on the area affected, additional stakeholders (e.g., community-based organizations) may be notified and engaged in communication efforts. For HDT and the City of Davis, communications plans were developed to respond to wastewater data at the city and sub-city scales in the following ways.

    a. **For the city wastewater treatment plant:**

        - Conducting outreach to local media and interviews with HDT or City spokespersons
        - Leveraging HDT and City communications channels (email, social, websites) to raise awareness, encourage testing, and reinforce healthy behaviors
        - Increasing advertising across the city to encourage appropriate behaviors and to get a free screening test at HDT or on the UC Davis campus.
        - Establishing a protocol to send a City-wide alert to all residents through the Yolo Alert messaging system.

    b. **For one or a few nodes in the city sewer system:**

        - Sending neighborhood text or email alerts
        - Leveraging neighborhood listservs like Nextdoor
        - Placing geo-targeted advertising
        - Conducting door-to-door information drops (e.g. flyers, door hangers)
        - Deploying HDT mobile testing team for a pop-up testing site

PART III: SETTING UP A WASTEWATER MONITORING PROGRAM

Step 1: Identify program lead and engage key stakeholders

Identify an Overall Program Lead to guide the entire wastewater monitoring program. Engage with other key stakeholders, such as local commercial labs, the city's public works department, the county's public health department, and other local health authorities. Host a meeting to discuss the potential applications of wastewater monitoring and to evaluate potential benefits to community health. Spark discussion on program roles and responsibilities. See below for a recommended list of stakeholders and role assignments.

Table 3. A Suggested Roster of Key Stakeholders to Engage

Key Stakeholders	Expected Role
City Manager	Overall Program Lead
Director of Public Works	Program Steering Committee member
County Public Health Officer	Program Steering Committee member
Public Works Operations Manager	Program Steering Committee member
Wastewater Treatment Plant Facilities Director	Program Steering Committee member
Emergency Operations Committee	Program Steering Committee member(s)
City Communications Lead	Communications Lead
Wastewater Treatment Plant Lab Manager	Program Scope Development Co-Lead
Wastewater Operations Manager/Engineer	Program Scope Development Co-Lead
Representatives from Commercial Labs	Sampling and Analysis Lead
Utilities Director (Building-level)	Building Sampling Analysis

Step 2: Develop wastewater monitoring program scope

Once leadership roles are assigned, work with the team to appropriately scope the community's wastewater monitoring program. Communicate the benefits, challenges, and limitations of each scale or combination of scales in relation to your local community's infrastructure and select the optimal scale(s) for sampling. Discuss and align on the regions to monitor, commercial lab vs. in-house sampling and analysis, and program staff roles required. Consult the section on "Considerations for Implementation" to guide program considerations for action thresholds, action protocols, and communication plans. Generate a preliminary budget with estimated costs for set up, equipment, maintenance, and staff to help secure appropriate funding. The table below captures HDT's current staff roles to help guide your municipality's hiring decisions and compensation. Since the program's inception, HDT has received significant financial support with plans to expand beyond the original scope, signaling the need for flexibility and capacity as monitoring programs mature.

Table 4. HDT's Program Staff Roles and Responsibilities

Role	Responsibilities	Role Type
Wastewater Treatment Plant Lab Manager	Collects and stores samples from the wastewater treatment plant	Part Time
Wastewater/Utilities Engineer	Plans sewer system sampling locations and manages sampling staff	Part Time
Sample Collector(s)	Deploys autosamplers, collects samples from sewer system nodes	Full Time
Sample Courier	Picks up and delivers samples to the lab for analysis	Full Time
Data Scientist	Analyzes lab results and identifies best methods for data disseminationmember	Part Time
Communications Associates	Prepares public notifications and messaging; supports Communications Lead member(s)	Temporary

Step 3: Hire and staff the program

Following the roles outlined in your program's scope, define a detailed program structure with clear ownership and reporting hierarchy by role. Assign the level of experience or expertise desired for each role to effectively recruit and hire qualified candidates. Among the leadership team, ask for referrals to fill open roles or assign responsibilities for existing staff. Create job postings to promote the remaining opportunities to the broader community. Staffing needs may fluctuate as sampling demand changes, requiring the need for temporary staff job postings and hiring in the upswings.

Step 4: Identification of sampler locations

Convene the program leadership involved with sampling and sample collection staff to help identify locations to install autosamplers. Assess what sampling coverage already exists from existing neighborhood infrastructure (if any) and the wastewater treatment plant. Then, the group can help identify gaps in coverage that an autosampler can begin monitoring. Apart from the strategic considerations of location selection, several tactical factors must be taken into consideration such as the size of manhole, ease of route coordination with couriers, and adherence to safety protocols. Most likely, staff will need to visit potential locations to ensure the autosampler placements are feasible for neighborhood and building-scale monitoring. The number of sampler locations identified and verified for installation can inform equipment procurement. The Centers for Disease Control provides **further guidance on developing a wastewater surveillance sampling strategy** to understand the inputs required to create a sampling plan.

Step 5: Equipment procurement

Depending on your local sewage infrastructure, equipment may need to be procured or replaced. In most cases, the equipment required is usually accessible by local wastewater entities; however, greater quantities will most likely be needed depending on the size of the agency. Standard equipment and material requirements include autosamplers, supporting batteries, cleaning supplies, courier vehicles, PPE for sewage collection, and lab analytical supplies. HDT recommends working with your commercial lab partner to assess required lab supplies and checking with your local public works office to secure adequate sewage collection PPE.

Step 6: Collection process

Once the sample collection staff has been identified and hired, in-depth training is necessary to ensure minimal disruption to the sewage system and full safety of staff. Key safety and collection procedure trainings can be provided by the local public works department. Coordinate a sample courier for sample transport to the analytical lab. Training for the courier may be required for appropriate sample handling. Engage the commercial lab partner and local public works department to understand time constraints for collection and lab analysis. This will inform the process development and ensure that the timing of courier handoffs support the desired results reporting cadence.

Step 7: Lab analysis and data collection

Work with the commercial lab partner and wastewater treatment plant to select and establish the analytical method and reporting procedures tailored to meet the community's public health needs. Data analysis should take into consideration the community's population, known levels of infection, and wastewater infrastructure (e.g., septic and decentralized sewage systems, pre-treated sewage). Once the sample and data management pipelines are outlined, align on a sampling cadence to inform results reporting and data resolution. Finally, negotiate a contract with the commercial lab partner to run and manage the sample analysis.

HDT analyzed samples using the lab facilities at the UC Davis campus following the workflow illustrated in Figure 4. HDT is exploring commercial lab partnership opportunities to expand the scope of wastewater surveillance across Yolo County. Testing of wastewater from SARS-CoV-2 is still a developing field. A number of protocols are publicly available (e.g., Table 5) and can help guide your program's lab analysis processes.

Healthy Davis Together Wastewater Surveillance Workflow

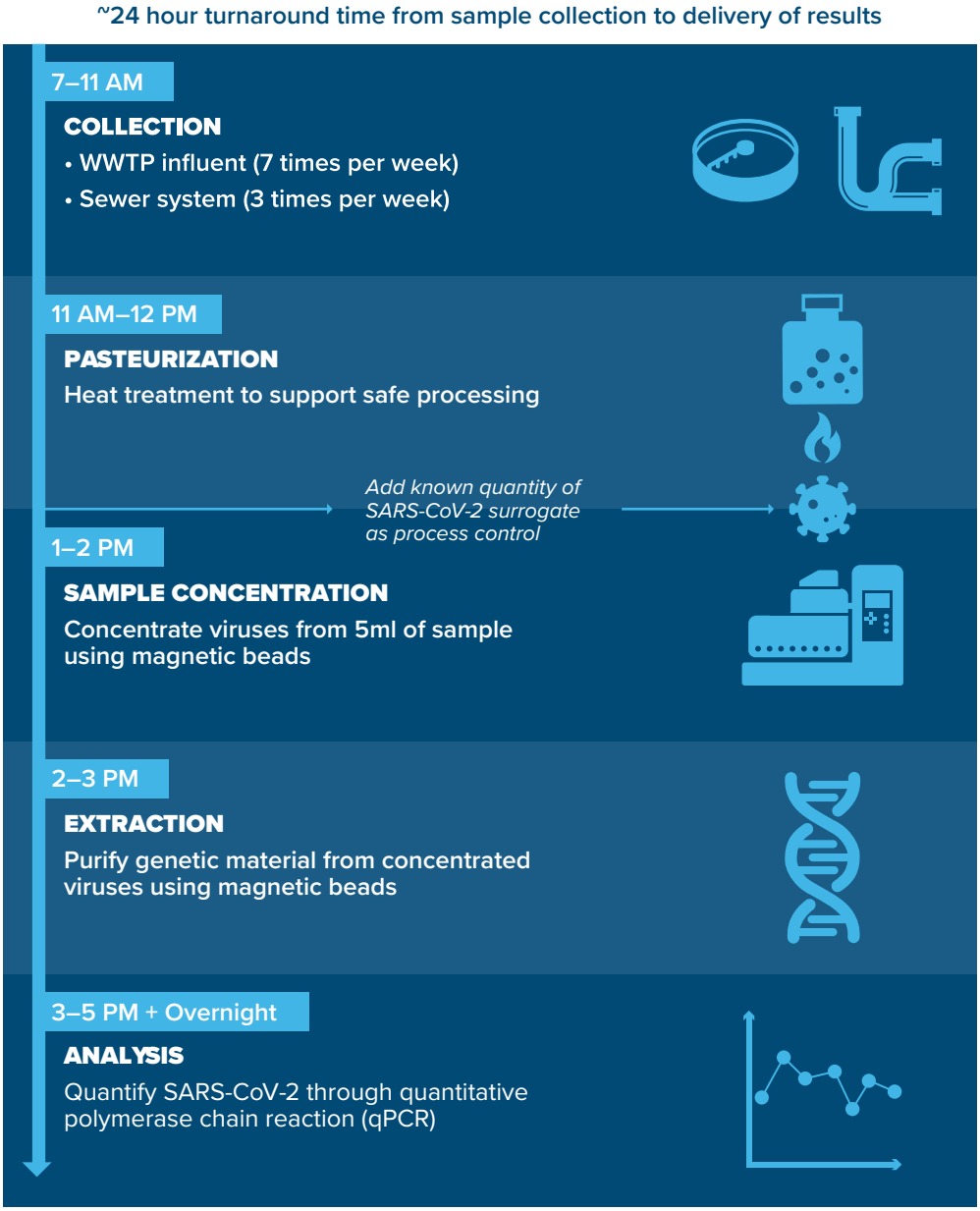


Figure 4. Visualization of the end-to-end lab analysis process flow used by HDT from collection to results

Table 5. Examples of Wastewater Sampling and Testing Protocols

Commercial Lab / Agency Name	Protocol
Eurofins	**Eurofins Covid-19 Sentinel™ Wastewater Test Provide Early Warning of a potential COVID-19 outbreak**
CDC	**Wastewater Surveillance Testing Methods**
Companion Testing Protocols by the Sewer Coronavirus Action Network (Verily Life Sciences, Stanford University, University of Michigan)	**High Throughput pre-analytical processing of wastewater settled solids for SARS-CoV-2 RNA analyses** **High Throughput RNA Extraction and PCR Inhibitor Removal of Settled Solids for Wastewater Surveillance of SARS-CoV-2 RNA** **High Throughput SARS-COV-2, PMMOV, and BCoV quantification in settled solids using digital RT-PCR**

Step 8: Community education and communication

Most community members do not spend time thinking about wastewater (sewage); analyzing wastewater samples to prevent the spread of COVID-19 will be a novel idea – and an opportunity to educate your community. Consider the following approach to communications planning:

1. **Setting the Stage**
    a. **Approval Protocols.** Your wastewater program will likely involve important partners such as city officials. They have a key role to play in community education; involve them from the start. Establish a set of protocols that will guide review of wastewater results and inform community notification decisions based on analysis of the sampling data. Set up regular meetings to keep everyone up to date, expedite decision-making, and implement rapid responses, as needed.public health resources. HDT has also applied this approach throughout the pandemic at sub-city and building scales. Samples representing smaller populations more frequently yield non-detect results, and an increase in virus levels above the detection limit represents a significant and easily identifiable change in the data.
    b. **Information Access.** Provide public access to wastewater data and results as part of your community education and to establish credibility and trust in the program. For example, designate a website page to wastewater sampling on an existing website or create a website and dashboard for your program. When possible, use images, graphics, and videos to help explain wastewater testing.
    c. **Clear Messaging.** Explain the basics: what wastewater testing is, why it's important, how it's done, what the results mean, and where to go for more information. Keep your messages simple and use language that people can easily understand – it's okay to say "poop". See sample messaging and communications in the **Resources.**

2. Getting the Word Out

a. **Communication Tools.** There are many tools that can help your community learn about wastewater samples and understand the benefits. For example, a simple fact sheet that includes frequently asked questions, an infographic that visually describes the wastewater process, flyers, post cards and door hangers, as well as social media graphics and video.

b. **Media Outreach.** You don't need to wait for a spike in wastewater virus levels to generate news coverage. You can use local news (print, radio, TV, related social) to announce your wastewater program to the public and to provide updates on program milestones and impact – in addition to coverage where there is a serious health alert. In addition to issuing a traditional press release, consider inviting the media to see the wastewater work in action as samples are collected in the city or in the lab and the samples are analyzed. It's also important to have designated spokespeople who are experts in the space and can explain the program to a variety of audiences.

c. **Partners.** In addition to working with city leadership, consider other organizations and associations that would be interested in your wastewater program and would be willing to help share information to their constituencies through their channels (blogs, emails, newsletters, social, webinars). Consider developing a partner toolkit that provides messages, customizable blog and newsletter language, and social media assets that can be easily used by partners to get the word out about the wastewater program.

d. **Social media.** If you have social media channels, build wastewater content into your editorial calendar and social media strategy. This will help create a steady drumbeat of information about wastewater monitoring and its long-term value to the community as an important part of the community's public health infrastructure.

3. Preparing for Rapid Response

a. **Be ready.** In event of an alarming, sustained increase in viral load, there is a time window for swift action that can make a difference. It's important to be ready for these moments. The approval protocols you established will facilitate quick decision-making.

- Everyone who needs to be informed in advance
  - City and county officials, other stakeholders
  - Testing program team
- Notification alert (via text/phone)
  - Message approved
  - Timing confirmed
- Media, if applicable
  - Statement and/or press release approved
  - Spokesperson prepared
  - Media outreach strategy confirmed
- Supporting materials
  - FAQ, relevant data
  - Website updates
- Media Monitoring
  - News
  - Social media

HDT has experienced great success with targeted mail notifications and text messages as these messages also provide actionable next steps to get tested nearby. Here's an example of a text notification:

Healthy Davis Together tests wastewater to provide early indication of the presence of COVID-19 in our community. Increased levels of the virus that causes COVID-19 were recently detected in wastewater samples from your area. This suggests new infections may be present. Drinking water in the City and your area remains completely safe. Please help us in reducing the spread of COVID-19 by getting free testing and following other public health behavior guidance. More information is available at HealthyDavisTogether.org

Step 9: Program Data Management

Setting up a strong program data management system helps to drive efficiency and visibility across the end-to-end collection to communications process. Data management can be automated by barcoding samples. Using barcodes allows for the data to be captured each time it is scanned, producing a database of when each sample was collected, picked up, delivered to the lab, and processed. Talk to your commercial lab partner to explore this option. This step not only extends to the sharing of sampling data but also the project management platforms and committee structures needed to build internal connectivity. Platforms such as Slack and Microsoft Teams have provided communication channels and widespread access to files for data sharing as the Wastewater Action Committee receives the data to help guide the overall program. Furthermore, it is important to set up compatible data sharing platforms between the program and commercial lab.

Step 10: Results Dissemination and Knowledge Sharing

Once the program is up and running, analysis results will need to be made publicly available. HDT recommends creating a public-facing website to post and refresh data each week as it has proved valuable to public messaging and knowledge sharing.

PART IV: RESOURCES

Table 6. Frequently Asked Questions: Public-Facing

1. Why test and monitor wastewater?	Wastewater testing can help slow and prevent the spread of COVID-19 in two ways. First, it is an inexpensive way to get information on city-wide infection trends over time. Trend data indicate if existing efforts to combat COVID-19 are working or if more needs to be done. Second, wastewater testing can identify where SARS-CoV-2 may be on the rise. Locating spikes helps inform where additional resources, like free testing and quarantine support, may be required.
2. What does HDT WW monitoring detect, just SARS-CoV2 or other pathogens too?	SARS-CoV-2 is the only pathogen HDT is monitoring in its environmental samples, which include wastewater, air filter, and surface samples. In addition, this type of sampling provides a regional overview and does not isolate individual households.
3. Can HDT wastewater monitoring detect drug use in a home?	No. HDT testing only assesses the concentration and distribution of SARS-CoV-2 in the community.
4. Will my neighborhood ever be quarantined because of positivity?	No. Decisions to quarantine people who are suspected of being exposed, or isolate people who are confirmed positive cases of COVID-19, are up to the county's department of public health. Yolo County's health department does not mandate quarantine on a neighborhood or regional basis.
5. Would we use mobile testing in a neighborhood?	Possibly. HDT is working with the city leadership to explore opportunities and challenges related to providing mobile testing units to certain locations in the city. These locations may include sites with high density of people, sites where people may have difficulty with transportation, and/or sites with aggregations of people who are at risk for poor outcomes from COVID-19.

6. Is my drinking water contaminated if the wastewater is contaminated? Should I worry about my drinking water?	No. Drinking water is not a route of transmission for SARS-CoV-2. In addition, water treatment processes inactivate SARS-CoV-2.
7. If there is robust environmental monitoring, does that mean I don't have to wear a mask or social distance?	No. Environmental Monitoring is a check on the status of a community, it is not a guarantee of safety. The best way for an individual to stay safe is to wear a mask while out in public, wash their hands regularly, practice social distancing, and get tested at least once a week.
8. Where can I read more about wastewater surveillance?	Wastewater testing is just one of the many tools and resources that can help keep Davis healthy. To learn more about wastewater surveillance as a strategy for containing COVID-19, please visit the Centers for Disease Control and Prevention (CDC)'s **webpage on the topic.**

Local News Press Release and Announcement of Wastewater Program

WASTEWATER MONITORING FOR COVID-19 EXPANDING IN DAVIS

New equipment increases monitoring capabilities for early detection of changes to virus levels and helps to prevent spread.

Davis, Calif. (March 29, 2021) – **Healthy Davis Together** wastewater monitoring operations, led by UC Davis researchers with support from the City's Department of Public Works, has deployed newly arrived wastewater sampling equipment to 15 additional sample collection locations (nodes), expanding monitoring to more neighborhoods served by the City wastewater collection system. The virus that causes COVID-19 (SARS-CoV-2) can be shed in the stool of infected individuals, including individuals who do not yet have symptoms or who never have symptoms. Regular testing of wastewater can detect spikes and be used as an early warning detection system so that action can be directed to individual testing efforts that help prevent spread.

"Davis is one of few cities to have a full-scale environmental monitoring program in place," said Heather Bischel, Project Lead for Wastewater Monitoring for Healthy Davis Together and Assistant Professor at UC Davis' Department of Civil and Environmental Engineering. "Recent low levels in wastewater confirm what we see with our low positivity rate. An elevated reading could mean there are asymptomatic infections that haven't been identified yet, or that virus is being shed by individuals already properly in quarantine and receiving care. Either way, it's important for residents to be kept informed so they can take appropriate action to stay well."

While Davis has maintained a low positivity rate of 1% or less for the past two months, Healthy Davis Together community COVID-19 testing continues to identify positives cases. Wastewater analysis remains an important detection and prevention tool. Elevations of virus levels serve as important reminders to remain vigilant, follow public health guidelines, and continue getting tested for COVID-19, even after being vaccinated. Since Healthy Davis Together started monitoring wastewater last November, the virus that causes COVID-19 has been detected in City wastewater, which is normal and expected until there is no longer COVID-19 in Davis.

Healthy Davis Together wastewater testing looks for data changes over time. Samples are collected from throughout the sewer system twice per week and analyzed in Dr. Bischel's lab. These data and the data from the City's Wastewater Treatment Plant, which is monitored daily, are viewed together to determine if the presence of the virus is going up, going down or staying the same. These findings are updated and shared on the Healthy Davis together website every Saturday. Beginning in April, community members who have registered to receive community messages through the Yolo Alert system will receive important wastewater updates. The City will also post important information on wastewater virus levels to neighborhoods via Nextdoor.

For more information about wastewater testing, visit: **https://healthydavistogether.org/wastewater-testing/**

If you have questions, please email **wastewater@HealthyDavisTogether.org**. Planning for a Healthy Davis Together wastewater monitoring webinar is underway and details will be posted on the website.

For information on free COVID-19 testing provided by Healthy Davis Together, visit **www.HealthyDavisTogether.org/testing.**

To sign up for Yolo Alert, visit **https://cityofdavis.org/emergency** and click on Emergency Notification Systems.

Press inquiries: **Media@healthydavistogether.org**

Healthy Davis Together is a joint project between UC Davis and the City of Davis to prevent the spread of COVID-19 in our community and facilitate a coordinated and gradual return to regular city activities and student life. Comments and questions are welcome at info@HealthyDavisTogether.org.

The UC Davis Genome Center testing lab operates under a CLIA-certified extension of the UC Davis Student Health and Counseling Services CLIA license.

WASTEWATER MONITORING

Media "Poop" Points & FAQ | April 2021

- UC Davis and the City of Davis launched Healthy Davis Together (HDT) last September with a goal to prevent the spread of COVID-19 and get the Davis community back to regular activities as quickly and safely as possible. We knew that to meet this goal, we would need to deploy every possible tool available to us, from public health behavior campaigns to establishing a free COVID-19 testing program available to anyone who lives or works in Davis and their households, to exploring the use of new technologies and environmental monitoring.
- One of the environmental monitoring tools Healthy Davis Together has deployed in Davis is testing the wastewater flowing through the sewer collection system. This wastewater is a byproduct of normal community water use, such as showering and using the toilet. **The virus that causes COVID-19 (SARS-CoV-2) can be shed in the stool of infected individuals, including individuals who do not yet have symptoms or who may never have symptoms.**
- Regular testing of wastewater can detect spikes and be used as an **early detection system** so that action can be directed to ramping up individual testing efforts that help prevent spread.
- Through Healthy Davis Together, UC Davis researchers and the City's Department of Public Works have set up wastewater **sample collection points at (25) locations** ("nodes") in the City's sewer ("wastewater") collection system throughout the city. Samples are collected from throughout the sewer system twice per week and analyzed in a UC Davis lab.
- **Data from sample collection points and the data** from the City's Wastewater Treatment Plant, which is monitored daily, **are viewed together to determine if the presence of the virus in a city area is going up, going down, or staying the same.** This information can be used by community members as a prompt to get tested and to remain vigilant by following recommended good health behavior practices.
- While Davis has a low overall positivity rate (less than 1%), Healthy Davis Together community COVID-19 testing continues to identify new positive cases. **Wastewater analysis is an important detection and prevention tool.** Wastewater data are updated and shared on the Healthy Davis together website every Saturday. **www.HealthyDavisTogether.org/wastewater-testing**

FAQ

Q. How can I find out about the status of wastewater being tested in my neighborhood?

The Healthy Davis Together website (**www.HealthyDavisTogther.org/wastewater-testing**) has information about wastewater testing, including a map of the of the sewer nodes where wastewater samples are being collected and data updates by neighborhood. Wastewater data are updated on the website every Saturday.

Q. What happens if wastewater testing where I live shows higher levels of COVID-19 virus?

Community members who have signed up for the Yolo Alert will receive an alert message. Additional communication efforts may also be used to share information and prompt community members to get tested and to remain vigilant by following recommended good health behavior practices.

Regardless of the level of COVID-19 detected in wastewater, it is important for community members to remain vigilant and follow health behavior guidance and to get tested regularly. Healthy Davis Together provides free COVID-19 saliva-based screening tests seven days a week. Getting tested regularly is the most powerful tool we have to avert the spread of the virus. For more information or to book an appointment for a test, visit **www.HealthyDavisTogether.org/testing.**

Q. How is Healthy Davis protecting people's privacy when they are monitoring wastewater?

Wastewater is only collected for monitoring as it leaves an entire neighborhood, not from an individual home or apartment. The testing cannot reveal if an individual or even a single household has COVID-19, only that the whole neighborhood has a rise in the presence of the virus in area wastewater.

Q. Will I be forced to get tested if COVID-19 is detected near me through environmental monitoring?

No. COVID-19 testing through Healthy Davis Together is quick, free, and always voluntary. The goal of testing is to empower people with the information they need to prevent spreading COVID-19 to others.

Q. Can Healthy Davis Together wastewater monitoring detect drug or other chemical use in a home or business?

No. The Healthy Davis Together wastewater monitoring program only tests for COVID-19 in our community.

Q. Can wastewater monitoring tell us how widespread the variants are here in Davis?

Wastewater detection of viral variants will be a feature available in the future. For now, the strongest indication of new variants showing up in Davis is the individual PCR COVID-19 test that is free and open for all residents and workers in Davis and their households.

Q. Is my drinking water safe?

Yes, your drinking water is safe. Davis does not recycle sewer water into drinking water.

Wastewater Monitoring FAQ and Educational Material

HEALTHY DAVIS TOGETHER

Environmental Monitoring: Wastewater Testing

The goal of **Healthy Davis Together** is to prevent the spread of COVID-19 and get the Davis community back to regular city activities as quickly and safely as possible. Environmental monitoring (regularly testing wastewater, indoor air, and certain surfaces) is another way we are learning about COVID-19 and opportunities to prevent its spread. While free COVID-19 testing at least once a week for everyone who lives and works in Davis is the most important action for all of us to take, environmental monitoring is an important learning component that helps us see where we can step up prevention efforts even more.

WASTEWATER (SEWAGE) TESTING

One of the environmental monitoring tools Healthy Davis Together is using to prevent the spread of COVID-19 is wastewater testing, also known as sewage testing.

What is sewage, or wastewater, testing?

Wastewater is a byproduct of normal community water use like showering, using the bathroom, and other activities. The virus that causes COVID-19 (SARS-CoV-2) can be found in stool and urine of infected individuals, including individuals who have not yet experienced (pre-symptomatic) or will not experience (asymptomatic) symptoms of COVID-19.

Why is wastewater testing important?

Wastewater testing can help slow and prevent the spread of COVID-19 in two ways. Wastewater sampling throughout the city can be used to both identify infection trends and serve as an early warning sign and encourage people to protect themselves and their loved ones by being tested.

How does wastewater testing work?

In Davis, UC Davis and the City's Department of Public Works have set up wastewater sample collection locations at key points ("nodes") in the City's sewage ("wastewater") collection system. Samples are collected each week from the different nodes for analysis in a UC Davis research lab. This type of sampling does not isolate individual households. The lab measures the level of SARS-CoV-2 in the wastewater samples to help identify new potential outbreak locations.

How are wastewater testing results used?

Wastewater samples are not collected from individual homes or apartments and do not identify any individual or household. Wastewater data is important complementary information to testing data and can be used to identify infection trends in a geographic region (e.g., a neighborhood), where to focus free COVID-19 testing, and possible early warning signs of a potential outbreak. This information will be used to encourage community residents to take action by getting tested.

Wastewater testing is one of many tools Healthy Davis Together is using to help prevent the spread of COVID-19. It's even more important for community members to remain vigilant and follow good health behavior practices from the County and City and to get tested at least once a week. Healthy Davis Together provides free COVID-19 saliva-based screening tests seven days a week. Conf'dential results are available within one to two days.

Healthy Davis Together is a joint project between UC Davis and the City of Davis to prevent the spread of COVID-19 and facilitate a coordinated and gradual return to normal city activities and student life.

Visit HealthyDavisTogether.org to:

- learn more about wastewater testing and other programs
- schedule your COVID-19 test

The saliva-based tests are free, quick and painless.

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HealthyDavisTogether.org

Yolo Alert Messaging System and Example Text Notification

“Healthy Davis Together tests wastewater to provide early indication of the presence of COVID-19 in our community. Increased levels of the virus that causes COVID-19 were recently detected in wastewater samples from your area. This suggests new infections may be present. Drinking water in the City and your area remains completely safe. Please help us in reducing the spread of COVID-19 by getting free testing and following other public health behavior guidance. More information is available at **HealthyDavisTogether.org**.”

SACRAMENTO · YOLO · PLACER
ALERT
Sacramento Region Emergency Notification System

HEALTHY DAVIS TOGETHER