REPORT OF THE AD HOC ADVISORY COMMITTEE ADVISORS ON THE JULY 11, 2021, FLOODING AT THE HYPERION WATER RECLAMATION PLANT AND RECOMMENDATIONS FOR FUTURE IMPROVEMENTS

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Executive Summary

On July 11, 2021, the City of Los Angeles' Hyperion Water Reclamation Plant (Hyperion) experienced a major sewage spill into the Pacific Ocean, and nearly catastrophic flooding of the facility. Critical equipment and motor vehicles were severely damaged, which caused a prolonged interruption in the treatment regime resulting in significant odor complaints and a lack of full treatment. In response to this event, the Los Angeles Board of Public Works formed the Hyperion Ad-Hoc Committee, which then brought together a group of advisors with wide-ranging expertise and perspectives to undertake an independent assessment of the cause of the July 11 event, and to make recommendations for the Bureau of Sanitation (BOS) to move forward. This Ad Hoc Committee and its Advisors have held ten meetings, received multiple briefings from the Bureaus of Sanitation and Engineering and consultants CDM-Smith and Brown and Caldwell, toured the Hyperion Headworks facility, and deliberated significantly before preparing this report.[1]

This report is not meant to be exhaustive, but to recommend short, intermediate, and long-term actions to both respond to the events of July 11, and to take the opportunity to prepare for Hyperion's ambitious planned upgrade to a full water recycling facility by 2035. The Committee Advisors believe that important improvements need to be made to restore public confidence in the transition to a full recycling facility.

Summary of Preliminary Findings

1. Recognizing that some studies are still ongoing to determine the cause of the July 11 event, and recognizing that a full understanding of all the factors that led to the spill and flood may never be completely reached, our key findings are presented here, with more explanation to follow later in the full report. The spill happened on a dry day with typical wastewater flow rate. The Brown and Caldwell investigation has uncovered some problems in the conveyance system, but

[1] In the interest of avoiding duplication, this report will not restate all findings in reports submitted, even in preliminary form, by the Bureau of Sanitation, CDM-Smith, and Brown and Caldwell. Interested readers are encouraged to also read those reports in tandem, as noted in the "References" below, with the caveat that some of their early suggestions have been superseded by further investigation, some of which is still ongoing. Those updates, where known, are referenced in this report.

there is little or no evidence in the conveyance system at this time to support an initial theory that a large influx of debris from outside the treatment plant suddenly overloaded the plant's Headworks[2]. At the time of this report, the best available information regarding the root cause of the spill is that a failure of equipment used to transport screenings out of the plant likely allowed those screenings to be recycled back to the Headworks and caused an overload of debris to the bar screens. That overload both "blinded" (or clogged) the bar screens and overloaded the bar screen motors causing them to "trip" (or turn) off. A secondary cause is likely the inability to safely remove a barrier, or "bulkhead," manually in the screen's emergency bypass channel before pervasive flooding to the plant occurred. That flooding of the plant itself caused electrical systems and pumps to go offline, which caused the plant to have reduced treatment capability for weeks, affecting discharge to the bay, causing odor complaints from neighboring communities, and impacting the water provided to the advanced treatment facilities at the West Basin Municipal Water District.

2. There appears to have been a lack of timely acknowledgement of a high liquid level alarm in the Headworks influent channels, which could have given plant operators warning that something was amiss in the Headworks facility where raw sewage first enters Hyperion. Several factors may have contributed to the delay, including the chaos of an unprecedented set of urgent circumstances, a lack of technology that could have resulted in quicker response (e.g., process/equipment sensors tied into the plant's distributed control system, strategically located video cameras, and audible alarms), inadequate internal communications and protocols, and insufficient staffing and emergency training for this type of incident.

3. The Bureau of Sanitation complied with legal requirements in providing timely notice of the spill to required agencies, including the Los Angeles County Department of Public Health (L.A. Public Health), the Regional Water Quality Control Board, and appropriate nonprofit environmental groups. However, greater intra-agency communication may have resulted in improved outreach and public protection.

[2] Headworks is a term that refers to the first part of every treatment plant which includes screens to remove debris such as rags, lumber, and large objects, sedimentation to remove sand, (called grit in treatment plant technology), and in some cases pumps. Removal of rags and grit is necessary to protect the downstream treatment processes.

This report provides a series of recommendations to reduce the risk of a future spill and accelerate the notification of future emergencies to the public, including capital improvements, training, audits, staffing, and new procedures. In assessing findings and developing these recommendations, the Ad Hoc Committee Advisors focused on immediately addressing the causes of the July 11 flood, but also on what those findings tell us about Hyperion's long-term challenges and potential vulnerabilities relative to its conveyance system, treatment system, flood risk, and capacity. With ever-expanding potential for natural or human-induced catastrophic events, the Ad Hoc Committee Advisors concluded that understanding and addressing long-term flood risk and capacity is crucial to planning for Hyperion's long-term resilience as a fundamental infrastructure asset. Simply put, as evidenced by the incident of July 11, 2021, Hyperion's ability to handle peak flow events – both now and in the future - without incurring flood damage needs to be ensured in the Headworks as well as other locations in the plant. In particular, there are three areas of flood risk – Headworks, secondary influent pump station, and final effluent pumping. It is essential that plant operations and safety are not compromised by failures at these three locations.

Ensuring that durability is especially necessary given the planned transition of Hyperion from a largely treatment/disposal facility with a significant recycled water program to a full wastewater recycling facility that can provide greater water resilience to the Los Angeles area by 2035. It is essential for the Bureau of Sanitation to make immediate short-term improvements to avoid spills and other emergency events, even as they plan to transition the entire Hyperion system to a state-of-the-art wastewater recycling system. Moreover, this unprecedented event, and the lessons derived from the after-incident analysis, can also serve as an opportunity to move more aggressively to upgrade all essential systems and infrastructure necessary to protect this critical facility, while it continues its planning and pilot project phases for the 2035 transition.

Appendix A Lists the primary individuals who participated in this report production and/or provided important information. Appendix B is a glossary of terms used in the report and also shows a block diagram of a typical treatment plant. Appendix C is an analysis of a hypothetical diversion of the flood waters; Appendix D shows pictures of the new technology used to survey the conveyance system.

Background

The City of Los Angeles' Hyperion Water Reclamation Plant experienced blinding (clogging) of its bar screens on the afternoon of July 11, 2021. The following six images in Panel 1 (below) show pictures of the Hyperion bar screens and some diagrams to show how bar screens function.

Panel 1

Figure 1: Backside of one of the Hyperion bar screens, showing sluice for transporting screenings, marked with letter S. Drive motor and gear box is at the top left of the screen.

Figure 2: Array of eight Hyperion bar screens, sluice marked with S.

Figure 3: Front view of the bar screen, which is covered in clear plastic for odor control, sluice marked with S.

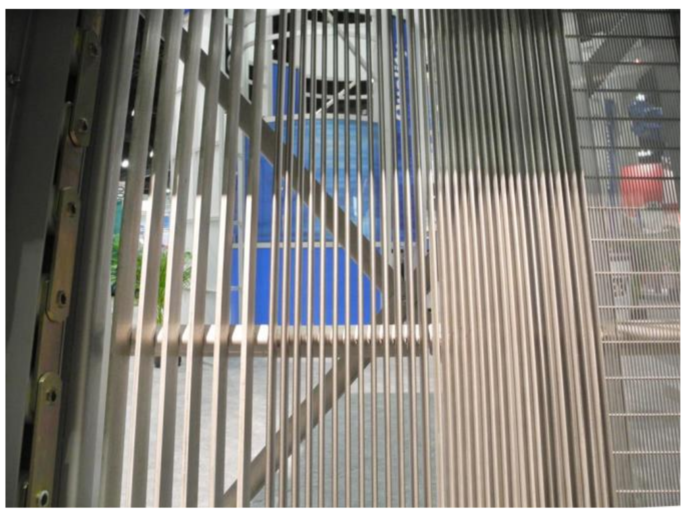

Figure 4: Picture of a vendor's bar screen offerings showing the geometry of the bars and screens of different spacings

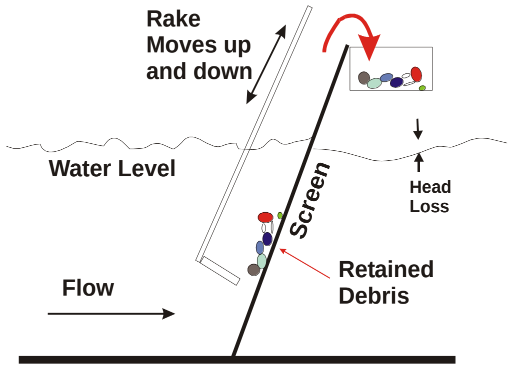

Figure 5: Schematic of a bar screen showing a rake type scraper (not in use at Hyperion), screenings hopper and the small change in water level (head loss).

Figure 6: Barriers, not in use.

The blinding of these screens resulted in the incoming raw wastewater levels in the influent channels at the Headworks building to rise above floor level and flow across the building down to the lower floors of the Headworks building, which includes chopper pumps and other important equipment. The raw wastewater then flowed through the outside doors of the building to other areas in the plant, including the 5-mile outfall pumps and the tunnels where activated sludge recycle pumps and other important electrical equipment are located. A large number of motors and electrical panels were destroyed, which caused reduced plant treatment efficiency for a significant period of time after the event. A number of motor vehicles were also destroyed by the flood waters. The overflow from the Headworks building also entered the plant's stormwater catch basins which eventually overflowed to the plant's 1-mile outfall[3]. Plant staff estimate that 17 million gallons of raw sewage flowed into the 1-mile outfall during the event, though approximately 4 million gallons that remained in the outfall were later pumped back to the plant for treatment and discharge to the 5-mile outfall. Fortunately, no wastewater was released directly to beaches. A large amount of equipment, including multiple vehicles parked in low locations, was destroyed. The Hyperion Plant has never experienced a flood of this kind, and the event revealed areas for improvement to its emergency action plan and the facility itself. Other consequences of the flood and recommendations are described in the Bureau of Sanitation's 30-day report.[4] The Committee

[3] Hyperion has two outfalls, which are large pipes that convey the treated effluents away from the beaches to improve dilution. Normally the 5-mile outfall is used for treated wastewater while the 1-mile outfall is used for stormwater overflow and for emergencies.

[4] The 30-day report was written based on the best available information at the time. As a result of additional investigations, including those requested by the Committee Advisors, some of the information in the 30-day report may be outdated.

Advisors acknowledge and appreciate the extensive efforts on the part of the Bureau of Sanitation workers and managers to restore plant efficiency and mitigate odors.

In an effort to understand the causes of the bar screen blinding, the Bureau hired two consulting firms to provide independent evaluation of the causes of the flood. Brown and Caldwell was hired to evaluate the conveyance (collection) system for evidence of debris accumulation and other problems that may have caused overloading of the Headworks and blinding of the bar screens. CDM-Smith was hired to evaluate the bar screens and the equipment associated with their operation such as alarms, controls, design, etc. Each consultant has provided a preliminary report but at the time of this writing neither consultant has completed their final report.

Brown and Caldwell used new technology to evaluate long, inaccessible sections of the conveyance system (see Appendix D). This involved launching a buoy into a sewer at an upstream access hole and then recovering the buoy at a downstream access hole. During the buoy's travel it records information and video of the crown of the sewer and obstructions or damage to the sewer's walls. This technology was required because many of the sewers leading to the Plant are more than a mile long and cross under Los Angeles International Airport's runways, blocking their access using conventional sewer survey equipment. Brown and Caldwell also used a remotely guided robot to inspect the sewers close to the plant and under the Headworks building. The Bureau of Sanitation routinely inspects sewers with closed circuit video cameras, but this technology is limited to approximately 100 meters on either side of a sewer access point. The Brown and Caldwell team used new technology, leased from an outside company and very much in demand by other agencies. The demand for this necessary technology to examine the mile-long inaccessible sewers leading up to the plant has delayed their progress.

Brown and Caldwell's first evaluation (2), which was limited to more readily accessible upstream sewers and did not include sewers closest to the Hyperion Plant, revealed a few problems in the sewers but no evidence in the sewers to support the theory that a large influx of debris suddenly overloaded the bar screens, which at first seemed the case. Their second round of evaluation, after a remotely operated, sonar-equipped robot was acquired, revealed a buildup of debris in the underground channels leading to the bar screens, but this buildup was of denser material such as grit (sand). Brown and Caldwell has indicated that, while the material it identified should be removed, it remained on the bottom of the channels at the time of the incident because of its high density and was not the principal source of blinding material (though it may have contributed to the problem). The second round of evaluation also revealed a large metal object near the entrance of one of the screens. No quantitative evaluation of the material that blinded the screens was possible due to the urgency of mitigating the flood, but from the photographs it appears to be typical rags and sanitary appliances associated with raw wastewaters. Further investigation of the conveyance system has been completed, and it does not appear that there was a surge of material that suddenly overwhelmed the bar screens from outside the plant. However, it is clear that debris accumulated at the bar screens which may have given the impression of a surge of debris arriving at the plant. More details are provided in Brown and Caldwell's first and second reports to the Committee Advisors (2,5). Panel 1 shows the bar screens under normal operation, a close up of typical bar screens, a schematic of how rake-type bar screens operate, and barriers not in use.

CDM-Smith was tasked with evaluating the equipment, systems, and practices inside the plant. The "bar screens" are a key element of the Headworks facility and were the key equipment that failed (their design is discussed more fully below in the recommendation section). This was important not only because of the flood, but also because these bar screens are new, having been installed starting in 2019. The original eight bar screens with ¾ inch openings were replaced with eight new screens of a different design to reduce odors and introduce other efficiencies: Four screens with 3/8-inch openings and four screens with ¾ inch openings. At the time of the event, the ¾ inch screens were on standby, acting as backup. It should be noted that as Hyperion transitions from treatment to reclamation, much finer screening and other measures at the initial stages of the facility will be required for greater levels of treatment and to protect more advanced treatment operations at the other end of the plant.

CDM-Smith has analyzed the flow and water level information collected by the plant's instrumentation to better understand the nature of the bar screen blinding, including the flows to the plant. Their report (3) shows that at about 12 noon on July 11, the liquid level in the Headworks channels below the building floor began rising from 34.5 feet, then at approximately 12:37 PM sharply rose to 35 feet, then rose gradually to 35.3 feet by 1:53 PM, and then rose rapidly to 36.51 feet by 2:11 PM. The level finally peaked at approximately 37.3 feet by 2:32 PM, ultimately rising above the floor. After this peak, the water level data are unreliable because the instruments were submerged. The Bureau of Sanitation's 30-day report estimated that at approximately 3:30-4:00 PM on July 11, wastewater began flowing out the Headworks building into the plant's internal streets. CDM-Smith's report also contains instantaneous flow rate measurements, but some of this data are suspect because of the effects of debris fouling flow measuring instruments.

In their report, CDM-Smith also examines the electrical systems associated with operation of the bar screens, adequacy of AC power, alarms, annunciators, and other electrical issues. Their report notes that an inlet channel alarm, which was visible but inaudible, was triggered at 2:11 PM on monitors in the plant's central control room but was not contemporaneously acknowledged by plant operators. The report also notes the presence of a barrier in the bypass channel. The bypass channel, when opened, allows flow through the system and around bar screens to the grit chambers. It is intended for use only when necessary for emergency bypass. A barrier or "stop log" is a device to manually isolate (block) that flow and must be installed and removed manually with a crane. Unfortunately, a barrier was in place at the time of the incident and was not removed until approximately 4:30 AM on July 12, once the flooding had subsided enough to allow safe access. Page 30 of the Bureau of Sanitation's report (1) is a chronology of the efforts to control the blinding and flood and should be consulted for exact details based on best available information at the time of that report. Panel 2 (below) shows pictures of the bar screens after the flood, and several areas of flooding.

Panel 2

Figures 7 and 8: Back sides of the bar screens, opened to remove screenings (instead of using the sluice).

Figure 9: Construction area, outside of Headworks building, inundated by flood waters.

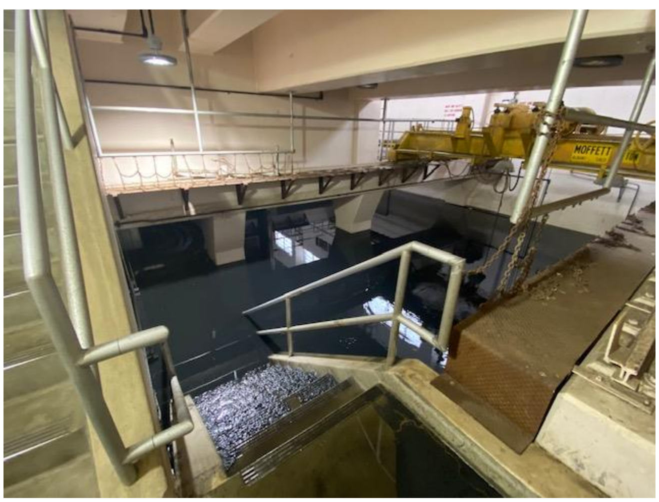

Figure 10: Flood waters in the EPP (Effluent Pumping Plant) basement area.

Figure 11: Flood waters in the Headworks building.

Panel 3 (below) shows the sluice transporting screenings during normal operation, the connections between the sluice and the chopper pumps below, the emergency overflow weir which likely inadvertently recycled screenings, spiral lifts, and internals of the spiral lifts.

Panel 3

Figure 12: Sluice transporting screenings.

Figure 13: Backside of the sluice showing three pipes from the sluice to the chopper pumps below.

Figure 14: Sluice showing emergency overflow weir, sluice continues through the wall to chopper and spiral lifts.

Figure 15: Internal screws from the spiral lifts, out for maintenance.

Figure 16: Spiral lifts lifting screening to a trailer for disposal

Figure 17: Chopper with operator.

Panel 4 (below) shows the chopper pumps, dewatering drums, and the outside of the Headworks building and road.

Panel 4

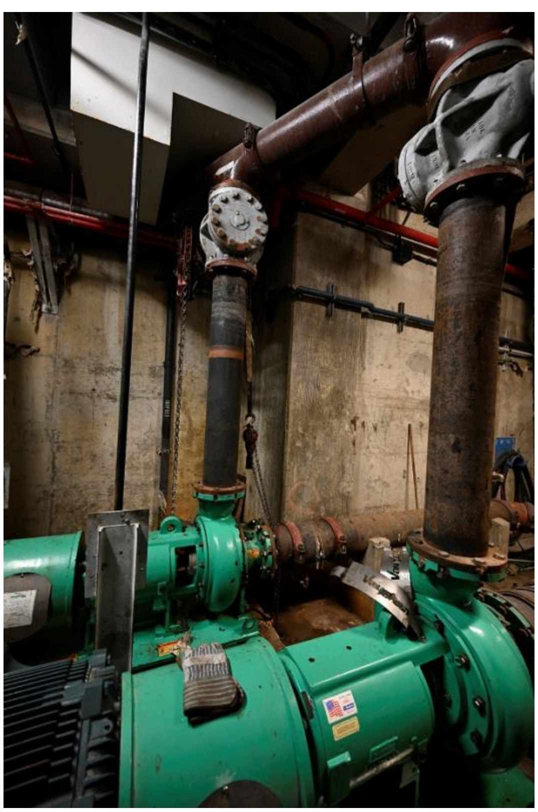

Figure 18: Chopper pumps showing discharge pipes leading upward to the dewatering drums.

Figure 19: Drum screen.

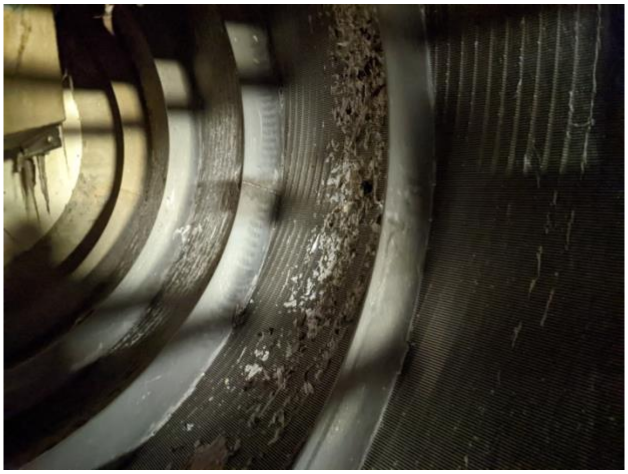

Figure 20: Internal of a drum screen.

Figure 21: Back of the Headworks building showing large doors for screenings removal trailers. Flood waters exited through these doors.

Figure 22: Road and parking area where flood waters flowed to the secondary treatment part of the plant.

The CDM-Smith report notes several areas for improvement, some of which might have made it easier to manage the bar screens to avoid blinding, but no issues so severe that they might have singularly caused the bar screen blinding alone. They document a series of equipment, timing, and other issues that combined to likely cause both the bar screen blinding and the failure of the bar screen motors to function adequately. Their report also describes the efforts of plant operators to place the backup bar screens in service, though they quickly blinded, and the motor's overload protectors turned them off to prevent permanent damage.

CDM-Smith notes that communication of the flood to other agencies and the public was made by Hyperion Plant staff beginning at 7:59 PM on July 11. The chronology of the communications is described on page 33 of the Bureau of Sanitation's report (1). The California Offices of Emergency

Services (OES) was notified first at 7:59 PM. Cal OES notified the LA County Department of Public Health at 8:11 PM. The National Response Center was notified at 8:18 PM. At approximately 11:15PM of the same day, a "SANI-GRAM" was sent to the City of LA Board of Public Works with copies to Heal-the-Bay, LA Waterkeeper, Natural Resources Defense Council, and other City offices. Four beaches nearest to the Hyperion Water Reclamation Plant were ultimately closed on July 12 and reopened on July 14 (4). The Bureau of Sanitation reports additional sampling for indicator organisms (total coliforms, E. Coli, Enterococcus) from July 13 to August 3, 2021. Their results showed normal bacterial levels near both outfalls. Their data are listed in the appendix of their report.

The post-flood reaction of some of these agencies and the public was to question the delay in closing the beaches. Only the L.A. County Department of Public Health has the authority to close beaches. The Committee Advisors are concerned about the apparent inadequacy of clear protocols and communication among the agencies and, in this case, the delay between the flood, its resulting spill, and beach closures. Part of the delay may be associated with the analysis time for indicator organisms that the LA County public health department uses to determine beach closures. It typically takes one day to sample, analyze results, and report, while beachgoers may be exposed. On the other hand, there has been a past policy of L.A. County Department of Public Health to close beaches proactively after a spill of a significant magnitude and reopen after testing assures the beach is safe. That policy was not followed in this case. The Committee Advisors are making a number of recommendations which are in the body of this report, including the need to create (or refresh) a protocol between the Bureau of Sanitation and the L.A. Department of Public Health to report a spill, its magnitude, and potential consequences, and ensure that the L.A. Department of Public Health err on the side of caution in these circumstances moving forward.

Ad Hoc Advisory Committee and Its Advisors

The Ad Hoc Advisory Committee and its Advisors are composed of two Committee Members and thirteen Advisors who have either knowledge of treatment operations and management, experience in running treatment plants, expertise in emergency preparedness and management, or a key function in a non-government operation (NGO) that relates to the environment.

Given the ambitious and course-defining planned transition of Hyperion from a purely reclamation facility to a full wastewater recycling facility – and its prominent future as part of the region's water reliability – the Committee Advisors pursued their investigation and recommendations through short and long-term lenses to avoid a repeat of what happened in the immediate and practical sense, while also ensuring that Hyperion is positioned to withstand future potential issues, whether they be anticipated or unanticipated, natural, or human-caused calamities. As such, recommendations are consistent with these perspectives and afford equal importance to both immediate necessities and long-term planning opportunities.

The affiliations and contact information of the Members and Advisors are included in Appendix A. The Committee Members and Advisors have met, as a whole, ten times over Zoom. Additionally, Committee Members and Advisors toured the Headworks of the Hyperion Plant on September 28 and 30. There have been additional meetings of select members of the Committee and Advisors at different times to focus on more detailed information. The Committee Members and Advisors have heard presentations by the aforementioned consultants, the manufacturer of the bar screens, the Bureau of Sanitation, and the Bureau of Engineering (BOE), and their respective presentations are referenced in this document. They have reviewed the reports by the Bureau of Sanitation (1), the County Public Health Department, (4) and the consultants (2, 3, 5). The list of attendees and key members of the staffs of these organizations are also listed in Appendix A.

The Committee Advisors have developed recommendations and a consensus of key factors in seven areas:

- Capital Improvements
- Conveyance System
- Assessments and Audits
- Operations – Headworks Procedures
- Operations – Training
- Operations – Staffing
- Emergency Response

The recommendations are described in the following sections. Additionally, where the Committee Advisors have identified what they think might be a cause based on information known to date, it is described.

Capital Improvements

Goal – Provide Short Term Recommendations to the Bureau of Sanitation to Improve Future Headworks Operation and Reduce Risk

The Headworks and its equipment are extremely complicated and represent the most challenging part of reclamation plant design. Typically, the Headworks of a treatment plant contain wastewater pumping, one or two levels of screenings, grit removal, and instrumentation to track plant loading.

Bar screens are necessary in the Headworks to remove trash, debris, and large objects to protect plant equipment as well as to improve the quality of reclaimed biosolids. Plants that have raw water influent pumps need protection and typically have a coarse screen, with 1-to-2-inch openings before the pump intakes. In such cases, a second screen is needed to remove finer debris. Hyperion has no influent raw wastewater pumps because it has gravity flow to the plant. Typically, fine screens with ¾ to 3/8-inch openings are positioned further downstream, whether the plant uses pumps or relies on gravity, as is the case at Hyperion. Bar screens do not remove grit or significant amounts of conventional wastewater pollutants such as biochemical oxygen demand, which are removed through sedimentation and other processes in the plant. Large plants always have mechanically cleaned screens. They are called bar screens because the mesh is created with thin bars (~ ¼ inch by 1 to 2 inches wide) oriented with the thin side perpendicular to the flow and spaced at intervals such as ¾ inches for fine screens. The mechanical cleaning is performed by a rake that moves up the screen with teeth inserted between the bars. The captured material, called screenings, is pushed to the top of the screen's conveyor and then falls behind the screen into a container for removal or another type of transport system. In the case of Hyperion, a transport system with a water sluice is used. The water sluice transports the water and screenings to a device that separates the screenings and dewaters them for disposal, usually to a landfill but in some cases to incineration. All parts of the system must function in unison.

To better understand the mechanism of bar screen operation, Figures 23 and 24 (below) are provided. They are schematics of screens, gates that control flow, and equipment used to transport screenings out of a plant to a landfill. Hyperion has eight bar screens, arranged roughly east to west with every other screen having 3/8-inch openings and stand by screens in between having ¾ inch openings.

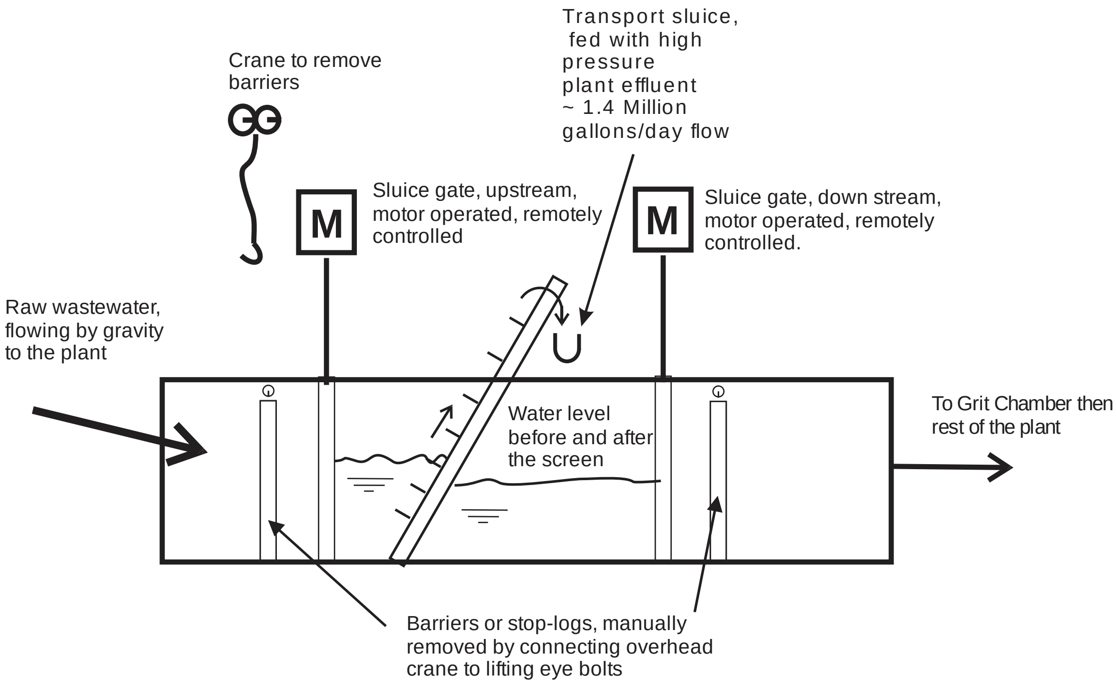

Figure 23: Elevation schematic of a bar screen with barriers and sluice gates. Note the water before and after the screen. The small difference is the head loss of the screen and the force required to push water through the screen. Normally this is 4.2 inches for the 3/8-inch screen to cause 133 million gallons/day flow rate.

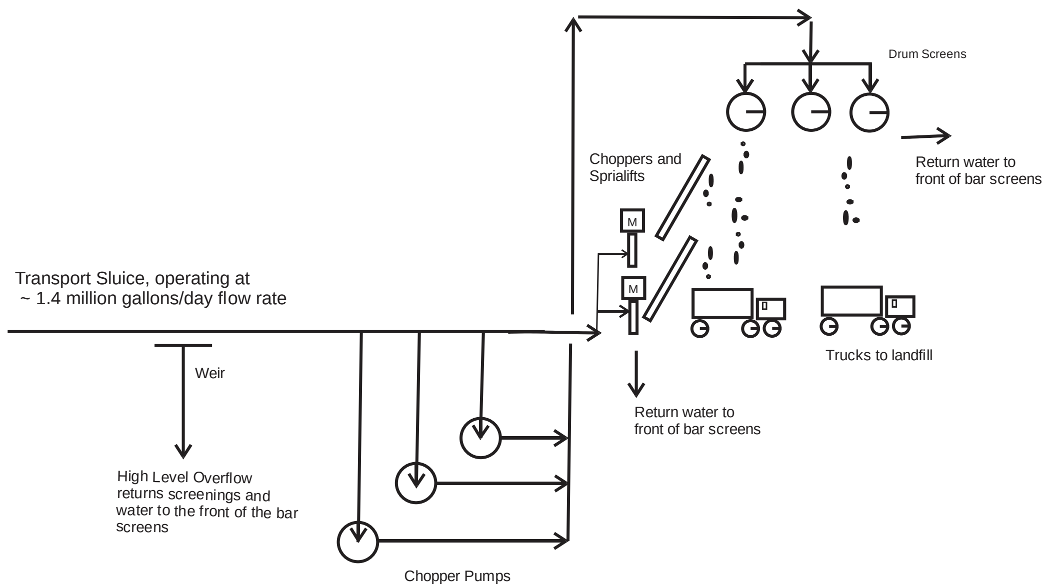

Figure 24: Schematic of screenings removal system. The sluice transports screenings to the pipes downward to the chopper pumps or to the choppers and spiral lifts. There is an overflow weir that allows water at high levels to overflow back to the front of the screen.

Figure 23 shows a typical screen with two electrically operated gates and two manually operated barriers. Generally, gates mounted in tracks with screw positioners to raise and lower the gate and are called sluice gates. Gates that do not have positioners are called stop-logs or barriers. Both are designed to control flow at 0%, fully closed, or 100% fully opened. Their nature is such that they cannot accurately control in variable positions. Stop-logs or barriers are purposely simple but reliable devices which do not require routine maintenance and are used when the sluice gates, which are motor operated, require maintenance. Sluice gates that are not routinely maintained often seize due to corrosion. Treatment plants normally have both types of gates. Hyperion maintenance records show that the sluice gates were maintained routinely.

Both gates and barriers are used to isolate equipment for maintenance. Sluice gates are more frequently operated and therefore are motorized. Barriers are less frequently operated and are raised and lowered with a crane, which is normally permanently mounted in the roof of the building on rails and is used for general purpose lifting as well as lifting the barriers. Figure 23 shows them both in the down position, extending from above liquid level to the bottom, making a seal. Note that the lifting eyes for the barriers are below the floor surface. There are usually covers and seals above the gates and barriers to prevent odor release and for safety. The sluice gates are used to isolate the screens for maintenance and the barriers are used when the sluice gates need to be maintained. The barriers are solid pieces of steel or wood and need minimal repairs which can be performed when they are removed.

The screens are between the gates and are located on an angle to facilitate transport of the screenings upward from the influent channels below the floor to the screening transport sluice. The traveling flights have fingers that extend between the bars to catch screenings and push them up. At the top, the screenings fall to the opposite side of the screen and into a hopper or transport mechanism. In the case of Hyperion, the transport is a water sluice. It transports screenings from all operating bar screens to a disposal system of chopper pumps and spiral lifts. Near the east end of the building there are connections to the chopper pumps and choppers and spiral lifts. Chopper pumps cut the screenings, which can be a foot or more long, as well as ropes, wires, and solid chunks of buoyant material into smaller pieces that can flow through pipes without clogging. The spiral lift is a different type of conveyance which lifts screening into a dump truck for disposal.

Note that the flow into the plant and through all the processes up to the secondary plant is by gravity. Generally, plants are designed to take advantage of gravity flow as much as possible in order to save energy. The disadvantage of gravity flow to a treatment plant is the absence of flow control into the plant. There is no valve or gate to reduce or stop flow into the plant. If all the sluice gates isolating the bar screens are closed, a flood is created upstream, unless storage is provided. Some storage exists in the conveyance system but too little to affect an event such as the Hyperion flood. Storage is expensive to create in an urban setting and is rarely constructed in separate sanitary sewer systems, although cities with combined stormwater and sewer systems do construct storage to deal with the high variability of flows to prevent sewage spills (examples include the cities of Milwaukee, Chicago, and San Francisco). These are multibillion-dollar projects that created billions of gallons of storage because they are combined sewer systems, where both wastewaters from homes and businesses and stormwater that runs off the streets are combined. During rainfall, the flow of stormwater can be 10 to 100 times the flow of raw sewage. In those cases, storage, while expensive, becomes essential to avoid the release of raw sewage into the community upstream of a plant and to store mixed stormwater and sewage for later treatment. It is also rare to have flow within a plant blocked to the degree that occurred at Hyperion and uncommon to have massive storage in separate sewer systems.

Figure 24 shows the equipment that transports the debris away from the screens and ultimately into trucks to haul compacted screenings to landfills. Figure 24 starts at the sluice in Figure 23, where the screenings drop from the top of the bar screens. The screenings are transported by rapidly flowing water to two types of devices to remove and compact them. There are three pipes that connect to the sluice. Screenings and transport water travel downward to the chopper pumps located in the basement. These pumps can be operated individually and are designed to handle the load without all three being in service. The pumps have a blade on the impeller which cuts or chops the screenings and lifts the transport water, now with chopped screenings, up to the third floor where they are dewatered using drum screens. Most of the water flows through the drum screens and is returned to the Headworks, upstream of the bar screens. The dewatered, chopped screenings drop into open-top trucks. This method for disposing of screenings was constructed as part of the large plant upgrade in the 1990s.

A second method of removing screenings was added later to improve overall reliability of the Headworks. At the end of the sluice, the transport water is split into two paths, both leading to a second type of chopper. From there, the screenings are fed to a spiral lift, which is a type of screw conveyor and allows water to drain while transporting the screenings upward to be dumped into the same trucks. There are at least two hypothetical cases that could have caused the screens to blind. The Bureau of Sanitation's 30-day report (1) suggests that a large mass of debris entered the plant and blinded the screens. This report was created early in the investigation and was based on the best available information at the time. This potential cause is possible, but the subsequent Brown and Caldwell reports did not find evidence in the conveyance system of a previous or current accumulation of debris. The report did find an accumulation of grit near and around the sluice gates. Although grit normally does not blind screens, the accumulation may have contributed to the problem.

Prior to the event, the Bureau of Sanitation 30-day report also notes the failure of a chopper pump on July 11, and a spiral lift was out of service before July 11. Based on the investigation by CDM Smith, it appears possible that both systems to remove screenings could not keep up with the rate of removal of screenings and forced an overflow and recycling of screenings at the point shown in Figure 24. The Committee Advisors conclude that this is the most likely explanation for failure of the screens. Recycling of screenings would eventually overcome the bar screens and result in blinding and the increase of the wastewater level upstream of the screens. Under normal conditions, these screenings would have been transported to the trucks via the choppers. This recycling of screenings could have led to ultimate flooding of the Headworks.

The Bureau of Sanitation's 30-day report also noted that after the stop log barrier was removed, incoming untreated wastewater could bypass the bar screens and flow into the downstream treatment processes. The barrier was not immediately removed when bar screen blinding first occurred. Operators reported that the water level had risen to the point where they could not have reached down into the flood water to attach a sling to connect to the crane. There was also danger in crossing the floor due to tripping hazards and electrocution. The operators had to wait until the water level subsided before they could connect the sling and remove the barrier. The barrier was removed at approximately 4:30 AM on July 12, when the plant was at its lowest influent flow rate since the previous afternoon. After the barrier removal, the water level dropped in the Headworks building and the flooding ended. The raw wastewater then flowed to the grit chambers. Consequently, screenings were then transported into the plant which created damage in downstream tanks and equipment and is still being repaired.

Capital and Operational Improvements Recommended for the Headworks Building and Screens

1. **Finalize DCS deployment and connections with consideration given to lessons learned from the flood.** CDM-Smith noted that not all of the potential functions of the overall wastewater system's Distributed Control System (DCS) were operational at the time of the flood and that completion of those connections could improve future operations by allowing the bar screens to operate in different modes (e.g., variable rake operation such as fixed frequency or variable frequency depending on head loss), as well as improving alarm functionality. Since the DCS connections are an ongoing project not yet completed, we recommend that the Bureau of Sanitation meet with the operators associated with the Headworks to see if there are modifications that should be made based on lessons learned after the flooding incident. The Committee Advisors encourage maximum integration of the DCS systems, including visible and audible alarm systems in both the Headworks facility and the main control room.

2. **Evaluate value versus risk of screenings recycle.** The removal of screenings from the sluice to the trucks should be made more robust with the goal of substantially reducing or eliminating recycling of screenings. Some alternative method for control of overflow of transport water is required, since the transport water in the sluice trough travels at 1.4 million gallons/day (MGD), and its overflow would create a flood by itself. The most important change would be to eliminate the recycle of screenings.

3. **Evaluate and develop new standard procedures.** Evaluate and develop new standard operating procedures for using and removing the barriers in the event of emergency. The Bureau of Sanitation should undertake a study to identify best practices in the field. Automated overflow systems or an enhanced ability to remove barriers while protecting worker safety should be a part of that analysis.

4. **Ensure comprehensive screen testing.** The backup bar screens overloaded when placed online, likely because the strain on the motors was greater than their capacity due to the excessive material being recycled to the screens. It is suggested that motor size and torque ratings be reviewed for adequacy. In particular, the motors on the ¾ inch screens should be evaluated for upgrading. It is recommended that the Bureau of Sanitation do a comprehensive testing and review program of the

bar screens and associated systems. It is important for plant personnel to have detailed knowledge of screen functionality, including key elements such as motor draw and raking cycles. It may be desirable to engage a consultant who has worked with treatment plants such as those with combined sewers, which have large peak flows with debris.

5. **Provide visual screen monitoring.** In the tours of the Headworks by the Committee Advisors, it was apparent that it was difficult to see the condition of the screens through transparent but often cloudy covers. The motivation for new screens was created in part to control odors and therefore the screens should continue to be covered. It is recommended that a closed-circuit video system be installed so that the screens can be viewed at all times by operators without having to walk up to the covers and peer inside. We envision a system similar to the system at security desks in buildings, where a guard can see multiple points on a single screen simultaneously. The bar screen motor currents should be logged and alarmed in both the local and central control rooms. The motor current will show the load on the screens and indicate an increase in material loading from outside or within the plant, as well as when it might be necessary to place additional screens online. Also, long-term monitoring of motor current will likely indicate wear in the screen transport mechanism and be an indicator for maintenance.

6. **Evaluate adequacy of screen motors and power and make necessary adjustments or overhaul.** The Committee Advisors and others are particularly concerned with the near-immediate failure of clean screens as they were placed online, suggesting that the motors or start-up torque was insufficient. Figure 23 shows the differential head before and after the screen and the manufactures specification for flow rate indicates that 4.2 inches of head will cause 133 MGD of flow. When the backup screens were placed online, the head could have been as much as 96 inches. Such high head would cause a very high instantaneous flow, perhaps as much as 1000 MGD. The high head may have pressed screenings into the open spaces and compacted them so that the rakes could not clear them. The operators report that, in the days after the event, they could only clean screens by inserting a hook through the screen and then pulling the screenings backwards. It is recommended that this problem be evaluated by the Bureau of Engineering/consultants to determine if the existing bar screen motors are adequate and that any improvements be made swiftly.

7. **Consider implementation of capital safety measures in the event of another incident.** It is hoped that a flood of this type never occurs again, but there are safety measures that can be taken to limit damage if it does happen. These recommended safety measures could also be useful in the event of a natural disaster:

    a. Construction of a high-level bypass should be considered so that flows above the high alarm level at the bar screens will be routed without operator intervention to the grit chambers.

    b. The road leading to the Headworks building was the conduit for flood waters to the rest of the plant. A study should be performed to see if the road can be recontoured or bermed to direct flood waters to a safe location. A gravity flow channel to the emergency storage basin or other outlet should be considered.

    c. Doors in the lower floors of the Headworks building were in some cases crushed by water pressure. These doors and especially passages to critical areas could be replaced with "submarine doors" to provide a seal, prevent crushing and protect the rest of the facility while directing flood waters to a safe outlet.

    d. The stairway entrances to the tunnels in the secondary part of the plant that house essential electrical equipment should be studied to determine if modifications can be made to prevent the entry of flood waters while still maintaining accessibility for essential operations.

Conveyance System

Goal – Improve Conveyance System Monitoring and Maintenance to Reduce Risk and Prepare for Both Reduced and Heavy Flows in the Future

Brown and Caldwell's first report found only a few problems in the conveyance system but none that could have caused a sudden discharge of debris. Their second set of observations, closer to the plant and under the LAX runway, indicate that, while they did not find evidence of large amounts of debris release, they did find accumulation of dense material such as grit, and one large metal object near the entrance of one of the screens. Therefore, it appears that there is insufficient evidence in the conveyance system of a large release of debris at the time of the flooding.

There are, however, important recommendations for the conveyance system:

1. **Perform conveyance system maintenance.** The problems found in Brown and Caldwell's investigation of the conveyance system should be addressed as soon as practicable. Although they are not the cause of the flood, they could lead to problems in the future, for example, under a heavy rain scenario.

2. **Remove accumulated heavy debris.** The grit accumulation in the channels in the Headworks should be further studied to develop a method for removal so as not to limit system capacity.

3. **Explore securing new monitoring technology.** The new equipment that made Brown and Caldwell's analysis possible is scarce and in high demand. The Bureau of Sanitation should evaluate whether it can incorporate this or similar new technology to expand their inspection program of long sewers to a more routine and timelier basis.

4. **Study and prevent debris buildup.** The buildup of debris and grit in sanitary sewers is not a problem unique to Hyperion. It is a national challenge resulting from the desired and necessary conservation and recycling efforts across the United States which can create situations where flows may no longer be great enough to move material as the systems were designed. Climate

change will make these efforts more important. Many of the existing sewers in the Hyperion conveyance system were designed for higher flow rate. At lower flow rate, the liquid velocity is reduced, which generally allows debris to accumulate in the sewers, which could then be washed out during high flows or emergency events. Bureau of Sanitation staff should participate in the national efforts to develop monitoring and other remedial procedures to avoid problems caused by low flows.

Assessment and Audits

Goal – Review of Critical Operations and Identification of Necessary Steps to Reduce Risk of Future Emergencies

We recommend actions to mitigate future emergencies through improved response and better preparation for unexpected conditions. This section also describes a wide array of additional suggested analyses covering Hyperion operations and capital project planning that should be prioritized to help fully transition Hyperion to a wastewater recycling facility.

1. **Engage and perform a third-party, top-to-bottom analysis.** In light of the critical importance of Hyperion, both in its current form and as it is being prepared for transition to a full wastewater recycling facility, the Committee Advisors feel that one of its most important recommendations is for the Bureau of Sanitation to engage a third party (or parties) in a top-to-bottom analysis of operations, staffing and management structure, capital project planning, organizational culture, communications, and emergency preparedness. This assessment should be prioritized as the Bureau moves into this monumental and critically important next step in its history. In addition, the Bureau of Sanitation should assign senior leadership responsibility for the facility and staffing upgrades necessary to both rapidly deal with preventing future flooding and prepare Hyperion for its transition to a full wastewater recycling facility. Senior leadership in the Public Works Department and potentially the Mayor's office should also be tasked with oversight of the pace and attention to this work.

2. **Evaluate and improve high water level alarms and annunciators.** There were high water level alarms for the influent channel level, yet operators were not able to avert flooding. An analysis

should be performed to understand what improvements to the alarm and response system would help prevent future flooding events by giving operators critical time to respond early in an event. The analysis should include consideration of the time needed to respond to avoid damage given quickly changing and increasingly dangerous circumstances like those present on July 11. The analysis provided by CDM-Smith suggests that there was a short time to attempt to fix the bar screen blinding before a flood would occur. That window may have been shortened further by the lack of full awareness and mobilization in the facility control room. The criticality and time sensitivity of alarms should be reflected in operator training, as well as through greater visibility and audibility. As soon as the analysis is completed for the Headworks building, similar analysis should be extended to the entire plant.

3. **Maximum conveyance flow analysis.** Hyperion must handle dramatic changes in daily flow rate – from approximately 260 MGD on dry days to as much as 800 MGD during wet weather due to inflow and infiltration. This increase is only a fraction of the peak flow that occurs in a combined sewer system but is potentially large enough to damage the plant. While the July 11 event was not related to a storm event, an analysis, which is essentially a risk assessment, should be performed to determine how much flow can be expected from future storms and how the plant should respond to avoid storm-related incidents.

4. **Ensure emergency power availability.** There were questions in several presentations on the existence of emergency power. An analysis should be performed to determine if sufficient emergency power exists for the bar screens and choppers. That analysis should include examining both strength and protection of electrical systems. The analysis should also be extended to the rest of the plant.

5. **Analysis of response.** An analysis should be performed to determine what additional actions should be taken or avoided if another event of this type were to occur, including examining the call up of backup operators, the timing of notifications to other agencies, and other emergency steps.

6. **Evaluate adequacy of DCS.** The need for additions to the DCS should be determined and implementation at the Headworks and throughout the plant should be prioritized.

7. **Evaluate public information capacity.** The capabilities of the public information system should be audited to determine what additions may be needed to assure optimal communication with other agencies and the public.

Operations – Headworks Procedures

Goal – Critically Review Operations and Activities During the Flood to Determine Critical Needs and Responses to Emergencies

This section makes recommendations for improvements in operations and procedures unique to the Headworks.

1. **Headworks staff.** Evaluate whether any changes are recommended for the roles and responsibilities of the staff on duty to operate and maintain the Headworks. Adequacy of staffing should be assessed, and this evaluation should include specific steps to ensure active monitoring of all critical systems and alarms and monitor screen performance and the potential problems identified in the CDM-Smith and Brown and Caldwell reports.

2. **Alarm response protocol.** Evaluate and develop revised procedures as appropriate for annunciating and responding to alarms, routine "boots on the ground" inspection of key process equipment, and documentation and logging of actions to be taken.

3. **New standard operating procedures.** Develop a new standard operating procedure, based on identified best practices, for using and removing barriers, more rapid notification to senior staff of unusual occurrences, and maintaining logbooks.

4. **Backup equipment.** Evaluate and develop revised procedures as appropriate for backup screens, choppers, and spiral lifts.

5. **Communications among shifts.** Identify and implement improvements to documentation to ensure that all shifts practice the same procedures and communicate with each other. Develop and/or update a standard documented inspection round as appropriate for all shifts.

6. **Periodic reviews.** Evaluate and conduct reviews (i.e., quarterly, or other frequency as appropriate) of logs to identify potential problems or lapses and improve communication.

7. **Training for future emergencies.** Evaluate and develop as appropriate a specific plan of action with appropriate training for a future bar screen failure event. Retrain periodically on any such action plan and make sure new operators are trained for this critical function.

Training

Goal – Identify Needs for Improved Training and Communication

1. **Cross-train staff to the extent possible.** Consistent with the recommended audit of alarms, ensure backup operators are trained and cross-trained to respond in an emergency.

2. **Urgent alarm response.** Ensure urgent alarms that require an urgent response are identified and trained for in addition to adding more visible and audible alarms for critical systems.

3. **Evaluate and enhance coordination – particularly in the event of emergency – between the entire wastewater plant system.** The three City of Los Angeles Plants, DC Tillman (DCT), Los Angeles/Glendale (Glendale), and Hyperion operate as a system in that they treat wastewater from the combined conveyance system. Also, DCT and Glendale return screenings, grit, waste sludges, and biosolids to the conveyance system for removal at Hyperion. The three plants should operate together to respond to emergencies when circumstances permit. It is recommended that procedures be evaluated and identified as applicable to promote improved operation and routine coordination among the plants in case of future emergencies; personnel should be trained on these procedures.

4. Communication within and among plants. Develop procedures for when to contact Plant management and engineering so their assistance and guidance can be utilized as soon as practical.

Staffing

Goal – Determine Additional Staff Needs to Respond to a Future Flood or Emergency

The Committee Advisors are concerned about the large number of open staff positions. This problem is particularly severe now because of COVID-19 but has also been a problem in the past.

1. **Evaluate staffing needs for optimum operations and preparation.** Consistent with recommendations made in the audit section of this report, evaluate, and update, if necessary, the ideal number and type of operations and maintenance staff needed for desired plant operations. Evaluate process engineer staffing and responsibilities related to Headworks process design.

2. **Alternate shift and holiday analysis.** Staffing analysis should be done for normal hours, evening hours, weekend hours, and predictable extreme events such as forecasted large rainstorms or holidays.

3. **Call-in staff.** Determine what "call-in" staff may be helpful and how best to manage call-ins.

4. **Retention of experienced Headworks operators.** The Headworks area is one of the least desirable places in the plant to work. Consider establishing greater incentives to work in the Headworks area to make the post more desirable.

Emergency Response/Community Outreach

Goal – Improve Coordinated, Timely and Transparent Emergency Spill Response to Further Protect Public Health and Safety and Enhance Public Trust in Hyperion Operations

In all regular and emergency response communications, the Advisors recommend that the City continue to strive towards full transparency and maximum protection of the public.

1. **Tighten intra-agency and inter-agency coordination, cooperation, and communication.** Evaluate and consider adoption of policies, protocols, and training to promote expedited and enhanced intra-agency response and inter-agency coordination between the City and other agencies such as the LA County Department of Public Health, including:

    a. Updated and reinforced cooperative protocols with the LA County Department of Public Health ensuring that the County has real-time, comprehensive information, as available, necessary to post notices and/or close beaches as expeditiously as possible whenever an emergency results in untreated sewage discharges.

    b. The Bureau of Sanitation's additional emergency response recommendations for reporting to regulatory agencies, continually improving community relations, public notifications, and the development of broader media outlets and contacts.

    c. Specific criteria for emergency response levels based on severity and proximity of spill.

2. **Develop protocols for after-action reports.** Establish protocols for preparation and distribution of after-action reports following any spill or emergency incident, identifying – to the degree possible given the information available at the time – potential causes, corrective actions, and recommendations for immediate responsive actions.

3. **Strengthen communication lines with neighboring communities.** Expand regular and ongoing engagement with neighboring communities to ensure lines of communication for real time, comprehensive community outreach immediately following a spill or emergency event, with particular emphasis on outreach to those most likely to be impacted (e.g., nearby communities, water users). Build on and institutionalize actions developed in this event. Adopt Bureau of Sanitation's emergency response recommendations related to external communications.

4. **Real-time communication with the public.** Evaluate and expand the Bureau's own extensive notification and outreach efforts, within its legal jurisdiction, to reduce potential human exposure in the event of a spill or emergency incident.

5. **Rapid bacteria testing.** Evaluate and, if appropriate, establish protocols for undertaking rapid bacteria testing in the event of a spill or emergency incident, to ensure the public has the most complete real time understanding of the scope of possible health threats until no longer necessary (e.g., no elevated indicator organism levels for 72 hours).

6. **Strengthen and model beach protections.** Evaluate and consider developing modeling techniques, within its jurisdiction, to determine how a spill will affect beach water quality in order to predict when beaches should be closed by L.A. County Department of Public Health and if they should be closed before testing indicates high concentrations.

Conclusions

This report has described the events of July 11 and 12 and referenced some of the Bureau of Sanitation's responses and the preliminary reports of the two consultants. These references should be consulted for more detailed information, understanding all reports were drafted based on the best available information at the time and may become outdated by subsequent investigation, some of which is documented in this report. The Committee Advisors recognize the dedicated efforts on the part of the Bureau of Sanitation to reduce the impact of the flood and restore normal plant operations. We also acknowledge and appreciate the work already ongoing to repair the plant and minimize the possibility of a recurrence or a similar event.

The report makes general and specific recommendations to reduce risks of future floods or spills and improve operations. Generally, the recommendations are divided into two broad categories – those designed to avoid future problems with the bar screens by changes in their construction, controls and operation, and conveyance system, and recommendations to ensure that Hyperion is positioned for the transition to a full wastewater recycling facility by 2035. The recommendations range from the areas of staffing, communication, organizational, and management structure, to emergency response and the development of an elevated sense of plant "ownership" in all parties involved in its operations.

We also make a specific, long-term recommendation that BOS and BOE analyze the conveyance system to predict the maximum short-term discharge that Hyperion can expect to receive in extreme events and compare this with the ability of Hyperion's three areas of flood risk – Headworks, secondary influent pumping, and final effluent pumping – to handle it. This analysis is crucial to reducing future risks to the plant and should include consideration of the use of the diversions to convey flood waters out of the plant to avoid plant damage. Appendix B compares the discharge of biochemical oxygen demand (BOD) and total suspended solids (TSS) that occurred to a hypothetical case of diverting the flood waters. The use of the diversion in emergencies should be restricted to extreme events to avoid plant damage, always including emergency disinfection, and be clearly communicated to regulators as to the need to divert wastewater.

The Ad Hoc Committee Advisors appreciate and thank the Bureau of Sanitation and the Bureau of Engineering for their assistance in this investigation as well as others that provided information.

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Appendices

Appendix A: List of members of the L.A. Board of Public Works, Ad Hoc Advisory Committee Advisors, and major participants from the Bureaus Engineering and Sanitations and consulting firms.

Appendix B: Analysis of the effluent quality of the Hyperion treatment plant after the damage caused by the flood compared to the mass discharge of flow if diverted to the 5-mile or 1-mile outfalls.

Appendix C: Selected photographs of the Hyperion Headworks and flooding.

Appendix D: Description of innovative equipment used in investigating the conveyance system and Headworks channels.

Appendix A. List of Members of the L.A. Board of Public Works, Ad Hoc Advisory Committee Advisors, and Major Participants from the Bureaus of Engineering and Sanitation and Consulting Firms

The completion and development of this report by the Hyperion Ad-Hoc Advisory Committee Advisors was made possible thanks to the hard work and commitment of so many people. This report, while authored by the Committee Advisors, is the culmination of the rich discussion, in-depth presentations, and constant support displayed throughout this undertaking by the Department of Public Works through the Advisory Committee and its Advisors, Bureau of Sanitation, and Bureau of Engineering with vital input from Brown and Caldwell, CDM Smith, and Headworks International.

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Advisors	
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Kenneth Frere	Construction Manager
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Michelle LaNoue	President and CEO
Wayne McCauley	Vice President and Senior Product Manager
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Cindie Bassett	Executive Assistant, L.A. Board of Public Works

Appendix B. Analysis of the Effluent Quality of the Hyperion Treatment Plant After the Damage Caused by the Flood Compared to the Mass Discharge of Flow if Diverted to the 5-Mile or 1-Mile Outfalls

A hypothetical question to be considered to avoid any future flooding incident is "What discharge mass to the ocean would have occurred if the flood had somehow been entirely diverted to the 5- or 1-mile outfalls?"

At the time of the incident, it was not possible to divert the flood waters in this manner. The Ad Hoc Committee Advisors modeled this scenario to evaluate an alternative option in the event of a similar future incident.

In this hypothetical case, the damage to the plant might have been avoided. Figure 25 (below) is a graph that shows the discharge of TSS and BOD after July 11 (graph from BOS's Zoom meeting with the City of El Segundo, 8/17/2021). The loss of secondary treatment caused the effluent TSS/BOD to increase at times to basically the influent concentrations. The vertical red bar is a model of the effluent BOD and TSS that might have occurred if the flood waters had been diverted. The mass discharges of BOD and TSS are calculated from the graph using a flow of 280 MGD.

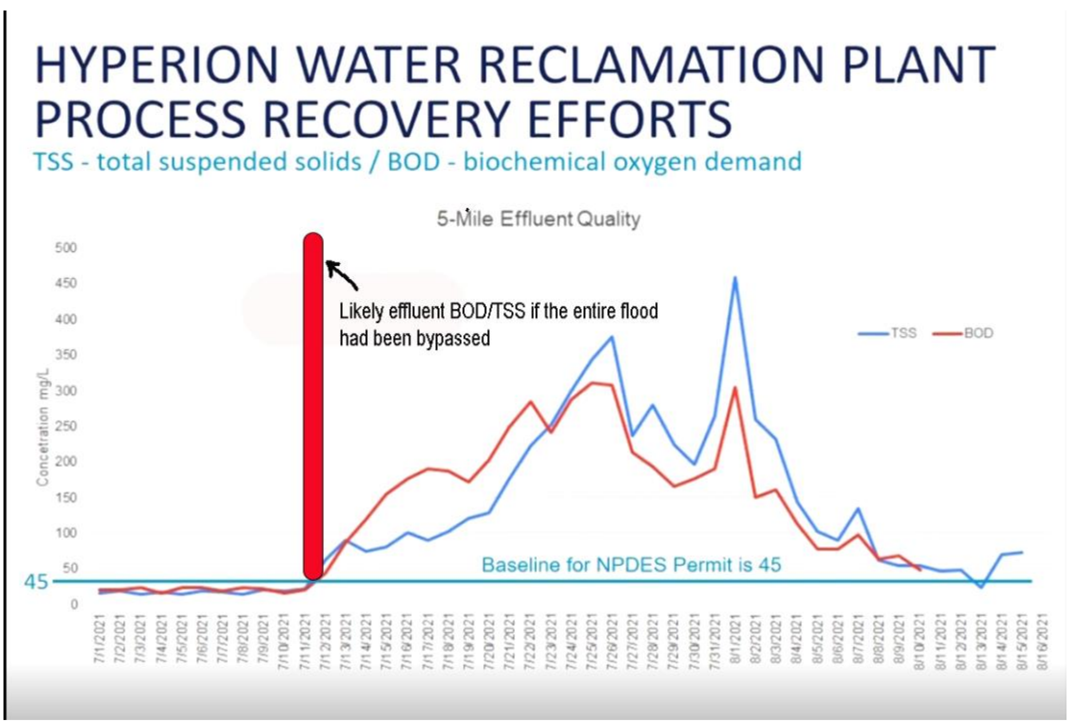


Figure 25: TSS and BOD discharges after the July 11 flood and a hypothetical discharge if all the flood water had somehow been diverted to outfalls, preventing damage to the plant.

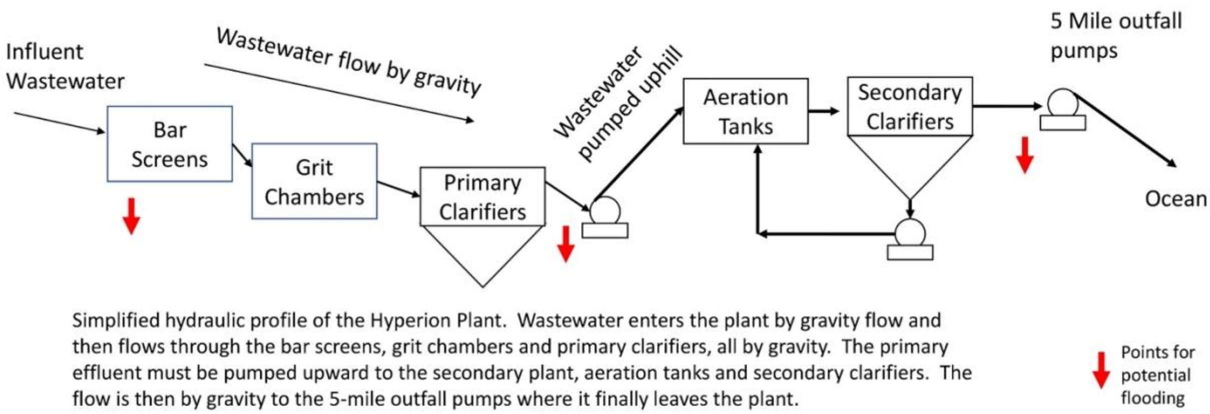
Ocean Discharges	BOD (tons)	TSS (tons)
Flood Event	5581	5663
Hypothetical Diversion	29.4	16.5

The modeling predicts that a hypothetical diversion which could have avoided Hyperion damage would also have reduced BOD and TSS mass discharges by more than 99%. Because this hypothetical is based on a model, actual results can differ. Additional analysis is needed prior to invoking this approach to better ensure that the model results would reflect a real time flooding incident.

The report recommends several measures to avoid a future flood and generally increase plant reliability and reduce risk. The report also recommends a more thorough analysis of flow capacity, in view of the possible delivery of 800 MGD or more from the conveyance system during a large rainstorm. Advisors familiar with Hyperion and the Hyperion staff have noted that there are three possible locations for failures that might cause a flood: Headworks, primary to secondary pumping, and final effluent pumping. The existing capital improvement recommendations are primarily to Headworks and do not affect the capacity of the other two potential flood points.

An additional but longer-term recommendation to the report is to have BOS and BOE perform a plant-wide analysis of flood risk which also includes an analysis of the conveyance system to better understand its peak flow during an extreme rainfall. The results of the analysis could recommend capital improvements and the feasibility (from an engineering, environmental, regulatory, and capital perspective) of the installation of a system that would allow the ready use of the 5-mile or 1-mile outfalls for flood control.

Figure 26 (below) shows a simplified hydraulic profile of the plant. The three most likely places where a flood could occur because of a massive power failure, earthquake, or tsunami damage are shown with red arrows. A flood in any of these places could damage the plant as well as traveling to the beach if allowed to continue. The possibility of plant flooding could theoretically be avoided if the plant were reengineered such that the 5-or 1-mile outfall could be used as emergency diversion. The analysis should include gravity flow analysis, since during an extreme emergency power for pumps might not be available. The use of diversions to the outfalls would only be used under an extreme emergency, after any flood-control storage is full, and to avoid damage to the plant or discharge directly to the beaches.



Simplified hydraulic profile of the Hyperion Plant. Wastewater enters the plant by gravity flow and then flows through the bar screens, grit chambers and primary clarifiers, all by gravity. The primary effluent must be pumped upward to the secondary plant, aeration tanks and secondary clarifiers. The flow is then by gravity to the 5-mile outfall pumps where it finally leaves the plant.

There are three potential flood points in the event of a catastrophic power failure or damage due to an earthquake:

1. At the headworks because the bar screens blind
2. Primary effluent because the secondary influent pump station loses power or is destroyed
3. 5-Mile pump station failure

Any of these locations can flood the plant and if not directed to the 1-mile outfall could eventually spill over to the beach.

Figure 26: Simplified Hyperion plant hydraulic profile

This would be a longer-term activity and would not preclude the short-term actions which we have already listed.

Appendix C. Glossary of Terms for Wastewater Treatment and Water Reclamation

The following terms are used in this report and documents cited in this report:

Alarm:	Treatment plants typically monitor certain conditions that are associated with proper operation. Examples are flow rates, temperatures, liquid levels, and many others. If the monitored parameter is out of range, an alarm occurs which is displayed by an annunciator. The annunciator can be bell, siren, buzzer, and/or a visual indicator such as a light on a panel or a flashing light on the equipment.
Bar Screens:	Raw wastewaters contain many different things, typically anything that can be flushed down a toilet or flowing into a drain. They are typically called debris and may be composed of rags, sanitary appliances, other plastics such as pill bottles, and construction material such as lumber. They must be removed prior to the influent pumps or prior to the grit chamber if the plant operates with gravity influent flow. Bar screens are used to remove these materials. They are called bar screens because they are usually composed of multiple rectangular bars, perhaps ¼ inch thick and 1-inch wide, with the ¼ inch side facing into the flow. Spacing between bars ranges from 3/8 inches to 2 inches depending on site specific conditions. Bar screens trap the debris in the wastewater and must have mechanisms to clean the bars and remove the debris, which are called screenings after they have been removed. Large, new plants typically have mechanical scrapers to clean the screens and operate automatically. Small plants often use manually cleaned screens, which require an operator to scrape the screens with a rake, similar to a garden rake. Treatment plants that practice advanced treatment for reclamation typically have an extra fine set of screens with 2 mm openings.
Berm:	A berm is a raised barrier to control the direction of water flow.
Blind:	Blind is a term that means fouled or clogged but refers to clogging at the surface such as the surface of a filter or screen.
BOD, BOD_5 or BOD_u:	Biochemical oxygen demand. This is a measure of water contamination, and it quantifies the pollutants to consume oxygen and is measured in a laboratory test. The pollutants which will react with oxygen due to microbial action or naturally occurring chemical reactions will contribute to the BOD. The reaction occurs over time and BOD_5 is the most commonly used form, referring to the reactions which occur over five days. BOD_u is the ultimate BOD, theoretically occurring over infinite time, but in reality being measured over 28 days. Units of measurement are normally

	mg/L (milligrams per liter). The BOD of tap water is zero while the BOD_5 of raw wastewaters can be 250 to 500 mg/L. Treated wastewaters are typically in the 5 to 15 mg/L range.
Chopper:	A chopper is a device that shreds or cuts solids and debris in a following sluice or pipe. It differs from a chopper pump in that it does not have a pumping impeller but only blades to chop up debris such as screenings and rags.
Chopper pump:	A chopper pump is a pump designed with a suction that will cut or grind debris or screenings into sufficiently small particles so that they can flow through the pump and discharge piping system without clogging.
Conveyance system:	The conveyance system, also called a collection system, is the system of pipes and channels that conveys wastewater from its origins to the treatment plant. Ideally conveyance systems flow by gravity but may contain pump stations at low elevations. A conveyance system may be composed of 4-to-6-inch diameter pipes at single family dwellings to pipes 10 or 15 feet in diameter at the treatment plant.
DCS:	Distributed control system. Treatment plants typically have a network that connects equipment and instruments to a computer that monitors and sometimes controls them. It is typically used to record data on how the plant is operating. Alarms are usually connected to the DCS to alarm for abnormal conditions.
Dewatering:	Dewatering reduces the volume of a waste by reducing its water content, usually by compressing the solids.
Disinfection:	Disinfection is a process, usually as the very last treatment process in a plant, that inactivates, kills, or removes pathogens. Disinfection does not sterilize the wastewater but dramatically reduces its pathogenic nature. Disinfection efficiency is measured by removal of indicator organisms, such as coliforms or enterococcus. Typically, effluent concentrations of coliforms for discharge to large receiving waters that are not closely located to drinking water sources is 100 or 200 MPN/100 ml. For reclaimed waters the limit may be 12 MPN/100 ml or less than 2 MPN/100 ml depending on the reclaimed water usage. Disinfection has most often been performed using chlorine, ozone, or ultraviolet light.
Diurnal flow:	Wastewaters typically vary during a 24-hour period, called a diurnal fluctuation. Most wastewaters have a minimum flow early in the morning, typically at 5 AM, and a maximum flow in the afternoon. The range of maximum to minimum is typically 2 or more.
Grit:	Grit is a term to describe particles in wastewater that are dense, having a specific gravity of 2.6 g/cm^3, and are most often inorganic. Sand is typical of the size and density of grit. Grit must be removed at the Headworks because it can damage downstream processes by abrasion and can also accumulate in tanks, reducing their effective volume.

Grit chamber:	A grit chamber is a gravity separation device, allowing the dense material, the grit, to settle out while not allowing the organic material to settle. In this way they can separate the grit for transport to a landfill while keeping the organic material in the flow to be treated by downstream processes.
Indicator organism:	An indicator organism is an organism, usually a bacterium, that can be reliably measured that indicates the tendency of a water to be pathogenic. Most common indicator organisms are coliforms, often divided into classes such as total coliforms, fecal coliforms, thermo-tolerant, and Escherichia coli. Enterococci is another type of indicator organism, often used in saltwater environments. Indicator organisms are usually not pathogenic but indicate the presence of pathogens. Coliforms are a special group of bacteria that can be measured by an inexpensive laboratory test and are discharged in the fecal material of mammals. Treatment plants are typically regulated for the maximum indicator organisms in their effluents, and beach water quality is also regulated.
Headworks:	Treatment plants are typically divided into three areas. The Headworks is the first part of the plant where the raw wastewater enters. Headworks typically include pumps, bar screens to remove rags, and debris and grit chambers to remove sand-like particles, commonly called grit.
mg/L:	Milligrams per liter. It is the mostly commonly used measure of concentration in waters and wastewaters. A mg/L is one milligram being contained in one liter or water. In water, a mg/L is equal to a part per million or ppm. In gases, mg/L and ppm are not equal.
µg/L:	Micrograms per liter. A common unit for pollutants at lower concentration than mg/L. Equals to 1 part per billion in water.
MGD:	Million gallons per day. It is the most common unit of water and wastewater flow rate. 1 MGD equals 694 gallons per minute (GPM) or 1.546 cubic feet per second - or 3.068-acre feet per day. A garden hose at full flow rate ranges from 5 to 10 GPM.
MPN:	Most probable number is a measure of bacteria counts in wastewater. It is different than a concentration because the number of bacteria in wastewater cannot be precisely measured but must be estimated using a statistical method called MPN.
Pathogen:	Pathogen is a disease-producing organism, a bacterium, a virus, a protozoan, or a prion. It does not include disease-producing or toxic chemicals such as lead. A water or sludge that contains pathogens is called pathogenic.
Primary treatment:	Primary treatment is usually the first process in a wastewater treatment plant that removes pollutants other than debris and grit. Primary treatment is composed of gravity sedimentation devices, called clarifiers or primary clarifiers. They also include surface scrapers that remove floatables such as oil and grease. Typically, primary clarifiers remove 35% to 40% of the BOD_5, and

	60% of the TSS. Prior to the Clean Water Act amendments of 1972 (PL-72-500), many domestic wastewater treatment plants only had primary treatment
Reclamation:	A term that refers to the process of treating wastewaters for reuse, such as for landscape irrigation, freeway dust control, a variety of non-potable uses, and in advanced cases for indirect potable reclamation where highly treated water is injected to aquifers to eventually flow to potable wells. In 2023, California will also have regulations for Direct Potable Reuse, which includes the full cycle from wastewater to drinking water through direct treatment.
Screenings:	Screenings is a term that refers to the rags and debris removed by bar screens or other screens. They are typically compacted and disposed in a landfill.
Secondary treatment:	Secondary treatment occurs after primary treatment and includes some type of biological treatment using bacteria. The bacteria metabolize the organic contaminants in the wastewater, converting a fraction of them to bacterial cells that can be removed by sedimentation or filtration. PL-92-500 required all plants in the United States to have some type of secondary treatment to remove at least an average of 85% of the BOD_5 and TSS or down to 30 mg/L of each, whichever is less. There are a number of different types of secondary treatment processes, such as activated sludge (most common, especially for large treatment plants), trickling filters, lagoons, and oxidation ponds.
Sludge:	Sludge is a term used for the last 100 or more years to describe solids associated with wastewater. It is an inexact term that can mean primary sludge, waste-activated sludge, or just miscellaneous solids found at the bottom of a tank. The term biosolids is a newer term and usually refers to solids that are composed of activated sludge bacteria. Most plants further treat sludges in anaerobic digesters that stabilize the sludge (less tendency to react and cause odors), reduce mass, improve dewaterability, and produce biogas. In using the term "sludge," it requires a modifier such as "primary" or "secondary" to be accurate.
Sluice:	Sluiceway is a channel that carries water. A sluice gate is a valve for controlling the flow of water in the channel. In treatment plants, sluice gates are used to control the flow of water or wastewater. These sluice gates are typically either completely open or completely closed. They can be operated using a gear box and a motor, by a crane, or even by hand if they are small. They are most often used in infrequent application to isolate equipment from the flow for access or maintenance.
Spiral lift:	A device that uses a screw-looking mechanism that can transport and dewater screenings so that they can be dropped into a truck or hopper.

Stop logs:	A stop log is a device to stop or reduce water flow in a channel. They are usually inserted in notches along the sides of the channel and are typically installed or removed with a crane. They are normally used in applications where changes are infrequent.
Tertiary treatment:	Tertiary treatment occurs after secondary treatment but is not a standard term. If a plant reports that it uses tertiary treatment, one must further investigate to know what processes it has. Tertiary treatment can be defined as something as basic as disinfection or filtration to advanced processes such as reverse osmosis.
Trip:	Trip refers to disconnecting piece of electrical equipment using a device such as a circuit breaker, fuse, or heater because of overcurrent, overloading, or shorting, and prevents additional equipment damage and fires.
TSS:	Total suspended solids. This is a measure of the particles in water. It is measured in a laboratory test using a filter that retains particles generally larger than 0.7 microns (a micron is one millionth of a meter). The particles in wastewater can be composed of inorganic material such as sand and clay, or organic material such food and fecal materials. TSS includes both the organic and inorganic parts. VSS, or volatile suspended solids, includes only the organic particles. Tap water usually contains less than 1 mg/L of TSS, while raw wastewaters may contain 200 mg/L. Treated wastewaters typically are in the 5 to 30 mg/L range.

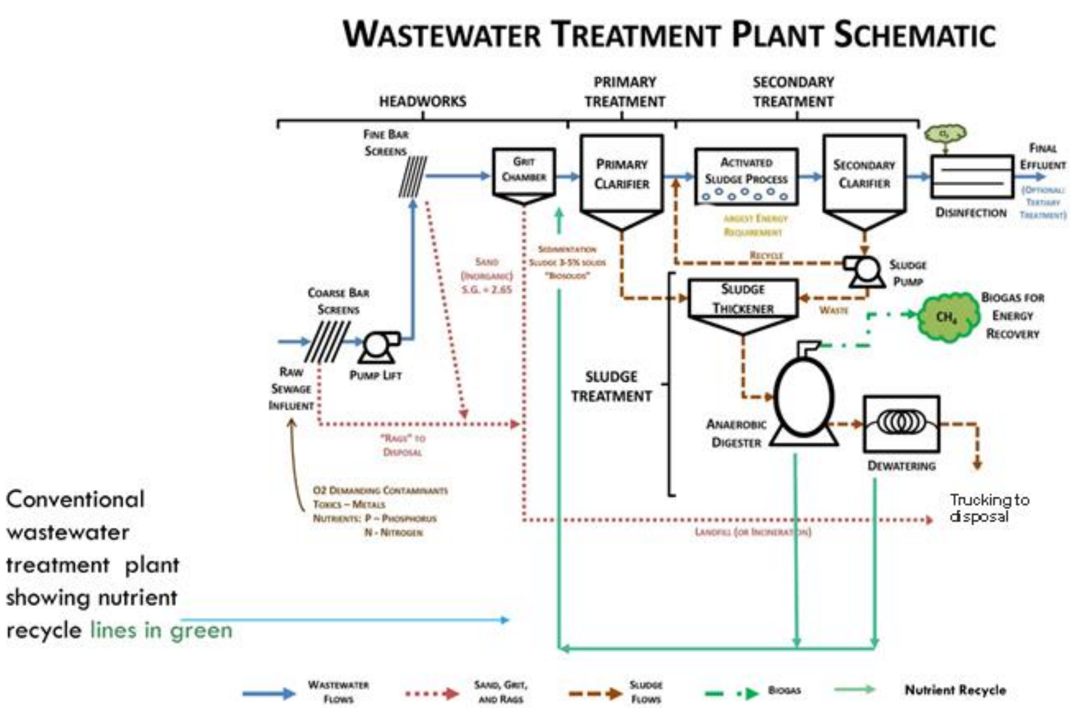
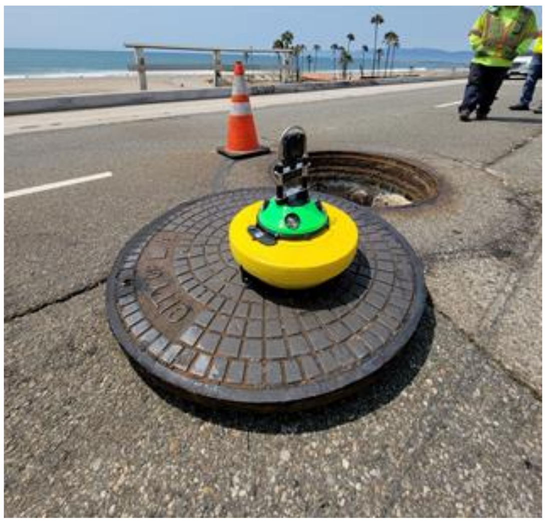


Figure 27: Schematic of a secondary wastewater treatment plant. Not all plants will have all items shown.

Appendix D – New Technology Equipment Used to Inspect the Conveyance System

The Hyperion conveyance systems contains several pipelines that are routed under the runways of the Los Angeles International Airport (LAX). These lines are a mile long in some cases and are therefore inaccessible to conventional sewer inspection equipment. Inspecting these lines required a unique approach using a floating "buoy" that was released into the sewer and collected data as it floated down to a collection point. The Brown and Caldwell team used equipment provided by Subterra (www.subterra.ai) called Sewer Scout™. The device was retrieved at the last accessible maintenance hole outside of the plant.



Figures 28 and 29: Left: Sewer Scout™ buoy prior to be deployed into the conveyance system.
Right: Confined space entry to a maintenance hole to retrieve the buoy.

The sewers between the last accessible maintenance hole to the bar screen channels were inspected using the RedZone Responder (www.redzone.com) robotic crawler, shown below. The Brown and Caldwell reports have more information on this equipment and its deployment.

Figure 30: RedZone Responder robotic crawler