City of Portland Environmental Services

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Biosolids Management Plan

June 2019

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

5001 N. Columbia Boulevard
Portland, Oregon 97203

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Mike Jordan, Director • **Nick Fish, Commissioner**

City of Portland

Bureau of Environmental Services

BIOSOLIDS MANAGEMENT PLAN

June 2019

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SECTION 1
EXECUTIVE SUMMARY

Table 1-1. Basic Information	
Facility Name:	Columbia Boulevard Wastewater Treatment Plant (CBWTP) - Principal Plant
Address:	5001 N. Columbia Blvd., Portland, OR 97203
NPDES Number:	101505 (renewed July 1, 2011) EPA Ref. OR-002690-5
Facility Name:	Tryon Creek Wastewater Treatment Plant (TCWTP)
Address:	195 Foothills Road, Lake Oswego, OR 97034
NPDES Number:	101614 (renewed November 4, 2004) EPA Ref. OR-002689-1
Contact:	Greg D. Charr, Biosolids/Residuals/Reuse Program Manager, 503-823-1876
Reporting Period:	January 1, 2018 through December 31, 2018
Biosolids Land Applied:	7,930 dry tons (7,194 tonnes) bulk Class B Land Applied at Madison Ranches: 5,792 dry tons (5,254 tonnes) Land Applied in Sherman County: 2,138 dry tons (1,940 tonnes)
Biosolids Landfilled:	1,206 dry tons (1,094 tonnes) Wasco County Landfill
Primary Hauler:	Gresham Transfer / Sutton Trucking. 503-255-7900
Land Appliers:	Madison Biosolids, Inc. 541-376-8107, Tribeca 360-518-0041

INTRODUCTION

The City of Portland recycled bulk Class B biosolids as a valuable soil amendment at land application sites in 2018. The City also landfilled a portion of its solids at the Wasco County Landfill. This management plan and report describes biosolids quality and indicates how the City beneficially recycled biosolids produced in 2018 in compliance with Oregon DEQ and U.S. EPA regulations.

BULK CLASS B BIOSOLIDS LAND APPLICATION

During 2018, 7,930 dry tons (7,194 tonnes) of dewatered biosolids cake (bulk Class B) produced at the Columbia Boulevard Wastewater Treatment Plant (CBWTP) were transported and land applied on 1,822.59 acres of permanent dry land pasture at Madison Ranches in north central Oregon (approximately 200 miles east of the CBWTP; Section 13) and 1,147.42 acres of dryland wheat in Sherman County (approximately 120 miles east of the CBWTP; Section 14). Land applied biosolids were dewatered to an average of 16.8% total solids cake via belt filter press prior to their hauling and land application under contract by Madison Biosolids, Inc. 1,206 dry tons of biosolids were also landfilled at the Wasco County Landfill.

Biosolids met 503.13(b)(2) trace inorganic pollutant limits during all months in 2018 (Section 12). If solids inorganic pollutant concentrations remain similar to levels found in biosolids land applied to dryland pasture during 2018, under 503.13(b)(2), at a rate of 3.73 dry tons per acre (8.36 Mg/ha) per year, biosolids could be land applied annually on permanent pasture for 233 more years based on molybdenum (Section 13).

During 2018, biosolids were applied at Madison Ranches within Oregon Department of Environmental Quality (DEQ) permitted rates (based on plant available nitrogen) to 1,822.59 acres (737.58 hectares) of land authorized by DEQ for Portland biosolids application (Section 13 and Appendix A). Biosolids were also applied to 1,147.42 acres (464.34 hectares) of DEQ authorized land in Sherman County in 2018 (Section 14 and Appendix A). Land applied biosolids were stabilized via anaerobic digestion to the extent that they met Class B pathogen reduction and vector attraction reduction criteria (Section 8). Management practices required under 503.14(a) thru (d) [agronomic application rates; no adverse affect on threatened or endangered species; no application on frozen or snow-covered ground which results in runoff; and no application closer than 10 meters to surface water] were observed by Madison Biosolids, Inc. (Appendix B). Site restrictions required under 503.32(b)(5) [livestock and public access; crop and grazing restrictions] were followed in biosolids amended areas.

SUMMARY AND CONCLUSIONS

During 2018, the City of Portland met EPA and Oregon DEQ regulations and recycled biosolids as a valuable commodity. The City's biosolids quality has improved dramatically over the last 30 years. The City's monitoring program strives to demonstrate regulatory compliance and assure product quality.

Land application of the City's biosolids at Madison Ranches provides both environmental and economic benefits. Biosolids application has improved soil quality, increased forage value and production, and stabilized sandy unvegetated areas at Madison Ranches (Section 13 & Appendix E). Biosolids have also off-set commercial fertilizer usage in Sherman County (Section 14).

Biosolids recycling via land application at the City's permitted sites (Madison Ranches, Sherman County) and newly permitted sites (Moro/Arlington/Wasco County Landfill – Section 9) will continue to be the major focus of the City's biosolids management program in 2019.

SECTION 2
PLAN OBJECTIVES

This management plan/annual report contains data and details on the origin, quantity and quality of biosolids generated at the CBWTP during 2018. In addition, this document describes solids production at the TCWTP; non-recyclable wastewater residuals management at the CBWTP and TCWTP; the impact the City's Industrial Source Control Program has had on solids quality; quantities of solids likely to be sent to land application sites during 2019; the influence biosolids land application activities have had on soil and forage quality and rangeland productivity; a description of an environmental monitoring forecast for 2019; and public outreach efforts.

Specific objectives of the plan are to:

- Provide DEQ with all required information on the origin, characteristics and use of Portland's biosolids necessary to demonstrate regulatory compliance.

- Advance the recycling of the City's biosolids as a beneficial soil amendment pursuant to Oregon Environmental Quality Commission (EQC) and EPA policies by documenting the City's continuous effort to improve and maintain biosolids quality and sound environmental stewardship in its land application operations. Both the Commission (OAR 340-50-006) and EPA (June 12, 1994, ***Federal Register***, p. 24358 and July 18, 1991, ***Federal Register***, p. 33186) encourage the land application of biosolids and biosolids derived products where these materials are managed in a fashion which protects the public health and sustains or improves environmental quality by enhancing soil tilth, fertility, and stability.

- Provide biosolids quality data (fertility and pollutant levels) and application site data (changes in soil and forage quality) useful for better communicating the impacts of Portland's bulk "Class B" biosolids management program at Madison Ranches and in Sherman County.

In addition, the following management program goals are contemplated for 2019 and beyond:

- Seek continual improvement in all aspects of biosolids management.

- Continue to pursue the development of sustainable, reliable, economically sound, socially responsible opportunities for long-range biosolids management.

- Coordinate with EPA, DEQ, and BES Industrial Source Control and Pretreatment Program for anticipated amendment of molybdenum Pollutant Concentration (PC) limit for land application.

- Continue to coordinate with EPA Region 7 and DEQ NW Region staff on new federal electronic reporting requirements for biosolids reporting (started 2017). Updated in 2018/2019 to EPANETBIO system.

- Provide support to BES Wastewater Engineering for solids management and permitting issues related to the lagoon reconstruction capital project.

- In recognition of EPA's final decision not to regulate dioxin-like compounds in land applied biosolids; continue to request DEQ to remove mandatory monitoring and reporting provisions for these trace organic contaminants from the CBWTP's NPDES permit. 2011 Update: In the newly issued NPDES permit (7/1/11) for the CBWTP, dioxin monitoring has been removed from the reporting requirements. Influent, effluent and biosolids dioxin and related compound monitoring will no longer be required. 2017 update: The CBWTP will no longer monitor dioxin and dioxin-like compounds in digested solids and dewatered cake (on a quarterly basis) since removal of legacy solids from the Triangle Lake lagoon via dredging will no longer occur (See Section 12).

- Investigate potential DEQ site authorization for additional land application sites (e.g., sites in Sherman, Umatilla, Morrow, Gilliam, Wasco and Benton counties or Willamette Valley) and other opportunities for Portland Class B biosolids land application.

- Continue to monitor legal cases and pending legislation (e.g., Kern County, CA, Wahkiakum County, WA, Nicola Valley, Canada, Lincoln County, OR) concerning biosolids land application and potential impact/precedent setting of final court decisions/settlements. In *City of Los Angeles vs. Kern County*, the court heard over twenty witnesses (including leading biosolids experts, hydrogeologists, chemists, and risk assessment experts) and received over 700 exhibits. Based on trial evidence and post-trial briefs, the judge issued a 48-page opinion in March of 2017. This opinion made numerous findings that land application of biosolids posed no risk, providing an important endorsement of the scientific and regulatory consensus regarding the safety of land application. The court held that "*the overwhelming weight of the evidence is that there is no basis in fact for any determination that land application of biosolids poses any risk…There is no evidence of risk to human health.*" The decision is particularly important because it is based on a full trial record of the benefits and lack of risk of biosolids land application.

- Continue partnership with Oregon State University to further identify the influence that Portland biosolids land application activities have had on soil properties and vegetation at Madison Ranches and Sherman County. New OSU publication entitled "Biosolids in Dryland Cropping Systems" published in 2018 (See Section 16).

- Continue to assess and evaluate compressed natural gas/renewable natural gas (CNG/RNG) fueling opportunities with Wastewater Engineering for contract haulers (e.g., Sutton Trucking, Tribeca Transport, Dietrich Trucking, Arrow Sanitary – grit & screenings).

- Fine tune Portland's biosolids management program via continued participation in the Northwest Biosolids Management Association (Northwest Biosolids) and the Oregon Association of Clean Water Agencies' Biosolids Committee.

- Continue to work with the Bureau's Field Operations, Investigations & Monitoring, and Laboratory Sections to maintain and continually improve the biosolids sampling/analysis quality assurance/quality control (QA/QC) program. ALS replaced Test America as the City's contract lab in 2016.

- Coordinate with Oregon DEQ, NRCS, OSU, Madison Biosolids, and partner growers in Sherman County to integrate biosolids land application into the NRCS Conservation Stewardship Program (See Section 14).

- Continue to monitor research and studies involving Per Flouro Alkyl Substances (PFAS) in biosolids and potential impact to land application.

- Provide training and orientation for new OSU Eastern Region Extension staff (replacing long-time OSU agronomist, Don Horneck).

- Effectively communicate key elements of Portland's biosolids management program to the general public (e.g., via farm field days, website updates, fact sheets and outreach documents, Short Schools, newspaper articles [(e.g., The Oregonian)], ACWA, WEF, Northwest Biosolids and similar organizations).

- Provide support to BES Wastewater Engineering for the upcoming Solids Handling Capital Improvement Project which will improve dewatering performance and capacity.

- Support the addition of FOG (Fats, Oils, & Grease) and/or food waste at the CBWTP. The new Organic Waste Receiving Facility is being planned to receive FOG for injection into the digesters. The system will also be able to receive commercial source separated food wastes (in the form of a slurry produced from food scraps). The material will be hauled in on tanker trucks in a pumpable form. FOG and commercial food waste are considered high strength organic wastes that are ideal for anaerobic digestion and enhanced biogas production. This biogas can then be converted to renewable energy-electricity, heat, pipeline quality renewable natural gas, or vehicle fuel. While there are numerous environmental and societal benefits to the project, this opportunity is mostly a means to generate revenue for the City via organic resource recovery – there will be a tipping fee for dropping the material at the CBWTP, and income from renewable natural gas production. The addition of FOG to the CBWTP's digestion system is anticipated in 2020 at ≈ 20,000-25,000 gal/day. Food waste could also be received in the future at ≈ 5,000 gal/day. Since both products are expected to enhance the digestion process (increased solids destruction and gas production), any increase to biosolids volume is expected to be negligible.

- Support Biosolids Inventory Reduction Project by fulfilling regulatory compliance obligations for Synagro biosolids process train (reporting, monitoring, and record keeping) and developing additional land application sites for biosolids reuse. In June 2019, site authorization letters were issued by DEQ for additional land application sites in the Moro/Arlington area and the Wasco County Landfill (Section 9, Appendix A).

- Complete open and competitive solicitation process with the City's Procurement Services to continue hauling and land application services in Sherman County.

SECTION 3
ESTIMATED SOLIDS PRODUCTION

Estimated biosolids production for the year is summarized in Table 3-1. Biosolids originated from first-stage digestion of raw thickened primary solids and thickened waste activated solids.

Table 3-1 Summary of CBWTP Estimated Solids Production - 2018[1]		
Parameter	**Average dry tons/day**	**Dry tons**
Estimated solids production	≈ 45	≈ 16,000
[1]Estimate based on process calculations from Heather McKenna – BES Wastewater Engineering.		

Biosolids final destinations for the year are summarized in Table 3-2.

Table 3-2 Summary of CBWTP Solids Destinations – 2018[1]		
Parameter	**Average dry tons/day**	**Dry tons**
Total Land Applied Biosolids	21.73	7,930
- Land Applied at Madison Ranches	-	5,792
- Land Applied in Sherman County	-	2,138
Total Landfilled Biosolids[2]	-	1,206
Total	25.03	9,136
[1]Based on truck ticket and lab data summarized by Willy Park, Engineering Technician III and Auburn Mills, Operations Specialist. [2]An additional 973 dry tons of digester cleanings were removed from the CBWTP and disposed of at the Wasco County Landfill in 2018. Data provided by Bill Sterling. Digesters 1 and 3 were cleaned in 2018.		

In 2018, solids produced at the CBWTP were dewatered and land applied, landfilled, or directed to Triangle Lake for seeding and stabilization prior to dredge removal. Solids sent to Triangle Lake undergo further biological stabilization and degradation. Land application amounts were lower in 2018 as the CBWTP continued to seed its newly constructed lagoon cells. Biosolids land applied in 2018 consisted of 98% freshly digested biosolids and 2% from the Triangle Lake stabilization lagoon.

BIOSOLIDS LAND APPLICATION

Bulk Class B biosolids were transported by contract haulers via truck/pup configuration vehicles. Solids were transported approximately 200 miles to Madison Ranches and approximately 120 miles to Sherman County (Sections 10, 13, & 14). Solids were unloaded onto one of several staging areas pending land application.

Biosolids applied as a soil amendment improved soil physical conditions and fertility. In addition, the conversion of raw wastewater solids to biosolids significantly reduced the volume of CBWTP solids requiring disposal.

SECTION 4
BACKGROUND

Before 1947, all City wastewater and stormwater flows were discharged directly into the Willamette River and the Columbia Slough through more than 60 outfalls. Over the years, discharge from these outfalls had a severe adverse impact on the area's waterways. Dissolved oxygen levels of zero were common in the Willamette River during the summertime.

In 1947, in an effort to restore water quality and allow beneficial uses of the area's waterways, the City embarked on an aggressive capital improvements program dedicated to the diversion, collection, and treatment of wastewater in a combined sewer system. One major element of the program included construction of the first phase of the CBWTP (completed in 1952; Section 5). Other major improvements, which benefited water quality, occurred with the construction of the TCWTP in 1965 (Section 6) and the expansion of the CBWTP and TCWTP to secondary treatment plants in 1974 and 1976, respectively. Further improvement of water quality should be realized with the operation of new dry and modified wet weather treatment facilities, which were placed online at the CBWTP in 2001 and 2008 (Section 5).

Pursuant to an Amended Stipulation and Final Order (ASFO), the City of Portland was required to eliminate 94 percent of combined sewer overflows to the Willamette River by 2012. Combined sewer overflows along the Willamette River are now intercepted and conveyed to the CBWTP. The first phase of combined sewer reconstruction, the West Side CSO, was completed in late fall 2006. The final phase, the East Side CSO, was completed in December 2011.

SERVICE AREA CHARACTERISTICS

The service area boundary for the City of Portland covers approximately 92,300 acres (31,585 acres are served by a combined sewer system, and 60,686 acres are served by a separate sanitary sewer system). Water consumption records indicate that 60% of the total dry weather flow originates from combined sewer services areas, while the remaining 40% originates from separated sewer services areas. Portland has a total of approximately 165,000 residential customers and 13,300 commercial customers. The wastewater load population equivalent to the CBWTP is about 778,000 (based on 0.2 pounds BOD per person per day).

Portland's sewer collection system consists of a network of 2,629 miles of collection system piping (1,004 miles of sanitary sewer including force mains, 913 miles of combined sewer, and 712 miles of sewer laterals) and 40,949 sewer manholes. The system also includes two wastewater treatment plants and 98 pump stations. There are 83 City-owned and operated pump stations, 5 pump stations owned by other public agencies that are operated and maintained by the City under satellite or easement agreements, and 10 privately-owned septic tank effluent pumping systems that are maintained by the City under agreements with the property owners.

HISTORICAL FLOWS – CBWTP

Dry-weather *(May through October)* flow records for the CBWTP indicate that hourly flows typically range from 25 mgd to 80 mgd. Wet-weather *(November through April)* flow records for the CBWTP indicate that hourly flows to the treatment plant vary depending upon storm intensity, but they can exceed 400 mgd.

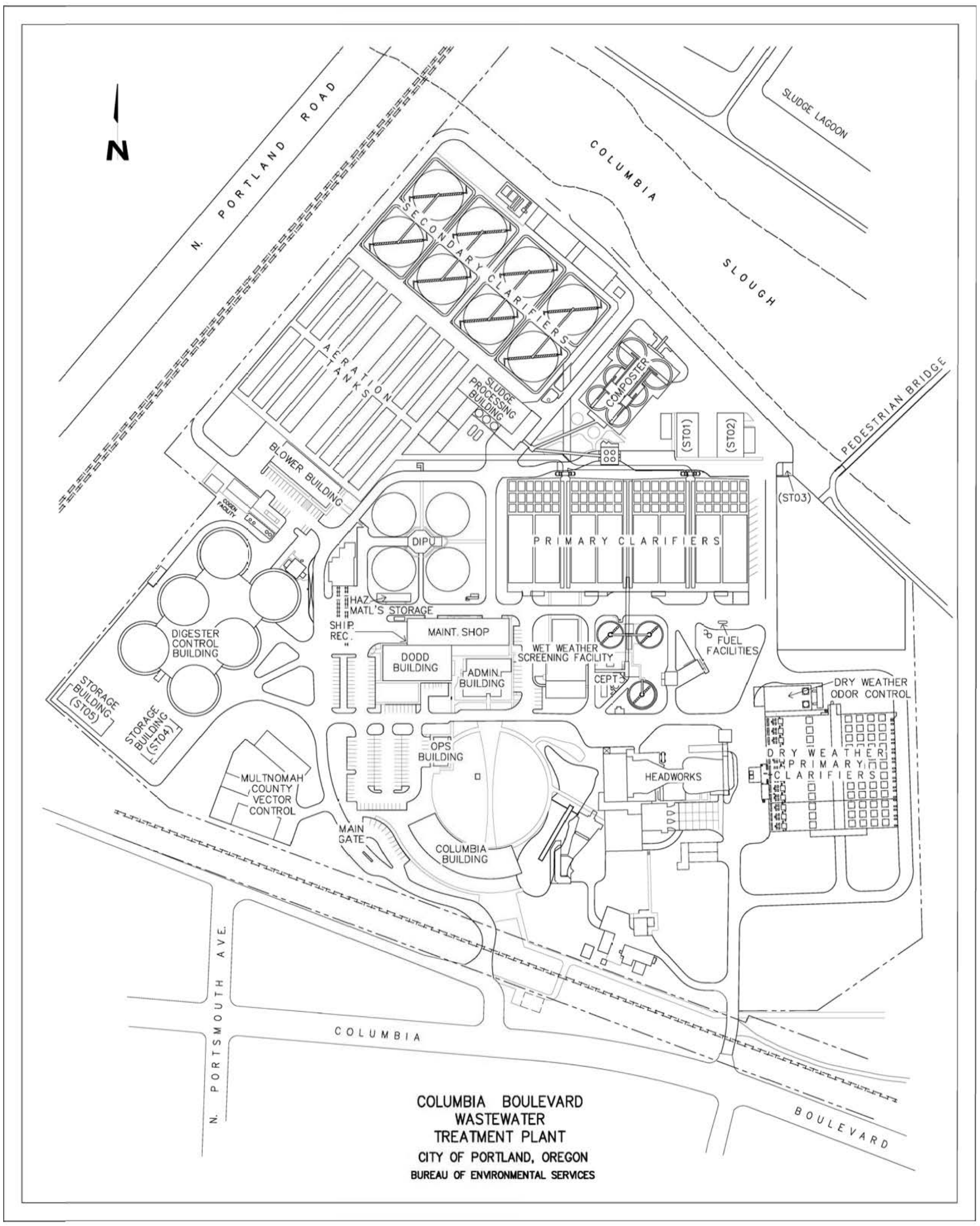
FUTURE FLOW PROJECTIONS

Portland identified two milestone years for establishing future flow projections for the CBWTP; 2010 and 2040. The corresponding average annual flows (AAF) projections for these milestone years were 100.3 mgd, and 123.2 mgd, respectively. The population estimates that correspond to these milestone years are 527,000 and 659,000, respectively.

SECTION 5
DESCRIPTION OF FACILITIES AT CBWTP

The CBWTP site is bounded by Columbia Boulevard and the Union Pacific railroad tracks to the south, Burlington Northern main-line railroad tracks to the west and Union Pacific railroad tracks to the north and east. The main mechanical plant is located on 73.5 acres (Figure 5-1 and 5-2). In addition to the main plant, a 22.5-acre tract immediately NW and across North Portland Road from the mechanical plant has been acquired for future treatment facility expansion. Also, the CBWTP complex includes a 51-acre area north of the mechanical plant where the Triangle Lake facultative solids lagoon is located.

Figure 5-1. Columbia Boulevard Wastewater Treatment Plant



HISTORY

The first major wastewater treatment plant constructed for the City of Portland was completed at 5001 North Columbia Boulevard in 1952 (Table 5-1).

Table 5-1. Chronological Development of CBWTP Facilities
• Primary Plant – Placed into service – 1952 • Effluent Chlorination System Construction – 1961 • Major Primary Plant Expansion – 1968 & 1969 – Upgrade included the enlargement of the plant's administrative building and the addition of a digester pump house. • Solids Lagoon Construction – 1970 • Secondary (Waste Activated) Plant Construction – 1974 • Construction of Four New Anaerobic Digesters – 1983 • Taulman-Weiss Within-Vessel Composter Construction – 1984 • Chlorine Containment Building Construction – 1992 • Biosolids hopper construction – 1993 • Outfall Diffuser Construction – 1995 • Reuse Water Reclamation Plant Addition – 1996 • Replacement Headworks (Preliminary Treatment) Construction – 1996 and 1997 • Solids Pump Booster Station Construction – 1998 • Chlorination System Addition – 1999 • 200 kW UTC PC 25 phosphoric acid fuel cell addition –1999 • Columbia Slough Consolidation Conduit Construction – 2000 • Wet Weather Influent Pump Station Construction – 2000 • Primary Clarifier Addition (Dry Weather Flow) – 2000 • Dechlorination Facility Construction – 2000 • Second Wet Weather Outfall Pipeline and Diffuser Construction – 2000 • Wet Weather Primary Clarifier Improvements – 2001 • Four Capstone 30 kW microturbines installed – 2003 • Belt Filter Press High Pressure Zone Installations – 2003 • Wet Weather Capacity Improvements – 2006 • Sodium Hypochlorite System Installed to Replace Gas Chlorine for Effluent Disinfection – 2006 • Effluent Pump Station Improvements – 2006 • 1.7 Megawatt Cogeneration Facility – 2008 • 4-New Alfa Laval-300ft^2 spiral heat exchangers (Digesters 5, 6, 7 and 8) – 2008 • Dry Weather (Primary) Clarifier Addition (4th Clarifier) – 2008 • Digester 3 Mixing Improvements – 2009 • Wet Weather Screening Facility – 2011 • Construction of two new digesters (D9 & D10) – 2011 • Chemically Enhanced Primary Treatment (CEPT) – 2012 • Secondary Process Improvement project, (SPI) – 2014.

The original plant provided preliminary and primary treatment, with no disinfection. It was designed for an average dry weather capacity (ADWC) of 60 million gallons per day (mgd) and peak wet weather capacity (PWWC) of 155 mgd. Raw solids generated by the original primary plant were stabilized by anaerobic digestion and stored in a sewage stabilization pond located at the northwest corner of the plant immediately south of the Columbia Slough in an area now occupied by the secondary plant. Disinfection of plant effluent by chlorination was added in 1961. A description of various plant modifications that have taken place since then follows.

The first major plant expansion, completed in 1969, increased the capacity of the primary treatment units to 100 mgd ADWC and 300 mgd PWWC. Parshall flumes replaced venturi flumes as flow measuring devices, and cyclonic grit separators replaced mechanically raked grit channels. Primary clarifier tankage was doubled, and two gravity primary sludge thickeners were added. Facultative sludge lagoons were also constructed immediately north of the plant across the Columbia Slough in 1970 (Section 9, Figure 9-1).

Secondary treatment by activated sludge was added in the northwest area of the plant during 1974. Plant capacity, after completion of the 1974 expansion, was 100 mgd ADWC, 200 mgd PWWC (secondary), and 300 mgd PWWC (primary).

A coarse grit removal system was added to the headworks in 1975. This modification included a septage dumping station.

Four new anaerobic digesters were added in 1983, tripling the plant's digestion capacity. The new digesters allowed 2 aeration basins, which had been used for aerobic digestion, to resume operation as aeration basins. A third primary sludge gravity thickener was also constructed during this period.

New belt presses replaced vacuum filters for dewatering biosolids in 1982 and a 60 dry ton per day Taulman-Weiss within-vessel composting system was constructed in 1984.

A new maintenance building and crew quarters were constructed in 1991 near the present administration building (Dodd Center).

New chlorination facilities were constructed in 1992 to meet revised Uniform Fire Code requirements for emergency scrubbers. In 1994, modifications to the secondary treatment system were completed. These modifications included reconfiguring the aeration tanks to plug flow selector technology, converting the aeration tanks to fine bubble diffusion, adding additional wide-range blower capacity to take advantage of the energy savings of the new diffusers, and modifying secondary clarifiers to improve performance and hydraulic capacity.

A 6.0 mgd peak (expandable to 12.0 mgd) reuse water reclamation plant was constructed immediately north of secondary clarifiers in 1996. The disinfected secondary effluent is processed through Envirex™ microscreens and the system is designed to produce reclaimed water for a variety of CBWTP process uses (e.g., wash down water, spray nozzles, scum cleaning and channel cleaning), and a water feature immediately southwest of the new headworks. Reclaimed water will also be used as an additional water supply for plant grounds green scape irrigation. The wastewater reclamation plant was designed to produce Class B (Level III) effluent.

For safety and modernization reasons, construction of a new headworks was initiated to replace the existing preliminary treatment building in 1996. The old headworks configuration and its numerous conveyors made maintenance and operations unsafe. Antiquated bar screens required manual cleaning and needed to be replaced with automatic screens. The replacement headworks was completed in 1997.

A new solids booster pump station was placed on line immediately northeast of Digester 8 in September 1998. The booster station facilitates pumping to Digesters 5 to 8 of thickened primary solids from existing gravity thickeners, dry weather primary clarifier solids, raw thickened waste activated solids and primary digested solids trucked to the CBWTP from the TCWTP. The pump station is designed to facilitate the transfer of thickened primary solids (3 to 7% total solids) to digesters from a 20,000-gallon wet well via three variable speed progressive cavity (200 to 350 gpm @ 40 psi) pumps.

In 1999, the disinfection (chlorination) system was expanded to increase capacity and provide various improvements to the system. Two new 10,000 pound per day and two-2,000 pound per day chlorinators were added. More flexibility was also added to the controls so that the chlorination system could be operated in compound, flow-paced, or residual mode. The improvements also provided flexibility to separately disinfect the secondary effluent (dry weather flow) and primary effluent (wet weather flow).

In 2000, many new facilities and major modifications were added to the CBWTP to capture and treat the Columbia Slough Combined Sewer Overflows (CSO), as required by the ASFO. The expansions and modifications included: a new Columbia Slough Consolidation Conduit (CSCC), a new Wet Weather Influent Pump Station (WWIP), three new Dry Weather Primary Clarifiers (DWCL), new Dechlorination Facilities at Hayden Island (HIDC), and extension of an existing outfall pipeline and a new outfall diffuser for wet weather flows. In 2004, construction was initiated to further increase influent and effluent pumping capacity in anticipation of increased flows resulting from CSO improvements to be completed in the next few years.

The CSCC is constructed parallel to the main interceptor (along North Columbia Boulevard), stretching from NE 13th Avenue and Lombard to the CBWTP. The CSCC consists of approximately two miles of 6-feet diameter pipeline and two miles of 12-feet diameter piping. It is designed to capture CSO that historically discharged to the Columbia Slough and store and convey wastewater pending treatment at the CBWTP. When there is no stormwater to be captured, a small flow of approximately 5 to 10 mgd is diverted from the main interceptor into the CSCC to prevent excess sediment deposition.

The wet weather influent pump station (WWIP) is constructed where the CSCC enters the CBWTP to lift the collected wastewater to the headworks for preliminary treatment. The WWIP consists of three low-flow pumps (10 mgd each), three high-flow pumps (25 mgd each) and three peak flow pumps (16 mgd) which provide a total pumping capacity of 153 mgd. Pumps are equipped with variable frequency drives. Odorous air generated and collected at the WWIP is conveyed to the odor control facility at the headworks for treatment.

Three new 40 mgd rectangular primary clarifiers (DWCL) were constructed in 2000 to receive and treat dry weather flows up to 120 mgd. Flow in excess of 120 mgd is diverted to the existing (wet weather) primary clarifiers. Flow to the DWCL is controlled by magmeters and modulating gates at a flow splitting structure downstream of the headworks. Only flow through the DWCL receives secondary treatment. The primary clarifiers are covered to prevent the escape of odorous air generated during sedimentation inside the clarifiers. Captured air is treated at an odor control facility adjacent to the clarifiers.

Dechlorination facilities (HIDC) were constructed at Hayden Island during 2000 to ensure chlorine residuals discharged into the Columbia River remain within permit limits. Liquid sodium bisulfite is injected into plant effluent, by metering pumps, before it is discharged into the Columbia River. Sampling for chlorine residual is performed, prior to and after sodium bisulfite injection, to control the amount of chemical used and to report the final value of the chlorine residual in the effluent. The HIDC has its own emergency generator for backup power.

A second outfall diffuser was added to an extended outfall pipeline in 2000. With the completion of this system, two separate outfall pipelines equipped with outfall diffusers now connect the CBWTP to the Columbia River. Intermediate linkages between outfall pipelines allow flows amid pipelines to be crossed so discharge can occur from either outfall diffuser.

In 2001, conversion of the existing primary clarifiers to wet weather service was completed. The conversion included automation of gates for filling and emptying and the addition of flushing, washdown, and dewatering equipment.

Sodium hypochlorite facilities were completed in 2006. These additional facilities included storage and dosing facilities to replace gas chlorine for effluent disinfection.

In 2006, improvements were completed which increased the capacity of the wet weather influent pump station; removed hydraulic restrictions at the headworks inlet structure and enabled connection of a wet weather headworks meter in the bypass channel; added diversion gates upstream from wet weather primary clarifiers, and replaced some wet weather primary clarifier inlet piping. Three peak flow pumps were added to the WWIP to increase its design capacity to 135 mgd.

In 2006, effluent pump station improvements and rehabilitation of a portion of the 102-inch outfall pipeline were completed in order to facilitate a peak discharge capacity of 450 mgd.

In April 2008, a 1.7 megawatt (two-850 kW internal combustion reciprocating engine generators) facility was placed on line. The combined heat power system is fueled by biogas generated via first-stage anaerobic mesophilic digestion and designed to provide 40 to 50% of the power needed to operate the CBWTP. Digester gas fuel is treated to remove moisture, H_2S and siloxane. Heat recovered from the system is used to heat the digesters.

In mid-December 2008, construction on a fourth 40 mgd dry weather primary clarifier was completed and placed on-line.

In March 2009, Digester 3 (Blend Tank) was retrofitted with a new pumped recirculation mixing system. The system is comprised of two ~1500 gpm chopper-style pumps and discharge nozzles designed to better suspend material within the tank.

In early 2010 a retrofitted wet-weather screening facility was placed into service. The new facility has a rated capacity of 150 MGD and is made up of 4 climber-style perforated plate screens.

In late December 2011, 2 new 2.8 MG primary digesters were placed online.

In September 2012, chemically enhanced primary treatment (CEPT) facilities were completed. The CEPT facilities add ferric chloride and polymer to improve settling of solids in the wet weather primary clarifiers.

In 2014, the SPI project was implemented to better utilize and extend the capacity of the activated sludge system. The improvements allow the existing plug flow process to operate in step feed or several wet weather, or high flow, operating modes to maximize the treatment capacity of the activated sludge system. The updated modes include:

Step Feed Mode; During normal operation of the step feed mode, primary effluent into the aeration basins is split to discharge 65 percent into Zone 1 and 35 percent into Zone 6.

Wet Weather Step Feed Mode; Intended to operate during heavier rain events (wet weather conditions) that exceed the 65/35 flow split under the normal step feed mode, the wet weather step feed mode sets a code- adjustable maximum flow rate to Zone 1 and all excess flows divert to Zone 6. During operation of this mode there is no longer a 65/35 flow split between Zone 1 and Zone 6. Zone 6 continues to receive excess primary flows until the clarifiers reach capacity. This mode operates during moderate rain events that overload the secondary clarifiers during the normal step feed mode.

Step Feed with RAS Storage (Wet Weather Mode); During long duration peak wet weather flow events the aeration basins operate in a step feed with RAS storage mode. During these events BOD loadings and temperatures in the secondary processes tend to be significantly reduced, encouraging the growth of filamentous organisms. In this mode, primary effluent is discharged at a 65/35 split between Zones 2 and 6. Zone 1 becomes the aerobic RAS storage zone, and Zones 2 and 3 become the anaerobic selector zones. Aeration in Zone 1 can be operated on and off by a timer. The secondary process can be operated under these flow conditions for several consecutive days.

Contact Stabilization (Wet Weather Mode); Contact stabilization mode is intended to maximize the capacity of the secondary treatment system and is intended to operate under the peak flow conditions. While operating in the contact stabilization mode all primary effluent is directed to Zone 6. Under this mode the solids loading rate in the clarifiers is reduced to a level greater than all other operation modes. However, this mode also runs the risk of detrimental sludge settleability impacts and can only be run for short time periods (typically one to two days).

FUTURE GROWTH - CBWTP

In 1995, a long-range facilities plan was completed for the CBWTP. The plan identified improvements necessary to meet community wastewater treatment needs through the year 2040. The facilities plan also addressed improvements to the Triangle Lake Lagoon and made long-range recommendations for the plant's biosolids recycling program. Future growth needs and CIP projects were further defined and identified in facilities plan updates in 2010 and 2016.

In addition to the facilities plan, the CBWTP Master Plan is required for conditional land use approval of projects planned at CBWTP. In 2011, the previous 2004 CBWTP Master Plan land use document was updated and then approved by the City's Bureau of Development Services (BDS). The projects identified at the time have either been completed, are in the process of being completed, or are planned to be completed over the next 5 to 10 years. The 2016 facilities plan update identified additional site improvements focused on increasing secondary capacity over the next 7 years. A master plan update is currently being finalized to be submitted for approval by BDS.

UNIT PROCESSES

Design criteria and a description of the capacity of the unit processes used at the CBWTP are summarized in Table 5-2. Process Flows are detailed in Figure 5-2.

HEADWORKS

Flow enters the plant through a box-section-shaped influent line and is split into two equal portions just upstream of influent pumping (Table 5-2). These flow streams can be isolated by two hydraulically operated sluice gates. There are also emergency bypass gates to allow gravity flow directly to primary treatment in the event that the influent pumping system fails.

PRELIMINARY TREATMENT

The Headworks preliminary treatment system is comprised of magnetic flow meters (one at the discharge of each influent pump) for flow measurement, bar screens that remove objects greater than 5/8" followed by screenings presses (never used), grit basins with grit washer separators, and a septage receiving station. A wet weather screening facility was brought on-line in 2011. (Table 5-2).

Four screens occupy the original flow channels leading to the Wet Weather Primary Clarifiers. Rising panels on each screen form a continuous filter with 6mm (1/4 inch) perforations to remove small contaminants and lifting tines on every fifth panel pick up larger objects. A minimum of two screens are started when flow is seen from either the Headworks Bypass Channel or the Wet Weather Influent Diversion Structure. Additional screens start automatically as flow increases.

The screened material is discharged into a sloped flume where water conveys it to two washer/compactors. One compactor can handle most of the screening material except when very high debris accumulation occurs, such as autumn leaf dropping. The second compactor can be set to start when high level is seen in the first one. Organic material is washed from the screenings during compression and sent to the treatment plant's Recycle Pump Station. The compacted screenings are discharged to a 10 yard box for disposal at a landfill.

PRIMARY TREATMENT

Following preliminary treatment, flow up to 120 mgd is routed to the dry weather primary clarifiers. Flow in excess of 120 mgd is diverted to the wet weather primary clarifiers. Flow to the dry weather clarifiers is controlled by modulating gates at a flow diversion structure downstream of the headworks. Primary effluent from dry weather clarifiers receives secondary treatment, prior to disinfection and discharge into the Columbia River. Primary effluent from the wet weather clarifiers is disinfected prior to discharge into the Columbia River.

Dry weather clarifiers have deep hoppers for collecting and thickening sludge as well as skimmers for removing floating scum. Solids which accumulate in the clarifiers are pumped directly to the digester booster pump station. The Wet weather clarifiers lack thickening sludge hoppers. Thin solids accumulating in these clarifiers are continuously pumped from the clarifiers to either the dry weather clarifiers or the gravity thickeners prior to being pumped to the digester booster pump station.

Table 5-2. Design Criteria and Capacity at the CBWTP	
Design Flow	
Average Dry Weather Capacity (ADWC)	110 mgd
Peak Wet Weather Capacity (PWWC)	450 mgd when pumping to Columbia River is required
Design BOD_5 Loading	
Average Dry Weather Month	159,294 lb./d
Maximum Dry Weather Month	241,860 lb./d
Design Effluent Requirements	
Maximum Monthly Average TSS	30 mg/l
Maximum Monthly Average BOD_5	30 mg/l
Influent Pumps (Wet Weather Influent PS)	
Number	9
Type	6 Submersible and 3 dry pit submersible
Speed	6 Variable and 3 fixed (600 rpm) speed
Capacity	3 @ 10 mgd, 3 @ 16 mgd & 3 @25 mgd
Horsepower	3 @ 90 hp, 3 @ 150 hp & 3 @ 250 hp
Influent Pumps (Replacement Headworks)	
Number	6
Type	Centrifugal
Speed	5 Variable and 1 fixed speed
Capacity	4 @ 75 and 2 @ 40 mgd
Horsepower	4 @ 450 and 2 @ 250 hp
Preliminary Treatment	
Trash Racks (seldom used)	
Number	4
Size	Clearance, 6 inch
Bar Screens	
Number	5
Spacing	Clearance, 5/8-inch
Grit Basins	
Number	6
Type	Mechanically induced vortex
Size	24 ft diameter
Efficiency	85 percent at 130 mgd
Perforated Plate Screens	
Number	4
Type	6 mm perforated panels w/tines
Size	37.5 MGD
Screenings Flume	
Number	1
Type	Stainless steel trough 2 % slope
Size	156 ft^3/hr
Washer/Compactors	
Number	2
Type	80:1 compression
Size	550 gpm, 156 ft^3/hr each
Primary Treatment	
Primary Clarifiers (Dry Weather)	
Number	4
Size	250 by 60 by 10-14 ft
Overflow Rate	2,666 gpd/sq ft @ 160 mgd

Table 5-2. Design Criteria and Capacity at the CBWTP	
Primary Treatment	
Primary Clarifiers (Wet Weather)	
Number	8
Size	225 by 58 by 10 ft
Overflow Rate	3,065 gpd/sq ft @ 290 mgd with one unit out of service
Aeration Basins	
Number	8
Size	381 by 40 by 17 ft
Volume (each)	1.8225 million gallons
Capacity (each)	20.0 mgd at an SVI of 80 ml/g
Design Organic Loadings	
Instantaneous Peak	120,000 BOD and 17,800 NH_3 lb./d
Diurnal Peak	90,000 BOD and 13,350 NH_3 lb./d
Minimum	20,000 BOD and 3,000 NH_3 lb./d
Detention Time	3.5 hrs at ADWC @ 100 mgd & 60% RAS
Aeration Equipment	
Type	Fine bubble diffuser
Mixer	
Type (Anoxic Zone)	Floating mixer
Secondary Clarifiers	
Number	8
Type	Square, peripheral-feed
Size	125 ft
Side Water Depth	12.5 ft
Surface Overflow Rate	800 gal/d/ft^2 at ADWC @ 100 mgd
Solids Loading Rate	32.4 lb/d/ft^2
Detention Time	2.79 hours at 100 mgd
Sludge Removal	Revolving suction arm
Sludge Recirculation	
Number of Pumps, Each Clarifier	2
Type	1 variable speed, 1 constant speed
Combined Capacity	62.5 mgd
Disinfection	
Type	Sodium hypochlorite
Control	Residual-paced, flow-paced or compound loop
Storage	75,000 gallons
Metering pumps	4 dry weather & 4 wet weather
Reactor	Chlorine contact pipe
Detention Time	22 minutes @ 300 mgd
Effluent Pumping	
Number	5
Speed	Variable speed
Type	Vertical Turbine
Rated Head	43 ft
Rated Capacity	90 mgd each

SECONDARY TREATMENT

Activated sludge unit processes used for secondary treatment were designed for an ADWC of 100 mgd and a PWWC of 200 mgd. The difference between the 300 mgd PWWC for primary treatment and 200 mgd for secondary treatment peak flow was designed to divert secondary treatment and blend with secondary effluent for subsequent disinfection and discharge. Actual daily capacity of the secondary system was limited to 80-100 mgd before the 1994 modifications. The secondary treatment capacity was increased to 135 mgd sustained peak (four hour) flow. Flow through the secondary treatment system is measured via an open channel compound-ultrasonic flow meter.

Primary effluent receiving secondary treatment is divided among eight aeration basins. Each basin is 381 feet long by 40 feet wide and operates with about 17 feet of water depth. Secondary influent, under plug flow mode of operation, enters the basin with the return activated sludge (RAS) at the head end of the basin. RAS can either be directed to the secondary influent channel or the head end of each basin. Secondary influent under step-feed mode of operation is also available. The units are designed to provide anaerobic selector technology at the front end of each basin via mixers. Effluent launders run the width of the end of each basin.

Outside the anoxic zone, aeration is provided by fine-bubble diffused aeration with full floor coverage of the basin. Aeration air is supplied by four centrifugal blowers.

The aeration basins must be operated in pairs. Basin pairs cannot be drained separately except for Basins 7 and 8. Openings in the center of the common walls in Basins 1 through 6 dictate that there be no differential head.

Each aeration basin has an associated secondary clarifier. The eight secondary clarifiers are 125-feet square tanks with 12.5 feet of side water depth and flat bottoms. The flow path through the clarifiers is peripheral feed and peripheral overflow. Sludge is withdrawn by direct pumping through articulated sludge collector arms. The clarifiers were originally designed for a surface overflow rate of 100 mgd at 800 gallons gpd/ft^2 and a peak overflow rate of 1,600 gpd/ft^2 at 200 mgd. Operational experience established a peak overflow rate of 640 gpd/ft^2 before 1994. After 1994, modifications increased the overflow rate.

Two RAS pumps, connected to a shared VFD, are connected to each clarifier. Both discharge into a common line containing a flowmeter and flow control valve. Under the original design, RAS was returned only to the basin associated with the clarifier from which it was drawn, resulting in eight independent activated sludge plants, side by side. A modification to the system permitted combining RAS from all eight clarifiers and returning the combined flow to the secondary influent channel upstream of the aeration basins. Since the SPI project of 2014, RAS is returned to each individual AB from a mix box via a return that runs along the floor of the Abs.

EFFLUENT PUMPING, DISINFECTION AND DECHLORINATION

As long as river stages remain normal, under most operating conditions, the 2 two-mile long outfall pipelines can carry 120 to 160 mgd CBWTP effluent by gravity to diffuser structures in the Columbia River. A diffuser consists of a flow diffusion manifold equipped with multiple discharge outlets of regulated rubber duckbills.

Under certain conditions of high river levels or increased plant flow, effluent pumping is required. Five 90-mgd pumps can be actuated to discharge through two outfall pipelines.
There are emergency bypass flow diversion structures at the Oregon Slough and the Columbia Slough as well as an open-ended outfall at the Columbia River (Outfall 2.2). The diversion structure discharging to the Columbia Slough is engaged only in case of an emergency.

The configuration of the wet well and control gates at the CBWTP effluent pump station permits either mixed wet weather-secondary or secondary effluent alone to be pumped by dry weather pumps. The wet weather pumps can pump wet weather effluent, or a combination of wet weather and secondary effluent.

Chlorine gas disinfection was replaced with sodium hypochlorite disinfection in winter 2005. Sodium hypochlorite solution is metered into plant effluent and retained in the discharge lines for sufficient time to enable disinfection to occur. Hypochlorite solution is stored in five tanks (with a combined capacity 75,000 gallons) and metered into effluent via peristaltic pumps (four variable speed dry weather and four additional variable speed wet weather flow pumps).

The outfall pipeline system to the Columbia River provides sufficient detention time to meet chlorine contact requirements if flow rates are within design limits. If high chlorine residual is detected in the plant effluent, sodium bisulfite is used to dechlorinate to ensure chlorine residual is below discharge limits.

SOLIDS HANDLING[1]

Unit processes used for solids handling at CBWTP include degritting, screening, gravity thickening (primary sludges); two-stage anaerobic digestion, belt press dewatering application of primary solids; and gravity belt thickening, two-stage anaerobic digestion, belt press dewatering and land application or lagoon storage of secondary solids. Digested primary solids and approximately 50 percent of the digested secondary solids were blended with previously digested, lagoon stabilized biosolids, dewatered and land applied. The remainder of the digested solids (largely digested TWAS) are pumped to the Triangle Lake Lagoon for storage and additional stabilization (Sections 3, 9 & 11).

Solids accumulated at the base of dry weather primary clarifiers are pumped directly to the booster pump station. Solids from wet weather primary clarifiers (approximately 0.5% density) are pumped to dry weather primaries for thickening to approximately 5% total solids. In the event dry weather primary repairs are required, solids removed from dry and wet weather primaries can be diverted to three-55 feet

[1]See Section 8 for additional details on solids processing and compliance monitoring at CBWTP.

diameter gravity thickeners (Table 5-3). Thickened solids are then passed through in-line grinders and pumped to the solids booster pump station and from there into anaerobic digesters.

Waste activated sludge (WAS) is thickened on three gravity belt thickeners to about 5% total solids and then pumped directly to first-stage anaerobic digesters.

Six of eight anaerobic digesters were used to stabilize primary and secondary solids. Five first-stage digesters (Digesters 5, 6, 8, 9 & 10) were used to process all primary solids generated at the CBWTP; digested primary and raw thickened secondary solids from the TCWTP; and 50 percent of the raw thickened waste activated solids produced at the CBWTP. The remaining 50 percent of raw thickened waste activated solids generated at the CBWTP were processed in first-stage Digester 7. Solids exiting Digester 7 were directed to the Triangle Lake storage lagoon for further stabilization.

After first-stage digestion, solids from Digesters 5, 6, 8, 9 & 10 were directed to either Digesters 1 or 2 (mixed second-stage digesters heated to 100°F) pending transfer via pumps to Digesters 3 and 4. Digester 3 was operated as a blend tank for combining freshly digested solids and older, previously digested solids derived from the Triangle Lake Lagoon (occasionally, Digester 4 also served as a blend tank). In addition, Digester 4 was used for gas storage. Solids withdrawn from these tanks were mixed with polymer, dewatered via belt filter presses, and transported to the City's biosolids application sites.

Currently, no supernating takes place from any digester. Digesters 5, 6, 8, 9 & 10 facilitate solids pumping to Digesters 1 and 2. Solids from Digesters 1 and 2 are transferred to Digester 4 via gravity or pumping. Solids are manually pumped from Digester 4 to Digester 3.

Digesters 5, 6, 8, 9 & 10 were automatically batch fed CBWTP with raw thickened primary solids, TCWTP digested primary solids and TWAS on a sequential basis at a rate of approximately 2,000 gallons per dose. Dose volumes and sequencing can be adjusted to accommodate digestion and solids processing needs. Digesters 5, 6, 8, 9 & 10 received batches of TWAS on a rotating basis. During each feed cycle, approximately 7,500 gallons CBWTP TWAS (1,500 gallons per digester) were fed to Digesters 5, 6, 8, 9 & 10 while roughly 7,500 gallons were directed to Digester 7. As is the case with thickened primary solids, the quantity of TWAS directed to digesters can be adjusted. A flow-totaling meter registered the combined flow fed to each first-stage digester on an on-going basis and volumes wasted to digesters were recorded daily.

Generally, grab samples of raw thickened primary and secondary digester feed sludges were collected separately at eight-hour intervals. A composite of the two digester streams feed sludges made from three daily subsamples was used to determine the mean total and volatile solids levels entering first-stage digestion.

Anaerobically digested primary and secondary biosolids were dewatered via four belt filter presses. All belt filter presses have been modified to achieve a denser cake (2 to 3% more solids) through the addition of six rollers and four more feet of belt length. Blended dewatered solids from the Triangle Lake Lagoon and freshly digested biosolids were trucked to Madison Ranches and Sherman County for land application at agronomic rates.

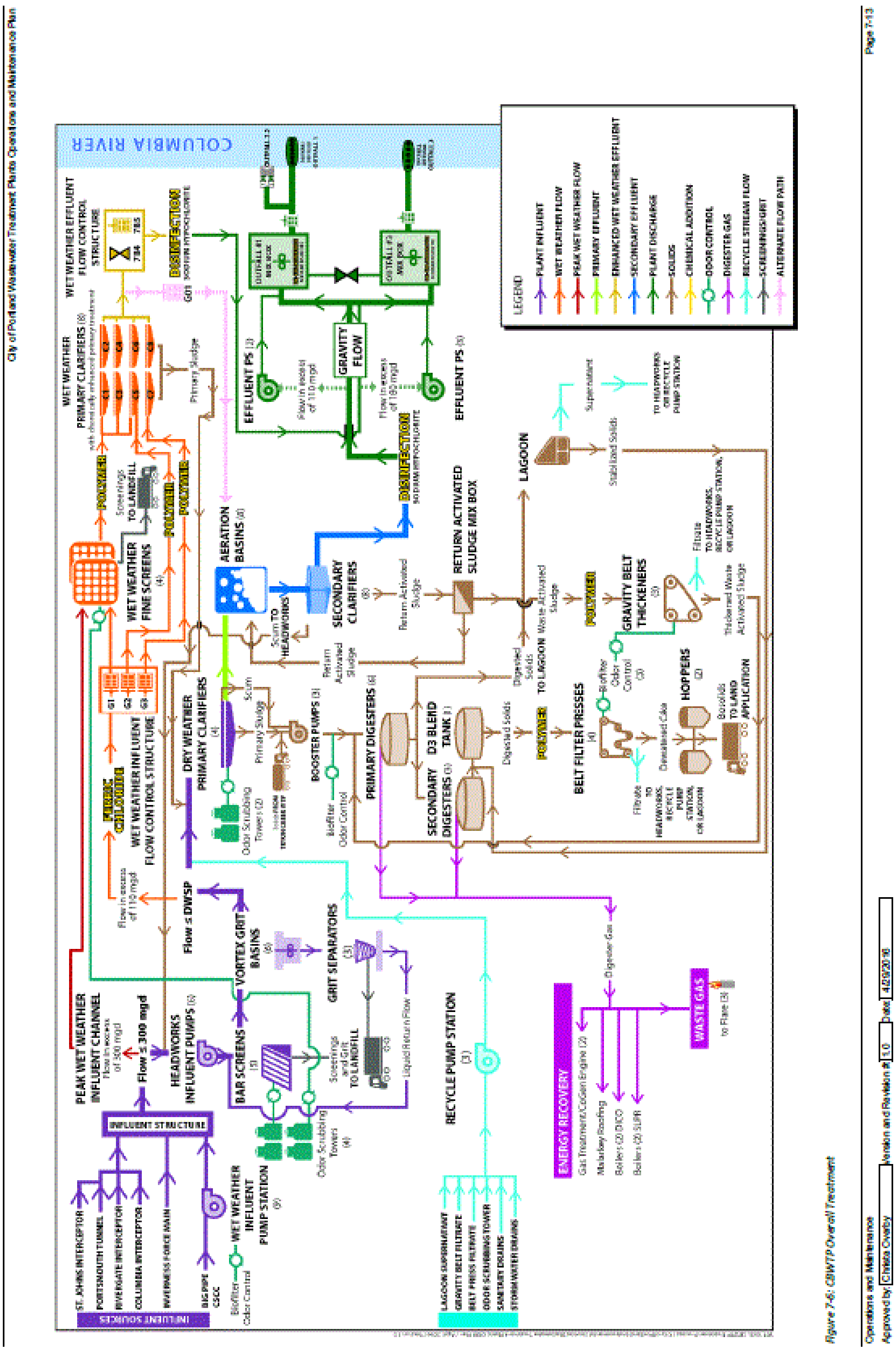
Table 5-3. CBWTP Solids Processes	
Item	**Value**
Primary Treatment and Gravity Thickening	
Primary Clarifiers (Dry Weather)	
Number	4
Size	250 by 60 by 10-4 ft
Overflow Rate	2,666 gpd/sqft @ 120 mgd
Gravity thickening of primary sludge (backup)	
Thickeners	
Number	3
Diameter, each, feet	55
Sidewater depth, feet	10
Gravity Belt thickening of secondary sludge	
Thickeners	
Number	3
Width, each, meters	3
Feed flow rate, each, gpm	900
Anaerobic digesters [1]	
Number	10
Diameter, feet	4 at 90 6 at 105
Sidewater depth, feet	4 at 25.3 6 at 37
Effective volume, each, cubic foot	4 at 160,000 6 at 320,000
Triangle Lake Biosolids Lagoon [3]	
Area, acres	37
Effective Sidewater depth, feet	14
Dredge capacity (2 dredges), gpm	1200 (Old), 1500(New)
Mechanical dewatering	
High solids belt filter presses	
Number	4
Belt width, meters	2
Solids loading rate, lb./hr/meter	750 to 1,000
Composter[2]	
Rated Capacity, dt/d	30
Practical Capacity, dt/d	8-10

[1]Including Digesters 3 & 4, the blend tanks used to collect newly digested and older lagoon solids prior to dewatering. Digesters 1, 2, 5, 6, 7, 8, 9 & 10 are heated via waste heat generated by the combined heat power cogeneration system. In October 2008, older 100 ft^2 heat exchangers serving Digesters 5 to 8 were replaced with new 300 ft^2 heat exchangers.

[2]The composter was taken out of service in 1999. In 2002, one-half of the composter (western-most two bio and cure reactors) was converted to an odor control system for the solids processing facilities.

[3]Lagoon is currently being reconstructed as part of a capital project.

Figure 5-2. Columbia Boulevard Wastewater Treatment Plant Process Flows Diagram



SECTION 6

DESCRIPTION OF FACILITIES AT TCWTP

The Tryon Creek Wastewater Treatment Plant (TCWTP) is a plug-flow activated sludge plant with fine air bubble diffusers and selector technology process capability (Figure 6-1). The original treatment facility was constructed at the confluence of Tryon Creek and the Willamette River at 195 Foothills Road, Lake Oswego, Oregon in 1964. The facility was expanded in 1976 and upgraded in 2002. The TCWTP receives principally domestic wastewater from a 10,200-acre natural basin, which drains the southwest portion of Portland and all of Lake Oswego.

The treatment plant's primary section can process flows up to 37.5 mgd. Flows above 40 mgd have occurred through the plant's primary system on infrequent occasions (flows >40 mgd last occurred in 1996). The secondary portion of the plant was designed for 8.3 mgd; however, it can treat peak flows up to 20 mgd for a limited duration. Primary effluent flows that exceed secondary clarifier process capacity are diverted around the secondary treatment system. All flow, both diverted primary and fully treated secondary, is disinfected before being discharged to the Willamette River at River Mile 20.3.

The average dry weather flow observed in 2018 was 4.42 mgd while the average wet weather flow during this period was 6.50 mgd and the annual average daily flow was 5.4 mgd.

In the past year, the monthly average population equivalent [population equivalency = average influent flow (mgd) times average influent BOD_5 (mg/l) times 8.34 (lb/gal) divided by 0.2 (lb/user)] for the TCWTP (based on BOD_5 loading) ranged from 42,734 to 59,497 users.

No septage is currently accepted at the TCWTP.

PRELIMINARY TREATMENT

Wastewater enters the TCWTP from two trunk lines. The north line receives flow from southwest Portland and the south line receives flow from the City of Lake Oswego. Flow passing through each line is metered separately, then combined for all subsequent treatment processes. During 2018, approximately 70.5% of the flow received by the TCWTP was generated by the City of Lake Oswego. Remaining flow was generated by sources within the City of Portland and unincorporated Multnomah County.

GRIT/SCREENINGS

Screenings are removed by two self-cleaning climber-type bar screens. In a later process, grit is separated from the settled raw sludge by centrifugal cyclones and grit classifiers. Screenings removed by the automatic rakes are stored in a dump truck. Once sufficient material accumulates, screenings are hauled to the Hillsboro Landfill. Grit removed by cyclone centrifuges/grit classifiers are stored in a second dump truck. Once a substantial quantity of material accumulates, the grit is hauled to the Hillsboro Landfill.

PRIMARY TREATMENT

Plant flow is distributed to five primary clarifiers. Clarifiers 1, 2 and 3 each have a capacity of 170,000 gallons and Clarifiers 4 and 5 each have a capacity of 330,000 gallons. All clarifiers are equipped with endless-chain-mounted flights. Flights collect floating scum as they travel along clarifier surfaces and settled solids as they travel along clarifier floors. Clarified primary effluent is pumped uphill to the secondary portion of the treatment works.

PRIMARY SOLIDS HANDLING

Floating scum is collected via skimming troughs and pumped to a 359,000-gallon first-stage primary anaerobic digester. Settled primary solids are withdrawn by fixed-rate pumps, degritted by cyclone separators, further thickened by a 33,000-gallon gravity thickener and pumped to the first-stage anaerobic digester.

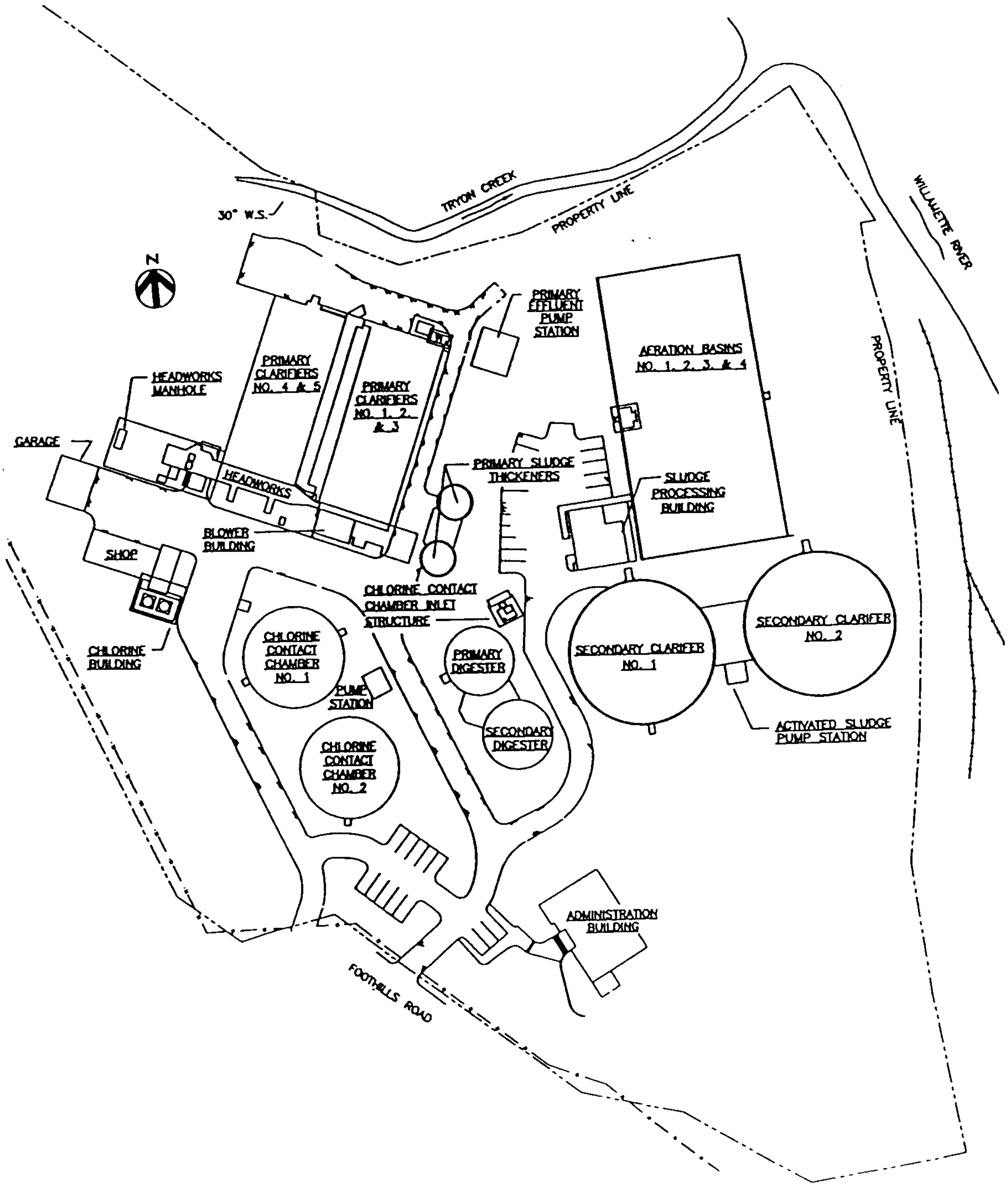
First-stage anaerobic digestion is used to reduce raw thickened primary solids volume and mass. The heated digester averaged 98.5 °F during 2018. Recirculating methane gas was used to mix the digester's solids. Solids from that digester are directed to an unheated, unmixed 326,000-gallon second-stage digester. 199 dry tons of digested primary solids (2,724,300 gallons; 1.75% average TS) were removed and transported to the CBWTP in 2018 (Table 6-1). Digested primary solids exported from the TCWTP were combined with raw primary solids derived from the CBWTP and pumped to first-stage anaerobic digesters for co-digestion.

Table 6-1. Solids Exported from the TCWTP to CBWTP – 2018

Type Solids	Quantity Solids Exported to CBWTP	
	Gallons per year	Dry tons per year
Digested Primary[1]	2,724,300	199
Raw Thickened Secondary[2]	3,828,700	758
Total dry tons exported from TCWTP to CBWTP		957

[1]Concentration of solids discharged from the base of the second-stage digester averaged approximately 1.75 % TS. Estimates provided by Kyle Stephens, Operations Supervisor.
[2]Thickened to approximately 4.75 % solids via gravity belt thickener; estimate provided by Kyle Stephens, Operations Supervisor. (4.13% weighted average TS between digested and TWAS).

Figure 6-1. Tryon Creek Wastewater Treatment Plant



SECONDARY TREATMENT

In the activated sludge treatment process, primary effluent and return activated sludge are mixed and aerated by fine air bubble diffusers in two-730,000 gallon aeration basins. An additional 730,000-gallon basin can be operated for further process detention time. Up to two 730,000-gallon basins are used as a storage-equalization tank during peak wet weather flow periods. In the aeration basins, non-settleable BOD_5 and TSS were metabolized into bacterial cell mass. The activated sludge from aeration basins flows to two 910,000 gallon secondary clarifiers where bacteria settle out and are returned to the aerators. Clarified effluent is disinfected using sodium hypochlorite and channeled through chlorine contact basins prior to discharge to the Willamette River.

SECONDARY SOLIDS HANDLING

Daily, biomass (equivalent to one day's increase in organic matter) associated with microbial growth/reproduction is removed from the activated sludge process. Removed raw waste activated solids were thickened to approximately 4.75% total solids on a gravity belt and transported to the CBWTP. In 2018, approximately 3,828,700 gallons (758 dry tons) of raw thickened waste activated solids were generated at the TCWTP (Table 6-1). Solids were hauled to the CBWTP, fed to first-stage anaerobic digesters and co-digested with new primary and thickened waste activated solids produced at the CBWTP.

Analyses of trace inorganics, nutrients, solids, and pH in two grab samples of primary digested solids collected in 2018 indicate regulated constituents fell well within pollutant limits established in 40 CFR Part 503.13(b)(3); Table 3 (Table 6-2).

Table 6-2. Mean Trace Inorganics, Nitrogen Species, Total Phosphorus, Potassium and pH Content in TCWTP Primary Digested Solids-2018

	Constituent[1]															
	As	Cd	Cu	Pb	Hg	Mo	Ni	Se	Zn	NO_3-N	NH_3-N	TKN	K	P	TS	pH
Month	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(std)
February	2.34	1.13	231	19	2.92	5.53	21	4.43	856	34	70,600	113,000	6,790	16,700	1.9	8.0
August	2.36	1.31	239	23	1.02	6.37	14	4.91	803	**31**	57,800	104,000	6,110	20,400	2.1	7.60
Mean[2]	2.35	1.22	235	21	1.97	5.95	18	4.67	830	33	64,200	108,500	6,450	18,550	2.0	7.80

[1]Dry weight basis.
[2]Values represent the mean of samples collected February 1 to 7, 2018 and August 1 to 7, 2018.
BOLD values reported below detection limit.

SECTION 7
SEPTAGE AND HAULED NON-RECYCLABLE WASTES

SEPTAGE PROCESSING

The Spill Protection and Citizen Response Section of BES' Compliance Division administers the septage program. Haulers that discharge septage at the CBWTP require both City authorization and a DEQ issued sewage disposal service business license. Requests to discharge solids from activities not specifically cited under DEQ issued sewage disposal service business license, (e.g., private lift stations) may be allowed on a case-by-case basis if written permission is provided by DEQ; such written approval requires prior BES sanction. Currently no businesses are permitted to discharge sanitary wastes to the CBWTP (Portland's Septage Ordinance and Hauler Procedures appear in the February 1998 Biosolids Management Plan; Appendix D). Permits are issued to pumpers annually and remain valid for one year (July 1 to June 30). Septage is not accepted at the TCWTP.

Septage is normally discharged at the CBWTP via a receiving station located immediately north of the replacement headworks. Septage introduced at that location is piped directly into the headworks influent wet well. Septage can also be directed to an old septage receiving station immediately south of the former screenings building to either a 14,500 gallon or 12,275 gallon collection tank where it can be isolated and tested to assure product characteristics indicate material received is of domestic sewage origin, prior to discharge to the City's sewerage system.

No septage was discharged at the CBWTP by a permitted sewerage disposal service business during 2018 (no septage has been received since 2005). In past years, septage was normally received between 7:00 a.m. and 4:00 p.m., Monday through Friday. With special, case-by-case, advance or emergency authorization from the Spill Protection and Citizen Response Section, septage can also be deposited at the CBWTP at any time 24 hours per day. Septages are only accepted from domestic sources located in Clackamas, Multnomah and Washington Counties. In addition to domestic septage from residences, occasionally small quantities of domestic septage from commercial establishments, including small businesses and restaurants are received at the CBWTP. No industrial process wastewater septages are allowed at the CBWTP.

GRIT, SCREENINGS AND VACTOR WASTES

During 2018 grit, screenings and vactor wastes collected from sewer lines feeding City treatment works were trucked from the CBWTP to the Wasco County Landfill (a small portion went to the Hillsboro landfill under the previous contract – 1/1/18 - 1/17/18) and grit and screenings from the TCWTP were hauled to the Hillsboro Landfill (Table 7-1). Material produced (grit and screenings) and accumulated and decanted (sanitary collection system residuals) at the CBWTP were transported to the Wasco County Landfill by Arrow Sanitary in 2018. Grit and screenings from the TCWTP were trucked to the Hillsboro Landfill in City owned and operated vehicles during 2018.

DIGESTER CLEANINGS

In 2018, Digesters 1 (392 dry tons) and 3 (581 dry tons) were cleaned by Synagro and the spoils (sand, grit, rags, plastics, etc.) were hauled to the Wasco County Landfill for final disposal. The total dry tonnage removed in 2018 was 973 dry tons.

Table 7-1. Grit & Screenings and Collections System Sediment Processed at CBWTP and TCWTP - 2018

	Material Attributable to Headworks CBWTP	Material Attributable to IRHP Operations CBWTP[1]	Material Hauled to Landfill from CBWTP	Material Hauled to Landfill from TCWTP	Material Hauled to Landfill from TCWTP + CBWTP[2]
Month	Tons	Tons	Tons	Tons	Tons
January	211	69	280	20	300
February	149	43	192	10	202
March	166	42	208	10	218
April	182	60	242	16	258
May	137	62	199	12	211
June	167	29	196	16	212
July	127	79	206	10	216
August	111	33	144	6	150
September	174	32	206	0	206
October	277	41	318	0	318
November	218	54	272	13	385
December	251	67	319	14	333
Total	**2,169**	**612**	**2,781**	**125**	**2,906**

[1]IRHP = sanitary collections system residuals (i.e., residuals from sewer cleanings and repairs)

[2]In 2018, sanitary residuals were hauled to the Wasco County Landfill and Hillsboro Landfill for final disposal under special waste permits.

SECTION 8
CBWTP SOLIDS PROCESSING
(PATHOGEN AND VECTOR ATTRACTION REDUCTION)

Prior to land application in 2018, Portland biosolids underwent treatment at the CBWTP to reduce pathogens and vector attraction. Pathogen and vector attraction reduction are required by both State rule [OAR 340-50-026(2)(b) & (c)] and federal regulation (40 CFR Parts 503.32 & 503.33).

PATHOGEN REDUCTION

Class B pathogen reduction was achieved by subjecting solids to anaerobic digestion and lagoon stabilization. In addition, land applied biosolids underwent additional pathogen reduction via environmental attenuation (desiccation, exposure to sunlight, predation from soil microbes, etc.). Two-stage mesophilic anaerobic digestion of freshly generated raw thickened primary and thickened waste activated solids lowered fecal coliform pathogen indicators to the extent that they met federal Class B levels required for land application (Table 8-1). Digester detention times for anaerobically digested biosolids are also reported in Table 8-2.

Table 8-1. Fecal Coliform Densities in 2018 for Anaerobically Digested Biosolids

Land Applied Biosolids					
Month	Fecal Coliform[1] Density	Month	Fecal Coliform Density	Month	Fecal Coliform Density
January	12,447 (8)	May	30,927 (8)	September	55,310 (8)
February	9,303 (8)	June	43,093 (8)	October	16,115 (8)
March	42,878 (8)	July	116,838 (8)	November	54,422 (8)
April	15,362 (8)	August	91,787 (8)	December	42,066 (8)
Annual Mean[2]			**33,802 (96)**		

[1]Top value represents geometric mean (MPN/g) for the month; lower value represents the number of samples used to compute the monthly geometric mean.
[2]Top value represents geometric mean (MPN/g) for the year; lower value represents the number of samples used to compute the yearly geometric mean.

Table 8-2. Detention Time & Temperature in 2018 for Anaerobically Digested Biosolids			
Month	**Required Detention Time (Days)**	**Actual Detention Time (Days)**	**Avg. Digester Temp.**
January	15	22.6	99.1
February	15	26.7	99.3
March	15	22.3	99.2
April	15	21.6	99.1
May	15	28.4	99.4
June	15	28.6	99.2
July	15	30.8	99.1
August	15	34.2	99.1
September[1]	15	47.0	99.2
October	15	36.2	99.0
November	15	34.8	99.3
December	15	34.3	99.1

VECTOR ATTRACTION REDUCTION

Pathogens, which might remain in Portland Class B biosolids, pose a risk only if they are present in sufficient numbers and there are routes that bring them into contact with humans or animals. Vectors are a principal mechanism for the transport and transmission of pathogens. They are capable of moving pathogens from one organism to another by direct transport or, biologically, by playing a specific role in the life cycle of the pathogen. Vectors include insects, rodents, and birds. Federal regulations recognize several vector attraction reduction options. All are designed to render biosolids less attractive to vectors. Federal regulations require that compliance with vector attraction reduction criteria be demonstrated separately from compliance with pathogen reduction standards.

Portland anaerobically digests raw thickened primary and thickened waste activated solids at the CBWTP to achieve vector attraction reduction pursuant to 40 CFR Part 503.33(b)(1). The combination of anaerobic digestion and any post digestion process (e.g., additional biological stabilization during treatment in the Triangle Lake Lagoon) must reduce volatile solids by 38% or more under 503.33(b)(1). Anaerobic digestion reduced volatile solids 61.3 % (average) during 2018 (Table 8-3).

Table 8-3. Volatile Solids Reduction Achieved During Solids Digestion-2018			
Month	Volatile Solids (%)[2]		Volatile Solids Reduction[5] (%)
	Raw[3]	Digested[4]	
January	76.3	56.4	59.9
February	80.7	54.5	71.4
March	80.3	54.4	70.6
April	71.8	54.5	52.9
May	82.0	55.4	72.7
June	79.3	58.2	63.6
July	83.8	61.0	69.8
August	83.0	61.8	66.8
September	75.3	63.3	43.6
October	75.3	59.1	52.7
November	78.8	59.5	60.4
December	75.4	59.8	51.4
AVERAGE			61.3

[1]Biosolids (7,392 dry tons) were land applied at Madison Ranches and in Sherman County.

[2]Data characterizing percent solids and percent solids reduction calculations provided by Willy Park, Engineering Technician III.

[3]Average volatile solids content (mass weighted) in a blend of raw thickened primary and raw thickened waste activated solids fed to first-stage anaerobic digestion.

[4]Belt press feed volatile solids content. Solids fed belt filter presses contained 98% digested solids & 2% digested and lagoon stabilized solids in 2018.

[5]Percent volatile solids reduction that occurred during first and second-stage digestion and facultative lagoon stabilization (using the Van Kleeck Method).

SECTION 9
TRIANGLE LAKE LAGOON

The CBWTP discharges solids to a facultative sludge lagoon (Triangle Lake) located immediately north of the Columbia Slough across from the mechanical plant (Figure 9-1). Further description of the lagoon and its historic uses appears in Appendix C with additional details in Appendix F of the February 1998 Biosolids Management Plan. During 2018, new solids (predominantly digested TWAS) were discharged to the Triangle Lake Lagoon to provide additional stabilization and higher belt press cake densities.

TRIANGLE LAKE LAGOON SOLIDS

In April 1989, CH2M Hill completed a *Lagoon Sludge Utilization Report* which estimated that approximately 81,300 dry tons (396 acre-feet) of solids were stored in the Triangle Lake Lagoon. The report advised roughly 62,900 dry tons of solids could be removed from the lagoon under the first stage of a two-stage (solids withdrawal and lagoon renovation) lagoon rehabilitation capital improvement project without disrupting the integrity of dike walls or the lagoon bottom. On April 9, 1990, lagoon solids removal was initiated. Approximately 63,307 dry tons of the solids were withdrawn from the lagoon by the conclusion of the capital improvement project (June 30, 1998). Between July 1, 1998 and the present solids derived from waste activated solids thickening and belt filter press dewatering side streams, digester discharges, and digester cleanings had accumulated in the lagoon, increasing the overall quantity of lagoon solids.

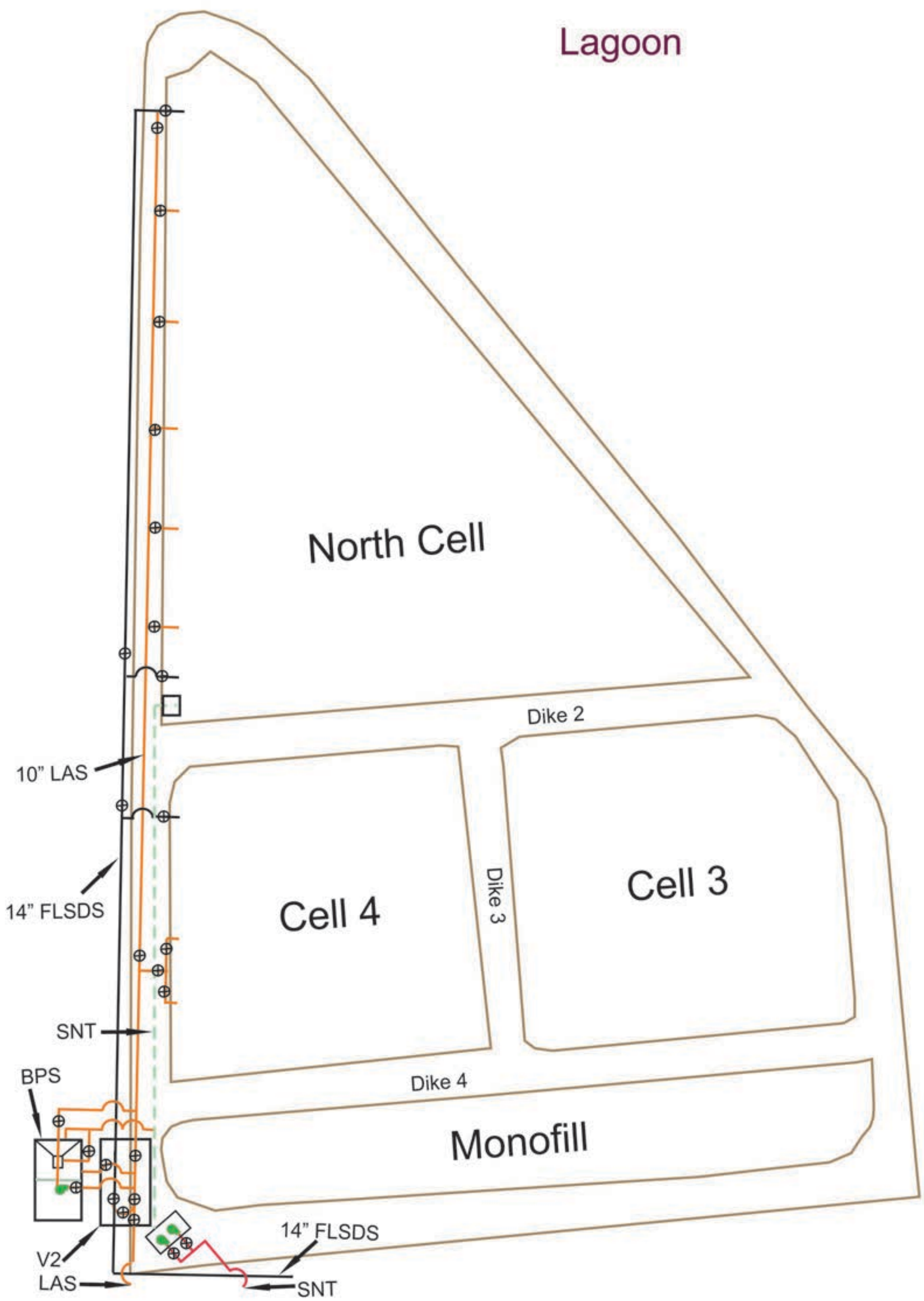
In August and September 1997, the quantity and quality of lagoon solids were surveyed by City staff to determine the location and number of dry tons and nature of solids that remained in the lagoon (1998 Biosolids Management Plan, Section 9 and Appendix G). A more comprehensive survey to define the quantity, distribution and quality of solids present in the lagoon was completed by Brown and Caldwell Consulting Engineers in June 2001 (2001 Biosolids Management Plan, Section 9 and Appendix C). Data from this survey was intended to be used as a basis for awarding solids removal bids during lagoon reconstruction.

A study performed in early 2010 by Crane and Merseth and City of Portland staff estimated the total quantity of solids remaining in the lagoon at 52,345 dry tons.

LAGOON RECONSTRUCTION

Lagoon renovation (compartmentalization and lining) is scheduled to occur in at least five phases over a period of approximately eight years. Phase I lagoon reconstruction (completed) entailed the construction of Dike 2 that subdivides the north and south halves of the lagoon into two roughly equal areas (Figure 9-2). Phase II reconstruction involved the development of a five-acre lined monofill (surface disposal unit) and lining of the two southernmost cells (Cells 3 and 4); Phase III entails placement of additional lagoon solids in the monofill; Phase IV involves the completion of lagoon Cells 1 and 2; and the final phase of construction (Phase V) includes the completion of the monofill and habitat restoration. Reconstruction will reduce the lagoon's overall water surface area from 37 acres to approximately 30 acres. In addition to lagoon reconstruction, approximately 5 acres along the southern portion of the existing lagoon will be landscaped and developed as part of Portland's 40-mile loop trail system during the next several years.

Figure 9-1 Triangle Lake Biosolids Lagoon (2018)



Lagoon predesign was completed in early 2000 and Phase I design work was finished during spring 2001. Final Phase II, Phase III and Phase IV design work was completed in spring 2002.

Phase I dike construction was completed in late fall 2001. To decrease its permeability, that dike was allowed to settle before further construction modifications were made. The dike will allow one-half of the lagoon (northern half) to remain in operation while the remaining portion of the lagoon is reconstructed. A monofill permit application was submitted to DEQ in December 2001. The DEQ Solid Waste Closure Permit needed to facilitate monofill construction was issued in June 2002. NPDES Form 2S (enabling monofill placement) was filed with EPA Region X in December 2001. A renewed monofill permit was issued by DEQ in 2016.

After delays due to available funding, the lagoon reconstruction and lining project was officially re-opened in September 2009. The Phase 2 project construction work advertised and bid in the spring of 2011 for the construction of the monofill and preparation and lining of lagoon Cells 3 and 4 in the southern part of the overall lagoon facilities. R&G Excavating was awarded the Phase 2 construction contract and notice to proceed was issued on September 20, 2011. R&G started construction of the monofill during the summer of 2012. Following two summers to allow solids to dry, a total of 56,781 wet tons (30,342 dry tons @ 53.4% total solids) from the southern part of the lagoon were introduced into the monofill. The partially filled monofill had a temporary cover until the next phase of construction where more dried solids will be added and the monofill will be closed with a final cover. A leachate manhole and pump is provided and maintained in the monofill to pump leachate back to the treatment plant. Newly created lagoon cells 3 and 4 (south half of the lagoon) were finalized and lined in the summer of 2015, and the construction contract reached Substantial Completion in September 2015. Cells 3 and 4 remained in stabilization mode for approximately two-and-a-half years, after which dredging restarted in 2018. The partially filled monofill has a temporary cover until the next phase of construction fills it to capacity with dried solids from the northern half of the lagoon. The monofill will then be closed with a final cover. Phase 3 and 4 (two construction phases were combined as a result of value engineering) of the project was awarded to Stellar J Corporation with a notice to proceed issued on May 12, 2016. Approximately 24,413 dry tons of solids were introduced into the monofill in 2018. To date, in 2019, approximately 10,000 additional dry tons have been added to the monofill, with more being placed on the geotextile to finish off the solids contained within the final monofill enclosure. The final quantity of dry tons to be placed in the monofill for Phase 3/4 will likely exceed 40,000 dry tons, representing a total monofill enclosure of more than 65,000 dry tons of solids.

Additionally, as part of Phase 3 and 4, the contractor may elect to land apply a portion of the solids that currently reside in the north cell of the lagoon. Per this possibility, the contractor and the City may elect to obtain site specific DEQ authorization to land apply biosolids to agricultural, silvicultural, horticultural, or reclamation sites located in Umatilla, Benton, Clackamas, Columbia, Crook, Deschutes, Gilliam, Hood River, Jefferson, Lane, Linn, Marion, Morrow, Multnomah, Polk, Sherman, Wasco, Washington, Wheeler and Yamhill Counties or a Department of Ecology (DOE) permitted site (General Permit or Biosolids Use Facility) in the state of Washington. Future land application sites will meet criteria noted in the City's current Land Application Plan (updated in June 2019).

SYNAGRO PROJECT

In 2018, the City began a project to accelerate removal of accumulated solids from the Triangle Lake lagoon. Due to events such as the Eagle Creek Fire and inclement weather conditions from 2016-2018 (which prevented biosolids hauling to land application sites), newly created lagoon Cells 3 and 4 had reached and exceeded design capacity. Construction on lagoon Cells 1 and 2 also experienced delays. Consequently, the City contracted with Synagro to augment its dredging and dewatering process in October 2018. Synagro operated portable belt presses and centrifuges to dewater material dredged from the lagoon. They also provided hauling services utilizing Tribeca Transport and Dietrich Trucking as subcontractors. An estimated 14,000 dry tons of material is expected to be removed from the Triangle Lake lagoon under this contract in 2018-2019. These solids are to be either landfilled at the Wasco County Landfill, Finley Butte Landfill (or other landfill) or beneficially reused on the City's existing land application sites in Sherman County or future land application sites to be permitted on the City's behalf by Synagro and their subcontractor, Tribeca. These new proposed sites will likely be in Sherman County, Gilliam County, Wasco County, or the Willamette Valley (Linn County and Marion County). At the end of 2018, Synagro had dewatered, hauled, and landfilled 1,206 dry tons of solids at the Wasco County Landfill. No land application for this project occurred in 2018 (see Appendix D for initial biosolids compliance data collected in 2018).

In June 2019, sites in the Moro and Arlington areas were authorized by DEQ for land application on dryland wheat ground (4,596.82 acres) in site authorization letters dated June 7 and June 11, 2019 (Table 9-1, Figures 9-2 and 9-3). Land application services will be provided by Tribeca. Additionally, a beneficial use of City biosolids at the Wasco County Landfill (190 acres) was granted by DEQ in a site authorization letter dated on May 29, 2019 and later amended on June 25, 2019 (Figure 9-4). City biosolids will be utilized to promote vegetative growth in vital areas throughout the property and to stabilize slopes and reduce disruption of native onsite soil. A full description of 2019 land application and landfill activities as part of the Synagro project will be provided in the City's annual reports to DEQ and EPA.

Table 9-1 DEQ Authorized Acreage in Moro/Arlington and at Wasco County Landfill

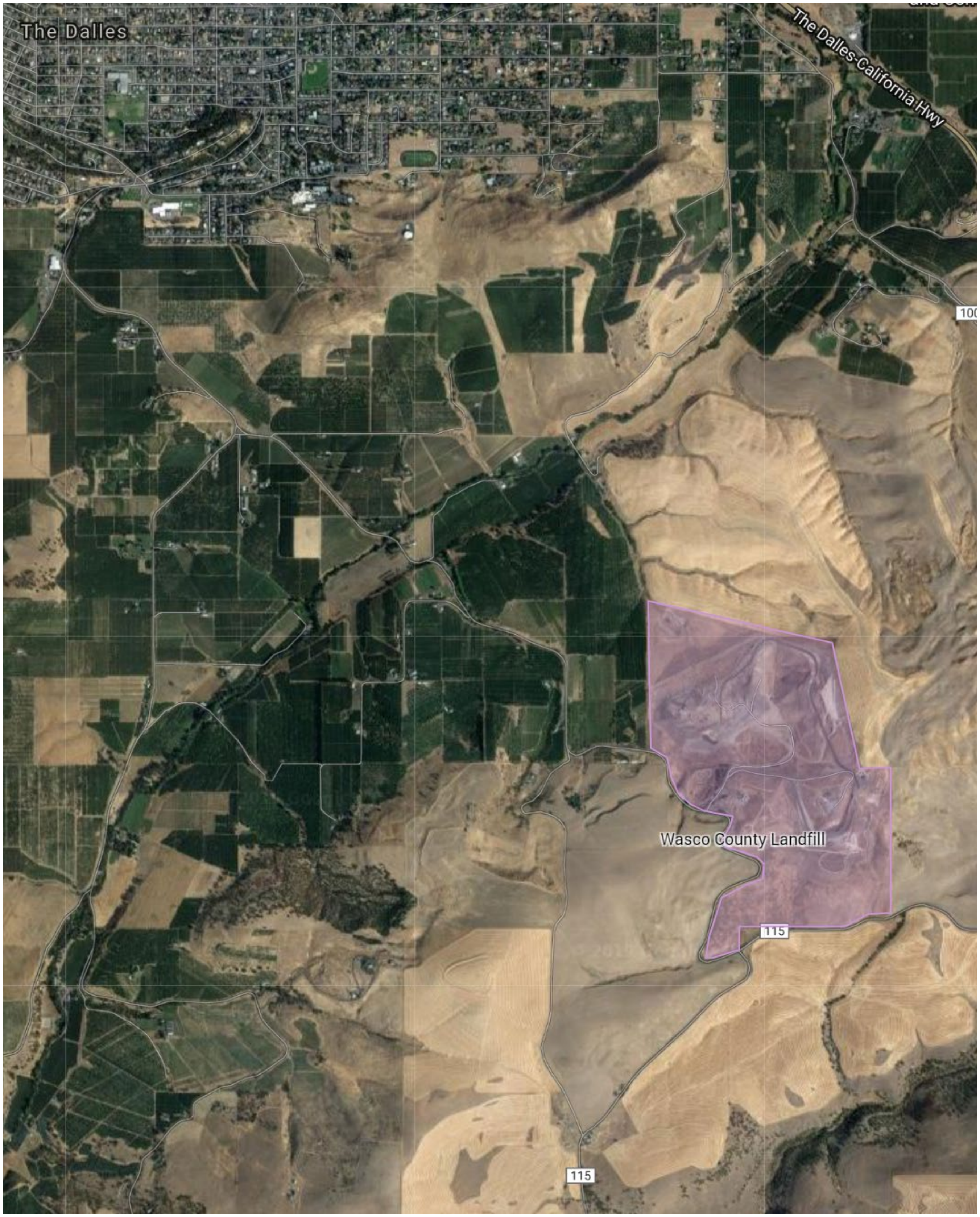
Owner/Operator	Tax Lot	Section	Township	Range	Acres[1]
Dave Pinkerton	8500, 8600, 400, 8900, 600, 2700	36, 35, 2, 11, 14, 22, & 23	1 So, 2 So	17 E	2,020.19
Jon Simantel	1905	34 & 35	2 No	19 E	700
Weedman Brothers	1500	19, 20, 29 & 30	1 No	21 E	1,876.63
Wasco County Landfill	100 & 200	24	1 No	13E	190
Total Acreage					**4,786.82**

[1]Acreage represents total tax lot acres. Spreadable acreage will be less than this amount due to farming practices, buffers, setbacks, etc. See Appendix A for site authorization letters.

Figure 9-2 Moro County Land Application Sites

Figure 9-3 Arlington County Land Application Sites

Figure 9-4 Wasco County Landfill Land Application Site



SECTION 10
BIOSOLIDS TRANSPORT

Portland biosolids are transported approximately 200 miles from CBWTP biosolids loading silos to staging areas located at Madison Ranches in northern Morrow and Umatilla counties and approximately 120 miles to staging areas in northern Sherman County by Gresham Transfer, Incorporated (GTI) and Sutton Trucking pursuant to contracts with the City, a detailed City approved contractor's work plan and a spill response plan.[1&2] The contractor's work plan includes specifications on truck and pup trailer equipment, truck loading, load weighing, truck cleaning at the CBWTP loading area and at staging areas, scheduled routine maintenance, haul routes, a traffic plan, driver hygiene and first aid requirements, driver disciplinary policies, chaining requirements, haul schedules, and plan update and coordination requirements between the contractor and the City. In 2019, the City added land application sites in the Moro area of Sherman County and the Arlington area of Gilliam County as well as at the Wasco County Landfill.

GTI commenced hauling dewatered cake to Madison Ranches in the summer of 1992 under Contract No. 28167 (executed August 18, 1992). That contract concluded at the end of 1995. GTI was awarded a second contract (Contract No. 30372; executed February 2, 1996) that was extended through December 31, 1998. A third three-year contract (Contract No. 40463) was awarded to Gresham Transfer to haul biosolids cake from the CBWTP to Madison Farms, effective January 1, 1999. The contract provided for the transport of approximately 27,000 dry tons of biosolids with up to two one-year extensions. By mutual agreement between GTI and the City, GTI's contract was extended through the end of 2003. The contract was extended nine additional months (January 1, 2004 to September 30, 2004) to enable the City to consider the authorization of new sites closer to Portland in light of federal regulatory action on dioxins in land applied biosolids prior to rebidding the next haul contract. Further, the contract was extended for 12 additional months (October 1, 2004 to September 30, 2005) to enable the City's Bureau of Purchases to determine if a new contract should be let via low bid, request for proposals or direct incumbent vendor negotiation process (enabled via special City strategic outsourcing ordinance). On August 31, 2005, a fourth, nine-year contract (Contract No. 40940; effective October 1, 2005 to September 30, 2014) was executed between the City and GTI. That contract, in part, enabled the City to acquire tax exempt (federal) fuel for use in biosolids transport. Fuel dedicated to Portland biosolids transport is staged at GTI's Fairview facility. An amendment to the new contract facilitated transporting Portland biosolids to northern Wasco County and to six townships in northern Sherman County. In 2010 a new five-year contract (Contract No. 31000149) with the option of up to 5 one-year extensions was established between Madison Biosolids, Inc. and the City. Under this contract, Madison Biosolids is contracted to haul and land apply biosolids in Sherman County. GTI provides hauling services for this contract as a subcontractor to Madison Biosolids, Inc. In 2014, a Request for Proposals for hauling services to

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[1] DEQ has been provided a copy of the City's updated spill response plan. The contractor's work plan can be made available to DEQ upon request. The spill plan and contractor's work plan are updated annually.

[2] In addition to biosolids spill response actions required by haulers and the City for biosolids trucked from the CBWTP; the spill response plan covers the transport of anaerobically digested primary biosolids and raw thickened waste activated solids between the TCWTP and the CBWTP; the transport of grit and screenings from the CBWTP and TCWTP to the Wasco County Landfill; and the conveyance of vactor waste (sewerage collection system sediments integrated with grit and screenings produced at the CBWTP) between the CBWTP and Wasco County Landfill.

Madison Ranches was posted on July 3, 2014. A pre-proposal meeting was held on July 10, 2014. One proposal was received on July 31, 2014 from GTI. The City issued a Notice of Intent to Award a price agreement to GTI on August 18, 2014. No protests were received. City Council approved the five-year contract award (with extensions available for an additional five years) on October 1, 2014 (contract # 31000609). Effective April 30, 2019, GTI was sold to Sutton Trucking in an asset sale. GTI's contract with the City was fully transferred to Sutton Trucking under contract # 31001556.

In 2018, due to difficulties experienced by GTI in hiring drivers due to a nationwide shortage of truck drivers, biosolids were also hauled to land application sites by Tribeca Transport under contract #31001416 and Dietrich Trucking under contract #31000946.

GTI trucked 7,116 dry tons of biosolids to Madison Ranches and Sherman County during 2018 (Section 13-14). Tribeca Transport hauled 434 dry tons to Madison Ranches. Dietrich Trucking hauled 380 dry tons to Madison Ranches. Overall hauling was below normal levels in 2018 as the CBWTP continued to seed its newly reconstructed lagoon cells. Approximately 15,000-16,000 dry tons are projected to be hauled from the CBWTP to land application sites in 2019.

Dewatered biosolids were loaded into truck/trailer (truck/pup configuration) units at an average rate of 34.72 wet tons per load (5.78 dry tons per load), depending upon dewatered cake total solids content; weighed on platform scales (located immediately below 75-80 wet ton solids storage/loading silos); transported to Madison Ranches or Sherman County; and unloaded at designated staging areas.

GRESHAM TRANSFER / SUTTON TRUCKING HAULING EQUIPMENT

Aluminum truck and pup boxes on GTI equipment first placed on line in mid-2002 have a 34 to 35.5 wet ton payload. All trucks and pup trailers used for biosolids transport after mid-March 1996 met or exceeded Federal Motor Carrier Safety Regulations (Part 393.92) and included Antilock Braking Systems (ABS). GTI received delivery of three new trucks in late 2017. These 2018 model year vehicles meet EPA's latest and most stringent diesel emissions standards. These standards require diesel engines to emit no more than 0.01 grams per brake horsepower hour (g/bhp-hr) of particulate matter (PM), 0.2 g/bhp-hr of nitrogen oxides (NOx), and 0.14 g/bhp-hr of non-methane hydrocarbons (NMHC) utilizing Diesel Particulate Filters (DPFs) and Selective Catalytic Reduction (SCR). GTI operates a previous-generation truck with trailer as a back-up unit. All trailers and pups have aluminum boxes which allow GTI to transport approximately two dry tons more payload than truck and pup steel box equipment used in the past. Truck and pup beds tilt to 50°, easing biosolids off-loading. Trailer and pup sidewalls and back walls are curved in a manner which promotes superior solids off-loading compared to the dump bed systems used in the past. Even greater solids removal efficiency can be realized if beds are pre-wetted at the CBWTP, via hosing, prior to loading solids from hoppers, although this practice is rarely used unless cake solids appear particularly adhesive, since this procedure adds weight to the load.

SPILL RESPONSE

During 2018, biosolids (1,372 loads) were transported from the CBWTP to Madison Ranches and Sherman County with no spill incidents. In the event of a spill, each truck driver is instructed to indicate the quantity of product spilled, spill location, and a detailed description of how the spill occurred. Trucks are equipped with flares and reflective markers (side tool boxes), which are to be placed in appropriate spots at the spill site. Spill plans and placards describing the properties of Portland bulk Class B biosolids which include phone numbers of hauler's dispatch office and Portland's spill response manager are to be kept in each transport vehicle (Table 10-1). The placard information is designed to alert a spill responder of the nature and relative risk associated with any spilled biosolids.

Drivers have been instructed to work with office staff immediately following a spill incident to complete a written notification document describing the nature of the spill. In addition, to assure that the City is alerted of any spills in a timely manner and to better document spill response, Portland has requested haulers contact the City immediately after the spill and provide the City with a written report of any spill incident within 3 business days of the event.

Any spill greater than 0.25 yd^3 or where biosolids have entered State waters requires the hauler's emergency coordinator to contact responders recognized in the City's spill response plan as businesses capable of providing sufficient personnel and equipment to respond to the incident. In addition, the emergency coordinator is required to alert the Oregon Response System Dispatcher (who will alert ODOT and DEQ), the treatment plant's 24-hour 503-823-2500 number, and Portland's Biosolids/Reuse Program Manager within 24 hours of the spill.

DRIVER EDUCATION

Portland biosolids program staff met with GTI drivers (January 17, 2018) at their annual safety training meeting to discuss the nature of biosolids, contractor on-site policies, and emergency response procedures. City-developed guidelines for driver hygiene, properties of the City's bulk Class B biosolids, and related information were distributed to drivers during the meeting. A similar meeting between the City and GTI was held on March 1, 2017. Updated product description and driver/applicator hygiene and personal protective wear guidelines were distributed at that time (Tables 10-1, 10-2).

Table 10-1. A Description of Portland Bulk Class B Biosolids
What Are Portland Bulk Class B Biosolids?
This Sutton Trucking vehicle is hauling Portland bulk Class B Biosolids to Madison Ranches, Echo, Oregon or Sherman County, OR. Biosolids (≈ 20% total solids and 80% water) are biologically stabilized residuals derived from the primary and secondary treatment of domestic wastewater at the City of Portland, Oregon's Columbia Boulevard wastewater treatment facility. The Oregon Environmental Quality Commission (EQC) and the Environmental Protection Agency (EPA) actively promote biosolids recycling via land application. Portland's biosolids are a beneficial recyclable material which improves soil tilth, fertility, and stability. These residuals have undergone anaerobic digestion, a controlled process recognized by the EPA and the Oregon Department of Environmental Quality (DEQ) to make them suitable for transport and land application. Digestion processes and biosolids quality are regularly monitored to assure Federal and State pathogen *[40 CFR Part 503.32(b)(2) & OAR 340-50-026(2)(b)]*, vector attraction *[40 CFR Part 503.33(b)(1) & OAR 340-50-026(2)(c)]*, and trace pollutant *[40 CFR Part 503.13(b)(1) & OAR 340-50-026(2)(a)]* levels are within regulatory standards. Test information on Portland biosolids quality, including priority pollutant scan data, is available upon request from the City of Portland (503-823-2491) and DEQ (503-229-5616).
Are Biosolids Considered Hazardous? - No
Portland biosolids are not considered a RCRA Subtitle C hazardous waste nor are they a toxic, biological, or radioactive waste. **In the event of spill, report to Sutton Trucking Dispatch Office at (503) 255-7902 or 1-888-444-7902 and City of Portland at (503) 823-8541, (503) 823-2438, or (503) 823-2491.**

Table 10-2. Guidelines for Biosolids Driver Protection
Although Portland bulk Class B biosolids present little threat to hauler health and safety, the potential exists for some disease-causing microorganisms to remain in solids transported from the Columbia Boulevard Wastewater Treatment Plant. A few common-sense practices should be observed to minimize driver exposure to pathogens that might remain in biosolids, including: • Wash hands before eating, drinking, or smoking. • Use water-less soap (disinfectant soap) for hand washing at remote sites where water is not available. • Avoid rubbing eyes, nose, and mouth after handling biosolids. • Do not smoke or consume food or drink in biosolids loading or unloading areas. • Wear gloves during solids loading and off-loading operations. • Wear protective clothing when there will be more than casual contact with biosolids (e.g., during the clean-up of spilled materials). • When clothing or body parts are exposed to biosolids, shower and change into clean clothes before leaving work. • Immediately clean and disinfect abrasions and lacerations. Keep all wounds protected from contamination.

SECTION 11
CONTINGENCY OPTIONS

SOLIDS TREATMENT FACILITY PROCESS INTERRUPTIONS/FAILURES

Since flows to the CBWTP are relatively large, the chance of a spill or illegal discharge affecting biosolids characteristics will be minimal. However, effective system safeguards are essential to assure both effluent and biosolids quality.

In the event of a digester upset, solids would be removed from the affected digester, reprocessed, directed to the Triangle Lake lagoon, or dewatered and landfilled. The CBWTP has some redundant capacity in its anaerobic digestion system. Digesters 5, 6, 7, 8, 9 and 10 (Figure 5-1) can be used to stabilize raw thickened primary, TWAS only or a blend of the two. Solids can also be discharged to the Triangle Lake Lagoon, returned to the Recycle Pump Station for reprocessing, or outright removed from the system via a contracted vactor/pumping service.

Biosolids produced for land application are monitored on a regular basis. Adjustments in process controls or management practices can be initiated if necessary. With emphasis on pollution prevention and safeguards in place such as the City's industrial pretreatment program, it is improbable that solids quality will decline in the future to the extent that trace elements regulated under 40 CFR Part 503.13(b)(1) or other pollutants would limit biosolids land application. Should trace inorganic or organic compound pollutant levels ascend to the point that they would limit product use; no biosolids would be produced or exported from the CBWTP for beneficial recycling.

In the unlikely event that a sharp decline in biosolids quality or future regulatory actions prevent biosolids land application, or if solids fail to meet pathogen reduction or vector attraction reduction standards, or if solids need to be expediently removed from the treatment plant (in excess of what land application sites can provide), solids will be tested to assure that they meet TCLP requirements and either be beneficially used as a daily, intermediate or final cell cover at local landfills, including but not limited to, the Hillsboro Landfill in Washington County, the Riverbend Landfill in Yamhill County, the Coffin Butte Landfill in Benton County, Columbia Ridge Landfill near Arlington, Wasco County Landfill in The Dalles, or the Finley Butte Landfill in Morrow County, Oregon or disposed at these facilities.[1&2]

No loads of biosolids were transported to land application for approximately 6 full days, (41 cancels) in 2018: January 1st and November 23rd created 5 cancels due to holiday scheduling. Inclement winter weather caused 6 cancels on February 21st.

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[1] Between January 11, 1992 and July 19, 1992, the City of Portland transported approximately 8,470 dry tons of dewatered solids removed from the Triangle Lake Lagoon to the Rabanco Landfill in Klickitat County, Washington pending DEQ reauthorization to land apply solids at Madison Ranches.

[2] In the past, digester cleanings contained Thorium 232 levels that the Oregon State Health Division considered unacceptable for land application. This radionuclide contaminated waste was co-disposed with municipal solid waste pursuant to DEQ authorization. The industry that discharged wastewater contaminated with Thorium 232 was identified and required to remove contaminated sediments from sewer lines and sumps and cease discharging these isotopes to the Portland's sewerage system.

Some solids transport was interrupted at other times due to low solids levels, causing 2 cancels. Contractor trucks out of service or repair, 10 cancels. Asset failure due to mechanical or electrical equipment failures associated with the dewatering or conveyance operations, 7 cancels. Preventative maintenance of City assets caused 9 cancels. Relocation to Sherman County, 4 cancels. Overall hauling was below normal levels in 2018 as the CBWTP continued to seed its newly reconstructed lagoon cells.

During transportation interruptions, when digesters are full, process sludge can be directed to the Triangle Lake Lagoon for additional stabilization prior to subsequent dredging and dewatering.

TRANSPORTATION SPILL RESPONSE PLAN

A Transportation Spill Response Plan has been developed to address any potential problems that might occur during raw solids, biosolids, or non-recyclable solids transport (Section 10). The plan (last amended June 2019) is updated annually or as important details change (new contracts, new contact information, updated responders, etc).

SECTION 12
BIOSOLIDS CHARACTERISTICS

PRETREATMENT PROGRAM

Portland has actively worked with industries to reduce toxic pollutants discharged to the CBWTP and TCWTP since 1974. As a result, many industrial users have installed pretreatment systems and implemented other control measures to reduce the level of pollutants discharged to the City's sewer system.

The Bureau of Environmental Service's (BES) Industrial Permitting Section has administered a state and federally approved industrial pretreatment program since March 3, 1983. The program controls the discharge of toxic pollutants from industrial sources that may interfere with the operation of Portland's wastewater treatment plants, collection systems, biosolids uses, and worker safety.

The Pretreatment program establishes technically based local pollutant limits for industrial wastewater effluent. The local limits were last evaluated in 2016 and are found in Table 12-1. The City monitors compliance through inspections, industrial self-monitoring and reporting, and City conducted effluent monitoring. Permittees are also required to prepare, implement, and maintain an updated *Accident Spill Prevention Plan* and to install spill control facilities where chemicals have a reasonable potential to reach City sewers.

Table 12-1. Existing Local Trace Metals Limits[1 & 2]

Parameter	Local Limit (mg/l)	Parameter	Local Limit (mg/l)
Arsenic	0.20	Molybdenum	1.40
Cadmium	0.70	Nickel	2.80
Chromium	3.53	Selenium	0.60
Copper	2.80	Silver	0.40
Lead	0.70	Zinc	3.70
Mercury	0.01		

[1]Revised local limits were approved by Oregon DEQ on June 20, 2016 and adopted as a Bureau of Environmental Services rule in June 2016.
[2]In addition to limits noted above, local limits have been adopted for cyanide, non-polar oil and grease, pH, pentachlorophenol, chlorobenzene, chloroform, trichloroethylene, 1,2–dichloroethane, 2,4–dinitrotoluene, nitrobenzene, chlordane and acrlyonitrile.

At the close of 2018, the Portland Pretreatment program had 123 industrial wastewater discharge permitees. There are three levels of industrial permitting:

- Significant Industrial Users – 67 industries of which 29 are regulated by federal categorical pretreatment standards.
- Non-significant Industrial Users – 39 industries.
- Non-discharging Categorical Industrial Users – 17 industries. These industries generate a categorical waste stream but do not discharge to the City.

The City's wastewater discharge permit for the CBWTP requires monitoring for various toxic pollutants. Metals, other inorganics, and organics testing of influent, effluent and first-stage digested solids are regularly analyzed under the program pursuant to Schedule E of the National Pollutant Discharge Elimination Systems (NPDES) permit for CBWTP.

Since 1993, the City has evaluated data for the concentrations of cadmium, copper, chromium, lead, nickel, zinc and other trace inorganics entering the CBWTP in plant influent, effluent, and biosolids. Biosolids test data gathered from 1981 through the end of 2018 provide graphic evidence that the pretreatment program has dramatically improved biosolids quality by decreasing toxic metals concentrations in biosolids since the program's inception. (Figures 12-1 through 12-6).

The City continues to investigate opportunities for additional pollution reductions. Future improvements are expected with the continued implementation of pollution prevention programs.

Figure 12-1. Portland Biosolids Total Metals Concentration

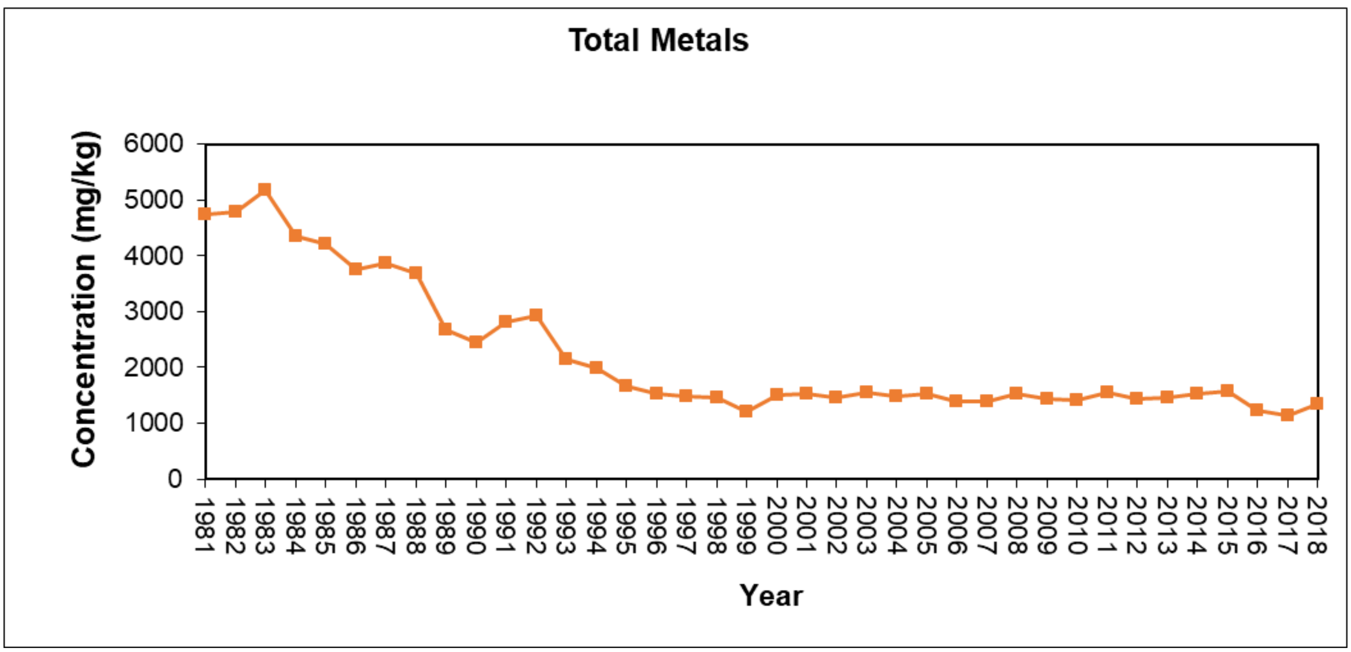


Figure 12-2. Portland Biosolids Cadmium

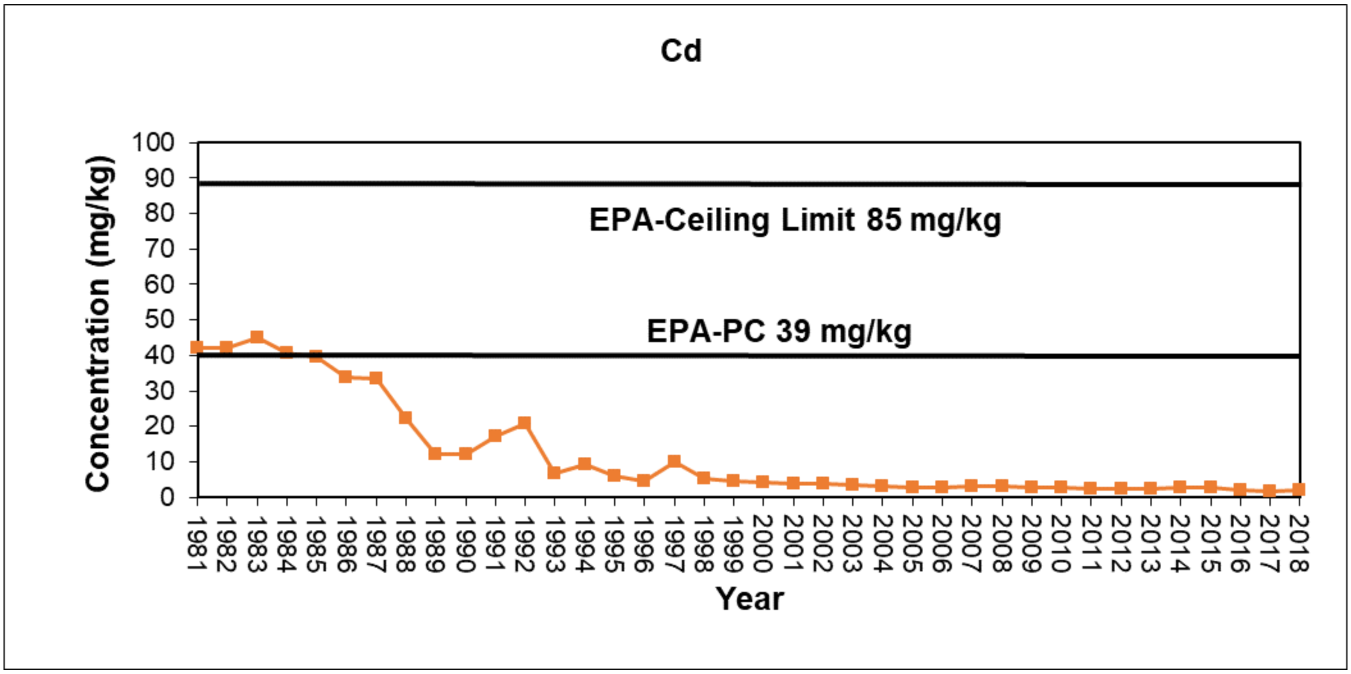


Figure 12-3. Portland Biosolids Copper

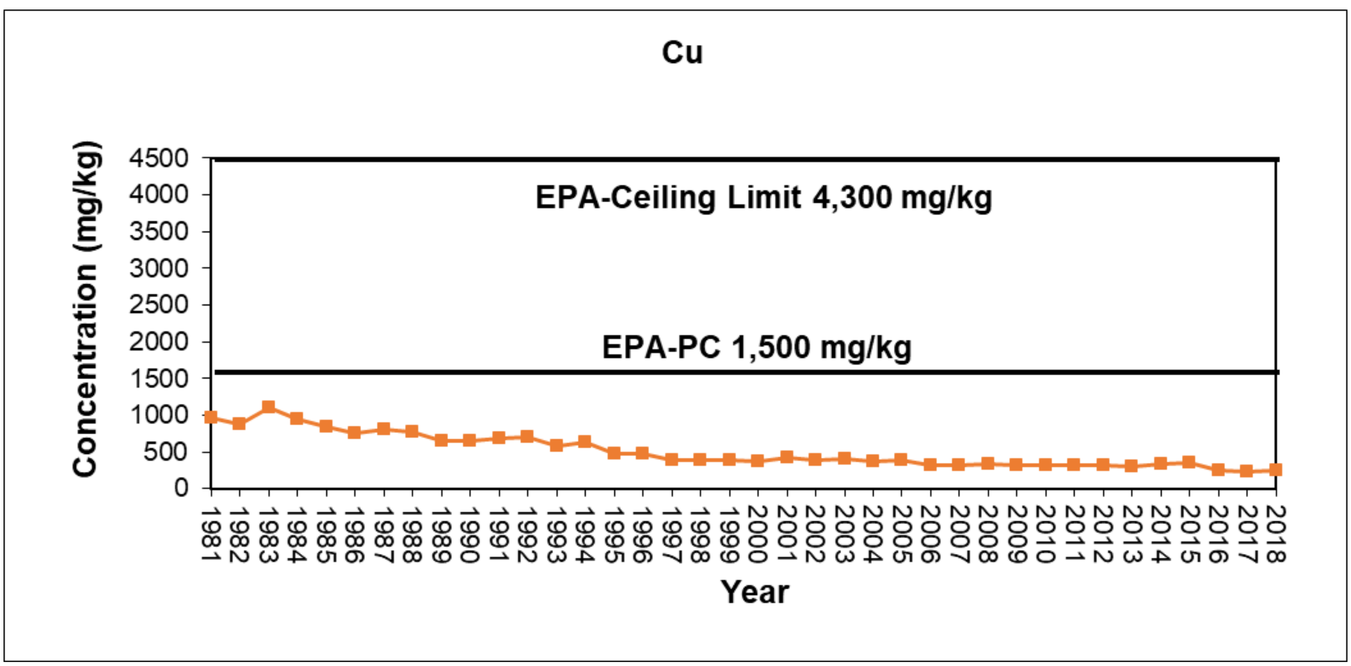


Figure 12-4. Portland Biosolids Lead

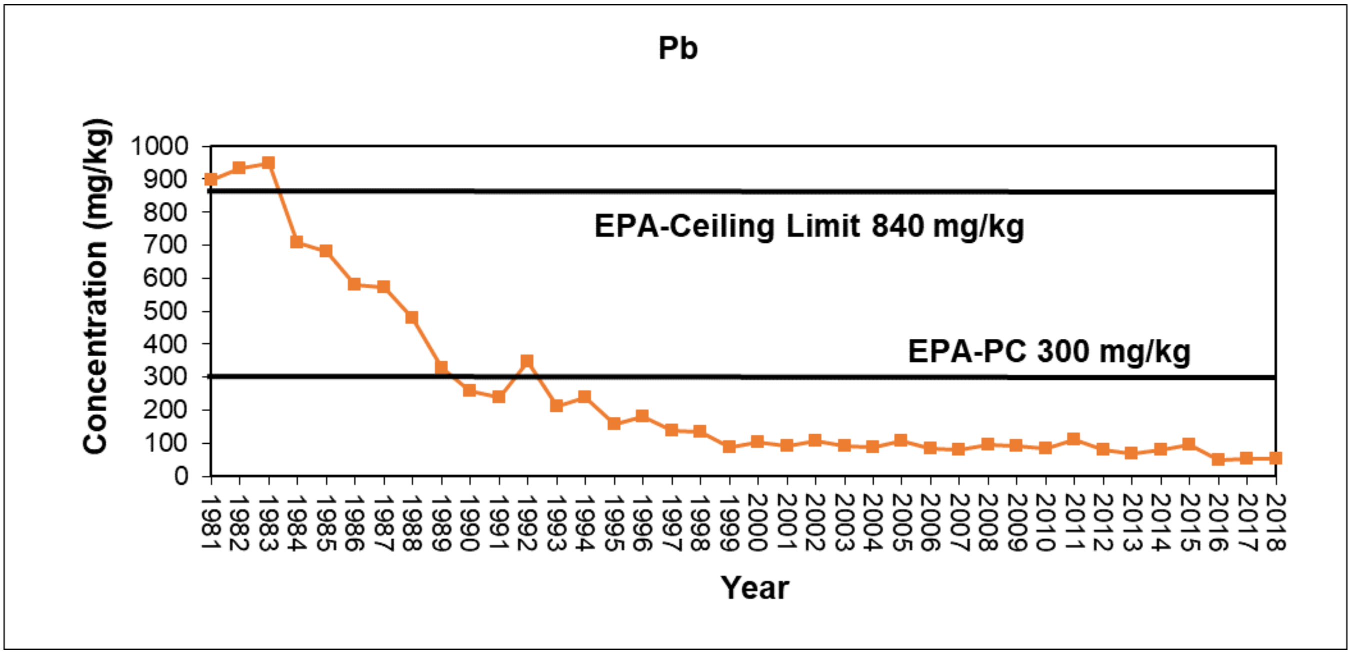


Figure 12-5. Portland Biosolids Nickel

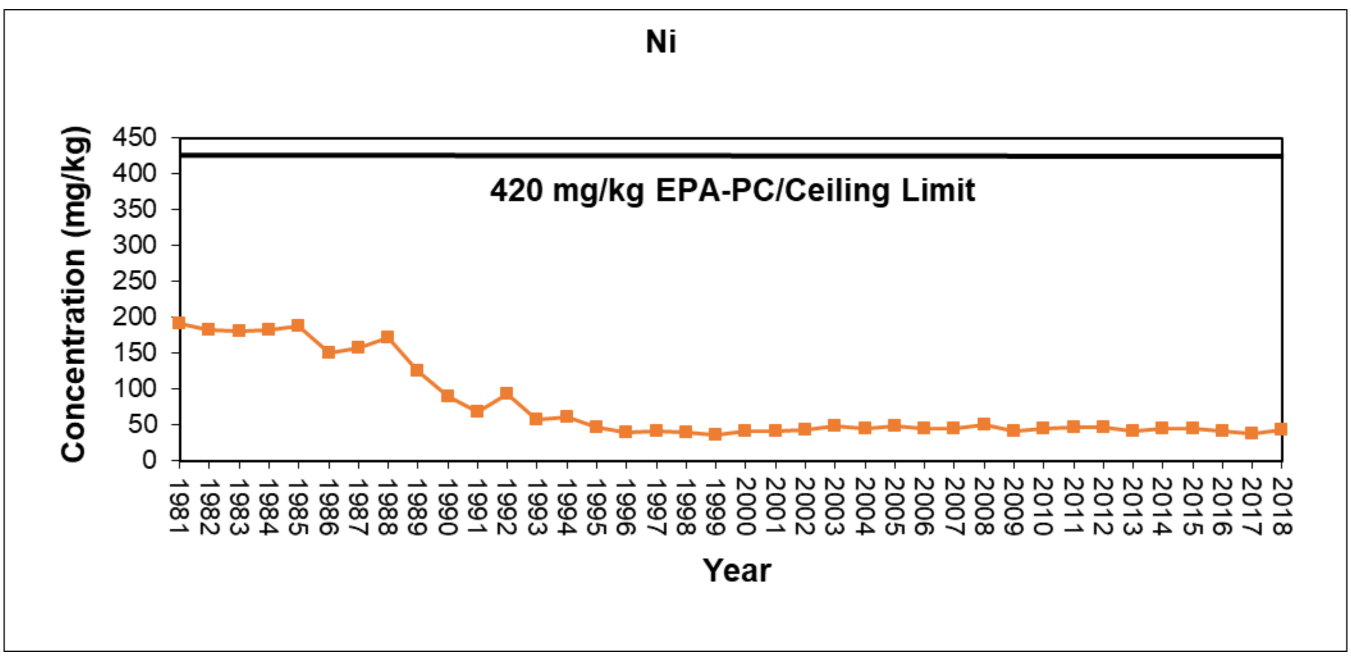
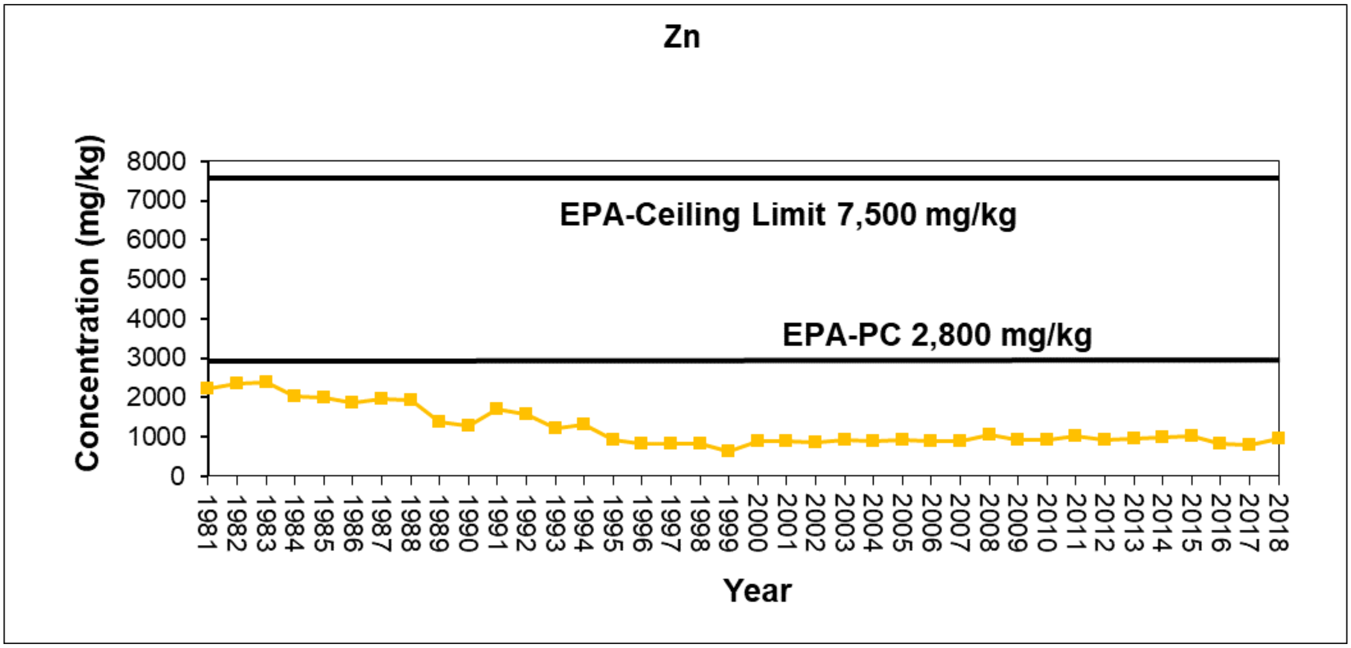


Figure 12-6. Portland Biosolids Zinc



Treatment processes which occur at the CBWTP are also effective in reducing several trace inorganics. A one-year CBWTP sampling program was conducted during 1994 as part of the City's on-going effort to examine the effectiveness of its local limits program. Table 12-2 summarizes the removal efficiencies for test parameters realized through primary and secondary treatment at the CBWTP and indicates removal efficiencies reported in the literature for these parameters. In addition to inorganics, findings from a 2010 Water Environment Research Foundation (WERF) study indicated that more than 90% of endocrine disrupting compounds (chemicals that may have adverse impacts on hormonal systems in humans and wildlife. Prominent EDCs include flame retardants, surfactants, and estrogens) are removed during activated sludge treatment and concentrations of most estrogenic compounds decreased through the solids treatment train (*Charting The Future of Biosolids Management* – WEF May 19, 2011).

Table 12-2. CBWTP Trace Inorganics Removal Efficiencies[1]							
	EPA Literature Values for Removal Efficiencies			**Historical CBWTP Data**			
Pollutants of Concern	Primary Removal (%)	Secondary Removal (%)	Overall Removal (%)	Overall[2] CBWTP Removal (%)	Primary (%)	Secondary (%)	Treatment[3] Removal (%)
Aluminum					43.1	82.6	90.1
Antimony [4]					21.4	67.1	74.1
Arsenic [4]	12.0	45.0	51.6	42.0	20.8	55.8	65.0
Barium				77.0	37.7	75.6	84.8
Beryllium [4]					63.7	54.1	83.3
Boron				13.2	-1.9	4.4	2.6
Cadmium [4]	15.0	67.0	72.0	56.0	31.2	73.3	81.6
Chromium	27.0	82.0	86.9	70.0	31.3	68.7	78.5
Copper	22.0	86.0	89.1	65.0	30.8	76.0	83.4
Iron				81.0	38.9	75.9	85.3
Lead	57.0	61.0	83.2	65.0	55.3	67.1	85.3
Magnesium					16.7	12.6	27.2
Manganese				55.0	20.3	24.5	39.9
Mercury [4]	10.0	60.0	64.0	29.0	20.1	12.7	30.3
Molybdenum				33.0	2.9	24.2	26.3
Nickel	14.0	42.0	50.1	47.0	26.1	44.0	58.6
Potassium				18.0	4.5	9.6	13.7
Selenium [4]					31.4	33.4	54.3
Silver	20.0	75.0	80.0	55.0	14.8	63.0	68.4
Tin [4]					52.4	75.3	88.3
Zinc	27.0	69.0	84.7	50.0	28.7	67.0	76.5

[1] Table from Section 7 of Final Report – *Update of Local Discharge Standards*; October 8, 1995.
[2] Overall removal efficiency determined from CBWTP monitoring records from 1976-1994.
[3] Removal efficiency calculated from treatment plant influent to secondary effluent - flow in bypass channel not considered in removal efficiency calculation.
[4] Removal efficiency calculated using raw sludge data, dewatered biosolids data, and EPA literature values for removal efficiencies.

BIOSOLIDS QUALITY

Table 12-3 indicates concentrations of arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium and zinc in first-stage anaerobically digested solids. This data reflects the trace inorganics level of contemporary solids processed at the CBWTP. Table 12-4 shows the concentrations of arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, NO_3-N, NH_3-N, TKN, total phosphorus and potassium in a blend comprised of 98% anaerobically digested solids and 2% anaerobically digested and lagoon stabilized solids dredged from Triangle Lake during 2018.

Before 2016, a portion of lagoon solids were produced prior to bans on the manufacture and sale of some pesticides and other organic chemicals between the mid-1960s and late-1970s, and the initiation of Portland’s industrial pretreatment program. Historical data recorded under the industrial pretreatment program (Figures 12-1 to 12-6) and lagoon solids testing which occurred in 1989, 1997 and 2001, suggest biosolids quality has improved significantly with time (Table 12-5). The quality of land applied biosolids should continue to improve over the next few years because of the continued implementation of successful pollution prevention and source control measures.

Compounds of Emerging Concern:

In recent years, there has been increased awareness and concern about the presence of “contaminants of emerging concern” in biosolids (COECs). This group of trace organic compounds includes pharmaceuticals, plastics, personal care products, flame retardants, and other related compounds. A risk assessment study was performed in 2015 by Kennedy/Jenks Consultants in partnership with the University of Washington. This study attempted to quantify the risk (Risk = Toxicity x Exposure) to human health associated with the presence of these types of compounds in biosolids. Utilizing very conservative risk scenarios for biosolids compost used in home gardening and land applied biosolids (dermal contact and direct ingestion), numerical risk assessment data was developed. The results showed that risk from the presence of these compounds in biosolids is negligible, even in very conservative exposure scenarios. It would take many lifetimes of working or playing around biosolids or compost made with biosolids to equal everyday exposure to many common products (e.g., it would take a home gardener working with biosolids compost over 77,000 years to get the equivalent of one dose of ibuprofen). Additionally, wheat fertilized with biosolids was tested for over 80 compounds in pharmaceuticals and personal care products and none were found in the wheat grain. (https://www.nebiosolids.org/s/Microconstituents-NWbiosolids_RISKbrochure-2016.pdf)

Table 12-3. Mean Concentration of Trace Inorganics in First-Stage Anaerobically Digested Solids-2018 [1]										
Month	Parameter (mg/kg, dry weight)									
	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Zinc
January	3.72	1.58	46.6	231	43.9	0.479	7.59	40.1	3.77	873
February	4.06	1.54	50.5	233	51.6	0.687	7.76	50.4	3.24	908
March	3.35	1.69	55.8	232	67.2	0.620	7.93	49.8	2.44	872
April	3.62	1.70	55.8	221	83.5	0.638	8.29	52.2	3.64	932
May	3.71	1.93	59.3	253	44.1	0.588	8.80	48.6	3.36	949
June	3.79	1.86	57.3	238	50.0	0.585	8.81	49.8	4.52	901
July	3.99	2.11	50.9	241	46.9	0.720	9.37	44.5	4.53	949
August	3.62	1.95	41.3	236	33.2	0.683	9.46	34.3	4.57	906
September	3.83	2.89	39.2	253	46.8	0.660	9.86	37.3	5.11	973
October	4.10	2.09	37.5	281	52.7	0.673	9.86	39.2	4.55	986
November	4.70	1.88	44.7	266	59.0	0.598	9.90	39.4	4.11	1,030
December	4.14	1.75	37.4	253	59.0	0.529	8.70	35.6	3.40	1,010
Annual Mean	3.89	1.91	48.0	245	53.2	0.622	8.86	43.4	3.94	941

[1] All numbers represent a dry weight basis of first-stage anaerobically digested solids.

Table 12-4. Mean Concentration of Trace Inorganics, Nitrogen Species, Potassium and Total Phosphorus in Portland Bulk Class B Biosolids Land Applied - 2018[1]																
	Parameter (mg/kg Dry Weight)														% by Weight	Dry Tons Produced
Month	As	Cd	Cu	Pb	Hg	Mo	Ni	Se	Zn	NO_3-N	NH_3-N	TKN	Total P	K		
January	5.22	2.12	327	61.8	0.860	10.30	52.3	4.77	1,170	5.4	8,170	45,800	19,700	2,170	6.58%	522
February	4.62	1.92	289	58.7	0.591	9.14	53.4	3.77	1,080	5.4	7,980	49,600	18,600	2,180	5.24%	415
March	3.94	1.81	269	53.5	0.602	8.84	49.9	3.65	1,060	5.1	7,100	48,000	17,800	2,110	8.40%	666
April	4.12	2.06	276	49.1	0.687	9.36	55.6	3.82	1,060	5.2	8,270	48,200	17,900	2,050	5.80%	460
May	4.42	2.18	284	54.1	0.666	10.20	61.0	4.77	1,060	5.5	7,610	50,400	18,300	2,000	6.56%	520
June	4.54	2.36	281	50.0	0.702	10.70	61.8	4.80	1,080	5.4	9,870	52,000	19,300	2,110	8.21%	651
July	4.01	2.31	281	44.8	0.779	9.56	46.1	4.88	1,080	6.2	9,720	60,700	18,600	2,110	7.52%	597
August	4.08	2.30	295	39.5	0.928	10.90	45.0	5.14	1,070	6.8	12,700	63,600	22,100	2,390	8.03%	637
September	4.03	2.83	284	49.6	0.891	10.20	38.5	5.19	1,090	6.9	15,000	64,900	23,200	2,920	7.29%	578
October	4.65	2.67	323	69.2	0.803	11.90	40.0	4.89	1,150	12.0	10,100	57,600	20,400	2,520	11.65%	924
November	4.77	2.39	314	72.3	0.997	11.30	40.2	4.77	1,220	6.9	10,900	58,800	19,100	2,390	12.62%	1,001
December	4.44	2.06	288	63.4	0.739	11.90	40.7	4.49	1,200	5.7	9,190	64,500	18,500	2,320	12.10%	960
Annual Ave.	4.40	2.25	293	55.5	0.770	10.36	48.7	4.58	1,110	6.4	8,100	55,342	19,458	2,273	100.0%	7,930
Weighted Ave.[2]	4.42	2.28	295	57.2	0.786	10.58	47.3	4.62	1,122	6.6	9,850	56,355	19,479	2,297		

[1]Characteristics describing Portland biosolids Class B pathogen reduction are detailed in Section 8.
[2]Number is arithmetic average, weighted by dry tonnage production (used throughout report). Represents a ratio of approximately 98:2 of digested solids and lagoon stabilized solids.

Table 12-5. A Comparison of Trace Inorganics Mean Pollutant Concentrations in CBWTP Solids Produced during 2018 with Triangle Lake Lagoon Solids					
Parameter (mg/kg Dry Weight Basis)	1989 Lagoon[2]	1997 Lagoon	2001 Lagoon[3]	First-stage[4] Digested	Bulk Class B[5] Biosolids
Arsenic	---	<10	8.5	3.89	4.42
Cadmium	47	54.8	27.5	1.91	2.28
Chromium	---	481	254	48.0	---
Copper	1,000	1,120	796	245	295
Lead	1,000	1,200	868	53.2	57.2
Mercury	---	4.23	5.44	0.622	0.786
Molybdenum	2.20	14.4	10.2	8.86	10.58
Nickel	120	118	85.6	43.4	47.3
Selenium	<1	5.39	8.5	3.94	4.62
Zinc	2,100	2,140	1,790	941	1,122

[2]All trace inorganics except for arsenic, chromium and mercury based on a 1989 lagoon solids survey (1998 Biosolids Management Plan; Section 9 & Appendix F). Arsenic, chromium and mercury were not evaluated during the 1989 survey.
[3]Samples were collected by Brown and Caldwell Consulting Engineers in a solids characterization survey conducted June 18 to 26, 2001 (2002 Biosolids Management Plan; Section 9 and Appendix C). Results indicated for arsenic and selenium are based on QA/QC sample splitting by Portland's WPCL and data derived from five grab samples of lagoon solids collected in late 2000 and early 2001.
[4]Reflects mean of anaerobically digested solids produced in first-stage Digester 5.
[5]Reflects weighted average of a blend of digested solids (98%) and digested and lagoon stabilized solids (2%) produced at the CBWTP during 2018. These solids were land applied at Madison Ranches and in Sherman County.

BIOSOLIDS CADMIUM

Cadmium levels (2.28 mg/kg; Table 12-6) in Portland bulk Class B biosolids land applied during 2018 were well below DEQ and EPA land application limits (85 mg/kg). In contrast to biosolids, some commercially available phosphate fertilizers contain cadmium at levels that exceed 100 mg/kg. Research indicates biosolids contain materials that bind lead, cadmium and other inorganic pollutants, reducing their bioavailability. These binding materials are not present in commercial inorganic fertilizers.

Under EPA's November 1992 risk assessment, biosolids cadmium content was limited by Pathway 3, the direct ingestion of biosolids by children[1]. The highly exposed individuals (HEIs) modeled in Pathway 3 were normal children between the ages of 1 and 6 that ingested solids from biosolids storage piles or from the soil surface daily for up to five years. In remote, exclusive farm use settings such as Madison Ranches and Sherman County, it is highly unlikely that a child younger than 6 years old would be unattended for a long enough time to ingest land applied biosolids.

EPA's risk model assumed that biosolids were not diluted with soil when exposure occurred. The risk assessment was based on a life time exposure to cadmium which would result in one cancer case per

[1]***Technical Support Document for Land Application of Sewage Sludge***, Volume 1, U.S. EPA, Office of Water, EPA 822/R-93-001a, November 1992.

10,000 HEIs. The risk level refers to excess cancer risk over and above the background cancer risk in unexposed individuals.

BIOSOLIDS LEAD

Portland biosolids lead levels (57.2 mg/kg in 2018) were well below EPA land application limits (840 mg/kg; Table 12-6). Although the annual weighted average lead content in land applied biosolids was less than EPA's 300 mg/kg pollutant concentration limit [503-13(b)(3), Table 3], land applied biosolids have occasionally exceeded that limit in some months *during past years* due to the influence of older, more highly contaminated solids removed from the Triangle Lake Lagoon which were blended with freshly digested solids (Table 12-4). Research conducted with biosolids that have been land applied in urban areas where soils are highly contaminated with lead suggests biosolids bind soil lead (via organic and inorganic components of the biosolids matrix), lessening its bioavailability.

Lead levels in the environment reached their peak in the mid-1960s and have declined steadily with the introduction of unleaded gasoline. Thus, lead contributed through sediments entering Portland's sewerage system via storm sewers should continue to decline with time.

Under EPA's November 1992 risk assessment, like cadmium, biosolids lead was limited by Pathway 3, the direct ingestion of biosolids by children between the ages of 1 and 6. In remote agricultural settings such as Madison Ranches and Sherman County, it is highly unlikely that a child in that age group would be unattended for a long enough time to ingest biosolids.

In Pathway 3, EPA used the integrated uptake biokinetics model (IUBK) to evaluate the effects from lead when children ingest biosolids. The model used a lead blood level not to exceed 10 micrograms per deciliter, a 30 percent absorption value, and a 95th-percentile population distribution to protect highly exposed individuals. Using these values in the model, results in an allowable lead concentration in biosolids of 500 mg/kg. In addition, the lead pollutant limit calculated by EPA's Land Application Technical Review Committee was based on the observation of body burdens (absorption) of animals fed up to 10 percent of their diet as biosolids. To minimize the lead concentration in biosolids, EPA elected to select a more conservative numerical limit for this pathway for the final Part 503 Regulation -- 300 mg/kg.

Several reasons supported this decision. First, such action would provide an additional margin of safety with respect to lead contamination of soil and thereby any threat to the bodies of growing children. Because childhood ingestion of dirt is widespread, and the potential consequences so severe, EPA concluded a highly conservative limit warranted, especially in the context of regulatory decisions that authorize a threshold pollutant such as lead to be added to the environment. In addition, a 300 mg/kg concentration of lead in soil corresponds to a lead concentration in biosolids that was consistent with the quality of current biosolids produced at all but a small number of publicly owned treatment works. The cost of the additional safety factor was therefore considered small relative to the potential benefit.

Coincidentally, this approach yielded the same pollutant limit calculated by EPA's W-170 Peer Review Committee based on the observation of animals fed up to 10 percent of their diet as biosolids.

BIOSOLIDS MOLYBDENUM

Molybdenum levels (10.58 mg/kg; Table 12-6) in Portland bulk Class B biosolids land applied during 2018 were well below DEQ and EPA land application limits (75 mg/kg). Molybdenum levels fell unexpectedly in 2016 (11.1 mg/kg vs. 15.2 mg/kg in 2015) and continued to stay low in 2017 and 2018. BES's Industrial Source Control and Pretreatment group hypothesized that local industries moved away from molybdenum use in cooling towers due to their higher cost when compared to alternatives (e.g., phosphorus-based compounds).

A revised risk assessment for molybdenum in biosolids is nearing completion by EPA which will likely result in a new Pollutant Concentration (PC) limit for land applied biosolids. Under EPA's previous risk assessment, biosolids molybdenum content was limited by Pathway 6, an animal eating biosolids amended plants (i.e., cattle grazing on biosolids amended forage). High levels of molybdenum can cause molybdenosis in cattle. This condition, caused by a copper deficiency, can cause diarrhea, emaciation, loss of weight, and even death. Molybdenosis can easily be remedied by providing copper supplements to cattle or by varying their diet (e.g., consumption of dried, stored grains in addition to biosolids amended forage). The previous risk assessment resulted in a PC limit of 18 mg/kg. This was challenged in court due to overly conservative assumptions and the PC limit was deleted by EPA. The ceiling concentration of 75 mg/kg has remained in place since the original risk assessment.

In late 2015, EPA completed a peer review of a revised risk assessment for molybdenum in land applied biosolids. Based on information from Rick Stevens of the Washington D.C. office of the EPA, a final internal review was completed in December 2015 with a public comment period in early 2016. EPA estimates that they will have a final decision on land applied molybdenum in the near future. It is anticipated that the new PC limit for Mo will be approximately 40 mg/kg.

TARGETED NATIONAL SEWAGE SLUDGE SURVEY

In 2006 and 2007, EPA conducted a Targeted National Sewage Sludge Survey (TNSSS) to determine nationwide contemporary levels of 145 constituents in biosolids and sewage sludges from 74 statistically selected sources which operate domestic wastewater treatment works receiving flows greater than one million gallons per day. Twenty-seven metals were examined under the survey. Survey results were published in January 2009. EPA currently regulates nine of the trace inorganics evaluated. EPA was considering possible rule promulgation on four additional metals (barium, beryllium, manganese and silver). Mean TNSSS concentrations exceeded amounts for these parameters in first-stage Portland biosolids produced in 2018 in most instances. Survey levels for barium, beryllium, manganese and silver were 572 mg/kg, 0.38 mg/kg, 1,165 mg/kg and 20 mg/kg, respectively; while corresponding quantities in first-stage digested biosolids in 2018 were 220 mg/kg, 0.44 mg/kg, 562 mg/kg, and 5.31 mg/kg, respectively. Values for these and other priority metals in both first-stage digested biosolids and land applied biosolids cake appear in Appendix D.

Table 12-6. A Comparison Between EPA Biosolids Pollutant Limits and Digested Portland Solids-2018				
Parameter	EPA Ceiling[1] Limit (mg/kg)	EPA Pollutant[2] Concentration Limit (mg/kg)	New First-stage[3] Digestion Solids (mg/kg)	Land Applied[4] Content (mg/kg)
Arsenic	75	41	3.89	4.42
Cadmium	85	39	1.91	2.28
Copper	4,300	1,500	245	295
Lead	840	300	53.2	57.2
Mercury	57	17	0.622	0.786
Molybdenum	75	75[5]	8.86	10.58
Nickel	420	420	43.4	47.3
Selenium	100	100	3.94	4.62
Zinc	7,500	2,800	941	1,122

[1]Pollutant limits established under 40 CFR 503.13(b)(1); Table 1.
[2]Pollutant limits established in 40 CFR Part 503.13(b)(3); Table 3.
[3]Represents new anaerobically digested solids produced within first-stage Digester 5.
[4]Represents a mixture comprised of 98% digested solids and 2% digested and lagoon stabilized solids during 2018.
[5]Pollutant concentration limit is likely to be adjusted in 2019 (e.g., ≈ 40 mg/kg) after EPA can further consider molybdenum data related to Florida research, a targeted 2007 national sewage sludge survey conducted by that Agency, and public comment on proposed rule modifications.

BIOSOLIDS NITROGEN, PHOSPHORUS AND POTASSIUM

Mean nitrogen, phosphorus and potassium concentrations in biosolids applied at Madison Ranches and Sherman County sites during 2018 appear in Table 12-4. Nitrogen, phosphorus and potassium levels in Portland biosolids generated during 2018 were similar to levels found in anaerobically digested lagoon-stabilized biosolids produced by other Oregon municipalities (e.g., Corvallis, the Metropolitan Wastewater Management Commission and Medford).

BIOSOLIDS pH, TOTAL SOLIDS AND VOLATILE SOLIDS

The mean pH of biosolids land applied during 2018 was 8.0 (Table 12-7). Total solids levels in land applied biosolids were lower in 2018 (16.8%) than those in 2017 (20.6%). This is likely due to drier weather in 2018 (rain events typically introduce inorganics which lead to higher total solids) and plant process changes (changes to TWAS-only digester discharge).

Table 12-7. Mean pH, Total Solids and Volatile Solids Content of CBWTP Biosolids–2018				
Month	Land Applied Class B Biosolids			
	pH	Total Solids[1] (% Dry Weight)	Volatile Solids (% of Total Solids)	% by wt.
January	7.8	18.3	59.4	6.58%
February	7.5	18.3	58.9	5.24%
March	7.9	19.1	58.6	8.40%
April	7.7	19.0	57.9	5.80%
May	7.9	18.1	58.9	6.56%
June	7.7	17.3	60.7	8.21%
July	7.8	16.0	63.8	7.52%
August	7.8	14.4	66.7	8.03%
September	8.0	14.2	66.8	7.29%
October	7.8	16.5	62.1	11.65%
November	7.9	15.9	61.4	12.62%
December	8.0	16.4	61.2	12.10%
Annual Mean	7.8	16.8	61.5	100.0%

[1]Data from WPCL Standard Methods oven drying of monthly composite dewatered cake samples.

TRACE ORGANICS

Trace amounts of some PCBs (polychlorinated biphenyls), dioxins and dibenzofurans were detected in Portland biosolids products during a national EPA survey (NSSS) in 1989. Portland's two wastewater treatment plants were among 174 treatment plants sampled to represent the biosolids quality of more than 15,300 secondary wastewater treatment plants operated in the U.S. Scientific research was limited on the fate of these materials at that time, although EPA's initial position on these compounds was that they appeared in such low levels in biosolids that they are unlikely to adversely affect the environment and the public health.

FEDERAL REGULATORY ACTION-LAND APPLIED BIOSOLIDS DIOXINS

In response to a consent decree prompted by a citizen's suit (Gearhart versus Browner; Civil Case No. 89-6266-HO), on December 23, 1999, under 40 CFR Part 503, EPA proposed risk-based numeric limits for land applied biosolids that recognize seven dioxins, ten dibenzofurans and twelve coplanar PCBs. Proposed Part 503 amendments (40 CFR Parts 503.8, 503.9, 503.10, 503.13 and 503.16) would have required monitoring, recordkeeping, and reporting. Also, the concentration of the 29 dioxin-like compounds would have been required to remain below 300 ppt (TEQ). Under an extension of the consent decree, (Gearhart vs. Whitman; Civil No. 89-6266; December 15, 2001) EPA was granted until October 17, 2003 to complete rulemaking on biosolids land application limits.

October 17, 2003, EPA announced that it decided not to regulate dioxins in land applied biosolids. The Agency's decision was based on careful evaluation of a revised/updated cancer risk assessment; a screening ecological risk analysis (SERA); a significant decrease in the concentration of biosolids-borne dioxins/dibenzofurans found under EPA's 2001 National Sewage Sludge Survey (NSSS) in contrast the much higher contaminant levels identified in biosolids during an earlier (1988) NSSS; and consideration that recently enacted air pollution abatement laws and other means of source control and pollution prevention are likely to continue to cause further decline of dioxin-like compounds.

Under its 2001 NSSS, EPA sampled biosolids from a stratified random sample of 94 POTWs selected from the 174 POTWs appraised under the 1988 NSSS. Portland's Columbia Boulevard Wastewater Treatment Plant's (CBWTP) biosolids were evaluated under both national surveys. Dioxin levels detected in Portland's contemporary biosolids fell within the 67^{th} percentile of the 2001 NSSS (30 ng/kg ($TEQ\text{-}WHO_{98}$).

After carefully weighing the collective body of scientific evidence it gathered and relative risks land applied biosolids-borne dioxin-like compounds pose to the public, EPA concluded that the increased cancer risks to the highly exposed individuals (HEI) [farm families theoretically exposed to the greatest levels of dioxins due to their occupational contact (application actions), long-term residence at biosolids amended farms and consumption of meat, dairy products, fish and produce generated at their farms where land applied solids have been placed] did not warrant regulation of these compounds. Even at levels of 300 ppt ($TEQ\text{-}WHO_{98}$), EPA viewed biosolids-derived dioxins could safely be land applied without unreasonable increase in incremental cancer risk.

EPA used a hazard quotient (HQ) approach to assess the potential for adverse ecological effects under its SERA. When HQs are less than one, exposures are less than ecological benchmarks, suggesting that there is minimal potential for adverse ecological effects. In the SERA for land applied biosolids dioxins, all HQs were less than one. Thus, the Agency elected not to establish numeric limits or management practices for dioxin in land applied solids based on environmental impacts.

In late 2015, EPA completed work on a re-evaluation of dioxin in land applied biosolids based on a non-cancer risk assessment. Based on information from Rick Stevens of EPA, this work is not expected to result in new limits for dioxin in land applied biosolids.

DEQ REGULATORY ACTION-LAND APPLIED BIOSOLIDS DIOXIN

Considering these findings, the City requested that DEQ remove Condition 3 (which required biosolids-derived dioxins and dibenzofurans to be managed pursuant to a January 15, 1991 Oregon Health Division advisory) in a June 26, 1998 site authorization letter enabling Portland's land application of dewatered biosolids cake at Madison Ranches (Appendix A). This condition was eliminated by the Department on December 24, 2003 (Appendix A). The risk analysis and body of evidence that EPA considered in its decision not to regulate dioxins in land applied biosolids reflects an updated comprehensive risk analysis and considerable scientific evidence that has been gathered and evaluated since the DEQ, EPA Region X, Health Division and the City completed a risk assessment of the relative risk that Portland dioxins would have on the public health and environment at Madison Ranches in 1990. In early 2005, the City requested that DEQ also eliminate biosolids dioxin monitoring and reporting requirements from draft CBWTP NPDES permit Schedule B. The removal of dioxin monitoring was reflected in the 2011 permit renewal.

PORTLAND BIOSOLIDS DIOXIN

Portland's CBWTP biosolids contained elevated levels of dioxins, dibenzofurans and PCBs compared to most other biosolids surveyed under EPA's 1989 NSSS. As a result, aside from measuring contemporary and land applied concentration levels, the City evaluated trace organics quality in lagoon stored solids in 1990, August 1997 and June 2001 (Table 12-8). Dioxin and dibenzofuran levels in Triangle Lake Lagoon averaged 417 ng/kg (TEQ-$NATO_{89}$) and 453 ng/kg (TEQ-WHO_{98}) when composite samples from lagoon were gathered in 1990 and 1997, respectively. When lagoon dioxins and dibenzofurans were resurveyed in June 2001, testing revealed contaminant levels ranged from 134.38 ng/kg (TEQ-WHO_{98}) to 256 ng/kg (TEQ-WHO_{98}) and averaged 193.22 ng/kg (TEQ-WHO_{98}) (2002 Biosolids Management Plan; Section 9; Table 9-7). Lagoon coplanar PCBs assessed under the 2001 survey ranged from 195.35 ng/kg (TEQ-WHO_{98}) to 332.15 ng/kg (TEQ-WHO_{98}) and averaged 265.27 ng/kg (TEQ-WHO_{98}).

Table 12-8. Mean Triangle Lake Lagoon Solids Dioxin and Related Compound Content–1990, 1997 and 2001

Survey Year	Lagoon Area & Dioxins Content ng/kg [1&2]			
	Northern	Central	Southern	Mean of All Areas Surveyed
1990[3]	355 519	499 303	450 376	417
1997[4]		533 477 348	---	453
2001[5]	330	545 535	424	458

[1]TEQ; dry weight basis. Toxicity for dioxins and dibenzofurans and coplanar PCBs for surveys conducted in 1997 and 2001 based on the World Health Organization's 1998 TEF scheme (Van den Berg 1998 et al.). Results for dioxins and dibenzofurans in solids surveyed during 1990 are based on the 1989 International scheme ($NATO_{89}$).
[2]Values expressed for the 1990 and 1997 surveys reflect toxic equivalents dioxins and dibenzofurans only. Coplanar PCBs were not assessed under these surveys. Values indicated for the 2001 survey include coplanar PCBs in addition to dioxins and dibenzofurans.
[3]Results represent composite samples collected from three solids removal areas of the lagoon on August 18, 1990 (1998 Biosolids Management Plan; Figure 9-3). These data are expressed on the basis of the International Scheme ($NATO_{89}$) for expressing toxicity. Values indicated are apt to be approximately 30% higher than they would have been based on the World Health Organization's 1998 scheme (Van den Berg et. al.). However, records could not be located to provide an actual breakdown of congeners and homologues used to derive numbers for the 1990 survey.
[4]Results represent composite samples of the bottom thirty inches of solids gathered from three regions in the south-central portion of the lagoon on August 28, 1997 (1998 Biosolids Management Plan; Figure 9-3 and Appendix G).
[5]Results based on eight composite samples collected throughout the lagoon between June 18 and June 26, 2001 (Section 9).

The overall concentration of dioxins and related compounds in lagoon solids discovered under the 2001 survey averaged 458.49 ng/kg (TEQ-WHO_{98}).

Assessments of lagoon biosolids PCBs concentrations were also conducted in 1990, 1997 and 2001. The average PCBs concentration over the entire lagoon in 1990 was 4.9 mg/kg. Under the most recent survey, average PCBs content of lagoon solids averaged 11.71 mg/kg (2002 Biosolids Management Plan, Table 9-4).

Due to their contaminant levels, most lagoon solids that are not blended with freshly digested biosolids and land applied will be directed to a 60-mil high density polyethylene lined monofill which will support a mitigated wetland at the southern end of the lagoon (Section 9). Any remaining solids will either be used beneficially as intermediate or final cell cover at a RCRA Subtitle C or D facility or disposed in a Subtitle D landfill. Higher quality solids may also be directed to land application.

The dioxins and dibenzofurans content of biosolids applied to Madison Ranches were analyzed on a regular basis from 1991 to 2017 (Tables 12-9 and 12-11). In addition, dioxins and dibenzofurans levels in freshly digested solids, which reflect contemporary trace organics quality, were monitored over the same time period (Tables 12-10 and 12-12).

The mean dioxin-like compound content of land applied belt press cake (when last monitored) averaged 38.58 ng/kg (TEQ-WHO_{98}) during 2017 (Tables 12-9 and 12-11). The sixty-seventh percentile level for dioxin-like compounds measured under the 2001 NSSS was approximately 30 ng/kg (TEQ-WHO_{98}) where non-detected congeners were assigned a value of one-half the method detection limit for computing total TEQ. The mean 95th percentile dioxin and dibenzofuran level discovered under the NSSS 2001 was 33.3 ng/kg (TEQ-WHO_{98}). The sixty-fourth percentile under the 2001 AMSA biosolids survey was 30 ng/kg (TEQ-WHO_{98}).

Portland's biosolids dioxin levels should continue to decline gradually with time. Studies of lake sediment and Greenland and Antarctic ice caps cores have demonstrated that there were negligible amounts of dioxin in the environment prior to 1920. Dramatic increases in environmental dioxin levels were demonstrated from 1920 to the present. From 1920 to approximately 1980, it appears that the level of dioxins in the biosphere sharply increased. After that time, dioxin levels began to decline. Declining levels of dioxins in the environment have been attributed to improved combustion and pollution control technologies and the imposition of regulatory measures.

Dioxin monitoring in belt press cake and digester solids was discontinued at the end of 2017. This decision was made in consideration of EPA's decision not to regulate dioxin and dioxin-like compounds in biosolids, the removal of dioxin monitoring requirements from the CBWTP's NPDES permit, the removal of legacy solids from the Triangle Lake facultative sludge lagoon as part of the lagoon reconstruction project, and dioxin levels falling to near background soil levels (urban) in the City's biosolids.

Figure 12-7. Bulk Class B Biosolids Dioxin and Dibenzofurans

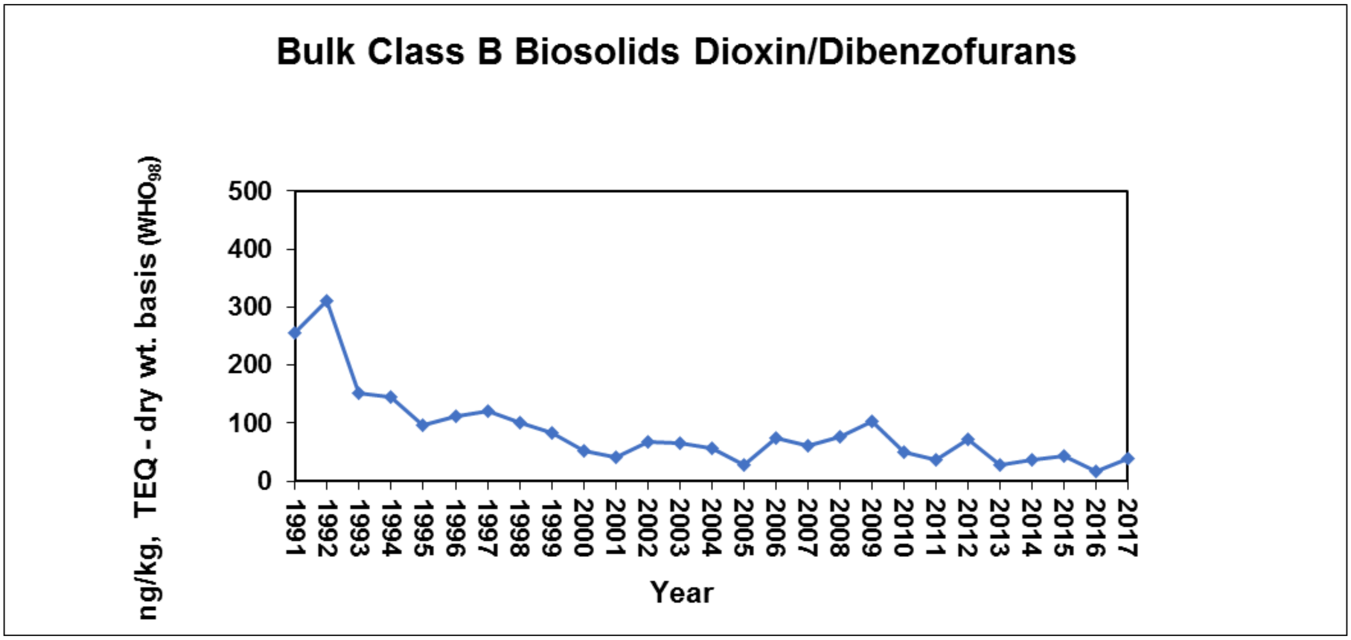


Figure 12-8. Contemporary Biosolids Dioxins and Dibenzofurans

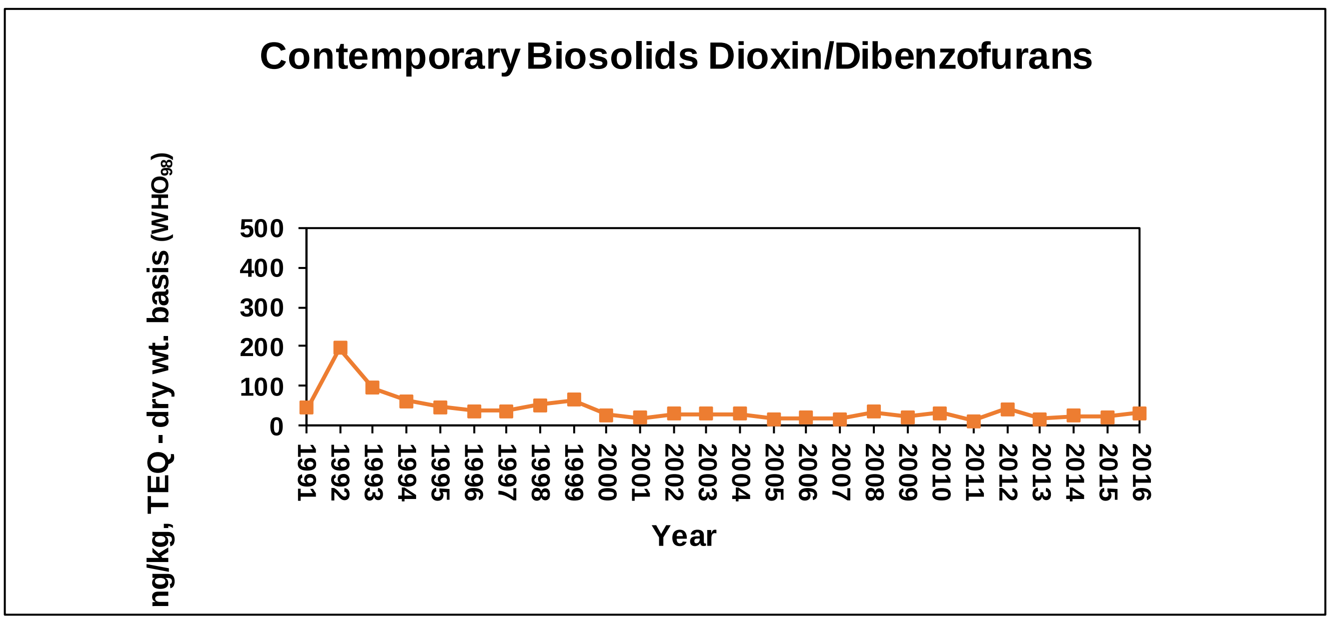


Table 12-9. CBWTP Class B Biosolids Dioxin and Dibenzofuran Homologue Distribution-2017																		
	Analyte/TEQ (ng/kg Dry Weight)[1]																	
Quarter[2]	OCDD	1234678-HpCDD	123478-HxCDD	123678-HxCDD	123789-HxCDD	12378-PeCDD	2378-TCDD	OCDF	1234678-HpCDF	1234789-HpCDF	123478-HxCDF	123678-HxCDF	234678-HxCDF	123789-HxCDF	12378-PeCDF	23478-PeCDF	2378-TCDF	Total
Q1	2.24	30.7	5.65	9.85	11.5	13.1	0.244*	0.14	4.07	0.36	3.11	1.75	2.79	0.610+	0.175+	4.95	0.37	91.60
Q2	0.31	3.55	0.47	1.86	1.05	2.8	0.770	0.05	1.14	0.07	0.63	0.48	0.6	0.15	0.06	1.46	0.11	15.55
Q3	0.17	1.89	0.24	0.73	0.65	1.26	0.175*	0.02	0.52	0.03	0.106*	0.080*	0.32	0.092*	0.03	1.05	0.24	7.59
Q4	1.07	9.84	1.32	4.07	2.73	6.920+	0.630*	0.09	2.79	0.2	1.92	1.35	1.71	0.328+	0.116+	4.090+	0.39	39.56
Average	0.95	11.50	1.92	4.13	3.98	5.720	0.770	0.08	2.13	0.17	1.887	1.193	1.36	0.15	0.045	2.49	0.28	38.58
% By Weight	2.5%	29.8%	5.0%	10.7%	10.3%	14.8%	2.0%	0.2%	5.5%	0.4%	4.9%	3.1%	3.5%	0.4%	0.1%	6.4%	0.7%	100.0%

[1]Value represents the percent, by weight, of the total concentration of dioxins and dibenzofurans (TEQ) recognized under the World Health Organization's 1998 (Van den Berg et. al.) scheme for defining compound toxicity equivalency.

[2] Represents a composite sample of biosolids cake collected over a period of three months.

* - Reported at Detection Limit. TEQ Calculated as [MDL]*(50%)*TEF.

[+] - Results are estimates.

All other TEQs Calculated as [Conc]*TEF.

Table 12-10. CBWTP First-Stage Anaerobically Digested Solids Dioxin and Dibenzofuran Homologue Distribution-2016																		
	Analyte/TEQ (ng/kg)[1]																	
Quarter[2]	OCDD	1234678-HpCDD	123478-HxCDD	123678-HxCDD	123789-HxCDD	12378-PeCDD	2378-TCDD	OCDF	1234678-HpCDF	1234789-HpCDF	123478-HxCDF	123678-HxCDF	234678-HxCDF	123789-HxCDF	12378-PeCDF	23478-PeCDF	2378-TCDF	Total
Q2	1.350+	10.3	1.22	3.62	2.81	6.85	0.973+	0.1	2.44	0.052*	1.290+	1.11	1.28	0.104*	0.11	3.9	0.42	37.93
Q3	0.361+	3.48	0.41	1.07	0.73	2.74	0.136*	0.03	0.55	0.058+	0.46	0.26	0.13	0.41	0.036+	1.24	0.28	12.38
Q4	1.430+	12	2.59	3.98	3.7	9.12	1.09	0.07	3.45	0.18	1.31	1.180+	1.69	0.4	0.09	3.74	0.36	46.37
Average	1.05	8.59	1.41	2.89	2.41	6.24	0.73	0.07	2.15	0.10	1.02	0.85	1.03	0.30	0.08	2.96	0.35	32.23
% By Weight	3%	27%	4%	9%	7%	19%	2%	<1%	7%	<1%	3%	3%	3%	1%	<1%	9%	1%	100%

[1]Value represents the percent, by weight, of the total concentration of dioxins and dibenzofurans (TEQ) recognized under the World Health Organization's 1998 (Van den Berg et. al.) scheme for defining compound toxicity equivalency.
[2] Represents a composite sample of biosolids cake collected over a period of three months.
[3] 2016 Qtr-1 result (143 ng/kg) was removed due to possible contamination or lab error issues. Value was not consistent with results seen over the last 25 years and not reflected in other related samples (e.g., Belt Press Cake Dioxin Qtr-1 = 23.62 ng/kg).
* - Reported at Detection Limit. TEQ Calculated as [MDL]*(50%)*TEF
[+] - Results are estimates.
All other TEQs Calculated as [Conc]*TEF

Table 12-11. Annual Portland Bulk Class B Biosolids Dioxin and Dibenzofuran Homologue Distribution																		
	Analyte/TEQ (mg/kg)[1,2]																	
Year	OCDD	1234678-HpCDD	123478-HxCDD	123678-HxCDD	123789-HxCDD	12378-PeCDD	2378-TCDD	OCDF	1234678-HpCDF	1234789-HpCDF	123478-HxCDF	123678-HxCDF	234678-HxCDF	123789-HxCDF	12378-PeCDF	23478-PeCDF	2378-TCDF	Total	Samples
1991	13.0	110	5.10	40.00	11.0	13.0	19.0	0.56	11.0	0.85	7.40	1.40	0.80	1.20	0.43	13.5	6.40	254.6	1
1992	9.14	135	4.73	91.20	22.0	15.9	6.07	0.17	5.19	0.31	4.91	2.37	2.00	0.39	0.50	9.08	2.08	311.3	6
1993	4.47	60.7	4.48	39.54	11.5	10.0	2.78	0.10	3.28	0.27	3.54	1.49	1.87	0.30	0.37	6.57	1.30	152.6	11
1994	6.62	54.8	3.51	26.38	9.81	5.72	7.05	0.20	6.20	0.43	4.14	1.14	3.76	1.17	2.21	10.5	0.80	144.4	11
1995	4.32	35.3	2.57	17.82	6.52	6.38	2.81	0.15	4.36	0.29	2.51	0.78	3.31	1.15	0.19	8.02	0.99	97.4	11
1996	4.33	33.2	2.72	17.16	9.37	14.8	8.78	0.17	4.25	0.27	3.43	1.53	2.11	1.17	0.62	7.64	1.17	112.7	11
1997	5.46	45.7	2.82	19.57	9.44	15.7	5.17	0.24	4.58	0.37	3.30	1.49	1.28	0.17	0.25	4.20	1.56	121.3	12
1998	4.29	46.7	1.58	17.21	7.42	9.52	3.26	0.11	2.52	0.22	2.47	1.23	0.87	0.09	0.13	2.14	1.16	100.9	12
1999	4.30	43.3	1.18	10.83	4.90	6.05	2.46	0.11	2.45	0.18	2.05	0.71	0.54	0.16	0.12	1.73	1.89	83.0	12
2000	2.31	22.0	1.21	6.72	3.44	4.38	1.73	0.09	2.29	0.09	1.76	0.79	0.99	0.24	0.11	2.82	0.72	51.7	13
2001	1.49	11.8	1.22	4.67	2.09	5.95	1.47	0.09	1.56	0.11	1.02	1.08	1.61	0.44	0.34	4.75	0.43	40.1	12
2002	2.74	21.8	2.13	9.38	4.65	8.70	4.57	0.16	1.85	0.16	2.17	1.10	1.45	0.65	0.20	6.44	0.55	68.7	12
2003	2.40	20.3	1.95	8.82	4.29	12.6	2.64	0.13	1.63	0.23	2.51	0.82	1.27	0.47	0.25	4.70	0.64	65.7	12
2004	1.97	16.9	1.68	6.33	3.43	11.3	2.13	0.11	2.19	0.22	1.65	0.87	1.12	0.39	0.24	4.96	0.44	56.0	12
2005	0.96	7.63	1.03	3.35	1.98	6.00	1.23	0.07	1.02	0.15	1.21	0.70	0.51	0.41	0.53	1.73	0.37	28.9	4
2006	2.53	21.3	2.15	9.15	4.55	11.4	3.03	0.14	3.65	0.27	2.25	1.50	1.50	0.73	1.99	7.23	0.56	73.8	4
2007	2.03	17.0	1.53	6.67	3.33	10.9	2.40	0.10	2.77	0.25	1.93	3.17	1.55	0.41	0.33	6.42	0.55	61.4	3
2008	3.12	26.1	1.72	10.28	5.45	11.4	2.53	0.22	3.81	0.29	2.52	1.07	1.27	0.35	0.94	5.09	0.60	76.8	4
2009	5.80	41.3	1.83	10.78	4.98	14.0	3.45	0.22	3.88	0.35	2.80	2.30	2.13	0.85	1.56	7.39	0.71	104.3	4
2010	1.89	15.0	1.21	5.38	2.90	8.5	1.91	0.13	2.57	0.21	1.87	1.08	1.61	0.61	0.22	5.43	0.72	51.3	4
2011	1.20	9.5	0.80	3.93	2.44	5.8	1.23	0.08	1.93	0.16	4.18	1.77	0.68	0.49	0.19	2.44	0.56	37.4	4
2012	2.83	22.8	2.08	6.13	3.43	10.9	2.25	0.24	4.55	0.33	4.98	1.63	2.00	0.64	0.87	5.29	0.73	71.6	4
2013	0.73	7.1	1.02	2.03	2.02	5.5	0.72	0.06	1.90	0.16	1.10	0.84	0.93	0.28	0.10	2.69	0.49	27.6	4
2014	0.54	4.9	0.87	2.07	1.55	4.9	0.54	0.05	1.28	0.10	1.22	0.77	1.00	0.32	0.15	3.08	0.40	23.8	4
2015	1.71	14.2	1.05	4.15	2.38	7.2	1.81	0.13	2.55	0.15	1.84	0.89	1.07	0.34	0.16	4.08	0.57	44.2	4
2016	0.44	4.36	0.63	1.69	1.13	4.07	0.40	0.05	1.12	0.08	0.77	0.50	0.74	0.16	0.05	1.29	0.21	17.69	4
2017	0.95	11.50	1.92	4.13	3.98	5.720	0.77	0.08	2.13	0.17	1.88	1.19	1.36	0.15	0.045	2.49	0.28	38.58	4
Weighted Average[3]	3.39	31.86	2.03	14.27	5.55	9.12	3.41	0.15	3.20	0.25	2.65	1.27	1.46	0.51	0.49	5.25	1.00	85.84	199

[1]TEQ; dry weight basis of homologue or congener based on the convention adopted by the World Health Organization (Van den Berg et al.) in 1998. [2]Reported values for non-detects are ½ the detection limit times the TEF for the constituent analyzed. [3]Values represent the weighted average of all samples analyzed from 1991 to date (based on number of samples taken).

Table 12-12. CBWTP Freshly Anaerobically Digested Solids[1] Dioxin and Dibenzofuran Homologue Distribution																			
	Analyte/TEQ (mg/kg)[2,3]																		
Year	OCDD	1234678-HpCDD	123478-HxCDD	123678-HxCDD	123789-HxCDD	12378-PeCDD	2378-TCDD	OCDF	1234678-HpCDF	1234789-HpCDF	123478-HxCDF	123678-HxCDF	234678-HxCDF	123789-HxCDF	12378-PeCDF	23478-PeCDF	2378-TCDF	Total	Samples
1991	5.20	5.00	0.72	3.30	1.60	11.5	1.80	0.34	1.20	0.15	1.40	0.53	0.77	0.42	0.15	3.50	0.28	44.37	1
1992	6.12	85.3	4.01	42.8	11.3	14.6	4.38	0.15	4.34	0.35	4.68	2.11	2.33	2.11	0.46	9.79	1.76	196.6	9
1993	3.35	39.8	2.76	14.7	6.35	7.37	2.15	0.09	2.85	0.25	4.08	1.89	1.52	0.30	0.40	6.02	0.98	94.84	12
1994	2.53	20.8	1.91	10.0	4.57	6.33	2.02	0.10	2.79	0.16	2.27	1.17	2.55	0.76	0.16	4.41	0.40	62.89	12
1995	1.23	12.3	3.00	6.14	2.69	9.53	1.26	0.06	1.90	0.11	1.46	0.62	1.65	0.30	0.16	3.64	0.30	46.35	12
1996	1.24	10.0	1.06	4.70	2.67	6.95	1.51	0.07	1.58	0.13	1.29	0.87	1.03	0.57	0.32	3.98	0.44	38.40	13
1997	1.63	14.0	1.19	5.45	3.11	3.90	1.32	0.09	1.66	0.14	1.88	0.56	0.53	0.08	0.12	1.65	0.95	38.26	11
1998	2.23	23.4	0.98	7.51	3.81	4.04	1.56	0.76	1.75	0.15	1.83	0.91	0.48	0.07	0.08	1.29	0.84	51.69	12
1999	3.62	36.0	1.39	6.92	3.72	4.11	1.19	0.01	1.87	0.22	2.18	0.78	0.52	0.15	0.10	1.36	1.14	65.27	5
2000	1.11	8.04	1.16	3.11	1.94	4.80	0.69	0.05	1.28	0.11	1.49	0.67	0.60	0.22	0.13	1.84	0.41	27.65	4
2001	0.68	5.17	1.16	2.27	0.66	2.77	0.79	0.04	0.93	0.07	0.70	0.43	0.61	0.25	0.12	1.75	0.19	18.58	3
2002	0.70	5.64	0.85	2.64	2.05	8.31	2.98	0.06	0.44	0.09	0.95	0.67	0.66	0.30	0.22	2.97	0.22	29.73	5
2003	0.82	7.80	1.15	3.18	1.95	6.58	0.84	0.06	0.06	0.10	0.98	0.76	0.49	0.33	1.06	2.78	0.30	29.23	4
2004	0.85	7.68	1.24	3.05	2.13	5.50	1.47	0.06	1.11	0.11	1.04	0.61	0.86	0.31	0.16	2.43	0.38	28.96	4
2005	0.46	3.78	0.63	1.60	1.13	4.10	0.73	0.04	0.63	0.10	0.74	0.44	0.41	0.25	0.13	1.91	0.28	17.34	4
2006	0.43	4.43	0.70	2.20	1.41	3.53	0.76	0.05	1.17	0.10	1.45	0.50	0.55	0.20	0.11	1.80	0.19	19.56	4
2007	0.41	3.65	0.49	1.60	0.86	3.36	0.81	0.04	0.81	0.07	0.73	0.35	0.50	0.25	0.73	2.17	0.21	17.04	4
2008	1.65	10.5	0.99	4.85	2.80	4.63	1.15	0.11	1.83	0.18	1.18	0.70	0.84	0.31	0.12	2.23	0.30	34.30	4
2009	0.75	6.05	0.74	2.26	1.60	3.58	1.28	0.09	1.21	0.11	0.84	0.66	0.78	0.25	0.13	1.95	0.33	22.58	4
2010	1.01	8.03	1.00	3.25	2.20	5.52	1.18	0.08	1.79	0.16	1.62	0.74	1.10	0.25	0.49	3.48	0.57	32.47	4
2011	0.35	2.75	0.25	1.15	0.60	2.50	0.50	0.02	0.60	0.06	0.49	0.32	0.42	0.25	0.13	1.25	0.23	11.85	4
2012	1.47	11.6	1.34	4.75	2.65	6.50	1.92	0.13	2.87	0.22	1.57	0.91	1.01	0.53	0.22	3.12	1.54	42.41	4
2013	0.41	3.75	0.59	1.62	1.05	3.22	0.40	0.04	1.10	0.09	1.11	0.51	0.51	0.27	0.542	1.775	0.31	17.37	4
2014	0.53	4.92	0.86	2.06	1.54	4.94	0.53	0.04	1.28	0.1	1.22	0.77	0.99	0.31	0.148	3.075	0.39	23.78	4
2015	0.73	5.75	0.73	2.42	1.65	3.82	0.46	0.05	1.49	0.12	1.09	0.67	0.78	0.42	0.095	2.075	0.35	22.76	4
2016	1.05	8.59	1.41	2.89	2.41	6.24	0.73	0.07	2.15	0.10	1.02	0.85	1.03	0.30	0.08	2.96	0.35	32.23	3
Weighted Average[4]	1.56	13.64	1.24	5.63	2.63	5.70	1.32	0.10	1.57	0.14	1.51	0.77	0.90	0.38	0.25	2.89	0.52	41.02	154

[1]Values reflect samples of Belt Press Cake-Compost prior to 2000 and samples of Digester 5 or Digester 6 from 2000 onward.
[2]TEQ; dry weight basis of homologue or congener based on the convention adopted by the World Health Organization (Van den Berg et al.) in 1998.
[3]Reported values for non-detects are ½ the detection limit times the TEF for the constituent analyzed.
[4]Values represent the weighted average of all samples analyzed from 1991 to date (based on number of samples taken).

COPLANAR PCBs

Concurrent with establishing multimedia standards for seven dioxins and ten dibenzofurans, EPA proposed regulating twelve coplanar PCBs with molecular structures they viewed exhibited analogous toxicological effects to dioxins. Portland last assessed coplanar PCBs levels in freshly digested biosolids in 2017 (Tables 12-13 and 12-15). First-stage anaerobically digested biosolids surveyed contained an average coplanar PCBs concentration of 0.691 ng/kg (TEQ-WHO_{98}). The mean coplanar PCBs level in contemporary biosolids assessed as part of AMSA's 2001 survey of biosolids dioxin-like compounds (200 samples from 171 POTWs) was 10 ng/kg (TEQ-WHO_{98}).

Coplanar PCBs levels in land applied biosolids were also evaluated in 2017 (Tables 12-14 and 12-16). The coplanar content in these biosolids averaged 4.9 ng/kg (TEQ-WHO_{98}) during 2017, slightly lower than reported in 2016, reflecting the influence of older lagoon derived solids trace contaminants (lagoon coplanar levels were 265 ng/kg TEQ-WHO_{98}; 2002 Biosolids Management Plan; Table 9-6). Coplanar PCBs comprised roughly 30% of total toxic equivalents recognized under proposed amendments to 40 CFR Part 503 and they represented nearly 21% of the dioxin and related compound toxicity under AMSA's 2001 biosolids survey.

EPA's decision to not regulate dioxin and related compounds (including coplanar PCBs) in land applied biosolids suggests biosolids coplanar PCBs levels will not restrict future Portland land application opportunities in the future. And concurrent with the program's decision to discontinue regular dioxin monitoring in biosolids, coplanar PCBs will no longer be tested for after 2017.

POLYCHLORINATED BIPHENYLS (PCBs)

PCBs began to appear in the environment around 1910. PCBs peaked in the early 1960s during the time that a primary treatment plant was operated at Columbia Boulevard. Some of the solids which accumulated during that period were stored in a temporary 16-acre lagoon which was emptied in the early 1970's to accommodate construction of a waste activated solids plant. Those solids were transferred to the Triangle Lake Lagoon in 1970. PCB levels as high as 47.8 mg/kg were detected at the base of the lagoon during a 1997 survey of lagoon solids quality (1998 Biosolids Management Plan, Section 9).

Concentrations of PCBs in land applied biosolids during 2018 appear in Table 12-17. Biosolids land applied in 2018 contained an average PCBs concentration of 0.497 mg/kg. Levels ranged from 0.4080 to 0.8330 mg/kg. PCB levels in one-week composite samples of first-stage anaerobically digested solids were also monitored during 2018. PCBs in freshly digested solids averaged 0.4652 mg/kg during this period (Table 12-18). Historical concentrations of PCBs for land applied and freshly digested solids are listed in Table 12-19 and Table 12-20.

PRIORITY POLLUTANTS

Priority pollutant scans of freshly digested solids have been made quarterly for several years to determine compliance with industrial pretreatment program requirements. Quarterly pollutant scans of biosolids destined for land application commenced in August 1996. Portland biosolids products 2018 priority pollutant levels are similar to levels reported for biosolids elsewhere. Priority pollutant scan data appear in Appendix D.

Table 12-13. CBWTP Class B Biosolids Coplanar PCBs Distribution-2017													
Analyte/TEQ (ng/kg)[1]													
Quarter	3,4,4',5-TCB (#81)	3,3',4,4'-TCB (#77)	3,3',4,4',5-PeCB (#126)	3,3',4,4',5,5'-HxCB (#169)	2,3,3',4,4'-PeCB (#105)	2,3,4,4',5-PeCB (#114)	2,3',4,4',5-PeCB (#118)	2',3,4,4',5-PeCB (#123)	2,3,3',4,4',5-HxCB (#156)	2,3,3',4,4',5'-HxCB (#157)	2,3',4,4',5,5'-HxCB (#167)	2,3,3',4,4',5,5'-HpCB (#189)	Total
Q1	0.003+	0.005	1.39+	0.19+	0.04	0.010	0.09	0.001+	0.071	0.071	0.000	0.002	1.87
Q2	0.001*	0.014	0.78*	0.13*	0.10	0.032	0.25	0.004	0.200	0.200	0.001	0.003	1.72
Q3	0.006*	0.037	5.15*	0.94*	0.26	0.086	0.64	0.005*	0.500	0.500	0.003	0.009*	8.13
Q4	0.002*	0.044	5.20*	0.32*	0.29	0.073	0.63	0.009	0.575	0.575	0.004	0.011	7.73
Average	0.003	0.025	3.130	0.395	0.17	0.050	0.40	0.005	0.337	0.337	0.002	0.006	4.86

[1] TEFs values based on the World Health Organization's 1998 scheme after Van den Berg et. al.
* - Reported at Detection Limit. TEQ Calculated as [MDL]*(50%)*TEF
+ - Results are estimates.
All other TEQs Calculated as [Conc]*TEF

Table 12-14. CBWTP First-Stage Anaerobically Digested Biosolids Coplanar PCBs Distribution-2017													
Analyte/TEQ (ng/kg)[1]													
Quarter	3,4,4',5-TCB (#81)	3,3',4,4'-TCB (#77)	3,3',4,4',5-PeCB (#126)	3,3',4,4',5,5'-HxCB (#169)	2,3,3',4,4'-PeCB (#105)	2,3,4,4',5-PeCB (#114)	2,3',4,4',5-PeCB (#118)	2',3,4,4',5-PeCB (#123)	2,3,3',4,4',5-HxCB (#156)	2,3,3',4,4',5'-HxCB (#157)	2,3',4,4',5,5'-HxCB (#167)	2,3,3',4,4',5,5'-HpCB (#189)	Total
Q1	0.000*	0.002+	0.29*	0.03*	0.02	0.006+	0.04	0.001+	0.04	0.04	0.000+	0.001+	0.47
Q2	0.000*	0.00	0.07*	0.02*	0.01	0.00	0.03	0.001+	0.02	0.02	0.00	0.000+	0.18
Q3	0.000*	0.00	0.55*	0.05*	0.02	0.002*	0.03	0.000*	0.025+	0.025+	0.000+	0.001*	0.71
Q4	0.001*	0.003+	1.16*	0.08*	0.02	0.005*	0.05	0.001*	0.04	0.04	0.000+	0.001+	1.40
Average	0.000	0.002	0.516	0.044	0.017	0.004	0.040	0.001	0.033	0.033	0.000	0.001	0.691

[1] TEFs values based on the World Health Organization's 1998 scheme after Van den Berg et. al.
* - Reported at Detection Limit. TEQ Calculated as [MDL]*(50%)*TEF
+ - Results are estimates.
All other TEQs Calculated as [Conc]*TEF

Table 12-15. Annual CBWTP Class B Biosolids Coplanar PCBs Distribution														
	Analyte/TEQ (ng/kg)[1,2]													
Year	3,4,4',5-TCB (#81)	3,3',4,4'-TCB (#77)	3,3',4,4',5-PeCB (#126)	3,3',4,4',5,5'-HxCB (#169)	2,3,3',4,4'-PeCB (#105)	2,3,4,4',5-PeCB (#114)	2,3',4,4',5-PeCB (#118)	2',3,4,4',5-PeCB (#123)	2,3,3',4,4',5-HxCB (#156)	2,3,3',4,4',5'-HxCB (#157)	2,3',4,4',5,5'-HxCB (#167)	2,3,3',4,4',5,5'-HpCB (#189)	Total	Samples
1998		0.114	10.5	0.063	1.028	0.318	1.867	0.159	1.790	0.365	0.054	0.026	16.300	2
1999		0.072	7.61	0.133	0.528	0.165	0.968	0.106	0.642	0.151	0.022	0.017	10.410	4
2001	0.017	0.172	9.0	0.250	0.957	10.517	0.084	0.033	1.483	0.287	0.010	0.030	22.810	3
2002	0.024	0.340	18.0	0.250	1.828	14.166	1.217	0.077	2.799	0.538	0.020	0.063	39.340	4
2003	0.016	0.217	13.8	0.595	1.280	0.503	2.483	0.048	1.824	0.365	0.014	0.039	21.207	4
2004	0.016	0.197	9.58	0.250	0.983	0.373	2.001	0.040	1.565	0.319	0.012	0.032	15.364	4
2005	0.007	0.118	7.87	0.665	0.650	0.256	1.422	0.032	0.945	0.186	0.007	0.022	12.179	4
2006	0.008	0.264	12.6	0.368	1.588	0.561	3.355	0.195	2.341	0.448	0.017	0.051	21.766	4
2007	0.014	0.247	12.5	0.319	1.347	0.490	2.965	0.105	2.003	0.399	0.015	0.045	20.492	4
2008	0.015	0.393	8.08	0.337	2.160	0.761	4.865	0.100	3.705	0.367	0.024	0.079	20.880	4
2009	0.020	0.304	13.23	0.250	1.617	0.703	3.657	0.148	2.344	0.455	0.018	0.058	22.799	4
2010	0.031	0.318	20.38	0.329	1.776	0.682	4.053	0.094	3.175	0.591	0.023	0.064	31.513	4
2011	0.009	0.156	8.79	0.250	0.886	0.422	2.175	0.061	1.456	0.291	0.012	0.039	14.548	4
2012	0.009	0.134	8.04	0.136	0.770	0.315	1.840	0.046	1.224	0.323	0.010	0.030	12.872	4
2013	0.003	0.042	3.01	0.054	0.277	0.105	0.645	0.015	0.451	0.094	0.003	0.009	4.705	4
2014	0.002	0.077	2.73	0.239	0.483	0.174	1.005	0.022	0.898	0.651	0.007	0.018	6.309	4
2015	0.005	0.115	6.63	0.155	0.574	0.204	1.380	0.033	1.066	0.156	0.008	0.028	10.350	4
2016	0.003	0.051	5.138	0.093	0.328	0.136	0.735	0.017	0.550	0.161	0.004	0.011	7.218	4
2017	0.003	0.025	3.130	0.395	0.170	0.050	0.400	0.005	0.337	0.337	0.002	0.006	4.860	4
Weighted Average[3]	0.011	0.178	9.487	0.276	1.012	1.540	1.981	0.068	1.607	0.341	0.014	0.035	16.553	73

[1] TEF values based on the World Health Organization's 1998 scheme after Van den Berg et al.
[2] No samples were collected in 2000.
[3] Values represent the average of all samples analyzed from 1998 to date.

Table 12-16. CBWTP First-Stage Anaerobically Digested Biosolids Coplanar PCBs Distribution														
	Analyte/TEQ (ng/kg)[1,2]													
Year	3,4,4',5-TCB (#81)	3,3',4,4'-TCB (#77)	3,3',4,4',5-PeCB (#126)	3,3',4,4',5,5'-HxCB (#169)	2,3,3',4,4'-PeCB (#105)	2,3,4,4',5-PeCB (#114)	2,3',4,4',5-PeCB (#118)	2',3,4,4',5-PeCB (#123)	2,3,3',4,4',5-HxCB (#156)	2,3,3',4,4',5'-HxCB (#157)	2,3',4,4',5,5'-HxCB (#167)	2,3,3',4,4',5,5'-HpCB (#189)	Total	Samples
1998		0.114	10.51	0.063	1.028	0.318	1.867	0.159	1.790	0.365	0.054	0.026	16.3	2
1999		0.062	6.473	0.138	0.504	0.148	0.824	0.123	0.589	0.129	0.020	0.014	9.02	3
2001	0.004	0.044	3.420	0.250	0.327	3.777	0.026	0.012	0.507	0.109	0.004	0.008	8.49	3
2002	0.005	0.103	6.500	0.250	0.588	4.842	0.382	0.026	0.900	0.187	0.007	0.019	13.8	4
2003	0.010	0.045	4.323	0.250	0.264	0.111	0.602	0.011	0.403	0.095	0.003	0.007	6.13	4
2004	0.003	0.034	3.225	0.250	0.179	0.063	0.394	0.008	0.311	0.069	0.002	0.006	4.54	4
2005	0.002	0.022	2.495	0.250	0.110	0.043	0.254	0.005	0.158	0.060	0.001	0.002	3.40	4
2006	0.003	0.045	2.628	0.195	0.318	0.131	0.734	0.021	0.479	0.099	0.004	0.009	4.66	4
2007	0.003	0.036	3.233	0.252	0.246	0.102	0.580	0.017	0.399	0.090	0.003	0.007	4.97	4
2008	0.003	0.042	4.068	0.250	0.297	0.134	0.689	0.020	0.508	0.102	0.004	0.010	6.13	4
2009	0.004	0.050	3.130	0.250	0.317	0.139	0.809	0.015	0.529	0.101	0.004	0.009	5.36	4
2010	0.005	0.063	5.110	0.250	0.445	0.183	1.061	0.020	0.627	0.143	0.005	0.014	7.93	4
2011	0.004	0.031	2.500	0.250	0.221	0.098	0.550	0.011	0.381	0.081	0.003	0.007	4.14	4
2012	0.003	0.061	2.698	0.186	0.368	0.133	0.894	0.020	0.621	0.130	0.005	0.014	5.09	4
2013	0.002	0.023	2.342	0.083	0.188	0.078	0.451	0.010	0.334	0.149	0.003	0.006	3.67	4
2014	0.002	0.026	2.924	0.032	0.199	0.075	0.428	0.007	0.326	0.070	0.003	0.006	4.10	4
2015	0.001	0.020	1.545	0.085	0.144	0.043	0.334	0.004	0.280	0.237	0.002	0.003	2.70	4
2016	0.000	0.006	0.380	0.013	0.038	0.019	0.085	0.002	0.057	0.016	0.001	0.002	0.625	4
2017	0.000	0.002	0.516	0.044	0.017	0.004	0.040	0.001	0.033	0.033	0.000	0.001	0.691	4
Weighted Average[3]	0.003	0.041	3.350	0.178	0.282	0.517	0.548	0.021	0.448	0.112	0.005	0.008	5.51	72

[1] TEF values based on the World Health Organization's 1998 scheme after Van den Berg et al.
[2] No samples were collected in 2000.
[3] Values represent the average of all samples analyzed from 1998 to date.

Table 12-17. Mean PCBs Concentration in CBWTP Class B Biosolids-2018								
	Aroclor (mg/kg Dry Weight)							
Month	1016	1221	1232	1242	1248	1254	1260	Monthly Total
Jan	0.1040*	0.2090*	0.1040*	0.1040*	0.1040*	0.1040*	0.1040*	0.833
Feb	0.0526*	0.1050*	0.0526*	0.0526*	0.0952	0.0526*	0.0526*	0.4632
Mar	0.0510*	0.1020*	0.0510*	0.0510*	0.0510*	0.0510*	0.0510*	0.408
Apr	0.0518*	0.1040*	0.0518*	0.0518*	0.0518*	0.0518*	0.0518*	0.4148
May	0.0550*	0.1100*	0.0550*	0.0550*	0.0550*	0.0550*	0.0550*	0.44
Jun	0.0558*	0.1120*	0.0558*	0.0558*	0.0558*	0.0558*	0.0558*	0.4468
Jul	0.0594*	0.1190*	0.0594*	0.0594*	0.0594*	0.0594*	0.0594*	0.4754
Aug	0.0675*	0.1350*	0.0675*	0.0675*	0.0675*	0.0675*	0.0675*	0.54
Sep	0.0648*	0.1300*	0.0648*	0.0648*	0.0648*	0.0648*	0.0648*	0.5188
Oct	0.0585*	0.1170*	0.0585*	0.0585*	0.0585*	0.0585*	0.0585*	0.468
Nov	0.0591*	0.1180*	0.0591*	0.0591*	0.0591*	0.0591*	0.0591*	0.4726
Dec	0.0607*	0.1210*	0.0607*	0.0607*	0.0607*	0.0607*	0.0607*	0.4852
Arithmetic Mean	0.0617	0.1235	0.0617	0.0617	0.0652	0.0617	0.0617	0.4971
*Reported at detection limit.								

Table 12-18. Mean PCBs CBWTP First-Stage Anaerobically Digested Biosolids -2018								
	Aroclor (mg/kg Dry Weight)							
Quarter	1016	1221	1232	1242	1248	1254	1260	Monthly Total
Q1	0.0505*	0.1010*	0.0505*	0.0505*	0.0505*	0.0505*	0.0505*	0.404
Q2	0.0050*	0.0100*	0.0050*	0.023	0.0050*	0.016	0.031	0.095
Q3	0.0600*	0.1200*	0.0600*	0.0600*	0.0600*	0.59	0.25	1.2
Q4	0.0120*	0.0130*	0.0740*	0.0190*	0.0190*	0.0066*	0.018	0.1616
Arithmetic Mean	0.032	0.061	0.047	0.038	0.034	0.166	0.087	0.465
*Reported at detection limit.								

Table 12-19. Mean PCBs Concentration in CBWTP Class B Biosolids								
	Aroclor (mg/kg Dry Weight)							
Month	1016	1221	1232	1242	1248	1254	1260	Monthly Total
1994				0.750	0.880	0.850	1.420	3.900
1995				0.160	0.930	0.550	0.930	2.570
1996	0.055	0.105	0.057	0.604	0.116	0.574	0.414	1.925
1997	0.050	0.110	0.050	0.370	0.640	0.560	0.590	2.370
1998	0.054	0.108	0.054	0.054	0.320	0.099	0.202	0.891
1999	0.089	0.179	0.112	0.095	0.335	0.178	0.270	1.258
2000	0.081	0.162	0.081	0.081	0.386	0.081	0.124	0.996
2001	0.067	0.134	0.067	0.108	0.227	0.150	0.141	0.894
2002	0.067	0.134	0.067	0.067	0.533	0.067	0.332	1.267
2003	0.047	0.092	0.047	0.047	0.315	0.063	0.241	0.852
2004	0.036	0.073	0.036	0.036	0.033	0.053	0.190	0.457
2005	0.049	0.099	0.049	0.049	0.323	0.049	0.160	0.778
2006	0.036	0.072	0.036	0.036	0.345	0.042	0.196	0.763
2007	0.033	0.067	0.033	0.033	0.428	0.108	0.203	0.905
2008	0.044	0.089	0.044	0.044	0.305	0.044	0.169	0.739
2009	0.033	0.067	0.033	0.033	0.450	0.033	0.239	0.888
2010	0.036	0.072	0.036	0.036	0.182	0.053	0.107	0.522
2011	0.159	0.319	0.159	0.159	0.159	0.161	0.159	1.273
2012	0.123	0.246	0.123	0.143	0.188	0.186	0.123	1.130
2013	0.071	0.142	0.071	0.074	0.071	0.086	0.079	0.592
2014	0.089	0.178	0.089	0.089	0.128	0.104	0.118	0.797
2015	0.179	0.284	0.175	0.168	0.208	0.216	0.203	1.432
2016	0.052	0.104	0.052	0.055	0.093	0.068	0.056	0.481
2017	0.051	0.102	0.051	0.051	0.051	0.064	0.051	0.420
2018	0.0617	0.1235	0.0617	0.0617	0.0652	0.0617	0.0617	0.4971
Arithmetic Mean	0.0679	0.1331	0.0689	0.1361	0.3084	0.1800	0.2711	1.1439

Table 12-20. Mean PCBs CBWTP First-Stage Anaerobically Digested Biosolids							
	Aroclor (mg/kg Dry Weight)						
Year	1016	1221	1232	1242	1248	1254	1260	Monthly Total
2000	0.020	0.041	0.020	0.019	0.020	0.020	0.020	0.160
2001	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.175
2002	0.065	0.115	0.065	0.065	0.065	0.065	0.072	0.512
2003	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.168
2004	0.054	0.093	0.054	0.054	0.054	0.054	0.054	0.417
2005	0.046	0.046	0.046	0.046	0.046	0.046	0.148	0.424
2006	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.126
2007	0.069	0.077	0.069	0.069	0.069	0.069	0.069	0.491
2008	0.028	0.056	0.028	0.028	0.028	0.030	0.028	0.226
2009	0.022	0.043	0.022	0.022	0.022	0.022	0.022	0.173
2010	0.022	0.044	0.022	0.022	0.022	0.023	0.022	0.177
2011	0.024	0.048	0.024	0.024	0.024	0.032	0.026	0.201
2012	0.030	0.060	0.030	0.030	0.030	0.033	0.030	0.243
2013	0.048	0.096	0.048	0.048	0.048	0.111	0.111	0.509
2014	0.027	0.054	0.027	0.027	0.029	0.027	0.030	0.219
2015	0.237	0.240	0.237	0.237	0.237	0.237	0.237	1.662
2016	0.029	0.072	0.062	0.050	0.042	0.029	0.030	0.313
2017	0.020	0.020	0.020	0.020	0.010	0.010	0.010	0.120
2018	0.032	0.061	0.047	0.038	0.034	0.166	0.087	0.465
Arithmetic Mean	0.044	0.065	0.047	0.046	0.045	0.055	0.056	0.357

SECTION 13
BIOSOLIDS LAND APPLICATION AT MADISON RANCHES

DEQ has authorized Portland biosolids to be applied on approximately 5,579.53 acres (2,259.71 hectares) at Madison Ranches (Appendix A).[1] Actively used areas of approved acreage appear in Table 13-1 and Figure 13-1.

Table 13-1. Madison Ranches Acreage Used for Portland Biosolids Application – 2018[1,4]

Section	DEQ Authorized[2] Acreage	Section	DEQ Authorized Acreage	Section	DEQ Authorized Acreage
1	17.95	15	541.6	26	307.7
6	22.67	18	38.62	27	421.46
7	28.47	19	20.54	28	343.4
11	87.09	22	594.9	29	98.22
12	101.4	23	341.9	34	83.5[3]
13	137	24	247.1	35	382.2
14	250	25	64.33	36	85.42

[1]Sections 1, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 27, 28, 29, 34, 35, and 36 are located in Township 3 North, Range 27 East, Willamette Meridian and Sections 6, 7, 18 and 19 are located in Township 3 North, Range 28 East, Willamette Meridian in Morrow and Umatilla Counties, Oregon.
[2]Although DEQ has authorized Portland biosolids land application on 5,579.53 acres, 2,200 to 5,076 acres (net acreage). typically receive biosolids. Acreage amended annually is determined by GPS measurements recorded by Lydia Wahls, Madison Biosolids, Inc.
[3]The west half of Section 34 was relinquished by the City of Portland in 2010 for use by Oak Lodge Sanitary District. Site authorization letter dated Feb 3, 2010 from DEQ can be found in Appendix A.
[4]Approximately 500 acres of ground will come out of the NRCS CRP program in 2020 and will be available for land application.

Sufficient area has been authorized at Madison Ranches to assimilate approximately 730,000 lb of Portland biosolids PAN (total authorized pasture acreage x 150 lb PAN/ac/yr). During 2018, 5,792 dry tons of biosolids containing 207,332 lb PAN were applied at Madison Ranches. The City and Madison Biosolids may seek additional site authorizations in 2019 on properties adjacent to Madison Ranches (Umatilla/Morrow County) to accommodate future growth of the City's biosolids program.

Biosolids were applied to 1,822.59 acres (737.58 hectares) at Madison Ranches in 2018. Dryland pasture ground received solids at rates ranging from 3.55 to 3.80 dry tons per acre (3.73 dry tons per acre average) in 2018 (Figure 13-1 & Tables 13-2 & 13-4).

During 2019, Portland projects approximately 10,000 dry tons of biosolids will be land applied at Madison Ranches; depending upon the extent of solids removal from the Triangle Lake Lagoon, the duration of the Sherman County project, and the impact of the lagoon reconstruction project (Table 13-3).

Figure 13-1: Portland Biosolids Amended Areas at Madison Ranches-2018

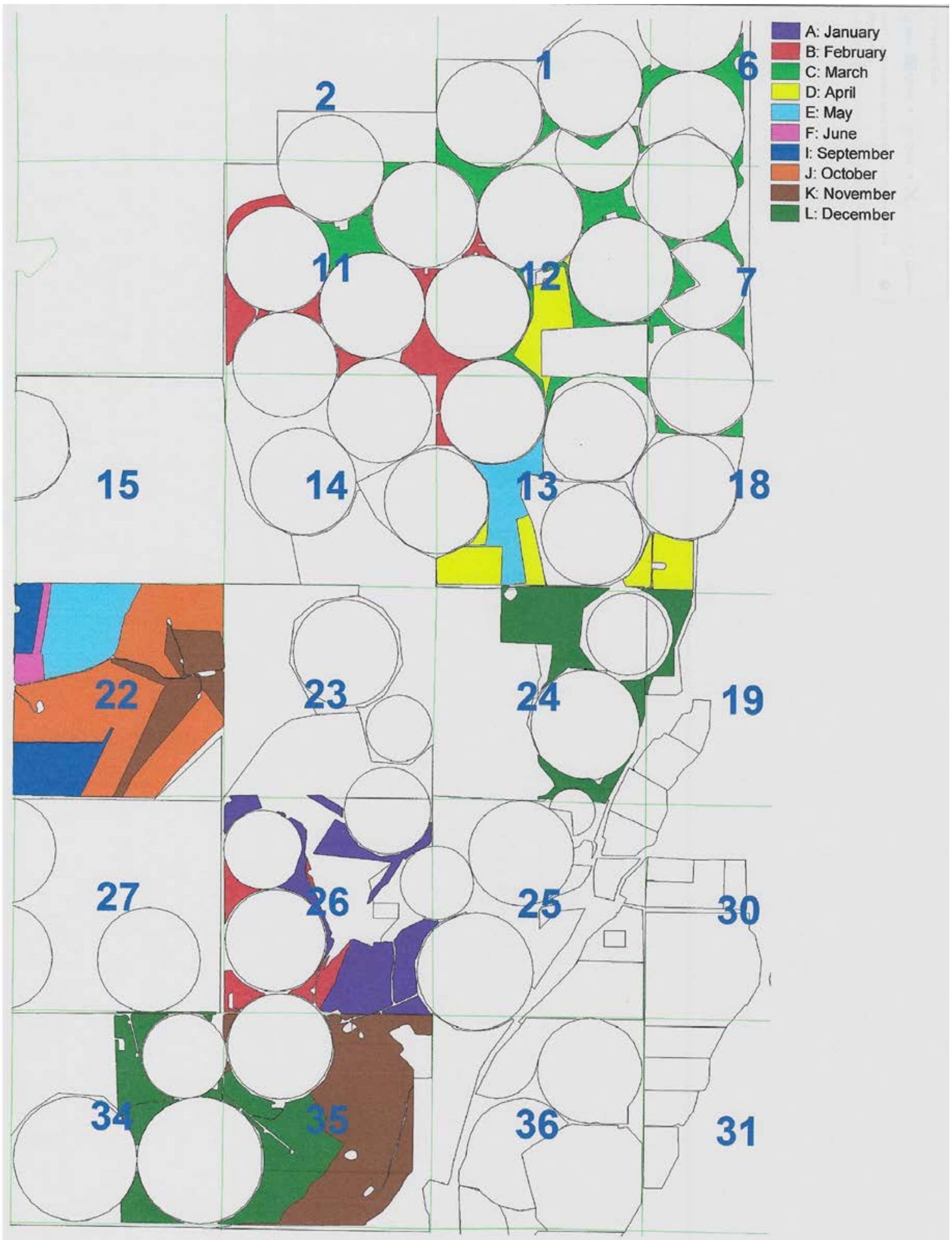


Table 13-2. Madison Ranches Acreage Amended with Portland Biosolids – 2018 [1, 2]			
Area Amended (Section)	**Net Acreage Amended**	**Date Amendment Initiated**	**Date Amendment Completed**
26	190.72 (pasture)	December 30, 2017	February 7, 2018
1,6,7,11,12,13,18	449.21 (pasture)	February 8, 2018	May 10, 2018
22[3]	594.90 (pasture)	May 11, 2018	November 7, 2018
35	376.38 (pasture)	November 8, 2018	December 12, 2018
34	79.37 (pasture)	December 12, 2018	December 18, 2018
19	22.07 (pasture)	December 19, 2018	December 20, 2018
24	109.94 (pasture)	December 20, 2018	To be completed in 2019
Total Area Amended	**1,822.59 acres (737.58 hectares)**		

[1]Data provided by Lydia Wahls, Biosolids Manager - Madison Biosolids, Inc.
[2]Biosolids were applied at rates ranging from 3.55 to 3.8 dry tons per acre (average ≈ 3.73 dry tons per acre) on dryland pasture.
[3]Biosolids were applied to 117.81 acres of Section 22 between May 11, 2018 and June 2, 2018. An additional 477.09 acres were amended with biosolids between September 17, 2018 and November 7, 2018 (594.90 acres total in the biosolids application cycle). The gap in application dates was due to the City applying biosolids in Sherman County during the late spring and summer months (dry weather season).

BIOSOLIDS APPLICATION RATES

Land application sites (perennial dryland pasture) have been authorized to receive biosolids annually at loading rates which will provide up to 150 lb plant available nitrogen (PAN) per acre per year or 300 lb PAN if sites are amended every other year. Biosolids were applied to dryland pasture at an average rate of 3.73 dry tons per acre (≈ 112-133 lb PAN per acre per year average) (Table 13-4). To account for variability in cake total solids density, nitrogen chemistry, and crop, biosolids were applied at rates ranging from approximately 3.55 to 3.8 dry tons per acre in 2018. Approximately 112-133 lb of PAN were applied to dryland pasture ground during 2018. The mean levels of ammonia, TKN and organic nitrogen were similar in 2018 to those detected in biosolids applied in 2017.

Table 13-3. Projected Portland Biosolids Land Application Schedule at Madison Ranches-2019[1]				
Projected Start Date	**Section(s)**	**Projected Completion Date**	**Acreage to be[2] Amended**	**Last Time Site Amended[3] with Biosolids**
January 31, 2019	14	February 21, 2019	250	April 27, 2016
February 22, 2019	28	March 21, 2019	343.4	November 19, 2016
March 22, 2019	29	March 30, 2019	98.22	December 7, 2016
March 31, 2019	15	May 15, 2019	541.6	September 4, 2015
September 1, 2019	23	September 30, 2019	341.9	November 17, 2017
September 31, 2019	25	October 5, 2019	64.33	December 4, 2017
TBD				

[1]The schedule indicated assumes an average of 3.8 dry tons per acre on most pasture and CRP sites, and 2 dry tons per acre on wheat sites and 4.5 dry tons per acre on irrigated circles. A portion of Portland biosolids will also be land applied in Sherman County in 2019 from approximately May 2019 – September 2019.
[2]Additional DEQ authorized acreage is available for biosolids land application in some areas, for example at the edges of center pivots, which will not be amended unless necessitated due to solids production or nutrient levels.
[3]Date when biosolids land application was completed in a particular section. A minimum period of at least 365 days or one growing season (crop rotation) will elapse between successive applications to the same site. This timing/rotational relationship was authorized by Dick Hetherington, EPA Region X Biosolids Coordinator on January 31, 2008.

Table 13-4. Estimated PAN in Portland Biosolids Applied to Madison Ranches-2018			
Nitrogen Species (%)			
NO_3-N	NH_4-N	Organic-N	TKN
0.00066	0.985	4.65	5.64
Total lb Available Nitrogen Applied during 2018[1 & 2]			
NO_3-N	NH_4-N	Organic-N	Total PAN
76.5 (34.7)	45,640.96 (20,702)	161,614.18 (73,307)	207,331.6 (94,044)
Total lb/Acre Available Nitrogen Applied to dryland pasture during 2018[3&4]			
NO_3-N	NH_4-N	Organic-N	Total PAN
0.05	29.39	104.08	133.52[5]

[1]Upper number indicates lb and lower number denotes kg.

[2]Calculations for determining lb PAN in Portland biosolids applied to Madison Ranches dryland pasture during 2018:

NO_3-N: (5,792 dry tons TS) (2,000 lb./ton) (6.6) mg-NO_3-N/1,000,000 mg TS) = **76.5 lb**

NH_4-N: (5,792 dry tons TS) (2,000 lb./ton) (9,850 mg-NH_4-N/1,000,000 mg TS) (0.4) = **45,640.96 lb**

Org-N: (5,792 dry tons TS) (2,000 lb./ton) (46,505 mg-Org-N/1,000,000 mg TS) (0.3) = **161,614.18 lb**

PAN: 76.5 lb NO_3-N + 45,640.96 lb NH_4-N + 161,614.18 lb Org-N = **207,331.6 lb.**

[3]Upper number indicates lb/ac biosolids applied at Madison Ranches during 2018 while lower number denotes kg/ha applied.

[4]Calculations for determining lb/ac available nitrogen in Portland biosolids applied to Madison Ranches dryland pasture during 2018:

NO_3-N: (3.73 dry tons/ac) (2,000 lb./ton) (6.6 mg-NO_3-N/1,000,000 mg TS) = **0.05 lb/ac**

NH_4-N: (3.73 dry tons/ac) (2,000 lb./ton) (9,850 mg-NH_4-N/1,000,000 mg TS) (0.4) = **29.39 lb/ac**

Org-N: (3.73 dry tons/ac) (2,000 lb./ton) (46,505 mg-Org-N/1,000,000 mg TS) (0.3) = **104.08 lb/ac**

PAN: 0.05 lb/ NO_3-N+ 29.39 lb NH_4-N + 104.08 lb Org-N **≈ 133.52 lb/ac**

[5]Actual PAN applied in 2018 was below this value since projected %TS never reached the estimated 20% (2018 weighted mean = 16.8%). Actual applied PAN was therefore closer to 112 lb N/ac.

FUTURE SITE LOADING RATES

Biosolids loading to dryland pasture, dryland wheat (if applied) and irrigated wheat or canola (if applied) during 2019 will be in the range of 3.8, 2.0 and 4.5 dry tons per acre, respectively; provided the solids chemistry (based primarily on the relative quality of solids removed from the Triangle Lake Lagoon) remains similar to what it was during 2018. Soils in biosolids amended areas will be sampled to assure nitrate levels remain under 10 mg/kg below the rooting threshold prior to further biosolids application. Biosolids nitrogen content will be monitored on a regular basis to reflect differences in freshly digested and lagoon solids characteristics affecting PAN (freshly digested biosolids are higher in PAN than lagoon stabilized solids).

REGULATED TRACE INORGANICS ADDITIONS

State and federal biosolids rules and regulations require biosolids trace inorganics to be tracked where one or more regulated constituent exceeds EPA pollutant concentration (PC) limit requirements [OAR 340-50-26(2)(a) and 40 CFR Part 503.13 (b)(3), Table 3]. The City routinely tracks the quantity of trace inorganics applied with its biosolids since lead levels in the 1980's and early 1990's occasionally fell between regulated PC (40 CFR Part 503.13(b)(3), Table 3) and ceiling limits (40 CFR Part 503.13(b)(1), Table 1) during periods when significant levels of solids were removed from the Triangle Lake Lagoon (Section 12). Table 13-5 indicates the quantity of Portland biosolids trace inorganics applied per acre at Madison Ranches during 2018.

Table 13-5. Portland Biosolids Trace Inorganics Applied To Madison Ranches – 2018

Parameter	Average[1] Concentration (mg/kg)	lb/ac[2]	Parameter	Average[1] Concentration (mg/kg)	lb/ac[2]
Arsenic	4.42	0.033	Molybdenum	10.58	0.079
Cadmium	2.28	0.017	Nickel	47.3	0.353
Copper	295	2.201	Selenium	4.62	0.034
Lead	57.2	0.427	Zinc	1,122	8.370
Mercury	0.786	0.006			

[1]Dry weight basis; values represent a weighted mean of solids applied during 2018.
[2]Site addition values are based on the mean pasture biosolids application rate in 2018 (3.73 dry tons per acre). Biosolids were applied at rates of 3.55 to 3.8 dry tons per acre on pasture during 2018. [mg/kg*(2,000/1,000,000)*dt/ac rate]

BIOSOLIDS HANDLING

Typically, three to eight loads of biosolids were trucked to Madison Ranches by contract haulers seven days per week (Section 10). Each load contained approximately ≈ 34.72 wet tons (≈ 5.78 dry tons) of biosolids (depending upon dewatered cake moisture content).

Staging areas at Madison Ranches where biosolids were deposited by trucks are semi-permanent. They are initially watered, mechanically compacted and graded to form a good operating surface and kept free of weeds. Biosolids are stored at staging areas for up to three weeks.

Portland biosolids were land applied by Madison Biosolids, Inc., under City contract, to DEQ authorized sites at Madison Ranches in Morrow and Umatilla Counties. Madison Biosolids, Inc. owns and leases equipment and employs operations and maintenance personnel to run the land application program. Madison Biosolids, Inc. also leases biosolids land application sites to the City.

Biosolids are land applied at Madison Ranches using four different pieces of equipment; a Case-IH (200 horsepower) tractor and a 15.5 yd^3 Knight Manufacturing hopper mounted on a farm trailer and three eleven-speed Ag-Chem 3104 Terragators™ fitted with 15.5 yd^3 Knight Manufacturing hoppers.

Terragators ™ are equipped with tire wells that have 45° angle steel deflector plates to prevent material from falling onto tires when biosolids are loaded into Knight boxes via front end loader. Generally, two or three pieces of biosolids land application equipment were operated concurrently. The Case-IH tractor and Knight hopper were acquired in fall 2001. This equipment is used to broadcast biosolids on nearly level to gently sloping ground at approximately the same rate as the two Ag-Chem 3104 Terragators™ fitted with Knight boxes. The Ag-Chem Terragator™ assemblies are used regularly while the Case-IH tractor and Knight hopper is generally used as a backup system, pending completion of repairs on the other equipment. Portland biosolids were typically applied by two or three operators on weekdays Monday through Friday.

Biosolids are loaded into Ag-Chem™ applicator equipment via a CAT 936 E loader equipped with a 3.5 yd^3 bucket. The loader can reach sufficiently high (12.1 ft) to allow the bucket to be positioned over the center of the Knight hopper. Knight hoppers on Ag-Chem Terragators ™ hold approximately one-third truck load of biosolids. Typically, approximately sixteen loads of biosolids (≈ 5 truck loads) are spread by each Ag-Chem applicator daily.

The speed of Terragators™ are regularly tested at various RPMs against a series of flag pins on diverse terrain to calibrate equipment. Applicator speeds are adjusted in the field to account for changes in landscape position and solids moisture content. The Terragator™ operator turns on a hand timer when solids land application commences and shuts the timer off during periods when equipment is turned around at the end of an application pass, pending starting a new pass. On a nearly level surface, approximately six minutes are required to distribute a load of biosolids when the Terragator™ is operated at usual speeds.

Past (1990 & 1991) land application of Portland biosolids by Biosystems Management International (BMI) using 6,000-gallon liquid tankers left ruts on the land surface in areas where tankers had commonly passed. Terragator™ land application implements are equipped with broad-based tires which do little to no damage to land surfaces.

Ag-Chem™ Knight hoppers have a capacity of approximately 26,000 lb. (13 wet tons; 2.6 dry tons at a cake density of 20%) and can apply approximately 47 dry tons per day under normal operating conditions.

Equipment operators typically applied solids to 20 to 30 acres daily. Portland biosolids are typically spread at a rate of about 10 dry tons per hour. On the average, a week's supply of biosolids can be land-applied over a period of approximately 26 hours on nearly level terrain. The actual time required to apply solids varies, depending on the distance between the staging area and the application location and the nature of the landscape. Portland biosolids land application activities were regularly tracked and mapped by City staff based on land application activity reports and daily GPS and spread records furnished by Madison Biosolids, Inc. Land application actions were also confirmed by staff during periodic visits at Madison Ranches in 2018.

VEGETATION

City of Portland biosolids have been distributed on some portions of Madison Ranches since the inception of Portland's biosolids land application operations in 1990. Annual and mixed perennial grasses have flourished in biosolids-amended areas. Annual grasses (e.g., cheatgrass; *Bromus tectorum*) provide excellent forage for early pasture in the late spring while deeper-rooted perennial wheatgrasses provide forage that can be grazed later in the year (winter range). Annual grasses go dormant in the early summer while perennials become dormant in the late summer. Since wheatgrasses are deeper rooted, they draw soil moisture long after shallower-rooted annuals become dormant, suppressing the growth of annual weeds such as Russian thistle.

Section 34 was established in Alcar tall wheatgrass, Nordin crested wheatgrass, and Siberian wheatgrass. These perennials had initially been planted when the site was placed into the CRP in 1985. Before that time, the area had been managed as dryland summer fallow which was strip-cropped. Cheatgrass was the dominant species on the site before it was converted to CRP ground.

Weeds like purple and yellow mustard abound in many of the areas where perennial grasses were established. Some grassed areas are sprayed to control thistle; however, weed control in yellow and purple mustard-infested areas has not been necessary since these plants do not interfere with normal grass growth or grazing. To establish better forage on biosolids-amended areas, Madison Ranches has been working with the NRCS to develop a reseeding plan for Section 23, using a mixture of perennial grasses:

- Nezpar Indian ricegrass
- Secar bluebunch wheatgrass
- Thickspike wheatgrass
- Sherman big bluegrass
- Sandberg's bluegrass

After shallow tillage (one to one and one-half inches) with a Noble sweep plow during the late fall or early spring (when soil moisture content is optimal), the site will be reseeded at a rate of 8-10 lb per acre.

As a less expensive alternative to native grasses, Madison Ranches is also considering seeding some biosolids-amended areas in Section 23 with the following grasses:

- P27 Siberian wheatgrass
- Sherman big bluegrass
- Secar blue bunch wheatgrass
- Luna pubescent wheatgrass (planted in the swales to result in higher forage production)

Based on the result of these grass trials, Madison Biosolids, Inc. may elect to seed grass mixes to other portions on Section 23 as well as to biosolids amended areas of Sections 14 and 15.

SITE MANAGEMENT

If needed to control brush, Noble plowing and reseeding is planned after at least five biosolids installments have been amended to a particular site (i.e., 20 to 25 dry tons minimum cumulative loading with biosolids). A mixture of wheatgrasses will be established to replace native annuals and perennials. Plowing and seeding can be accomplished in one pass over the field. Once established in perennial grasses, biosolids-amended areas are scheduled to be re-plowed (Noble plow) periodically if needed to control brush.

SOIL QUALITY BENEFITS

Portland biosolids have improved soils by providing organic matter and nutrients. Their application has also significantly benefited upland soils at Madison Ranches by mitigating problems of soil erosion and low soil productivity. Organic matter provides a food source for soil microbes; increases the soil's ability to conserve water, making more water available for plant uptake; reduces solubility of trace organic compounds such as pesticides, lessening their tendency to leach and exert undesirable toxic effects; stabilizes soil by binding soil particles together, stemming wind and water erosion; and adds to soil tilth.

Although not considered a high-grade fertilizer, biosolids contain plant nutrients including nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, manganese, iron, copper, zinc and molybdenum. Nitrogen, phosphorus, potassium and other plant-essential nutrients supplied by Portland biosolids contribute to long-term improvements in soil fertility. Biosolids application rates are designed to meet the nitrogen requirements of the crop. On some soils, such as those that occur at Madison Ranches, micronutrients supplied by biosolids may improve crop yields. However, many of the trace and micronutrients available in biosolids are not economically feasible to land apply commercially, particularly to dryland forage operations.

An estimate of Portland biosolids organic matter and nutrient additions supplied to amended areas of Madison Ranches during 2018 appears in Table 13-6. Values were based on nutrients assayed in biosolids during May 2005, the organic matter in Portland biosolids in 2005 and an assumed dryland pasture application rate of 3.73 dry tons per acre (2018 average).

Over ten years of testing by OSU and others has demonstrated biosolids land application at Madison Ranches has significantly increased soil organic matter and fertility in the upper soil profile (1996 to 2006 Biosolids Management Reports; Table 13-7). Historically, the soil organic matter content in biosolids amended areas has been approximately 130% higher than in non-amended areas. Evidence that biosolids additions have enhanced soil fertility are indicated in soil samples collected from 0" to 6" by Madison Biosolids, Inc. during 2018 (Table 13-7). DTPA extractable manganese levels were elevated (but well within Oregon State University soil test interpretative guidance recommendations) where soil pHs were lower. Since solubility of manganese increases as pH decreases, higher DTPA extractable manganese values appear to be associated with an area where lower soil pH was measured.

In May 1997, Portland biosolids amended and adjacent non-amended areas were examined to determine if solids land application had affected soil conditioning properties in the top six inches of the soil profile. Data and information related to soil texture, total porosity, available water holding capacity, organic matter content, CEC, and bulk density appear in Table 13-9 of the 2006 Biosolids Management Plan. Soil testing determined the addition of biosolids at Madison Ranches decreased soil bulk density and increased total soil porosity, organic matter and available water holding capacity.

In fall 2008, Oregon State University Soil Scientists made a retrospective assessment of the impact Portland biosolids had on soil fertility at Madison Ranches. They examined soil quality data gathered from both index sites and the entire farm area where biosolids had been land applied between 2001 and 2007. Seven-year entire-farm mean test values during the period confirmed soluble salts (EC), pH and boron remained well within acceptable levels for crop production. Biosolids increased plant available nutrients values in soils 1.5 to 20 times when compared to nearby dryland sites that had not been fertilized with biosolids or other fertilizers. Entire farm test values for some micronutrients (e.g., copper, zinc and manganese) and phosphorus were higher than most crops would consume. However, trace micronutrients were well within levels considered non-toxic to plant growth. Although higher than required by crops, the phosphorus values in amended fields do not constitute an environmental risk since there is no danger of runoff to surface or groundwater.

Table 13-6. An Estimate of Organic Matter and Nutrients in Biosolids Applied to Madison Ranches - 2018					
Constituent	Percent dry weight[1,2]	lb/dry ton	(Pasture) lb/ac/yr[3]	(Irrigated Wheat) lb/ac/yr[4]	Tons/yr[5]
Organic matter	45.9	918	3,424	5,793	2,658.5
Total N	4.6	92	343	580.5	266.4
NH_4-N[6]	1.07	21.4	79.8	135.03	61.97
P_2O_5[7]	4.49 (1.96)	89.8 (39.2)	334.95 (146)	566.6 (247.4)	260.1 (113.5)
K_20[8]	0.436 (0.362)	8.72 (7.24)	32.5 (27.0)	55.0 (45.7)	25.3 (21.0)
Calcium	1.91	38.2	142.5	241.0	110.6
Magnesium	0.644	12.88	48.0	81.3	37.3
Sulfur	0.92	18.4	68.6	116.1	53.3
Iron	1.85	37	138.0	233.5	107.2
Copper	0.05	1	3.73	6.31	2.90
Zinc	0.1	2	7.46	12.62	5.79
Manganese	0.032	0.64	2.39	4.04	1.85
Boron	0.004	0.08	0.30	0.50	0.232

[1]Mean of three samples collected by Portland operations staff May 14, 15 and 16, 2005.
[2]Samples tested by Agri-Check, Inc., in May 17, 2005. Biosolids were acid digested pursuant to Soil Science Society of America Book Series 3; Soil Testing and Plant Analysis; 1990; p. 406. Cake P, K, Ca, Mg, S, Fe, Cu, Zn, Mn and B were analyzed on a Perkin Elmer ICP, Series 3000DV unit; OM was assessed using the Loss on Ignition method; TN was determined via the Kjeldahl method; and NH_4-N was analyzed via KCl extraction.
[3]Based on an average dryland pasture application rate of 3.73 dry tons biosolids per acre during 2018.
[4]Based on an average irrigated wheat loading rate of 6.31 dry tons per acre in 2012.
[5]Accounts for the mass of organic matter and plant available nutrients in 5,792 dry tons biosolids [(5,792 dry tons biosolids*lb/dry ton*(ton/2000 lb)].
[6]The NH_4-N analysis was done after biosolids were dried. Thus, results are lower than typically found when biosolids are processed by Portland's WPCL pursuant to EPA Method 350.1.
[7]Upper value denotes P_2O_5 and lower value indicates total P.
[8]Upper value denotes K_2O and lower value indicates total K.

Table 13-7. Soil Quality (0-6") in Biosolids Amended Areas of Madison Ranches - 2018[1&2]																		
Location	Date	Parameter[3&4] (Concentration unit)																
		pH Std.	S.salt mmho/cm	OM%	P mg/kg	K mg/kg	Ca meq/100g	Mg meq/100g	T Bases meq/100g	NH_4-N mg/kg	SO_4-S mg/kg	B mg/kg	Zn mg/kg	Mn mg/kg	Cu mg/kg	Fe mg/kg	Na meq/100g
Sec 26 NE	5/30/2017	6.5	0.41	2.07	152	740	4.6	2.2	8.8	2.3	8	0.37	7.5	17	6.1	46	0.08
Sec 26 NW	5/30/2017	6.4	0.37	2.44	139	817	6.4	2.8	11.4	4.7	15	0.44	9.3	19	7.2	41	0.07
Sec 26 SESW	5/30/2017	5.6	0.36	3.05	203	831	5.8	2.2	10.2	7.1	15	0.52	21.2	43	13.3	93	0.11
Sec 1, 6, 7	5/30/2017	6.6	0.31	1.47	100	583	5.4	2.5	9.5	2.8	9	0.31	3.3	17	3.4	33	0.08
Sec 11, 12	5/30/2017	6.7	0.47	0.98	121	417	5.3	2.2	8.7	0.6	10	0.33	4.2	18	3.9	52	0.09
Sec 13	5/30/2017	6.8	0.34	2.24	137	505	5.2	2.1	8.7	3.4	16	0.34	11.0	18	9.4	51	0.11
Sec 18	5/30/2017	7.0	0.35	2.05	144	517	6.0	2.0	9.4	1.0	12	0.42	10.2	15	8.0	56	0.08
Sec 22 SW	3/15/2018	6.2	0.24	1.54	135	536	6.3	2.4	10.2	2.3	10	0.27	7.8	32	7.2	58	0.09
Sec 22 SE	3/15/2018	6.7	0.42	2.15	153	658	10.8	2.4	15.0	3.7	12	0.41	11.2	18	8.8	41	0.10
Sec 22 NW	3/15/2018	6.5	0.42	1.74	172	700	8.3	2.4	12.6	8.5	14	0.33	9.6	27	8.7	81	0.12
Sec 22 NE	3/15/2018	7.0	0.42	1.35	129	572	11.4	3.0	16.0	3.0	8	0.31	4.1	15	5.3	35	0.10
Sec 35 SW	3/16/2018	5.9	0.32	2.36	180	732	6.4	2.4	10.8	4.4	13	0.29	12.3	39	8.7	61	0.11
Sec 35 SE	3/16/2018	6.3	0.40	2.72	165	768	6.9	2.4	11.3	2.5	10	0.24	6.7	26	5.6	45	0.06
Sec 35 NENW	3/16/2018	7.1	0.60	2.28	83	509	10.6	3.2	15.2	2.8	13	0.49	2.9	6	4.4	18	0.11
Sec 34 E	3/16/2018	6.2	0.32	4.15	163	716	7.2	2.6	11.7	3.7	15	0.36	25.5	46	13.1	60	0.10
Sec 19	3/20/2018	5.7	0.32	4.47	162	950	6.8	2.1	11.4	4.5	17	0.46	24.3	21	14.3	96	0.11
Sec 24 NE	3/21/2018	6.2	0.38	2.76	192	777	6.4	2.4	10.9	3.8	13	0.36	22.3	28	13.7	70	0.08
Sec 24 NW	3/21/2018	6.2	0.32	3.80	147	613	6.5	2.0	10.1	4.9	11	0.33	26.6	23	16.7	60	0.07
Mean		6.4	0.40	2.40	149	663	7.0	2.4	11.2	3.7	12	0.40	12.2	23	8.8	55	0.1

[1]Samples were composited from subsamples collected during 2018 from the top six inches of biosolids amended soils by Madison Biosolids, Inc. and analyzed by Kuo Testing Labs, Inc.
[2]Biosolids amended dryland pasture sites had received biosolids at rates ranging from 1.8 to 5 dry tons per acre beginning in April 1990.
[3]Data is expressed on a dry weight basis. Reporting units are noted below the parameter indicated.
[4]Values represent bicarbonate extractable phosphorus, exchangeable potassium, exchangeable calcium, exchangeable magnesium, extractable sulfate-S, hot water extractable boron, DTPA extractable zinc, DTPA extractable manganese, DTPA extractable iron, and DTPA extractable copper concentrations.
[5]Mean of soils sampled in biosolids amended areas of Madison Ranches.

SOIL NO_3-N TESTING

Groundwater contamination caused by Portland biosolids amendment activities is highly unlikely at Madison Ranches since the vast majority of acreage receiving biosolids is managed as dryland pasture; soil moisture conditions in irrigated sections are routinely evaluated with a neutron probe to help safeguard against over-irrigation; sites occur in upland areas where distance to groundwater exceeds 300 feet; restrictive salt pan (caliche) layers occur throughout the soil profile; the mean annual precipitation in the area is seven to nine inches; and biosolids are applied in dewatered cake form at or below DEQ permitted application rates.[1] As an added safeguard to ensure that land application actions do not impact groundwater quality, routine annual testing of soil NO_3-N levels in Portland biosolids land application sites at Madison Ranches is performed to confirm NO_3-N concentrations 24” to 36” beneath the surface remain less than 10 mg/kg. Application of Portland biosolids occurs only after soil testing indicates the NO_3-N content in a composite soil sample collected from a depth of 24” to 36” is less than 10 mg/kg.

Soil NO_3-N concentrations are assessed in areas representing roughly 160-acre (quarter-section) units. Mean soil NO_3-N levels detected in Portland biosolids amended Madison Ranches areas during 2018 appear in Table 13-8. In the event testing reveals that the soil NO_3-N content in the compliance zone exceeds DEQ's 10 mg/kg regulatory limit, no application of biosolids is permitted to take place in the affected area until an additional growing season has elapsed and/or soil resampling indicates that NO_3-N levels have decreased below the 10 mg/kg regulatory limit.

SURFACE WATER PROTECTION

To assure nitrogen, phosphorus and other biosolids-borne materials do not enter surface water, DEQ has established a 200-feet minimum buffer between Butter Creek and a 1,320 feet buffer between Lost Lake and biosolids amendment areas (Appendix A). DEQ buffers offer considerably more protection than buffers recognized under federal regulations [40 CFR Part 503.14(c)-33' minimum] particularly since Portland biosolids are land applied in cake form and areas between amended locations are vegetated with grass while federal regulations permit the introduction of liquid biosolids to sites lacking vegetation. Further, vegetative growth stimulated by biosolids amendments suppressed eolian dust deposits into nearby surface waters.

[1]A more detailed description of site characteristics at Madison Ranches appears in the 1998 Biosolids Management Plan; Appendix J.

Table 13-8. Mean Soil Nitrate Content at Portland Biosolids Amended Areas of Madison Ranches-2018								
		Soil Nitrate Content (mg/kg)[4]			Previous Application[5]		2018 Application	
Sample Location[1, 2, 3]	Sample Date	0" - 6"	6" - 24"	24" - 36"	Start	End	Start	End
Sec 26 NE	5/30/2017	0.8	5.5	1.8	12-Oct-15	05-Nov-15	01-Jan-18	7-Feb-18
Sec 26 NW	5/30/2017	1.3	1.7	5.4	12-Oct-15	05-Nov-15	01-Jan-18	7-Feb-18
Sec 26 SESW	5/30/2017	3.1	8.7	4.9	12-Oct-15	05-Nov-15	01-Jan-18	7-Feb-18
Sec 1, 6, 7	5/30/2017	0.8	0.5	4.1	06-Nov-15	18-Dec-15	8-Feb-18	10-May-18
Sec 11, 12	5/30/2017	3.1	0.9	2.7	06-Nov-15	18-Dec-15	8-Feb-18	10-May-18
Sec 13	5/30/2017	1.9	1.5	2.7	06-Nov-15	18-Dec-15	8-Feb-18	10-May-18
Sec 18	5/30/2017	0.8	0.7	5.1	06-Nov-15	18-Dec-15	8-Feb-18	10-May-18
Sec 22 SW	3/15/2018	3.8	2.5	5.0	21-Dec-15	18-Jan-16	11-May-18	7-Nov-18
Sec 22 SE	3/15/2018	13.6	14.6	8.7	21-Dec-15	18-Jan-16	11-May-18	7-Nov-18
Sec 22 NW	3/15/2018	4.0	15.9	6.6	21-Dec-15	18-Jan-16	11-May-18	7-Nov-18
Sec 22 NE	3/15/2018	5.2	9.2	4.9	21-Dec-15	18-Jan-16	11-May-18	7-Nov-18
Sec 35 SW	3/16/2018	28.9	41.7	7.8	21-Jan-16	23-Feb-16	8-Nov-18	12-Dec-18
Sec 35 SE	3/16/2018	11.3	10.5	7.9	21-Jan-16	23-Feb-16	8-Nov-18	12-Dec-18
Sec 35 NENW	3/16/2018	12.4	20.7	9.0	21-Jan-16	23-Feb-16	8-Nov-18	12-Dec-18
Sec 34 E	3/16/2018	2.0	4.6	5.8	24-Feb-16	29-Feb-16	12-Dec-18	18-Dec-18
Sec 19	3/20/2018	17.6	10.6	8.0	2-Mar-16	4-Mar-16	19-Dec-18	20-Dec-18
Sec 24 NE	3/21/2018	4.0	4.1	6.6	4-Mar-16	31-Mar-16	20-Dec-18	31-Dec-18
Sec 24 NW	3/21/2018	4.3	13.7	7.7	4-Mar-16	31-Mar-16	20-Dec-18	31-Dec-18

[1]At least one growing season had elapsed at sites prior to soil sample collection.
[2]Madison Ranches areas amended with Portland biosolids were all within Umatilla or Morrow County.
[3]Sections sampled based on quarter sections in most instances. Actual sampling locations were defined via GPS coordinates and illustrated on maps which are maintained as part of Madison Biosolids Inc.'s environmental monitoring records.
[4]Values expressed as mg/kg; dry weight basis; tested by Kuo Testing Laboratories, Inc.
[5]A minimum interval of 365 days elapsed between biosolids land application events.

FORAGE QUANTITY AND QUALITY BENEFITS

On April 28, 2017, samples of forage produced on a City of Portland biosolids amended area and an adjoining non-amended site were collected by Dr. Ray Qin, Oregon State University and analyzed by AgSource, Inc., to determine forage/feed value. Forage was tested for protein and nutrient content. Forage values appear in Table 13-9. No forage sampling occurred in 2018 as the City and Madison Ranches continue to pursue a replacement for the late Don Horneck (OSU Ag Extension).

Table 13-9. Forage Value of Biosolids and Non-Biosolids Amended Dryland Grasses at Madison Ranches 2017[1&2]

Parameter	Biosolids Amended Pasture[3]	Non-Amended Pasture[4]	Percent Change
Biomass (lb/ac)	729.2	508.5	43%
Crude Protein (%)	-	-	-
Neutral Detergent Fiber (%)	-	-	-
Acid Detergent Fiber (%)	-	-	-
Sulfur (%)	0.255	0.129	98%
Calcium (%)	0.682	0.695	-2%
Phosphorus (%)	0.459	0.246	87%
Magnesium (%)	0.24	0.172	40%
Potassium (%)	2.29	0.987	132%
Sodium (mg/kg)	70.1	90.6	-23%
Iron (mg/kg)	518	836	-38%
Zinc (mg/kg)	81.9	21	290%
Copper (mg/kg)	13.9	5.9	136%
Molybdenum (mg/kg)	-	-	-
Manganese (mg/kg)	197	74.1	166%

[1]Analyses performed by AgSource, Inc., a laboratory recognized by the National Forage Testing Association.
[2]Dry weight basis.
[3]Samples composited by Dr. Ray Qin, OSU, from biosolids amended areas were gathered from sites in Section 11, Township 3 North, Range 27 East, Willamette Meridian, Umatilla County on April 28, 2017.
[4]Samples composited from unamended areas were gathered from BLM sites in Section 2, Township 3 North, Range 27 East, Willamette Meridian, Umatilla County on June 25, 2015. These sites adjoined amended sites where forage was sampled.

To help characterize the influence that biosolids have had on forage quality, comparisons of biomass and forage fertility levels were made from amended and non-amended sites in the same vicinity of Section 11 (Table 13-9 and Figure 13-2). Biomass on the amended area was approximately one-and-a-half times (1.4) greater than biomass on the non-amended control (729.2 lb/ac on the amended site versus 508.5 pounds per acre on the non-amended site). Biomass production on biosolids amended lands is largely dependent on weather conditions (e.g., precipitation and ambient temperature). Biomass numbers in 2017 were also impacted by recent cattle grazing of amended sections (no forage sampling took place in 2016). Biomass in 2017 was lower than it was in 2015 (729.2 lb/ac-2017 versus 3,022.3 lb/ac-2015), probably because of a decrease in annual precipitation and temperature during fall and spring months in 2016-2017 in contrast to the same period the previous year. Although important, weather conditions seem to play a lesser role in affecting biomass production on non-biosolids amended soils. Biomass levels, because of other limitations, vary less widely at the same non-amended control sites (Figure 13-2). Biomass on non-amended sites appears to be more influenced by soil fertility levels than seasonal weather conditions.

Figure 13-2. Dryland Pasture Biomass

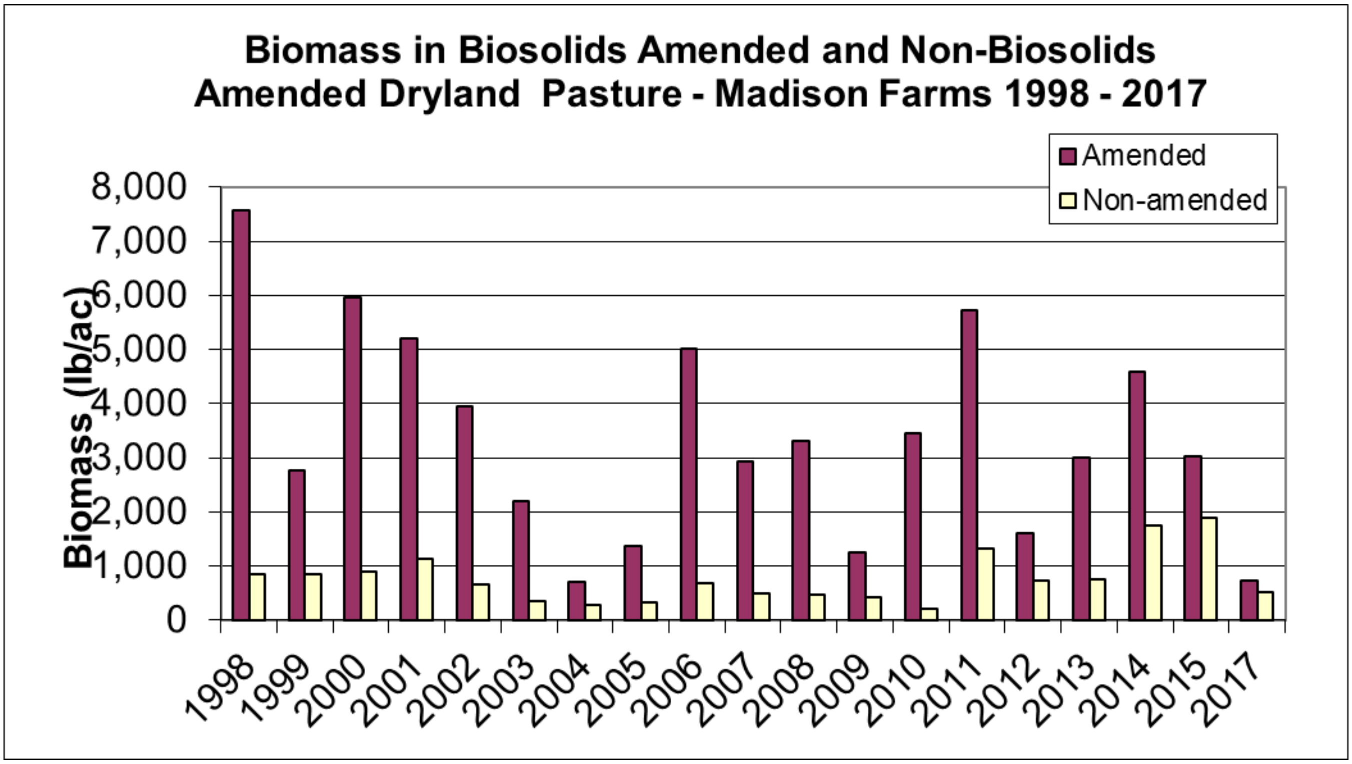


Table 13-10. A Comparison of Nutrient Levels in Biosolids and Non-Biosolids Amended Forage at Madison Ranches – 2017[1,2&3]

Nutrient	Concentration		lb/ac	
	Amended	Non-Amended	Amended	Non-Amended
TKN/Total N (%)	2.9	1.53	21.15	7.78
Sulfur (%)	0.255	0.129	1.86	0.66
Phosphorus (%)	0.459	0.246	3.35	1.25
Potassium (%)	2.29	0.987	3.35	5.02
Calcium (%)	0.682	0.695	4.97	3.53
Magnesium (%)	0.24	0.172	1.75	0.87
Boron (mg/kg)	4.27	4.31	0.00	0.00
Zinc (mg/kg)	81.9	21	0.06	0.01
Manganese (mg/kg)	197	74.1	0.14	0.04
Copper (mg/kg)	13.9	5.9	0.01	0.00
Iron (mg/kg)	518	836	0.38	0.43
Molybdenum (mg/kg)	-	-	-	-
Sodium (mg/kg)	70.1	90.6	0.05	0.04

[1]Sampled by Dr. Ray Qin, OSU, on April 28, 2017.
[2]Subsamples were composited into a single sample from amended and non-amended areas of Sections 11 and 2, respectively, in Township 3 North, Range 27, East, Willamette Meridian, Umatilla County, Oregon. Amended and control areas were similar soils on the same landform. Amended and control sites were approximately 50 feet apart.
[3]Analyzed by AgSource, Inc.

Biosolids land application has significantly improved forage value. The 2015 per acre biomass protein content in amended forage areas was approximately five times higher than it was in non-biosolids amended forage (91.58 lb/ac versus 19.38 lb/ac). In addition, the acid detergent fiber content in biosolids amended forage was lower than in non-amended forage, verifying that biosolids amended grasses were more readily digestible. On a per acre yield basis, the mass of total nitrogen, sulfur, phosphorus, potassium, magnesium, boron, zinc, manganese, copper, iron and sodium present in above-ground forage biomass all increased on biosolids amended land (Table 13-10).

Biosolids application on cheatgrass, the dominant vegetation in most Portland biosolids amended areas, has typically extended the forage growing season about 30 days. On amended sites, cheatgrass extracts water and nutrients deeper into the subsoil with the onset of dry weather. This results in a more gradual decline in the protein content of biosolids amended forages. Cheatgrass root mass on unamended sites remains at approximately the same depth ($\approx$ four inches) but grass roots on amended areas extend to depths up to 28 inches.

The more extensive root system associated with amended sites suppresses the influence of moisture and thermal stresses common during mid-spring months. Annual grasses grown on non-amended areas are readily influenced by hot days and cold nights, causing them to mature quickly and lose their feed value. In contrast, cheatgrass on biosolids amended sites continues to grow during this period, provided plant growth is not suppressed by frost.

Historical site monitoring at Madison Ranches has demonstrated several benefits to forage associated with biosolids application. Most years during early spring months (e.g., March and April) the protein content of both biosolids amended and non-amended semi-arid grass is typically as high as 30 percent. Protein dilution continues as grasses further mature in non-amended forage areas. Protein content in amended grasses remains higher for a longer time, sustaining feed value during this period. As grass matures, protein levels remain high in biosolids amended cheatgrass, but are diluted rapidly in non-amended areas, resulting in feed value loss. As grass continues to mature, the protein level in non-amended forage areas starts at a lower level and drops more rapidly than it does in amended areas. In amended areas, grass protein content starts at a higher level and gradually decreases, sustaining feed value over a longer time period. Forage protein content in non-amended areas generally drops sharply to five to seven percent by mid-May. Protein levels in biosolids amended and nonamended cheatgrass were 18.94% and 6.38%, respectively, when samples were collected on June 25, 2015.

OREGON STATE UNIVERSITY GRASS YIELD AND QUALITY STUDY

In fall 2008, OSU soil scientists evaluated annual grass yield and quality data collected at Portland biosolids and near-by non-biosolids amended (non-fertilized) sites at Madison Ranches from 1999 to 2007 (Appendix E). At the initiation of forage monitoring period (1999), the cumulative site application rate was up to 40 dry tons per acre. By 2007, the cumulative biosolids application rate (1990 to 2007) was up to 75 dry tons per acre. The no-biosolids amendment control sites received neither biosolids nor synthetic fertilizers during the 17-year interval.

Because of annual variations in climate, grass yields and nitrogen uptake in biosolids application areas varied substantially over the years. With biosolids, the median annual grass yield was approximately 3,000 lb/ac, with grass nitrogen uptake of 100 lb/ac (625 lb protein/ac). In years with optimal environmental conditions (e.g., 2000 and 2006), grass yields were 5,000 to 6,000 lb/ac with grass nitrogen uptake of 140 lb/ac.

In the absence of biosolids, the grass was not able to take advantage of years with above-average precipitation. Without biosolids, the median annual grass yield was approximately 670 lb/ac, with grass nitrogen uptake of 7 lb/ac (45 lb protein/ac). Over the nine-year monitoring period (1999 to 2007), biosolids increased grass yield by 530% and protein production by 1,150%.

In addition to producing more grass, forage quality was improved via biosolids application. Improved quality attributes were largely due to greater leafiness of grass plants following biosolids application. Grass plants receiving higher levels of fertility (due to biosolids) responded by producing more shoots and leaves.

Forage monitoring documented consistent increases in digestibility of forage with biosolids application (reduced grass fiber and increased protein) and higher concentrations of nutrients.

Biosolids provided a rich source of nitrogen, phosphorus, sulfur, zinc, copper and manganese, so increased forage concentrations of these elements were present where biosolids had been applied. Biosolids had a small impact on forage magnesium and little affect on grass molybdenum and calcium. Biosolids application increased the forage copper-to-molybdenum ratio, reducing the danger of molybdenosis (a nutritional imbalance sometimes observed in cattle consuming forage with low copper-to-molybdenum ratios).

Overall, OSU's evaluation of historical monitoring data indicated dramatic benefits to grass yield and quality had resulted from biosolids application, even on dryland pasture with annual precipitation of seven to nine inches. They concluded major factors responsible for increased productivity were probably principally linked to increased nitrogen availability and increased soil water storage.

BEEF PRODUCTION BENEFITS

The forage production of Portland biosolids amended areas has increased three to over twenty-fold (depending on annual precipitation and ambient temperature) over that of unamended areas. Cattle stocking rates (calves per acre) have increased because of greater forage production and the extended availability of green forage in late spring.

Preceding the application of biosolids to Madison Ranches dryland pasture (April 9, 1990), approximately 250 head of cattle were able to graze on native range in the area where Portland biosolids were subsequently applied. This translated into 1,234 animal unit months (AUM) [Animal unit months are an expression of the number of head of cattle times the number of days they graze in a particular geographic area divided by 30.4].

Prior to the introduction of biosolids, optimal dryland grazing resulted in beef weight increases approaching one and one-half pounds per head per day. Weight gains would often decline to around one-half pound per head daily near the end of the grazing season. This corresponded to roughly 37,500 pounds of beef annually. With the introduction of biosolids, beef cattle accumulate as much as three and one-quarter pounds per head daily and average one and eight-tenths pounds gain daily. Typically, up to 777,600 pounds of beef are produced on biosolids amended ground, resulting in an increased yield of over 2,000%.

The addition of Biosolids to rangeland soils has resulted in a dramatic increase in stocking rate at Madison Ranches. Total grazing on Madison Ranches produced approximately 4,200 AUMs in 2018. The AUMs during this period were slightly elevated on the range ground compared to previous year due to very low rainfall during the winter and spring of 2015, and 2016. While 2017 was a good year for recovering the range ground, the farm herd manager did not graze all available feed to help recover from the previous year's drought. With range conditions recovered to normal levels, the 2019 season cattle numbers should also return to normal. The herd manager projects that the AUMs from the range ground will hold steady to slightly increase to roughly 4,200 AUMs for the 2019 season. The herd manager is also implementing a more managed grazing plan that breaks the large pastures into several smaller pastures. This plan will keep cattle on smaller pastures for a shorter period. With more pastures, each pasture will be allowed more recovery time. This practice is expected to increase the farms AUMs by 7%-15% over the next 3 years as well as help to limit the effects of short-term droughts.

ENVIRONMENTAL AND ECONOMIC BENEFITS

Several barren, unvegetated areas with sandy soils have been successfully amended with biosolids. Vegetation, where none previously existed, quickly emerges in damaged areas following biosolids amendment, checking localized wind erosion. In areas where biosolids were initially applied at a rate of five dry tons per acre annually, approximately two years were required before non-vegetated zones revegetate. Biosolids have also aided trafficability in land application areas. Before biosolids were applied to dryland sites, four-wheel drive pickups commonly became stuck in sparsely vegetated loamy sand soils. Increased vegetation following biosolids application has reduced or eliminated this problem.

Deer and other wildlife abound on biosolids land application areas. More than 300 deer regularly inhabit biosolids amended areas during winter months. The Oregon State Department of Fish and Wildlife (ODFW) occasionally surveys deer populations to determine deer numbers, reproduction rates, sex ratios, etc. Other wildlife observations indicate that coyotes, rabbits, small rodents, game birds, hawks and eagles have also increased at or near biosolids amended areas.

In 2005, Kent Madison consulted with a representative from the Pendleton Office of the Oregon Department of Fish and Wildlife (Mark Kirsh) who confirmed that biosolids land application activities have not negatively impacted threatened and endangered species nor their critical habitat. No known threatened or endangered species occur in Portland biosolids amended areas of Madison Ranches.

The Madison Ranches application program directly benefits the local community by providing full-time employment for five people related to Madison Biosolids, Inc.'s solids application operations. In addition, GTI employs up to nine drivers from the local community.

A study conducted by the University of Iowa quantified the carbon footprint associated with the City's land application program at Madison Ranches. In an era with concerns about global warming and climate change, the overall carbon footprint is an important environmental consideration for any biosolids management program. The study showed that the amount of fuel used by the trucks hauling the biosolids from the CBWTP to Madison Ranches and in the land application equipment equated to approximately 1,250 tons of CO_2 released to the atmosphere per year. Sequestered carbon, however, associated with the increased forage and soil carbon on biosolids amended ground equated to a carbon offset of -8,970 tons of CO_2 per year. Thus, the overall land application program represents a net carbon deficit of -7,720 tons of CO_2 per year. This amount of sequestered carbon is equal to the amount of CO_2 released by the burning of over 600,000 gallons of diesel fuel. In a related study, OSU showed that forage grown on biosolids amended ground releases 8,800 tons of beneficial oxygen annually to the atmosphere.

SOIL/FORAGE MONITORING

Portland biosolids-amended soils and soils from non-biosolids amended areas of Madison Ranches are periodically analyzed to define the influence that land application operations have on trace inorganics and organic compound accumulation. A description of soil and forage monitoring parameters, geographic areas sampled, sample type, compliance thresholds, and the number of samples typically analyzed annually appears in Table 13-11. Supplementary parameters of general interest to the public and regulatory authorities, including the EPA in pending rule making consideration (e.g., priority inorganics) were also evaluated in 2018 (Appendix D).

Soils sampled for trace inorganics determination were collected from the top six inches of Portland biosolids amended areas prior to the commencement of land application activities and annually thereafter since 1990. Four composite samples gathered from an area representing approximately 1,884 acres, were collected for determination trace inorganics (Ag, Al, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Ti, Tl, V and Zn) in November 2018 (Table 13-12). Each composite sample was made up of approximately 20 subsamples from sites that ranged in area from 320 to 633 acres. Samples were acid digested by Portland's WPCL.

Based on the characteristics of biosolids applied in 2018, molybdenum will determine the total quantity of solids that can be beneficially recycled at Madison Ranches under federal and state regulations [40 CFR Part 503.13(b)(2) and OAR 340-50-026(2)(a)]. The mean soil molybdenum concentration in Portland biosolids amended dryland pasture areas of Madison Ranches in 2018 was 1.66 lb/ac. Federal regulations permit biosolids to be land applied until the soil molybdenum content reaches 20.05 pounds per acre. Roughly 18.4 more lb/ac of molybdenum could be applied to biosolids amended soils (Table 13-13).

Regulated trace inorganic soil additions are required to be surveyed under state and federal regulation when biosolids trace inorganics content exceed pollutant concentration limits recognized under Part 503.13(b)(3). Due to varying higher contaminant levels in older lagoon solids typically blended with freshly digested solids, historically, lead has occasionally surpassed trace pollutant concentration limits (300 mg/kg) but lead levels have remained well within federal Part 503.13(b)(1) ceiling concentration limits (840 mg/kg). Even where trace inorganic pollutants fall inside Part 503.13(b)(3) PC limits, the City remains committed to on-going baseline soil monitoring. This will help assure that Portland biosolids continue to be managed in an environmentally responsible manner.

Long-range site loading limits (site life) represent a conservative, risk assessment based, expression of the quantity of an EPA regulated trace inorganic constituent that can be present in the soil before interfering with any agriculture and other land uses. They are established to be protective of both public health and the environment. If solids inorganic pollutant concentrations remain like levels found in 2018, under Part 503.13(b)(2), at a dryland pasture application rate of 3.73 dry tons per acre per year (2018 average), biosolids could be land applied for 233 additional years (Table 13-13). Site life would be based on molybdenum.

Table 13-11. Portland Biosolids Amendment Area Soil/Forage Sampling Protocols at Madison Ranches[1]

Parameter	Sampling Unit Area	Description	Compliance/Planning Threshold	Typical No. Samples
Soil Dioxin[2]	≈ 1,400 acres + control	20 core samples at 0-6 inches depth	10 ng/kg-TEQ	7 + control
Soil Coplanar[2] PCBs	≈ 1,400 acres + control	20 core samples at 0-6 inches depth	none	3 + control
Soil PAHs[2]	≈ 460 to 1,110 acres + control	20 core samples at 0-6 inches depth	none	5 to 7 + control
Soil Nitrate[3]	≈ 160 acres	10 core samples at 0-6, 6-24 & 24-36 inches	10 mg/kg NO_3-N at 24-36 inch depth	≥ 60 per year + 3 controls
Soil Trace[4&5] Inorganics	Total site + control	20 core composites samples at 0-6 inches depth	Part 503.13(b)(2),Table 2	5 to 7 per year + control
Forage	Specific areas in Sections 2 and 11 defined via GPS	Composite sample comprised of 3 representative samples of forage from amended and control areas	none	One composite from amended area and one composite from control area
Forage PCBs	160 acres	3 representative samples of forage if biosolids PCBs content exceeds 10 mg/kg	0.2 mg PCBs/kg	None unless biosolids concentration levels >10 mg/kg; then 3 + 3 controls

[1] Coordinates indicating subsample collection locations are maintained in Portland's biosolids management program records.

[2]Dioxin, coplanar PCBs, and PAH-SIM sampling may be conducted once every five years in the future (or as needed). Compliance threshold for soil dioxin based on pulp and paper industry.

[3]Soil nitrate-nitrogen sampling units are sampled based on quarter section. Overlap exists in areas between quarter sections in some instances where less 160 acres are available for amendment in a particular section (e.g., due to the presence of non-biosolids amended center pivot zones that occupy substantial territory in a quarter section). Actual sampling locations are recorded annually, via GPS coordinates and illustrated on maps which are maintained under Madison Biosolids, Inc.'s. environmental monitoring records.

[4]Trace Inorganics: As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se and Zn.

[5]In addition, soils are occasionally tested for Ag, Al, Ba, Be, B, Co, Fe, Mg, Mn, Na, Sb, Sn, Ti, Tl and V.

Table 13-12. Soil Trace Inorganics in Biosolids and Non-Biosolids Amended Areas at and Near Madison Ranches-2018 [1&2]										
Biosolids Amended Areas at Madison Ranches										
Location[3] (Area No.)	Parameter/Concentration (mg/kg)[4]									
	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Zinc
1	2.96	0.325	17.2	24.8	10.7	0.0564	0.751	11.3	1.43	73.1
3	3.86	0.292	16.8	27.7	11.4	0.0939	0.661	13.6	1.49	68.8
5	4.51	0.616	22.6	36.4	18.4	0.0931	1.07	15.6	1.58	103
Mean (mg/kg)	3.78	0.410	18.9	29.6	13.5	0.0811	0.827	13.5	1.50	81.6
lb/ac	7.55	0.820	37.7	59.3	27.0	0.1623	1.66	27.0	3.00	163.3
Non-Biosolids Amended Areas Adjoining Madison Ranches										
Location[5] (Area No.)	Parameter/Concentration (mg/kg)[5]									
	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Zinc
8	3.88	0.194	16.4	17.2	8.33	0.0138	0.409	12.4	1.65	56.7
lb/ac	7.76	0.388	32.8	34.4	16.7	0.0276	0.818	24.8	3.30	113.4

[1]Composite soil samples were collected by Kuo Testing Labs from a depth of 0 to 6 inches and analyzed by Portland's WPCL on November 1, 2018 using SW-846, Method 6020.
[2]Assumes one 6” acre furrow slice in soils at Madison Ranches weighs approximately 2,000,000 pounds.
[3]Amended Sites 1, 3 & 5 represent composite samples collected from Sections 1,6,7,11,12,13&18, 22, and 15 in Township 3 North, Ranges 27 and 28 East, Willamette Meridian, respectively. Sites 2, 4, 6 & 7 were not sampled this year since they were not amended in 2018 (a portion of the City’s biosolids are now diverted to Sherman County every year).
[4]Dry weight basis.
[5]Sites where subsamples were collected by Kuo Testing Labs, Inc., from BLM land in Sections 2, 12 and 24 in Township 3 North, Range 27 East, Willamette Meridian on November 1, 2018.

Table 13-13. Trace Inorganics in Portland Biosolids Amended Soils at Madison Ranches and Projected Site Life - 2018							
Parameter	Trace Inorganics Quantity Present and Allowed Under Federal Regulation (lb/ac)					Forecasted Trace Inorganics Additions and Site Life[1]	
	Trace Inorganics in Amended Soils-2018[2]	National Modal Soil[3]	Additional Mass Allowed under 503[4]	Total Mass Allowed Under 503	Additional Mass Allowed at Amended Sites	lb/ac Added During 2018[5]	Remaining Site Life (yr)[6]
Arsenic	7.55	6	36.57	42.57	35.01	0.033	1,062
Cadmium	0.820	0.04	34.79	34.83	34.01	0.017	2,000
Copper	59.3	38	1,338	1,376	1,317	2.201	598
Lead	27.0	8	267.6	275.6	248.6	0.427	583
Mercury	0.1623	0.2	15.16	15.36	15.2	0.006	2,592
Molybdenum	1.66	4	16.05	20.05	16.05	0.079	**233**
Nickel	27.0	36	374.64	410.64	374.64	0.353	1,087
Selenium	3.00	0.42	89.2	89.62	89.2	0.034	2,513
Zinc	163.3	108	2,497.6	2,605.6	2,498	8.370	292

[1]Assumes the pollutant concentration limits remain the same as they were during 2018, biosolids quality stays the same as it was during 2018, and an annual loading rate of 3.73 dry tons per acre applied to dryland pasture.
[2]Values derived from the mean of composite soil samples gathered from biosolids amended areas at Madison Ranches in November 2018.
[3]Value represents the 50% mean national soil pollutant concentration, the pollutant concentration that was used as a basis to derive pollutant loading limits in the Part 503 Regulation for biosolids land application.
[4]Cumulative loading allowed pursuant to 40 CFR Part 503.13(b)(2), Table 2.
[5]Based on weighted arithmetic average of trace inorganics applied to Madison Ranches during 2018 and a continued application rate of 3.73 dry tons/ac/yr.
[6]Assumes biosolids quality will remain the same as was in 2018.

PCBs concentrations in biosolids averaged 0.4971 mg/kg during 2018 (Section 12).

Intermittently, during past years, PCBs levels in exported biosolids have exceeded DEQ's 10 mg/kg regulatory threshold when older, more highly contaminated solids from the Triangle Lake Lagoon dominated the solids mixture that was land applied. Between April 30 to May 6, 1997, solids testing revealed PCBs concentrations averaged 15.1 mg/kg. Biosolids transported to Madison Ranches during that period were distributed over an area up to 445 acres. Forage and soils from biosolids amended areas that had received solids with these higher PCBs levels were tested to assure the mean plant tissue PCBs concentration is less than 0.2 mg/kg, and areas of concern were temporarily fenced to exclude livestock until testing demonstrated feed quality met regulatory limits. No PCBs were detected at a method detection level of 0.1 mg/kg in affected amended soils nor in composited grass samples collected from the three areas in question (1999 Biosolids Management Plan; Table 13-15).

Madison Ranches soils were also sampled for PCBs in 1995. PCBs were below analytical detection limits (<0.05 mg/kg in all areas sampled). Soil PCBs were not sampled between 1995 and the end of 2018 since, except for the one-week excursion described above, PCBs concentrations have been considerably less than 10 mg/kg (mostly non-detects). In the unlikely event that future Portland biosolids contain PCBs more than 10 mg/kg, forage PCBs content will be tested prior to grazing to assure fodder PCBs content is less than 0.2 mg/kg.

Lagoon-derived solids applied to Madison Ranches between April 9, 1990 and July 8, 1991 also contained PCBs which exceeded 10 mg/kg. Forages grown on sites amended with solids containing greater than 10 mg/kg PCBs were tested following one growing season. Forage PCBs levels were less than 0.2 mg/kg) (1998 Biosolids Management Plan; Appendix K).

Scientific research has demonstrated that chemical migration (mobility) of PCBs is sensitive to the organic fraction of the soil. Only at an extremely low carbon content (<0.03%) is leaching apparent. The organic matter in biosolids acts as a binder to prevent PCBs and related chemicals migration. Plant uptake and volatilization of PCBs is low because of the low solubility and high molecular weight of these compounds. Thus, PCBs in biosolids applied at Madison Ranches should not adversely impact area forage, ground or surface water and air quality.

Dioxin-like-compounds, like PCBs, have low solubility and large molecular weights. They too, are not readily taken up by forage grasses grown on biosolids amended soils at Madison Ranches. A composite sample of grass from a biosolids amended area of Madison Ranches was tested for dioxin-like-compounds in March 1999 (Table 13-14). Little (if any) dioxin was present in forage. A low level of octachlorinated dibenzo-p-dioxins (0.0062 ng/kg TEQ) was reported, however it is doubtful that this compound was actually present in the grass since it has the highest molecular weight (i.e., is the least likely of the congeners considered to be available for uptake) of any dioxins measured. The congener's reported presence may be due to cross contamination during sampling, a coating of dust on the forage with trace quantities of dioxins, or laboratory contamination (OCDD is present at low levels throughout the atmosphere and a contaminant of common concern to dioxin testing facilities).

Due to the high analytical costs of dioxins, dibenzofurans and coplanar PCBs and EPA's decision not to regulate these constituents in land applied biosolids, the City elected to monitor Madison Ranches biosolids amended soil levels of these compounds on five or more-year intervals.

When last sampled in 2016, soil dioxin and dibenzofuran levels in biosolids amended areas [3.26 ng/kg-(TEQ-WHO_{98})-average] of Madison Ranches were below EPA's proposed 10 ng/kg (TEQ) threshold for residuals of these compounds on sites amended with solids from the pulp and paper industry (Tables 13-15 and 13-16).

Table 13-14. Mean Dioxin and Dibenzofuran Levels in Forage Grown on Madison Ranches Soils-1999[1&2]			
	Concentration[3]	MDL[3]	TEQ[4]
OCDD	6.2	5.0	0.00062
1234678-HpCDD	ND	0.69	0.00345
123478-HxCDD	ND	0.36	0.018
123678-HxCDD	ND	0.38	0.019
123789-HxCDD	ND	0.33	0.0165
12378-PeCDD	ND	0.36	0.18
2378-TCDD	ND	0.20	0.1
OCDF	ND	0.38	0.000019
1234678-HpCDF	ND	0.15	0.00075
1234789-HpCDF	ND	0.14	0.0007
123478-HxCDF	ND	0.23	0.0115
123678-HxCDF	ND	0.23	0.0115
234678-HxCDF	ND	0.21	0.0105
123789-HxCDF	ND	0.26	0.013
12378-PeCDF	ND	0.24	0.006
23478-PeCDF	ND	0.25	0.0625
2378-TCDF	ND	0.16	0.008
			TEQ 0.462 ng/kg

[1]Forage Sample collected by Dr. Don Horneck, Agri-Check, Inc., in March 1999.
[2]Sample collected from an area within Section 24, Township 3 North, Range 27 East, Willamette Meridian that had received approximately 40 dry tons biosolids.
[3]ng/kg; dry weight basis.
[4]Reported values for non-detects are one-half the method detection limit (MDL), times the TEF for the congener analyzed. TEQ's reflect World Health Organization 1998 conventions.

Trace soil dioxin and dibenzofuran levels found in biosolids amended areas in 2016 suggest land application activities have not significantly elevated the concentration of dioxin congeners above background concentrations found locally in non-amended areas. [1.96-3.98 ng/kg (TEQ-WHO_{98}) on biosolids amended ground versus 0.16 ng/kg (TEQ) on non-amended sites] (Table 13-15). The mean concentration of 2, 3, 7, 8-TCDD detected on biosolids amended and control sites was insignificant (Tables 13-15 and 13-16). Soils in most solids amended areas had received biosolids for approximately two decades. Amended soil dioxin-like compound levels [1.96-3.98 ng/kg (TEQ- WHO_{98})] remained below the national soil average [8 ng/kg (TEQ)] on all sites.

Soil dioxin-like compound levels in biosolids amended areas at Madison Ranches fall well below the United States Department of Health and Human Services Agency for Toxic Substances and Disease Registry's 1,000 ng/kg-TEQ residential soil action level. The Department considers levels below the 1,000 ng/kg-TEQ threshold protective of public health, a level below which means to avoid exposure, including site cleanup, would be unnecessary. Background levels of dioxin and related compounds are substantially lower in rural, compared to urban soils according to a 2000 EPA survey. Mean level in rural soils was 2.8 ng/kg-TEQ while the mean level in urban areas was 9.4 ng/kg-TEQ.

Since it was thought conceivable that dioxin affixed to airborne particulates could be transported by wind action, ambient air monitoring was conducted at Madison Ranches in 1991 to determine if measurable quantities of dioxins could be found downwind from Portland biosolids land spreading operations during high wind periods (1998 Biosolids Management Plan; Appendix L). Air sampling was limited to wind events with speeds greater than 15 miles per hour since the potential for increased dust suspension in air elevates with increasing wind speed. Samples were collected for 24-hour periods during high wind events.

Two high-volume polyurethane foam air samplers were located downwind from biosolids amended areas. A third sampler was located upwind from amendment sites. No dioxins or dibenzofurans were detected during three separate sampling episodes. Thus, any dioxin movement facilitated by wind action at Madison Ranches was considered insignificant.

As noted earlier, biosolids amendments have effectively reduced wind erosion and blowing dust in areas once characterized by considerable, on-going air disturbance.

In addition to certain dioxins and dibenzofurans, EPA considered 12 coplanar PCBs to exert dioxin-like toxicity. These compounds were grouped together with dioxins and dibenzofurans, and from a regulatory perspective, regarded as dioxins and related compounds during the risk assessment process EPA used to determine if it would regulate these trace contaminants in land applied biosolids. Coplanar PCBs levels were last assessed on biosolids amended and non-amended soils in 2005. Coplanar PCBs levels in amended soils ranged from 0.008 to 0.101 ng/kg (TEQ-WHO_{98}) and averaged 0.063 ng/kg (TEQ-WHO_{98}) (Table 13-17). Negligible quantities of these compounds appeared in non-amended soils (0.008 ng/kg-TEQ-WHO_{98}) since, unlike dioxins and dibenzofurans, these compounds are not generally considered discrete combustion source contaminants. Rather, they are considered residual sewerage system contaminants. Levels of coplanar PCBs appear to contribute to approximately six percent of the overall dioxin and related compound burden to the soil.

Table 13-15. Mean Soil Dioxin and Dibenzofuran Levels Found at and Adjoining Portland Biosolids Amended Areas of Madison Ranches-2016

Sampling Area[1]	Dioxin/Furan Content[2&3] (ng/kg TEQ)
Background Areas Which Had Not Received Biosolids (Bureau of Land Management Sites)[4]	
Sections 2, 12 & 24 Township 3 North, Range 27 East, Willamette Meridian	0.16
Biosolids Amended Areas[4]	
Sections 14 & 15, Township 3 North, Range 27 East, Willamette Meridian	3.57
Section 22, Township 3 North, Range 27 East, Willamette Meridian	3.98
Sections 19,23,24, & 25, Township 3 North, Ranges 27 & 28 East, Willamette Meridian	3.52
Sections 34 & 35, Township 3 North, Ranges 27 & 28 East, Willamette Meridian	1.96

[1]Results derived from composite grab samples representing units of approximately 3,347.4 acres.
[2]Represents the mean concentration (ng/kg TEQ-dry weight basis; signal-to-noise values) of pollutant found in the upper six inches of soil.
[3]According to Table 4-10, Chapter 4, Volume II, of EPA's ***Estimating Exposure to Dioxin-Like Compounds*** (EPA/600/6-88/005 Ca, 005 Cb, 005 Cc), the mean soil dioxin/furan level representative of a typical US soil is 8.0 ng/kg TEQ.
[4]Values represent composite samples collected from biosolids non-amended and amended areas during November 2016 by Kuo Testing Labs.

Table 13-16. Mean Dioxin and Dibenzofuran Levels in Madison Ranches Soils-2016					
Analyte[1&2]	Biosolids Amended Areas[3]				
	Site 2	Site 3	Site 4	Site 6	Annual Mean[4]
OCDD	0.110	0.150	0.110	0.080	0.11
1234678HpCDD	1.050	1.420	1.100	0.006	0.89
123478-HxCDD	0.094	0.088	0.093	0.119	0.10
123678-H xCDD	0.390	0.470	0.450	0.490	0.45
123789-HxCDD	0.215	0.249	0.245	0.252	0.24
12378-PeCDD	0.611	0.688	0.642	0.495	0.61
2378-TCDD	0.196	0.054	0.201	0.072	0.13
OCDF	0.000	0.001	0.000	0.000	0.00
1234678-HpCDF	0.130	0.150	0.130	0.090	0.13
1234789-HpCDF	0.010	0.011	0.009	0.006	0.01
123478-HxCDF	0.097	0.098	0.085	0.047	0.08
123678-HxCDF	0.079	0.069	0.056	0.039	0.06
234678-HxCDF	0.115	0.097	0.088	0.063	0.09
123789-HxCDF	0.034	0.045	0.024	0.012	0.03
12378-PeCDF	0.025	0.015	0.012	0.004	0.01
23478-PeCDF	0.387	0.340	0.246	0.159	0.28
2378-TCDF	0.017	0.034	0.024	0.030	0.03
Total (TEQ)[5]	**3.570**	**3.980**	**3.520**	**1.960**	**3.26**

[1]Represents the mean concentration (ng/kg TEQ-WHO_{98} dry weight basis; signal-to-noise values) of pollutant found in the upper six inches of soil.
[2]Reported values for non-detects are one-half of the detection limit, times the TEF for the constituent analyzed (WHO-98).
[3]Samples collected by Kuo Testing Labs during November 2016. Sites 2, 3, 4 & 6 correspond to composite soil samples gathered from Sections 14 & 15; 22; 19, 23, 24 & 25; 34 & 35 of Township 3 North, Ranges 27 and 28 East, Willamette Meridian, Umatilla County, respectively.
[4]Values represent arithmetic mean for each analyte.
[5]Total TEQ results are arithmetic sum of analytes.

Table 13-17. Mean Coplanar PCBs Levels in Madison Ranches Soils - 2005					
	Biosolids Amended Areas[1,2,3&4]				Non-Amended Area
Analyte	Site 1 ng/kg	Site 2 ng/kg	Site 3 ng/kg	Mean of All[5] Sites ng/kg	Site 4 ng/kg
3,4,4',5-TCB	0.000004	0.000031	0.00002	0.00002	0.000004
3,3',4,4'-TCB	0.00011	0.0008	0.0008	0.001	0.00011
3,3',4,4'5-PeCB	0.01	0.058	0.08	0.047	0.0053
3,3',4,4',5,5'-HxCB	0.0007	0.00079	0.0009	0.001	0.0007
2,3,3',4,4'-PeCB	0.0003	0.0036	0.004	0.003	0.0003
2,3,4,4',5-PeCB	0.0001	0.0012	0.001	0.001	0.0001
2,3',4,4',5-PeCB	0.0008	0.007	0.008	0.005	0.00083
2'3,4,4',5-PeCB	0.00003	0.000167	0.0002	0.0001	0.00003
2,3,3',4,4',5-HxCB	0.0005	0.006	0.007	0.005	0.00046
2,3,3'4,4',5'-HxCB	0.0001	0.0013	0.0016	0.001	0.00011
2,3',4,4',5,5'-HxCB	0.000005	0.000005	0.00006	0.00004	0.000005
2,3,3',4,4',5,5'-HpCB	0.00002	0.00017	0.0002	0.0001	0.00002
Total[6]	0.008	0.08	0.101	0.063	0.008

[1]TEQ: dry weight basis.
[2]Represents the mean concentration (ng/kg TEQ; signal-to-noise values) of pollutant found in the upper six inches of soil based on the World Health Organization's 1998 TEF Scheme (Van den Berg et al).
[3]Reported values for non-detects are one-half the detection limit times the TEF for the constituent analyzed.
[4]Samples for Sites 1 to 4 collected by Agri-Check, Inc. during October 2005. Sites 1 to 4 correspond to composite soil samples gathered from Sections 1, 6, 7, 11, 12, 13, 14, 15 and 18; 19, 22, 23, 24 and 25; 26, 34, 35 and 36; and BLM owned areas in Sections 2, 12 and 24 of Township 3 North, Ranges 27 and 28 East, Willamette Meridian, Umatilla County, respectively.
[5]Value represents arithmetic mean for the three biosolids amended areas.
[6]Total TEQ results are an arithmetic sum of analytes.

SECTION 14
BIOSOLIDS LAND APPLICATION IN SHERMAN COUNTY

DEQ has authorized Portland biosolids to be applied on 12,521.89 acres (5,067.43 hectares) in Sherman County (Appendix A). Areas of approved acreage appear in Table 14-1.

Table 14-1 DEQ Authorized Acreage in Sherman County

Owner/Operator	Tax Lot	Section	Township	Range	Acres[1]
Randy Hilderbrand	1700	8	1 No	18 E	156.34
Randy Hilderbrand	3100	18	1 No	18 E	320.88
McGregor/Hayes	1100 & 1800	5 & 8	1 No	18 E	314.54
Pinkerton Bros.	6500, 6600, 6700, 7300, 7301, 7400 & 7500	29 & 32	1 No	17 E	634.36
Pinkerton Bros.	1300 & 1500	4	1 So	17 E	559.91
Pinkerton Bros.	7600	33	1 No	17 E	218.32
Jon & Rob Simantel	200, 2400, 2700 & 2800	1, 11, 12, 13, 14, 23 & 24	1 No	18 E	2,946.32
Jon & Rob Simantel	3700	20, 21, 28 & 29	1 No	18 E	1,753.89
Jon & Rob Simantel	100, 9300 & 9400	1 & 36	1 No & 2 No	18 E	788.88
Jon & Rob Simantel	1300, 1500, 1600 & 1900	7, 8, 17 & 18	1 No	19 E	924.70
Dan Thomas- Thomas Bros.	2200 & 3000	11 & 15	1 No	18 E	239.09
Dan Thomas- Thomas Bros.	3600 & 5100	19 & 30	1 No	18 E	844.69
Weedman Bros.	3400	19	1 No	18 E	168.26
Weedman Bros.	8100	31	2 No	18 E	158.18
Weedman Bros.	8600	33	2 No	18 E	310.9
Weedman Bros.	900	4	1 No	18 E	316.07
Mike McArthur	3600 & 700	7 & 12	1 No	17&18 E	210.66
Kevin McCullough	600,700,1000,&1200	5,6 & 31	2No & 3No	18E	1,340.50
Kevin McCullough	1500	6	1 No	18E	315.4
Total Acreage					**12,521.89**

[1]Acreage represents total tax lot acres. Spreadable acreage will be less than this amount due to farming practices, buffers, setbacks, etc. Site authorizations for Weedman TL 3102 and Hilderbrand TL 1200 were relinquished in 2016 per request from landowners. Additional land application sites were approved by DEQ NW Region in the Moro area of Sherman County in 2019. See Section 9 for details.

The Sherman County project was the result of a year-long Request For Proposals process (RFP # 109947) conducted by the City of Portland in 2009. The process resulted in K&S Madison, Inc. (now Madison Biosolids, Inc.) being deemed the successful offeror for a seasonal land application program in Sherman County (see 2009 Biosolids Management Plan for detailed discussion). Contract # 31000149 with K&S Madison, Inc. was executed on April 1, 2010. The City of Portland formally launched its Sherman County program on June 28, 2010 and completed land application of this first season on October 7, 2010. A previous pilot program in Sherman County occurred in 2000 (see 2000 Biosolids Management Plan).

During 2018, 2,138 dry tons (13,756 wet tons) of biosolids were land applied in Sherman County to 1,147.42 acres (464.34 hectares). Dryland wheat fields received biosolids at rates ranging from 1.52 to 2.94 dry tons per acre (2.12 dry tons per acre average) (Figure 14-1, Table 14-3).

In 2019, Portland projects approximately 3,000-5,000 dry tons of biosolids will be land applied in Sherman County beginning in Spring 2019 (weather permitting). A projected schedule for 2019 is presented in Table 14-2.

Table 14-2. Projected Portland Biosolids Land Application Schedule for Sherman County-2019[1]

Field	Projected Start Date	Projected Completion Date	Acreage to be Amended	Last Time Site Amended with Biosolids
McCullough 9	May 1, 2019	June 1, 2019	500+	May 2016
TBD				

[1]The remainder of the 2019 application schedule has yet to be determined. The City of Portland and Madison Biosolids, Inc. anticipate being in Sherman County from approximately May 2019 through early September 2019.

Figure 14-1. 2018 City of Portland Land Applied Areas in Sherman County

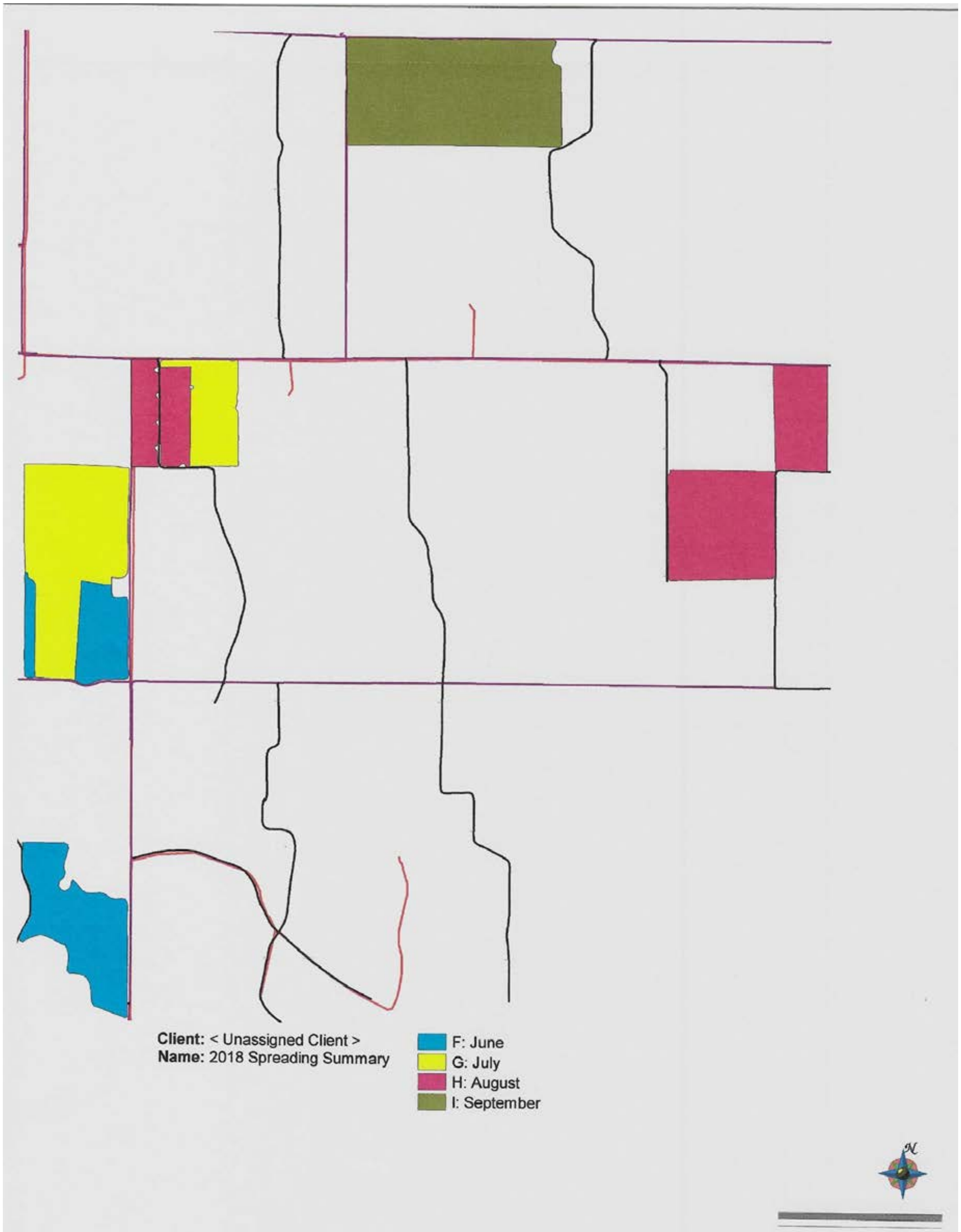


Table 14-3. Sherman County Acreage Amended with Portland Biosolids – 2018 [1, 2]			
Area Amended (Owner-Site #)	**Net Acreage Amended**	**Date Amendment Initiated**	**Date Amendment Completed**
Hayes 22	139.72 (dryland wheat)	June 4, 2018	June 16, 2018
Hilderbrand 3	303.63 (dryland wheat)	June 17, 2018	July 22, 2018
Hilderbrand 4	155.42 (dryland wheat)	July 23, 2018	August 7, 2018
Hayes 14	237.76 (dryland wheat)	August 8, 2018	August 25, 2018
Weedman 5	310.89 (dryland wheat)	August 26, 2018	September 14, 2018
Total Area Amended	**1,147.42 acres (464.34 hectares)**		

[1]Data provided by Lydia Wahls, Madison Biosolids, Inc.
[2]Biosolids were applied at rates ranging from 1.52 to 2.94 dry tons per acre (annual average ≈ 2.12 dry tons per acre) on dryland wheat.

PRE-APPLICATION TESTING

Along with pre-application soil testing of nitrogen and moisture content (to determine biosolids application rates), the City of Portland also conducted pre-application soil testing for soil fertility, trace inorganics, and dioxins/furans for all new biosolids-amended Sherman County sites. This data is summarized in Appendix D.

BIOSOLIDS APPLICATION RATES

The City of Portland and Madison Biosolids, Inc. consulted with Dr. Don Wysocki and Dr. Sandy Macnab (Oregon State University Extension) to determine dryland wheat application rates in Sherman County. Dr. Wysocki advised the City to use anticipated crop yields and a nitrogen requirement factor from Fertilizer Guide 80 (FG80) – *Winter Wheat in Summer-Fallow Systems - Low Precipitation Zone* (Wysocki, Horneck, et al). to determine field-specific application rates. Dr. Macnab recommended that the City and Madison Biosolids, Inc. test for pre-application nitrogen and soil moisture to a depth of six feet. In calculating field-specific application rates, Dr. Macnab further recommended that all nitrogen in the first three feet and 50% of nitrogen in the 4-6 foot profile be deducted from the calculated nitrogen requirement.

The City and Madison also interviewed the individual farmers and landowners in Sherman County to discuss historical and anticipated crop yields for fields to be amended with biosolids in 2018. Typically, dryland wheat yields ranging from 50 - 60 bushels per acre are used to calculate field specific biosolids application rates. Actual yields since the program began in 2010 have met or exceeded this range (e.g., McCullough fields have yielded greater than 80 bushels/acre when amended with City of Portland biosolids). 2018 application rate data for Sherman County is summarized in Table 14-4. A comparison of projected versus actual yield and protein content is summarized in Table 14-5.

Land application sites in Sherman County have been authorized by DEQ to receive biosolids at loading rates which will provide PAN on a field-specific basis depending on historical/expected crop yields and desired grain protein content. Biosolids were applied to dryland wheat at an average rate of 2.12 dry tons per acre (≈ 62.7 lb PAN per acre per year average).

Table 14-4. Sherman County Soil Nitrogen & Applied PAN 2018

	Biosolids Estimates[1]							Pre-Existing Soil NO_3-N																	
Field #	NO_3-N (mg/kg)	NH_3-N (mg/kg)	TKN (mg/kg)	% Solids	NH_3 Volatization Factor	Org-N Mineralization Factor	Biosolids PAN (lb/dry ton)	0'-1' (mg/kg)	1'-2' (mg/kg)	2'-3' (mg/kg)	3'-4' (mg/kg)	4'-5' (mg/kg)	5'-6' (mg/kg)	Usable PAN[2] in soil profile (mg/kg)	Usable PAN[3] in soil profile (lb/ac)	Yield Expectation (bu/ac)	Targeted % Grain Protein	N Required Per Bushel[4] (lb N/bu)	Estimated PAN Required (lb/ac)	Calculated PAN to apply (lb/ac)	Calculated Rate (dt/ac)	Targeted Rate (dt/ac)	Targeted PAN (lb/ac)	Actual Rate [5] (dt/ac)	Actual PAN [6] (lb/ac)
22	4.9	6680	43500	20.1%	80%	30%	24.8	1.2	0.9	1.2	2.4	4.2	5.4	9.3	32.6	60	9%	2.0	120	87.5	3.53	2.6	65	2.48	61.4
13	4.9	6680	44000	20.1%	80%	30%	25.1	2.9	4.1	6.6	2.2	2.2	2.2	16.9	59.2	60	9%	2.4	144	84.9	3.38	2.9	75	2.94	73.7
4	6.0	8810	56400	16.7%	80%	30%	32.1	1.3	1.7	6.3	3.6	7.2	2.8	16.1	56.4	60	9%	2.4	144	87.7	2.73	2.3	75	2.04	65.5
14	5.8	9090	54400	16.5%	80%	30%	30.8	1.8	1.6	2.7	4.5	2.5	2.7	11.0	38.3	60	9%	2.0	120	81.7	2.65	1.9	60	1.73	53.3
5	6.8	9910	61700	14.7%	80%	30%	35.1	10.7	3.4	5.5	4.5	4.2	0.9	24.4	85.4	60	9%	2.4	144	58.6	1.67	1.6	55	1.52	53.3

[1] Based on most recent testing prior to field application.
[2] Useable PAN evaluated as 100% NO_3 in 0'-3' zone and 50% NO_3 in 3'-6' zone.
[3] Assumes silt loam bulk soil density = 1.22 - 1.25 (Soil Weight of ≈ 3.5 million lb/ac-ft) per OSU Extension Office - Dr. Don Wysocki
[4] Lower of either value from OSU Fertilizer Guide FG-80 or farmer preference (2.0 - 2.4 lb N/bu)
[5] Actual Rate estimated as (Wet Tons Applied * Solids Content) / acres
[6] Actual PAN estimated as (Actual Rate) * Biosolids PAN (using QA/QC WPCL TS%)

Table 14-5. 2016 Projected vs. Actual Yield and Protein Follow-Up				
Field Number	Yield (bu/ac) (projected)	% Protein (projected)	Yield (bu/ac) (actual)[1]	% Protein (actual)
Hayes 14	60	9.0	61.5	9.0
Hayes 22	60	9.0	63.5	9.0
Weedman 5	50	9.0	55-65	9.0
Hilderbrand 4	60	9.0	60-65	9.0
Hilderbrand 3	60	9.0	60-65	9.0

[1]Yield values are estimates. Biosolids amended fields often represent only a fraction of harvested fields total yield values. Yields are from previous crop cycle (two years ago with crop-fallow rotation).

FUTURE SITE LOADING RATES

Biosolids loading to dryland wheat during 2019 will likely be in the range of 2.0 to 3.0 dry tons per acre; depending on expected crop yields and provided the solids chemistry remains similar to what it was during 2018. Biosolids nitrogen content will be monitored on a regular basis to reflect differences in freshly digested and lagoon solids characteristics affecting PAN (digested biosolids are usually higher in PAN than lagoon stabilized solids).

REGULATED TRACE INORGANICS ADDITIONS

State and federal biosolids rules and regulations require biosolids-trace inorganics to be tracked where one or more regulated constituent exceeds EPA pollutant concentration (PC) limit requirements [OAR 340-50-26(2)(a) and 40 CFR Part 503.13 (b)(3), Table 3]. The City routinely tracks the quantity of trace inorganics applied with its biosolids annually since lead levels *in past years* have occasionally fallen between regulated PC (40 CFR Part 503.13(b)(3), Table 3) and ceiling limits (40 CFR Part 503.13(b)(1), Table 1) during periods when significant levels of solids were removed from the Triangle Lake Lagoon (PC limits have not been exceeded since the early 1990's). Table 14-6 indicates the quantity of Portland biosolids trace inorganics applied per acre in Sherman County during 2018.

Table 14-6. Portland Biosolids Trace Inorganics Applied To Sherman County - 2018					
Parameter	Average[1] Concentration (mg/kg)	lb/ac[2]	Parameter	Average Concentration (mg/kg)	lb/ac
Arsenic	4.42	0.019	Molybdenum	10.58	0.045
Cadmium	2.28	0.010	Nickel	47.3	0.201
Copper	295	1.251	Selenium	4.62	0.020
Lead	57.2	0.243	Zinc	1,122	4.76
Mercury	0.786	0.003			

[1]Dry weight basis; values represent a weighted mean of solids applied during 2018.
[2]Site addition values are based on the mean dryland biosolids application rate in 2018 (2.12 dry tons per acre). Biosolids were applied at rates of 1.53 to 2.94 dry tons per acre on dryland wheat during 2018. [mg/kg*(2,000/1,000,000)*dt/ac rate]

BIOSOLIDS HANDLING

In 2018, four to six loads of biosolids were trucked to Sherman County by GTI, seven days per week. Each load contains approximately 34-35 wet tons of biosolids (depending upon dewatered cake moisture content).

Biosolids staging areas in Sherman County are temporary. They are occasionally watered with a water truck to control dusting and to form a good operating surface. Landings are applied with biosolids and put back into dryland wheat production upon completion of the field. Biosolids are authorized to be staged for up to three weeks on designated staging areas, however biosolids are typically applied after a staging time of no more than 2-3 days.

Portland biosolids were land applied by Madison Biosolids, Inc., under City contract # 31000149, to DEQ authorized dryland wheat sites in Sherman County. Madison Biosolids, Inc. owns and leases equipment and employs operations and maintenance personnel to run the land application program. Sites in Sherman County are leased directly to the City of Portland by Sherman County landowners.

Biosolids were land applied using two eleven-speed Ag-Chem 3104 Terragators™ fitted with 15.5 yd^3 Knight Manufacturing hoppers. Biosolids were typically applied by 1-2 operators on weekdays, Monday through Friday (See Section 13 for detailed description of land application equipment).

Biosolids were loaded into Ag-Chem™ applicator equipment via a CAT 936 E loader equipped with a 3.5 yd^3 bucket. The loader is able to reach sufficiently high (12.1 ft) to allow the bucket to be positioned over the center of the Knight hopper. Knight hoppers on Ag-Chem Terragators ™ hold approximately one-third of a truck load of biosolids. Typically, approximately eighteen loads of biosolids ($\approx$ 6 truck loads) can be spread per day by each Ag-Chem applicator.

Equipment operators typically apply solids to 20 to 30 acres daily. On the average, a week's supply of biosolids can be land-applied over a period of approximately 26 hours on nearly level terrain. The actual time required to apply solids varies, depending on the distance between the staging area and the application location and the nature of the landscape. Portland biosolids land application activities were regularly tracked and mapped by City staff based on land application activity reports and daily GPS and spread records furnished by Madison Biosolids, Inc. Land application actions were also confirmed by staff during periodic visits to Sherman County throughout 2018.

OSU RESEARCH FUNDING

Lease agreements signed between the City of Portland and Sherman County landowners include a fee for use of City of Portland biosolids. The City has partnered with Oregon ACWA to route the revenue generated from this fee to the Ag Research Foundation at Oregon State University (OSU). Dr. Dan Sullivan of OSU Crop and Soil Science utilizes the funding for biosolids-based research, studies and publications. Some of the proposed studies include:

1. Nitrogen fertilizer replacement value of heat-dried biosolids;
2. Soil amendments for long-term urban soil improvement;
3. Biosolids-based potting media for woody ornamental plants.

The contributions made by the City of Portland will expand the scope of these current projects and will facilitate initiation of new research projects. Funds provided by the City will: 1) support data collection, sample analysis, statistical analysis, and other research-related activities; 2) support peer-reviewed publication of research; 3) support delivery of research-based information to local, regional and international audiences (agricultural professionals, biosolids managers, and the general public); and 4) support collection of preliminary data for emerging research projects.

Thus far, research publications utilizing these funds have included updating PNW508, *Fertilizing with Biosolids* and the 2018 publication, *Biosolids in Dryland Cropping Systems*.

ENDANGERED SPECIES

All DEQ-approved sites in Sherman County are located on cultivated ground which endangered and threatened species are not known to utilize as habitat.

SURFACE WATER PROTECTION

No surface waters exist in any of the City's currently approved sites in Sherman County.

NRCS CONSERVATION STEWARDSHIP PROGRAM (CSP)

A recent challenge encountered in the City's Sherman County program is the Conservation Stewardship Program (CSP) of the Natural Resources Conservation Service (NRCS). Due largely to the financial incentives associated with the program, the majority of the City's partner wheat growers in Sherman County have signed onto this federal program for the minimum required 5-year contract (can be renewed for at least one additional 5-year period). Enrollees in the CSP program are required to adopt conservation "enhancements" in their agricultural practices. For dryland wheat growers, the main enhancement is called "Precision Application Technology" which requires "the use of precision agriculture technologies to apply nutrients to fit variations in site-specific conditions found within fields."

It initially appeared that the CSP program was incompatible with biosolids land application. However, after local NRCS staff had extensive discussions with Oregon DEQ (Pat Heins), Oregon State University (Dan Sullivan), and the growers in Sherman County, NRCS gave their approval to allow biosolids land application for sites that are enrolled in the CSP program.

Growers will need to calculate the P-Index, a NRCS-developed tool to gauge the potential of phosphorus to migrate off-site. If the index calculation comes out "Low", biosolids can be applied at levels that provide excess phosphorus. Fields that result in a "Medium" or higher level should be set aside from biosolids application until the excess phosphorus can be utilized by the crop. Biosolids will also need to be applied in zones (low, medium, high) that approximately match yield maps generated by the growers during wheat harvest. Another option is to apply a "base-layer" of biosolids, with the growers using commercial fertilizer to supply the "medium" and "high" levels on top of biosolids. Biosolids application does not need to be GPS-based and biosolids are not required to be incorporated.

SECTION 15
REGULATORY OVERSIGHT

Biosolids production and bulk Class B biosolids land application activities are regulated by both the DEQ and EPA Region X. Portland biosolids and biosolids handling operations comply with applicable DEQ (OAR Chapter 340, Division 50) and EPA (40 CFR Part 503), regulatory requirements. The DEQ approved Portland's biosolids management plan on May 18, 1987 (Appendix A). Land application plans for the CBWTP and TCWTP were updated in September 2017 (next scheduled update in 2022). Portland's biosolids land application operations are conducted under site specific, DEQ issued authorization letters (Appendix A).

MONITORING, RECORD KEEPING AND REPORTING

Portland routinely monitors solids processing and production operations at the TCWTP and CBWTP, as well as use activities at land application sites, to assure compliance with state and federal pollutant standards [required under OAR 340-50-026(2)(a) and 40 CFR Part 503.13]; pathogen reduction criteria [required under OAR 340-50-026(2)(b) and 40 CFR Part 503.32]; vector attraction reduction standards [required under OAR 340-50-026(2)(c) and 40 CFR Part 503.33]; and management practices and site restrictions [required under OAR 340-50-026(2)(d) and 40 CFR Part 503.14 and 503.32(b)(5)] (Appendix B).

Anaerobically digested primary and thickened waste activated solids production levels are monitored at the TCWTP (Section 6). Digested primary solids and TWAS from the TCWTP are integrated with raw thickened primary solids generated by the CBWTP prior to undergoing first and second-stage mesophilic anaerobic digestion at the CBWTP. Mean cell residence time and operating temperature during digestion are tracked to determine compliance with pathogen and vector attraction reduction criteria (Section 8). In addition, dewatered biosolids cake fecal coliform densities are monitored to confirm Class B pathogen status. During 2018, data including DEQ regulated trace inorganics, classicals and nutrients, were also collected to characterize anaerobically digested primary solids from the TCWTP (Section 6, Table 6-2). The ultimate quality and stability of TCWTP solids are reflected in the quality of solids generated by the CBWTP.

CBWTP bulk Class B biosolids directed to land application were periodically monitored for total Kjeldahl nitrogen, nitrate-nitrogen, ammonia-nitrogen, total phosphorous, potassium, pH, total solids, volatile solids and other parameters which appear in Table 15-1 during 2018.

The City also monitored fecal coliform, PCBs, priority organics, priority inorganics, and PAH-SIM in land applied biosolids (Sections 8 and 12 and Appendix D). Further, soils beneath biosolids amended areas at land application sites were monitored for trace pollutants required under 40 CFR Part 503.13, priority inorganics, nitrate-nitrogen and additional soil properties (Sections 13 and Appendix D).

Table 15-1. Portland Biosolids and Biosolids Land Application Site Monitoring Program [1]			
Parameter	First-stage Anaerobically Digested Solids	Dewatered Blend of Lagoon & Anaerobically Digested Solids	Biosolids Amended Soils
Trace Inorganics[2]	Monthly	Monthly	Annually
PCBs[3]	Quarterly	Monthly	As needed
Dioxins/Dibenzofurans[4]	As needed	As needed	As needed
Coplanar PCBs[5]	As needed	As needed	As needed
Nitrates[6]	Quarterly	Monthly	Annually
Nutrients & Classicals[7]	Quarterly	Monthly	Annually
Priority Pollutants[8]	Quarterly	Quarterly	Not monitored[9]
Fecal coliform[10]	Not monitored	Monthly	Not monitored
PAH-SIM[11]	Quarterly	Quarterly	As needed[11]

[1]First-stage anaerobically digested solids are tested as an on-going assessment (internal controls evaluation) of the quality of freshly generated solids at the CBWTP.
[2]Testing performed by Portland's Water Pollution Control Laboratory (WPCL). Metals tested monthly include As, Cd, Cu, Pb, Hg, Mo, Ni, Se and Zn. In addition, first-stage anaerobically digested solids & Class B biosolids cake (quarterly), and biosolids & non-biosolids amended soils at Madison Ranches (annually) are analyzed for Al, Ba, Be, B, Co, Fe, Mg, Mn, Sn, Ti, Tl and Sb as well as Cl, F and Br.
[3]Testing performed by Water Pollution Control Laboratory (WPCL). Soils not routinely monitored for PCBs.
[4]Testing performed by ALS Environmental or PACE Analytical Services, Inc. Samples of land applied biosolids were comprised of composited grab samples collected over a three-month period every two hours that dewatering occurs. First-stage anaerobically digested solids were composited from daily grab samples gathered over an entire month.
[5]Testing performed by ALS Environmental & Pace Analytical Services, Inc. Samples taken in the same manner as for dioxins/dibenzofurans.
[6]Biosolids testing performed by Portland's WPCL and soils testing by and Kuo Testing Labs, Inc., Othello, Washington.
[7]Testing performed by Portland's WPCL. Soil and plant tissue nutrient concentrations were tested by Agri-Check, Inc., Umatilla, Oregon and some soils nutrients were also analyzed by Kuo Testing Labs, Inc., Othello, Washington.
[8]Testing of priority organics in first-stage anaerobically digested solids and dewatered cake performed by City of Portland's WPCL.
[9]Priority inorganics monitoring only (conducted by Portland's WPCL).
[10]Testing performed by Portland's WPCL.
[11]First-stage anaerobically digested solids and dewatered biosolids land applied at Madison Ranches were analyzed by ALS Environmental. Soils at Madison Ranches were tested by Portland's WPCL.

Analytical methods and testing facilities used to evaluate solids products and soils appear in Table 15-2.

Table 15-2. Biosolids Program Analytical Methods & Testing Facilities		
Parameter	Method	Testing Facility [1]
Arsenic	SW-846, Method 6020[2&3]	WPCL
Cadmium	SW-846, Method 6020	WPCL
Copper	SW-846, Method 6020	WPCL
Lead	SW-846, Method 6020	WPCL
Mercury	SW-846, Method 6020	WPCL
Molybdenum	SW-846, Method 6020, (ICP-MS)	WPCL
Nickel	SW-846, Method 6020	WPCL
Selenium	SW-846, Method 6020	WPCL
Zinc	SW-846, Method 6020	WPCL
Thorium 232	SM Method 7120 (Gamma scan)	TA
Priority Pollutant Metals	SW-846, Method 6010 or 6020	WPCL
Total, Fixed & Volatile Solids	SM-2540G[4]	WPCL/ALS
Total Phosphorous	EPA 365.4 through 2016; 6010 starting in 2017	WPCL
pH	EPA Method 9045	WPCL
Total Organic Carbon	EPA, Method 9060-Modified	ALS
TKN	EPA 351.2, PAI-DK01	WPCL
NH_3-N	EPA 350.1	WPCL
NO_3-N	EPA 300.0	WPCL
PCBs as Aroclors	SW-846, Method 8082	WPCL
Organo-chlorine Pesticides	SW-846, Method 8081	ALS
Semi-volatile Organics	SW-846, Method 8270	ALS
Volatile Organics	SW-846, Method 8260B	ALS
Dioxins/Dibenzofurans	EPA, Method 1613B[5]	P or ALS
Coplanar PCBs	EPA, Method 1668A[6]	P or ALS
PAH-SIM[7]	EPA Method 8270-SIM	ALS
Fecal coliform	SM-9221E (MPN)	WPCL

[1]Analytical facilities: **TA** = Test America (Beaverton, OR & Bellevue, WA or occasionally at alternative Test America lab locations); **WPCL** = Portland Water Pollution Control Laboratory; **P** = Pace Analytical Services, Inc, Minneapolis, Minnesota; **ALS** = Axys Analytical Laboratory Services, Ltd., Sidney, BC, Canada and **Q** = Quanterra Environmental Services Laboratory (Sacramento, CA & Richland, WA).

[2]SW = "**Test Methods for Evaluating Solid Waste; Physical/Chemical Methods**," EPA Publication SW-846, Second Edition (1982) with Updates I and II and Third Edition (1986) with Revision I.

[3]Method 6010 = Inductively Coupled Plasma-Optical & Method 6020 = Inductively Coupled Plasma-Mass Spectrometry

[4]SM = "**Standard Methods for the Examination of Water and Wastewater**," 22nd Edition, American Public Health Association, Washington, D.c., 2012.

[5]Method 1613B: **Tetra-Through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS**.

[6]Method 1668A; **Toxic Polycholorinated Biphenyls by Isotope Dilution High Resolution Gas Chromatography/High Resolution Mass Spectrometry**.

[7]First-stage anaerobically digested biosolids and biosolids cake tested by TA and soils analyzed by WPCL.

Both the City and its contract appliers maintain records, including site application logs, which indicate the location, quantity and quality of biosolids applied daily at land application sites. Recorded information is used, in part, to assure that site access and re-entry restrictions related to cattle grazing operations, crop harvesting, soil nitrate-nitrogen testing, and other stipulations listed under DEQ's site authorization letters have been followed (Appendix A). Site logs and data characterizing solids handling operations are available for DEQ review.

Solids spills are to be reported to the Oregon Emergency Response System and DEQ within one hour of occurrence and summarized in annual biosolids activities reports (Section 10). First-stage anaerobically digested solids priority pollutant scans required under the City's industrial pretreatment program are reported in annual pretreatment and biosolids management program reports.

Reports on biosolids production, quality, use activities, monitoring, record keeping, and reporting requirements required by EPA Region X (electronic submission through EPANETBIO), pursuant to 40 CFR Parts 503.16 through 503.18, are submitted annually by February 19 of the year succeeding the reporting period. The City will continue to report this data and information to EPA pending delegation of federal program administration to DEQ.

Quality assurance/quality control procedures and chain-of-custody procedures are closely followed by City, contract sampling (Kuo Testing Labs, Inc., Agri-Check, Inc., AgSource, and OSU), and analytical staff (Kuo Testing Labs, Inc., Agri-Check, Inc., AgSource, Pace Analytical Services, Inc., Axys Analytical Services, Ltd., Quanterra and ALS Environmental). Field blanks and blind duplicate samples are periodically used to make QA/QC checks when sampling and analytical work occurs.

SECTION 16
PUBLIC OUTREACH

Although the management of biosolids has been identified as a relatively low risk activity by EPA, DEQ, the National Academy of Sciences National Research Council, and other members of the scientific community, public concern regarding biosolids quality, and the impacts solids land application actions have on public health and the environment remains.[1] To help build and sustain public acceptance and trust, the City of Portland conducts an active community outreach program. Portland regularly provides an opportunity for public review of the biosolids program and Madison Ranches affords interested citizens an opportunity to tour biosolids land application operations upon request.

Field Days and Informational Meetings

On April 28, 2009 a public information meeting and tour of the City's land application operations took place at Madison Ranches. Twenty-four members of the general public, including neighbors adjoining and abutting land application areas, the National Resource Conservation Service, Oregon State Department of Fish and Wildlife, Bureau of Land Management, DEQ, OSU Cooperative Extension Service, the Mayors of Hermiston and Echo, the Oregon Wheat Growers Council, Morrow County Commissioners, Umatilla County Commissioners, the Columbia Basin Agricultural Research Center, Lamb Weston food processors, Greenwood Resources Poplar farms, the Northwest Biosolids Management Association and the local press (***East Oregonian***) were sent written invitations (mid-April 2009) to the Farm Field Day. Spot ads announcing and inviting the general public to attend the event were placed in the ***East Oregonian*** (April 19, 2009) and the ***Hermiston Herald*** (April 18, 2009) inviting the general public to the occasion.

Thirty-two individuals: neighbors; other farmers; Madison Biosolids, Inc. land application staff; an OSU Extension Office representative; a large, commercial agricultural manure composter (Organics Company), representatives from a local poplar farm (Greenwood Resources), Lamb Weston food processors, soil consultants (Cascade Earth Sciences), college students, wastewater utilities (City of Portland, Washington County Clean Water Services, and Clackamas County Water Environment Services) and DEQ's Eastern Region Office attended the field day. They were provided summaries characterizing Portland biosolids and why Portland considered Madison Ranches an ideal location for solids application; the City's measures of safeguarding solids against contamination from industrial pollutants; the City's historical biosolids program at Madison Ranches; means of solids management and regulation at Madison Farms; the influences that Portland biosolids have had on improving forage quantity and quality and soil quality at Madison Ranches (presented by Dr. Don Horneck, OSU) and Kent Madison's biosolids, biosolids to biodiesel, canola pressing and biodiesel production, aquifer recapture and recovery, Lamb Weston

[1] EPA reviewed extensive worldwide data, including findings from field trials and laboratory experiments on human health and assessed environmental impacts related to biosolids use or disposal. Information gathered from these field trials and biosolids land application sites demonstrated no environmental degradation or human health impacts when biosolids were used in accordance with federal criteria. Biosolids applications resulted in increased soil fertility, due to additions of macro and micronutrients; increased organic matter and tilth; decreased erosion and increased moisture delivery to the ecosystem. No negative human health impacts have been documented when the biosolids that have met all of the federal regulations have been applied under good management practices.

and Hermiston Generating irrigation, Oregon Winds wind farm power generation projects. During the field tour that followed presentations at the Madison Ranches maintenance shop, biosolids amended areas, applicator equipment loading, and biosolids application operations were observed (Section 15, Township 3 North, Range 27 East, Willamette Meridian). Land application operations were followed by a quick tour of the wind farms and canola pressing and biodiesel production operations. Several Field Day attendees were complimentary of the event.

The City elected to hold farm field days on an as-needed basis since recently no concerns on Portland biosolids management actions, or their environmental or public health impacts have been registered with the City, DEQ, EPA or Madison Biosolids, Inc. Both Portland and Madison Ranches owners remain open to providing interested parties a tour and perusal of product characteristics and biosolids-related site management actions on a continuing basis.

The City began applying biosolids in northern Sherman County in June of 2010. Public notice on intended land application actions was posted in the Condon Times Journal and The Dalles Chronicle on August 15, 2008 and the Sherman County e-News on August 15, 2008 (Appendix E). Further public notice and opportunity to comment occurs immediately prior to the first scheduled land application event at a particular DEQ authorized land application site. In January of 2010, Kent Madison and City of Portland staff gave a biosolids presentation to Sherman County farmers and landowners at the Lean-To Cafe located in Wasco, OR. On May 23, 2012, the City of Portland, OSU, and Madison Biosolids staff participated in an OSU-sponsored Crop Hop event in Moro and Wasco, OR. Approximately 20 individuals from the Wasco-Moro area attended the event. City of Portland staff gave a presentation on the wastewater treatment process as well as an overview of biosolids regulations. Dr. Dan Sullivan of Oregon State University Crop & Soil Science presented results of OSU studies which have demonstrated the benefits of biosolids to dryland wheat. Finally, Madison Biosolids staff gave a field demonstration of biosolids land application on one of the City's DEQ-authorized sites in Wasco (farmed by Rick Hayes).

In 2008, wind tower construction commenced at Madison Ranches. Since biosolids were actively being applied in areas near tower assembly, formal notice and guidelines were developed for construction workers (Appendix E). Workers are required to sign a statement acknowledging the presence of biosolids to be sure they are aware of their presence and appropriate protective clothing and hygienic practices that should be followed in areas where biosolids have recently been applied.

In addition to educating the general public on the nature of Portland's biosolids land application program, annually the City meets with biosolids transporters to review solids makeup, their potential pathogen content, and basic hygiene and first aid practices which should be followed during product handling (Section 10). On January 17, 2018, staff reviewed and discussed technical information on these topics to GTI drivers. A similar meeting was held between the City and drivers on February 15, 2017.

Website & Articles

The public also has an opportunity to learn about Portland's biosolids production and land application program by visiting the City's website. The website is kept current by program staff with the assistance of the BES Communications. The website was updated with current information in 2018 with input from OSU Crop & Soil Science. http://www.portlandoregon.gov/bes/article/41872. Additionally, a more detailed outreach document was created with the aid of OSU and BES Communications staff (See Appendix E). This document was developed to provide a more detailed description of the biosolids program for interested members of the public, news media requests, elected officials, etc.

The City's biosolids program has also been featured in stories published by the Oregonian http://www.oregonlive.com/portland/index.ssf/2012/02/river_of_sewage_flows_from_sel.html and the Food Rights Network in 2012.

Program Recognition

As an acknowledgment for its exceptional leadership on a variety of technical, educational and regulatory fronts regionally and nationally, the City received an outstanding leadership award from the Northwest Biosolids Management (NBMA) in September 2008. In recognition for its outstanding efforts in developing and implementing a cost-effective, environmentally beneficial biosolids management program, on September 8, 2003, the City received the first-ever Excellence in Biosolids Management Award offered jointly by the NBMA and Pacific Northwest Clean Water Associations (PNCWA). The award was based, in part, on Portland's on-going measurement of impacts associated with its land application operations and means of communicating those observations to the general public.

On October 11, 1999, EPA recognized Portland's beneficial biosolids use program as one of the best of its class nationally (operating programs for domestic wastewater treatment works processing greater than 5 mgd). The Bureau received EPA's 2nd place award for what was acknowledged as an "outstanding beneficial use of biosolids program." EPA based its selection on the Bureau's "collaborative and highly effective utilization program" and "its means of operating a successful program while challenged with special contaminants of local and national interest including PCBs and dioxin-like compounds." The award was presented on October 11, 1999, at an annual Water Environment Federation and Technology Conference in New Orleans.

In 2013, Oregon DEQ recognized the City's Madison Farms program with the following statement: "The City of Portland has operated a program for the beneficial reuse of biosolids on agricultural crops and range lands at Madison Farms since 1990. Land applied biosolids have provided valuable organic matter and nutrients to both agricultural crops and pasture. In addition, biosolids from the City of Portland have been used to establish and improve the growth of native vegetation on steep, highly erodible slopes, which reduces soil erosion and preserves valuable top soil. The City of Portland's biosolids program has operated in compliance with state requirements and serves as an example of a well-run program to other biosolids programs within Oregon as well as nationally."

Other Publications and Outreach Documents

During 1997, the City developed a brochure "From Waste to Resource", which described Portland's means of producing biosolids products at the CBWTP (Appendix E). The brochure emphasized Portland's land application program in north central Oregon. It described the production of biosolids, why they are recycled, the relative risk they pose to public health and the environment, and their means of regulation. Fact sheets describing and interpreting the regulation and relative risks of Portland biosolids-borne cadmium, lead and trace organic compounds are updated annually (Appendix E).

In 2009, City staff assisted the Oregon Association of Clean Water Agencies' (ACWA) Biosolids Committee in composing a biosolids fact sheet addressing many common concerns about biosolids and land application. http://www.oracwa.org/pdf/biosolids-fact-sheet_3-2012.pdf In 2013, City staff also assisted Oregon ACWA in the creation of an updated biosolids media guide. http://www.oracwa.org/documents/ACWABiosolidsMediaGuide4-09web.pdf

In 2015, City staff collaborated with OSU Crop & Soil Science to update the "Fertilizing with Biosolids" publication. https://catalog.extension.oregonstate.edu/pnw508

From 2015-2018, the City collaborated with OSU Crop & Soil Science to feature the Madison Ranches program in the 2018 OSU publication, "Biosolids In Dryland Cropping Systems". https://catalog.extension.oregonstate.edu/pnw716