City of Molalla
Clackamas County, Oregon

WASTEWATER TREATMENT PLANT 2017 LAGOON TEST REPORT

JULY 2017

The Dyer Partnership Engineers & Planners, Inc.

Project No. 100.29

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City of Molalla
Clackamas County, Oregon

Wastewater Treatment Plant
2017 Lagoon Leakage Test Report

July 2017

Project No. 100.29

REGISTERED PROFESSIONAL ENGINEER
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July 11, 2006
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1. INTRODUCTION

Leak testing for the City of Molalla's wastewater lagoons was performed by The Dyer Partnership, Engineers and Planners, Inc. in July of 2017. The leak testing was conducted in accordance with the Oregon DEQ *Guidelines for Estimating Leakage for Existing Sewer Lagoons.*

2. LAGOON PROCESS

The Molalla Wastewater Treatment Plant (WWTP) process utilizes two lagoons, in series, for primary wastewater treatment. The data collection for the lagoon leak test was completed during normal plant operation, for both lagoons simultaneously. Based on the fact these lagoons work in series, it was not possible to isolate the individual lagoons during the testing period. Bypassing Lagoon No. 1 would create a short circuiting of flow in Lagoon No. 2 and result in inadequate treatment. The WWTP flow through the lagoons is noted below and is shown on the schematic included as Appendix A of this report:

1. Flows from the plant Headworks gravity flow to an Aeration Basin.
2. Flows from the Aeration Basin are pumped to Lagoon No. 1. Pumped flows to Lagoon No. 1 are metered by an 18-inch magnetic flow meter.
3. Flows from Lagoon No. 1 gravity flow to Lagoon No. 2 through a 14-inch diameter line.
4. Flows from Lagoon No. 2 gravity flow to two Dissolved Air Flotation (DAF) Units. Each DAF unit is served by a 14-inch gravity line, which are flow metered by magnetic flow meters on each line.

The physical properties for the lagoons from the 2008 NPDES Permit Renewal Application documentation (Tetra Tech) are found in Table 1, below.

Table 1: Lagoon Properties

	Max. Depth	Surface Area at 6-foot depth		Lagoon Perimeter	Lagoon Side Slope	Volume (6-foot depth to 12-foot depth)		
	(ft.)	(ac.)	(s.f.)	(ft.)		(gal.)	(gal./ft.)	(gal./in.)
Lagoon No. 1	12	11.4	496,584	3,380	3:1	23,651,940	3,941,990	328,499
Lagoon No. 2	12	13.6	592,416	3,480	3:1	27,993,272	4,665,545	388,795
Totals						51,645,212	8,607,535	717,294

On July 10, 2017 Project Delivery Group completed a topographic survey of the Molalla lagoons. The purpose of the survey was to establish the water elevation and associated water surface areas of both lagoons at the start of the 10-day test period. The surface of Lagoon No. 1 was found to have an elevation of 320.04 feet (NAVD 88) and a total surface area of 521,014. sq. ft. The surface of Lagoon No. 2 had a surface elevation of 312.20 feet (NAVD 88) with a total surface area of 629,893 sq. ft. The storage volume at the test period depth of Lagoons No. 1 and

No. 2 is 324,765 gal./in and 392,634 gal./in, respectively. Therefore, the lagoons are calculated to have a total storage volume of **717,399 gal./in** at a total surface area of both lagoons of 1,150,907 sq. ft. This closely matches the volume per depth value of 717,294 gal./in noted in Table 1 and will be used for the calculations in this report.

3. TEST PERIOD

Data for the leakage analysis was collected over a ten day period starting Monday, July 10, 2017 and ending Thursday, July 20, 2017. Data collection occurred at 8:00 am each morning, starting with the initial readings on July 10th. Therefore, "Day 1" represents the 24 hour period between 8:00 am, July 10th and 8:00 am, July 11th. The subsequent days follow the same 24 hour period, from 8:00 am to 8:00 am the following day.

4. DATA COLLECTION METHODS AND EQUIPMENT

The equipment and methods used to collect data for the analysis of the leak testing included:

- Influent Lagoon Flow – An 18-inch magnetic flow meter was installed on the effluent line of the transfer pump station that delivers wastewater from the Aeration Basin to Lagoon No. 1. The meter was installed in September of 2016 to assist in the data collection for this test. It should be noted that this meter was installed directly downstream of a vertical 45 degree bend. The City was able to verify from the manufacturer that the installation would produce less than one percent (1%) error in flow readings.
- Precipitation – One rain gauge with 1/100 of an inch accuracy is located at the Wastewater Treatment Plant was available to record rain fall.
- Lagoon No. 1 Level – The initial lagoon level was established using the staff gauge in Lagoon No. 1 with an associated distance measurement from the top of the Lagoon No. 1 effluent structure to the water surface level. All measurements were taken to the nearest 1/16 of an inch from the same location on the effluent structure, down to the water surface level.
- Lagoon No. 2 Level – The initial lagoon level was established using the existing, sloped staff gauge in Lagoon No. 1. The staff gauge is angled up 16 degrees from the horizontal. Each morning a tack was installed at the water surface elevation on the staff gauge and the distance from this tack to the previous day tack was measured to the nearest 1/16 of an inch. The change in lagoon depth was calculated using this measurement and the 16 degree slope of the gauge.
- Lagoon Effluent Flow – Two existing 14-inch magnetic flow meters were used to record the effluent flow from Lagoon No. 2 to the Dissolved Air Flotation (DAF) Units.
- Evaporation – A 4-foot diameter evaporation pan with a Novalynx Analog Output Evaporation Gauge was used to record evaporation. This pan is recommended in the Oregon DEQ *Guidelines for Estimating Leakage for Existing Sewer Lagoons***.**

5. RESULTING DATA

A. Influent Flow

The total wastewater influent flow to the lagoons was 10,272,062 gallons over the 10-day test period, as recorded by the magnetic flow meter on the effluent transfer pump station line. Based on the volume of 717,399 gal./in. in the lagoons at or near the surface test period surface elevations, this equates to an increase in lagoon level of 14.32 inches over both lagoons, or **1.432 inches per day**. The daily flow data is listed in Table 2, below.

Table 2: Lagoon Influent Flow

	Daily Flow	
Day	(gal.)	(in.)
Day 1 (10/11 – 10/12)	234,465	0.33
Day 2 (10/12 – 10/13)	888,239	1.24
Day 3 (10/13 – 10/14)	898,910	1.25
Day 4 (10/14 – 10/15)	852,863	1.19
Day 5 (10/15 - 10/16)	890,909	1.24
Day 6 (10/16 - 10/17)	816,052	1.14
Day 7 (10/17- 10/18)	916,188	1.28
Day 8 (10/18 - 10/19)	866,121	1.21
Day 9 (10/19 - 10/20)*	1,809,927	2.52
Day 10 (10/20 - 10/21)*	2,098,388	2.92
Total	10,272,062	14.32

* Lagoon influent flow increased on days 9 and 10 due to the recirculation of wastewater from the DAF units to the aeration basin and lagoons.

B. Precipitation

There was no measurable precipitation during the 10-day test period.

C. Lagoon Levels

Over the testing period Lagoon No. 1 had an overall surface level elevation increase of 5.3 inches, which equates to an increase in storage volume of 1,721,257 gallons. Lagoon No. 2 had an overall surface level elevation decrease of 3.18 inches, which equates to a decrease in storage volume of 1,248,575 gallons. Therefore, there was a net storage amount of 472,682 gallons in the lagoons, which produces an overall increase in lagoon depth of 0.659 inches over both lagoons during the test period or **0.066 inches per day**. Daily lagoon depths are shown in Tables 3 and 4.

Table 3: Lagoon No. 1 Levels

	Change in Depth		Lagoon Depth
	(in.)	(ft.)	(ft.)
7/10/17	-	-	9.40
7/11/17	0.00	0.000	9.40
7/12/17	-1.20	-0.100	9.30
7/13/17	0.75	0.063	9.36
7/14/17	0.06	0.005	9.37
7/15/17	-0.37	-0.031	9.34
7/16/17	-0.63	-0.053	9.28
7/17/17	-0.06	-0.005	9.28
7/18/17	0.50	0.042	9.32
7/19/17	2.50	0.208	9.53
7/20/17	3.75	0.313	9.84
Totals	5.30	0.442	-

Table 4: Lagoon No. 2 Levels

	Change in Depth		Lagoon Depth
	(in.)	(ft.)	(ft.)
7/10/17	-	-	10.10
7/11/17	-0.62	-0.12	9.98
7/12/17	-0.69	-0.08	9.90
7/13/17	-1.17	-0.09	9.81
7/14/17	-0.31	-0.13	9.68
7/15/17	-0.41	-0.03	9.65
7/16/17	1.52	0.13	9.78
7/17/17	1.45	0.12	9.90
7/18/17	-1.43	-0.12	9.78
7/19/17	-0.28	-0.02	9.76
7/20/17	-1.24	-0.10	9.66
Totals	-3.18	-.265	-

D. Effluent Flow

The total effluent flow from the lagoons to the DAF units during the 10-day test period was 6,673,000 gallons, as recorded by the two DAF unit magnetic flow meters. Based on the volume of 717,399 gal./in. in the lagoons (Table 1), this equates to a decrease in lagoon levels of 9.30 inches, or **0.930 inches per day**, over both lagoons during the test period. The daily effluent flow data is listed in Table 5, below.

Table 5: Lagoon Effluent Flow

	Daily Flow			
	DAF No. 1 Meter		DAF No. 2 Meter	
Day	(gal.)	(in.)	(gal.)	(gal.)
Day 1 (10/11 – 10/12)	95,000	0.13	197,000	0.27
Day 2 (10/12 – 10/13)	209,000	0.29	496,000	0.69
Day 3 (10/13 – 10/14)	263,000	0.37	687,000	0.96
Day 4 (10/14 – 10/15)	259,000	0.36	592,000	0.83
Day 5 (10/15 - 10/16)	267,000	0.37	705,000	0.98
Day 6 (10/16 - 10/17)	201,000	0.28	454,000	0.63
Day 7 (10/17- 10/18)	0	0.00	0	0.00
Day 8 (10/18 - 10/19)	81,000	0.11	306,000	0.43
Day 9 (10/19 - 10/20)	222,000	0.31	566,000	0.79
Day 10 (10/20 - 10/21)	264,000	0.37	809,000	1.13
Totals	1,861,000	2.59	4,812,000	6.71
Combined Total (gal.)	6,673,000			
Combined Total (in.)	9.3			

E. Evaporation

The measured evaporation during the 10-day test period was 2.452 inches. A correction factor of 0.8 was applied to the pan evaporation. The standard correction factors for pan coefficients are typically 0.7 to 0.9. The resulting evaporation within the lagoons was 1.97 inches or **0.197 inches per day** over the test period.

6. SEEPAGE CALCULATIONS

A. Flow Balance

The calculations for determining the seepage from the lagoons was derived through a simple flow balance for the system using the inches per day flows determined above. The equation used in the calculations is:

Seepage (in./day) = Influent (in./day) + Precipitation (in./day) – Lagoon Storage (in./day) – Effluent (in./day) – Evaporation (in./day)

The equation above results in:

Seepage (in./day) = 1.432 in./day + 0 in./day – .066 in./day – 0.930 in./day – 0.197 in./day = **0.239 inches per day**

B. Volume Check

As a check to the above flow balance calculation, a 10-day volume balance is shown below in Table 7. Flows contributing to influent flow to the lagoons are shown as positive numbers and flows contributing to effluent and storage within the lagoons are shown as negative. The balance of these volumes is considered as the total amount of seepage during the test period, and is found to be 1,719,130 gallons over the 10-day test period or 171,913 gallons per day. Based on the storage the lagoons of 717,399 gallons per inch, the balance value is equal to seepage amount of 2.40 inches or **0.240 inches/day**.

Table 7: Lagoon Volume Balance

Flow Element	Total Flow 10 Day Test Period (gal.)	Avg. Daily Flow 10 Day Test Period (gal./day)
Lagoon Influent Flow (Gal.)	10,272,062	1,027,206
Precipitation (Gal.)	0	0
Lagoon 1 Storage (Gal.)	-1,721,257	-172,126
Lagoon 2 Storage (Gal.)	1,248,575	124,857
Lagoon Effluent (DAF No. 1) (Gal.)	-1,861,000	-186,100
Lagoon Effluent (DAF No. 2) (Gal.)	-4,812,000	-481,200
Evaporation (Gal.)	-1,407,250	-140,725
Balance/Seepage (Gal.)	1,719,130	171,913

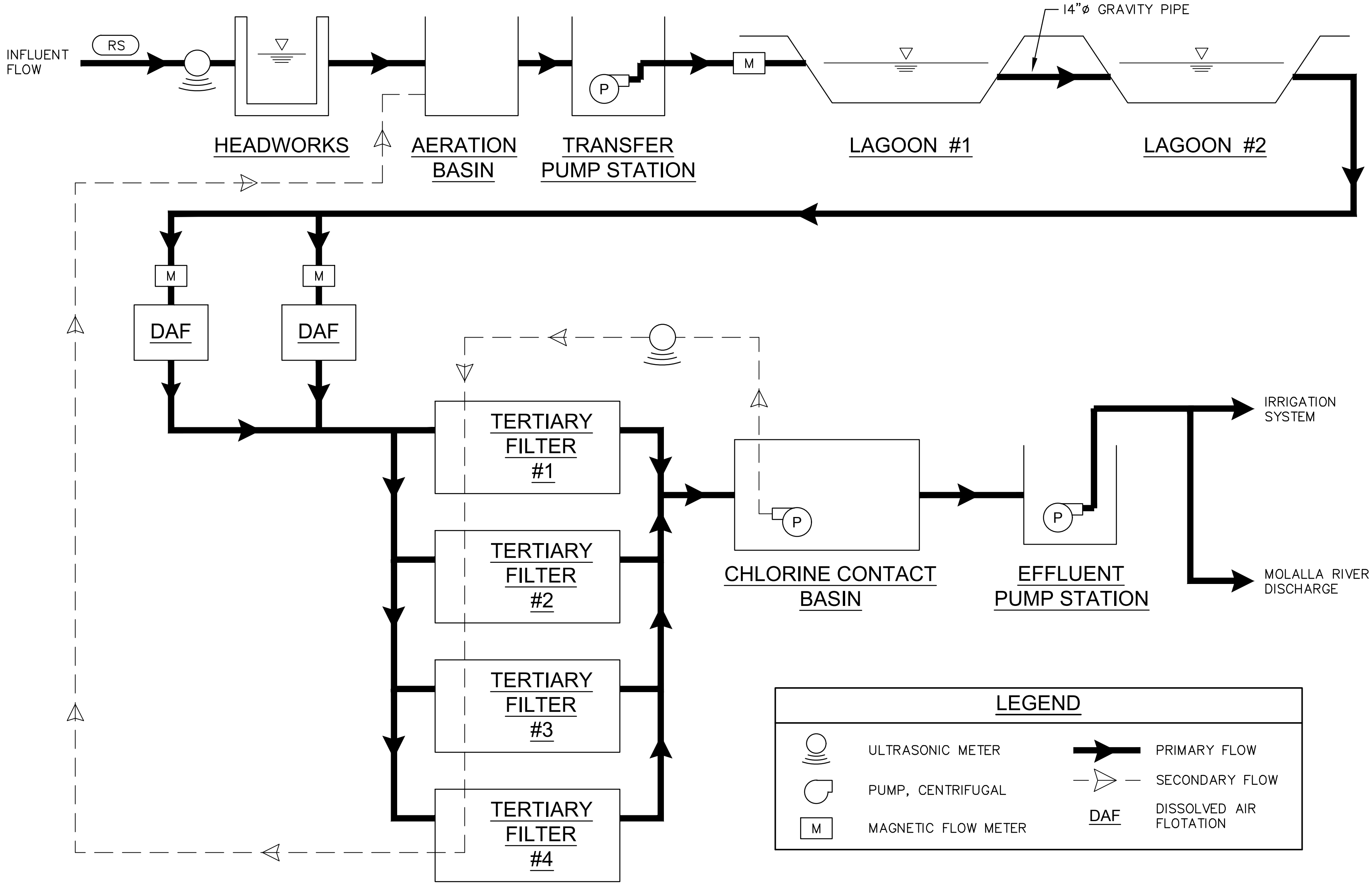
7. CONCLUSION

The guidelines for estimating leakage from existing sewage lagoons produced by the Oregon DEQ states that seepage rates as high as 1/8 of an inch per day or less are considered normal. Seepage exceeding ¼-inch per day indicates a seal failure, or absence of adequate initial seal.

The lagoon leakage test did not exceed ¼-inch per day. The lagoon leakage test **PASSED.**

Appendix A

Figure A – Wastewater Treatment Plant Flow Schematic



THE DYER PARTNERSHIP ENGINEERS & PLANNERS, INC.	***CITY OF MOLALLA*** ***WWTP 2017 LAGOON LEAK TEST***	FIGURE NO. ***A***
DATE: JULY 2017 PROJECT NO.: 100.29	***WWTP FLOW SCHEMATIC***	

Appendix B

Lagoon Design Properties and Survey

FLOW DATA

Existing and Projected Flows

	2005	2015	2025
ADWF – Average dry weather flow	0.80 mgd	1.1 mgd	1.4 mgd
MMDWF – Max month dry weather flow	1.28 mgd	1.7 mgd	2.3 mgd
AWWF – Average wet weather flow	1.30 mgd	2.3 mgd	3.0 mgd
MMWWF – Max month wet weather flow	2.04 mgd	3.1 mgd	4.1 mgd
PDF – Peak day flow	7.06 mgd	8.5 mgd	10.3 mgd

DESIGN DATA

Effluent Quality

Required Effluent Quality	BOD5 < 10 mg/l	TSS < 10 mg/l
Anticipated Filter Effluent Quality	BOD5 < 5 mg/l	TSS < 5 mg/l

Headworks (2002 Construction)

Type of screens	In-channel fine screens, perforated plate
Number of screens	1
Peak flow capacity, each	9.25 mgd
Bypass screen	Manually cleaned screen
Screenings washing	Yes
Screenings compaction	Yes
Septage	Excluded
Headworks, influent flow measurement	
Number of flumes	1
Throat width	24 inches
Peak flow capacity	21.4 mgd
Minimum flow capability	0.27 mgd

Aeration Basin (1980 Construction)

Dimensions	
Size (bottom of basin)	200 feet by 54 feet
Side slopes (horiz:vert)	2:1
Maximum side water depth	10 feet with 2 feet freeboard
Basin volume, maximum	1,300,000 gallons
Basin liner	Asphalt-concrete
Aerators	
Type	Aspirating
Number	6
Horsepower, each	10 horsepower
Basin outlet	Overflow weir to pump station

Transfer Pump Station (2002 Construction)

Estimated PIF from basin	9.25 mgd
Main pump type	Centrifugal submersible w/vfd
Main pumps	
Operating	1
Standby	1
Main pump capacity each	5800 gpm at 51 ft tdh
Jockey pump type	Centrifugal submersible w/vfd
Jockey pump number	1
Jockey pump capacity (one forcemain)	2500 gpm at 49 ft tdh and 2100 gpm at 56 ft tdh
Station peak capacity	7800 gpm (11.23 mgd)
Required operating volume	4060 gal
Wet well levels	
Maximum W.S. El	286.0 ft
Minimum W.S. El	272.0 ft
Operating volume	55,820 gal (includes aeration basin)

Transfer Forcemain (2002 Construction)

Number	2
Material	HDPE
Size	18-inch (nominal, ID)
Length	1630 feet
Velocity at 2500 gpm	3.2 feet/sec
Velocity at 2100 gpm	2.6 feet/sec
Velocity at 7800 gpm	4.9 feet/sec
Outlet to lagoon 1	
Number/size	4-ports/12-inch

Lagoon No. 1 (1980 Construction)

Lagoon dimensions	
Surface area	11.4 acres (at 6-foot (average) depth)
Maximum depth	12 feet with 3 feet of freeboard
Working depth (max. To min.)	9 feet
Lagoon volume, maximum	137 acre-feet (45 mg)
Lagoon liner	Native clay
Aeration	None
Outlet	
Size	10-inch
Type	Surface weir and fixed pipe on bottom of lagoon

Lagoon No. 2 (1980 Construction)

Lagoon dimensions	
Surface area	13.6 acres (at 6-foot average depth)
Maximum depth	12 feet with 3 feet of freeboard
Working depth	9 feet
Lagoon volume, maximum	163 acre-feet (53 mg)
Lagoon liner	Native clay
Outlet	
Size	14-inch
Type	Fixed pipes at two depths

Dissolved Air Flotation (DAF) (1980 Construction)

Capacity	2.0 mgd
Tank Diameter	31 feet
Surface area	750 square feet (sf)
Hydraulic loading rate	2.59 gpm/sf, including recycle
Hydraulic capacity	2.80 mgd, including recycle
Chemical feed rates	
Alum	75 – 150 mg/l (not used)
Soda	37 – 75 mg/l (not used)
Polyaluminum Chloride	35 – 70 mg/l
Acid	0 – 10 mg/l (not used)
Operating parameters	
Pressurized recycle flow	350 to 700 gpm
Operating pressure	45 to 80 pounds per square inch (psi)
Maximum horizontal velocity	3.1 feet per second
Maximum daily sludge	2290 pounds dry solids, 15,300 gallons
Recycle Pumps	
Number	2
Size	20 HP
Flow	350 gpm
Recycle Flow Meter (Existing)	
Type	Propeller
Size	6 Inch
Range	0-2 MGD
Influent Flow Meter (FM-2) **(2007 Construction)**	
Type	Electromagnetic Insertion Type
Size	12 Inch
Range	0-10 MGD

Dissolved Air Flotation (DAF) **(2007 Construction)**

Capacity	2.0 mgd
Tank Diameter	38 feet
Surface area	1,075 square feet (sf)
Maximum surface loading rate	2.0 gpm/sf, including recycle
Hydraulic capacity	3.1 mgd, including recycle
Chemical feed rates	
Polyaluminum Chloride	35 – 70 mg/l
Operating parameters	
Pressurized recycle flow	350-700 gpm
Operating pressure	125 PSI
Maximum horizontal velocity	<3.1 FPS
Maximum daily sludge	1,670 pounds dry solids, 10,000 gallons
Recycle Pumps	
Number	2
Size	25 HP
Flow	350 gpm
Recycle Flow Meter (FM-3)	
Type	**Propeller**
Size	6 Inch
Range	0-2.5 MGD
Influent Flow Meter (FM-1)	
Type	**Doppler**
Size	14 Inch
Range	0-14 MGD

Plant Air (Proposed)

Air Compressor	
Type	Rotary Screw
Size	15 HP
Output	51 ACFM
Operating Pressure	125 psig

Gravity Filters (1980 Construction) – To Be Abandoned

Capacity	2.1 mgd
Number of filters	2
Surface area, total	310 square feet
Maximum loading rate	5 gpm/sf
Hydraulic capacity	2.2 mgd
Media	
Type	Gravel, sand, and anthracite coal
Depth	22" gravel, 9" sand, 21" coal
Backwash / surface wash	Automatic on timer or pressure differential
Backwash rate	20 gpm/sf
Surface wash	103 gpm

Gravity Filters **(2007 Construction)**

Capacity	4.0 mgd
Number of filters	4
Surface area, total	573 square feet
Maximum loading rate	4.85 gpm/sf
Hydraulic capacity	4.0 mgd
Media	
Type	Gravel, sand, and anthracite coal
Depth	12" silica sand, 24" anthracite coal
Backwash control	Manual, timed or pressure differential
Backwash rate	15 gpm/sf
Backwash flow (1 filter)	2,147 gpm
Backwash duration	4 – 8 minutes
Backwash volume	8,600 – 17,200 gallons
Air Scour Blower	
Type	Rotary Positive Displacement
Size	15 HP
Air scour rate	3.0 scfm/sf
Air Scour flow (1 filter)	429 scfm @ 4 psig
Backwash Flow Meter (FM-5)	
Type	**Transit Time**
Size	16 Inch
Range	0-17 MGD
Filter Effluent Flow Meter (FM-4)	
Type	**Transit Time**
Size	18 Inch
Range	0-23 MGD

REV	DATE	DES	CHECK	APPROVALS	REVISION DESCRIPTION	DATE: JAN 2007
						DESIGNED: ECN
						DRAWN: ECN
						CHECKED: JCM
						APPROVED: JCM

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TETRA TECH
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Portland, Oregon 97223
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CITY OF MOLALLA
2008 NPDES PERMIT RENEWAL
Figure 3
DESIGN DATA 1

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"

Disinfection (1980 Construction)

Type	150-pound gas cylinders
Chlorinator capacity	100 ppd
Feed rate, minimum	30 to 50 pounds / million gallons
Residual, minimum	2 mg/l
Chlorine Contact Chamber	
Sidewater depth	4 feet with 1 foot of freeboard
Volume	67,500 gallons
Length to width ratio	24

Outfall to Bear Creek (1980 Construction) – To Be Abandoned

Size and material	18-inch concrete
Length	270 feet
Single port	
Type	Perpendicular to streamflow
Stream gauge	
Type	Box culvert with 10' weir
Measurement	Manual staff guage

Effluent/Irrigation Pump Station (2000 Construction)

Pumps	
Type	Vertical turbine
No. Of pumps	2 + 1 future
Capacity	500-7,000 gpm
Motor horsepower	300 bhp
Motor control	VFD
Wet well	
Type	12-ft id manhole
Operating volume, pump 1 on to pump off	3,800 gal
Level control	Pressure transducer
Lift station (In Plant)	
Pump type	Submersible
No. Of pumps	2
Capacity, each pump	175 gpm at 15 ft tdh
Motor horsepower	3 bhp
Speed	1750 rpm
Wet well	6-ft ID manhole
Level control	Pressure transducer

Plant Standby Power Generator (2000 Construction)

Reliability Class	I
Location	Eff/Irr Pump Station
Type	Diesel Engine
Size	750 KW
Transfer Switch	Automatic

Plant Alarm System

Type	After Hours via Auto Telephone Dialer

Effluent/Irrigation Forcemain (2000 & 2006 Construction)

Material	PVC and HDPE
Size (Nominal Inside diameter)	24 inches
Length	27,000 feet (approx. entire length)
Capacity	
Design Capacity	10.1 mgd
Design Velocity	5.0 fps
Approx. Operating Range of Flows	1.0 to 4.0 mgd
Operating Velocities	0.5 to 2.0 fps

Discharge Monitoring Structure (2006 Construction)

Dechlorination (for surface water discharge conditions only)	
Feed Solution	Ascorbic Acid
Chemical Feed Pumps	2 – 13 gph (with 1000:1 Turndown)
Feed Control	Flow and Cl2 residual paced
Effluent Sampler:	
Type: Flow Paced or Time Composite	For Bacteria BOD, TSS, NH3, pH,
Continuous Monitoring/Recording:	
Temperature	Probe.
DO	Probe
Chlorine	Residual Analyzer (2)
Flow Measurement:	
Type	Electromagnetic Multi-port Insertion Type
Size	12-inch

Molalla River Outfall (2006 Construction)

Material (for outfall extension and diffuser)	HDPE
Size (Nominal ID)	24 inches
Length	23 feet
Diffuser Design	
Number of Ports	Three (Duckbill)
Diameter of Port	Eight inches
Minimum Summer Submergence	One Inch
Minimum Winter Submergence	12 Inches

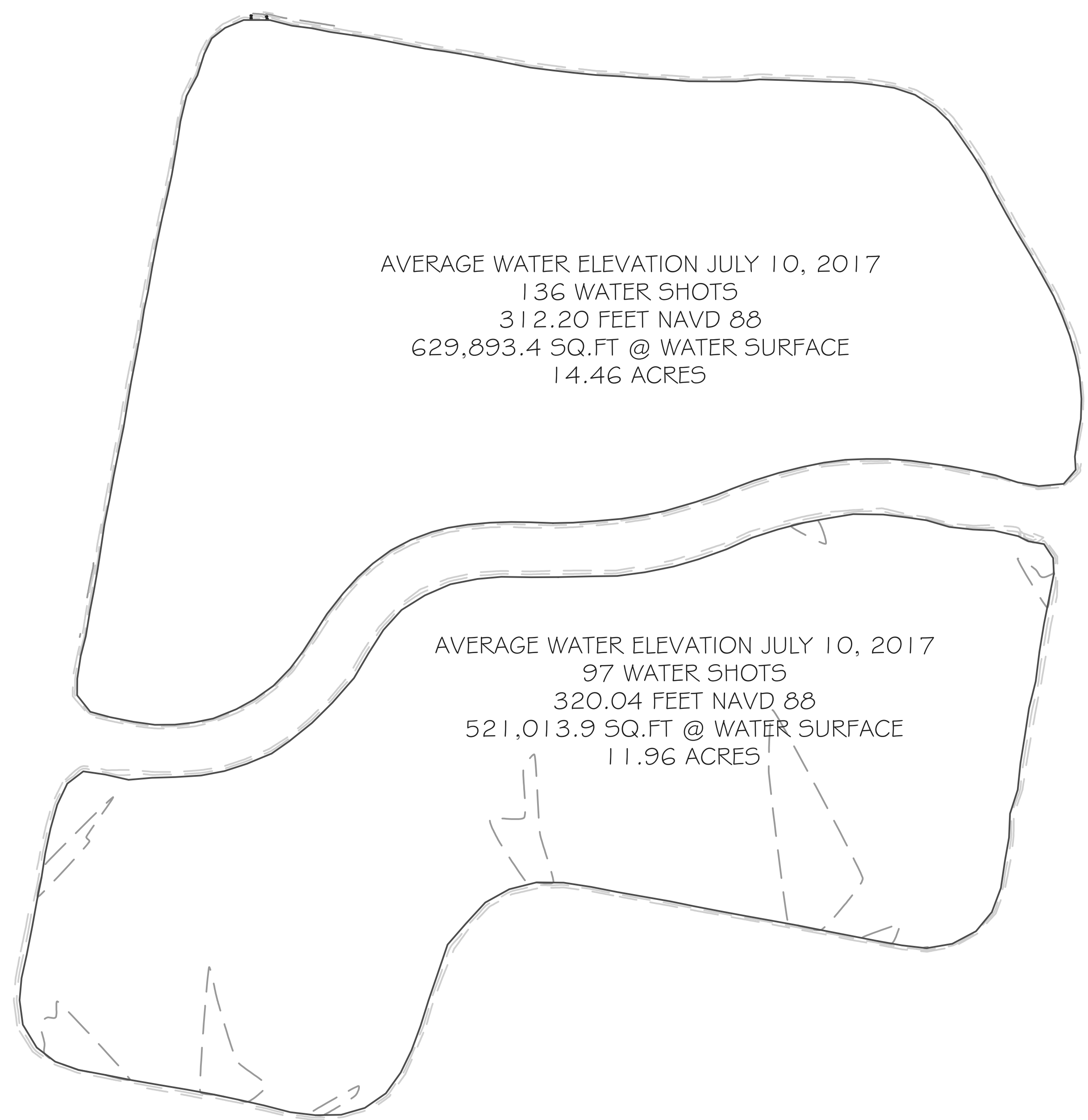
DATE: JAN 2007
DESIGNED: EGN
DRAWN: EGN
CHECKED: JCM
APPROVED: JCM

REV | DATE | DES | CHECK | APPROVALS | REVISION DESCRIPTION

TETRA TECH
7080 SW Fir Loop
Portland, Oregon 97223
503-684-9097 Fax: 503-598-0583

CITY OF MOLALLA
2008 NPDES PERMIT RENEWAL
Figure 4
DESIGN DATA 2

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"



PREPARED BY:

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DATE SIGNED:

PREPARED FOR:

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REVISIONS

NO.	DESCRIPTION	DATE	BY

PROJECT NO:	####
HORIZ DATUM:	####
VERT DATUM:	####
HORIZ SCALE:	AS SHOWN
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DESIGN:	####
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SHEET TITLE

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Appendix C

Data Collection Table

City of Molalla
Lagoon Leak Test Data Sheet

Date/Time	Pump Station Meter (Totalizer - Gal.)	DAF No. 1 Meter (MG)		DAF No. 2 Meter (MG)		Precipitation (In.)	Temp (°F)	Biosolids Haul Away Total (MG)	Staff Gauge Reading		
		8:00 am Total	12:00 am Total	8:00 am Total	12:00 am Total				Lagoon 1	Lagoon 2	
7/10 0800	358848216	Ø	Ø	Ø	Ø	Ø	70	Ø	58.55"/9.4	10.1	
7/11 0800	359082681	0.095	0.209	0.197	0.450	Ø	67	Ø	58.55"	-2.25"	
7/12 0800	359970920	0.095	0.259	0.243	0.654	Ø	67	Ø	59.75"	-2.50	
7/13 0800	360869830	0.099	0.261	0.276	0.656	Ø	63	Ø	59.00"	-4.25	
7/14 0800	361722693	0.097	0.283	0.212	0.739	Ø	66	Ø	58 15/16"	-1 2/16"	
7/15 0800	362613602	0.081	0.282	0.178	0.632	Ø	67	Ø	59 15/16"	-1 8/16"	
7/16 0810	363429654	Ø	Ø	0.007	Ø	Ø	64	Ø	59 15/16"	+5 12/16"	
7/17 0800	364345842	Ø	Ø	Ø	Ø	Ø	67	Ø	60.00"	+5.25"	
7/18 0800	365211963	0.081	0.228	0.306	0.705	Ø	68	Ø	59.50"	-5 3/16"	SHUT DOWN BP
7/19 0800	367021890	0.075	0.263	0.167	0.570	Ø	66	Ø	57 00"	-1.00"	BP
7/20 0800	369976693	0.076	0.222	0.406	0.709	Ø	66	Ø	53.25"	-4 8/16"	BP - IRL

Appendix D

Data Entry and Analysis Spreadsheet

City of Molalla
2017 Lagoon Leak Test
July-17
Transfer Pump Station Meter Readings

	Totalized Meter Readings (gal)	Daily Flow		
	8:00:00 AM	(gal)	(in)	Test Day
Monday, July 10, 2017	358,848,216			
Tuesday, July 11, 2017	359,082,681	234,465	0.33	Day 1
Wednesday, July 12, 2017	359,970,920	888,239	1.24	Day 2
Thursday, July 13, 2017	360,869,830	898,910	1.25	Day 3
Friday, July 14, 2017	361,722,693	852,863	1.19	Day 4
Saturday, July 15, 2017	362,613,602	890,909	1.24	Day 5
Sunday, July 16, 2017	363,429,654	816,052	1.14	Day 6
Monday, July 17, 2017	364,345,842	916,188	1.28	Day 7
Tuesday, July 18, 2017	365,211,963	866,121	1.21	Day 8
Wednesday, July 19, 2017	367,021,890	1,809,927	2.52	Day 9
Thursday, July 20, 2017	369,120,278	2,098,388	2.92	Day 10
Friday, July 21, 2017				
Totals		10,272,062	14.32	

Lagoon Storage (gal/in)	717,399

City of Molalla
2017 Lagoon Leak Test
July-17
Lagoon Levels

Lagoon Properties at Test Depth						
	Depth	Volume			Slope of Staff Gauge	
	(ft)	Area	(gal/ft)	(gal/in)	(deg)	(rad)
Lagoon #1	9.4	521,014	3,897,185	324,765	N/A	N/A
Lagoon #2	10.1	629,893	4,711,603	392,634	16	0.27925268
Total		**1,150,907**	**8,608,787**	**717,399**	N/A	N/A

Lagoon No. 1						
	Reading	Change in Depth		Depth	Change in Volume	
	(in)	(in)	(ft)	(ft)	(gal)	
Monday, July 10, 2017	58.55			9.40		
Tuesday, July 11, 2017	58.55	0.000	0.000	9.40	0	Day 1
Wednesday, July 12, 2017	59.75	-1.200	-0.100	9.30	-389,718	Day 2
Thursday, July 13, 2017	59.00	0.750	0.063	9.36	243,574	Day 3
Friday, July 14, 2017	58.94	0.060	0.005	9.37	19,486	Day 4
Saturday, July 15, 2017	59.31	-0.370	-0.031	9.34	-120,163	Day 5
Sunday, July 16, 2017	59.94	-0.630	-0.053	9.28	-204,602	Day 6
Monday, July 17, 2017	60.00	-0.060	-0.005	9.28	-19,486	Day 7
Tuesday, July 18, 2017	59.50	0.500	0.042	9.32	162,383	Day 8
Wednesday, July 19, 2017	57.00	2.500	0.208	9.53	811,913	Day 9
Thursday, July 20, 2017	53.25	3.750	0.313	9.84	1,217,870	Day 10
Totals		5.30	0.442		1,721,257	

Lagoon No. 2						
	Reading	Change in Depth		Depth	Change in Volume	
	(in)	(in)	(ft)	(ft)	(gal)	
Monday, July 10, 2017	0.00			10.10		
Tuesday, July 11, 2017	-2.25	-0.62	-0.12	9.98	-243,432.80	Day 1
Wednesday, July 12, 2017	-2.50	-0.69	-0.08	9.90	-270,917.15	Day 2
Thursday, July 13, 2017	-4.25	-1.17	-0.09	9.81	-459,381.26	Day 3
Friday, July 14, 2017	-1.13	-0.31	-0.13	9.68	-121,716.40	Day 4
Saturday, July 15, 2017	-1.50	-0.41	-0.03	9.65	-160,979.76	Day 5
Sunday, July 16, 2017	5.50	1.52	0.13	9.78	596,803.00	Day 6
Monday, July 17, 2017	5.25	1.45	0.12	9.90	569,318.65	Day 7
Tuesday, July 18, 2017	-5.19	-1.43	-0.12	9.78	-561,465.98	Day 8
Wednesday, July 19, 2017	-1.00	-0.28	-0.02	9.76	-109,937.39	Day 9
Thursday, July 20, 2017	-4.50	-1.24	-0.10	9.66	-486,865.61	Day 10
Totals		-3.18	-0.265		-1,248,575	

City of Molalla
2017 Lagoon Leak Test
July-17
DAF Meter Readings

	DAF No. 1					DAF No. 2				
	Meter Readings (MG)		Daily Flow			Meter Readings (MG)		Daily Flow		
	8:00:00 AM	11:55:00 PM	(MG)	(in)	Test Day	8:00:00 AM	11:55:00 PM	(MG)	(in)	Test Day
Monday, July 10, 2017	0	0				0	0			
Tuesday, July 11, 2017	0.095	0.209	0.095	0.13	Day 1	0.197	0.45	0.197	0.27	Day 1
Wednesday, July 12, 2017	0.095	0.259	0.209	0.29	Day 2	0.243	0.654	0.496	0.69	Day 2
Thursday, July 13, 2017	0.099	0.261	0.263	0.37	Day 3	0.276	0.656	0.687	0.96	Day 3
Friday, July 14, 2017	0.097	0.283	0.259	0.36	Day 4	0.212	0.739	0.592	0.83	Day 4
Saturday, July 15, 2017	0.081	0.282	0.267	0.37	Day 5	0.178	0.632	0.705	0.98	Day 5
Sunday, July 16, 2017	0.000	0.000	0.201	0.28	Day 6	0	0.000	0.454	0.63	Day 6
Monday, July 17, 2017	0.000	0.000	0.000	0.00	Day 7	0.000	0.000	0.000	0.00	Day 7
Tuesday, July 18, 2017	0.081	0.228	0.081	0.11	Day 8	0.306	0.705	0.306	0.43	Day 8
Wednesday, July 19, 2017	0.075	0.263	0.222	0.31	Day 9	0.167	0.570	0.566	0.79	Day 9
Thursday, July 20, 2017	0.076	0.222	0.264	0.37	Day 10	0.406	0.709	0.809	1.13	Day 10
Totals			1.861	2.59				4.812	6.71	

Lagoon Storage (gal/in)	717,399

City of Molalla
2017 Lagoon Leak Test
July-17
Evaporation

	Evaporation Pan Depth		
	Logger Reading 8:00 AM (in)	Change in Level (in)	Test Day
Monday, July 10, 2017	8.008		
Tuesday, July 11, 2017	7.704	-0.304	Day 1
Wednesday, July 12, 2017	7.464	-0.240	Day 2
Wed Water Level Adjustment	7.238		
Thursday, July 13, 2017	7.033	-0.205	Day 3
Friday, July 14, 2017	6.863	-0.170	Day 4
Saturday, July 15, 2017	6.630	-0.233	Day 5
Sunday, July 16, 2017	6.358	-0.272	Day 6
Monday, July 17, 2017	6.111	-0.247	Day 7
Tuesday, July 18, 2017	5.860	-0.251	Day 8
Wednesday, July 19, 2017	5.590	-0.270	Day 9
Thursday, July 20, 2017	5.330	-0.260	Day 10
Total		-2.452	

Precipitation & Pan Coefficient Adjustments	
Evaporation (in)	-2.452
Pan Coefficient	0.8
Corrected Evaporation (in)	-1.962
Lagoon Storage (gal/in)	717,399
Evaporation Total (gal)	-1,407,250

City of Molalla
2017 Lagoon Leak Test
July-17
Volume Summary

Flow Element	Total Flow 10 Day Test Period (gal.)	Avg. Daily Flow 10 Day Test Period (gal./day)
Lagoon Influent Flow	10,272,062	1,027,206
Precipitation	0	0
Lagoon 1 Storage	-1,721,257	-172,126
Lagoon 2 Storage	1,248,575	124,857
Lagoon Effluent (DAF No. 1)	-1,861,000	-186,100
Lagoon Effluent (DAF No. 2)	-4,812,000	-481,200
Evaporation	-1,407,250	-140,725
Balance/Seepage	1,719,130	171,913

Appendix E

Oregon DEQ Guidelines for Estimating Leakage from Existing Sewer Lagoons

State of Oregon

Department of Environmental Quality Guidelines

Guidelines for Estimating Leakage from Existing Sewage Lagoons

PURPOSE AND SCOPE

These guidelines provide for relatively inexpensive test equipment and procedures to be used for prioritizing problem lagoons used for treating domestic sewage. Such tests are not definitive. They should be considered preliminary and approximate.

Tests based on these guidelines can only indicate whether the seal on an existing lagoon probably remains intact, or approximately how much it may be leaking. Preliminary tests of this type are not suitable for sewage lagoons where there is a strong likelihood of contamination, or an immediate urgency to protect a priority aquifer.

EXCLUSIONS

Such preliminary testing is not suitable for various types of lagoons which may contain stronger wastes than sewage. For example, leak tests for sludge, septage, strong industrial wastes, and landfill leachate lagoons may warrant a higher level of accuracy. To attain greater accuracy entails considerable time and expense, requires more equipment to develop wind and temperature records, and involves calculations outside the scope of these guidelines.

Such accuracy is seldom warranted for sewage lagoons. In critical groundwater pollution situations, where lagoon seepage is a known concern, immediate installation of monitoring wells and a formal program of groundwater monitoring are normally warranted. In such situations, no program of leak testing is probably accurate enough to substitute for direct groundwater monitoring. Leak testing would only delay the definitive determinations that must be made.

GENERAL APPROACH

The general objective of a leak test is to estimate the average rate of seepage through the bottom of the lagoon. Normally each lagoon cell is isolated and tested separately, which better pinpoints the location of any major leaks. The rate of seepage is expressed in inches per day or centimeters per second.

Leak testing should be restricted to July and August, when rainfall is minimal and the ground is dry enough to exclude significant runoff. Tests conducted at other times will have more variables and may underreport seepage due to runoff effects.

To obtain reasonable precision, each cell of a lagoon should be isolated and tested over a period of 10 - 15 days. Cell depth and pan evaporation measurements should be taken daily. If the lagoon cell cannot be isolated, then daily influent/effluent flows must also be measured. Daily measurements are preferred over weekly to improve precision and to minimize random measurement errors.

Lagoon liquid depth should suit the purpose of the test. To determine average seepage rates, lagoons should be at average operating depth.

In priority areas, any rate of seepage greater than zero may warrant direct sampling and monitoring of the groundwater. Seepage of 1/8" per day or less is normal. However, this low rate can cause groundwater contamination where lagoon contents are strong and background levels are high quality. Seepage exceeding 1/4" per day indicates a seal failure, or absence of adequate initial seal.

EQUIPMENT REQUIREMENTS

Each cell of a lagoon needs to be equipped with a staff gauge for level measurements. Stilling wells to dampen wave action are recommended, and will allow a staff gauge to be read to 1/8" - 1/16". Precipitation can be measured to about 1/100" with a good rain gauge. Evaporation can be measured to roughly 1/1000" with a hook gauge.

The following specifications for rainfall and evaporation equipment are based on Weathertronics equipment manufactured by Qualimetrics, Inc. of Sacramento, and available in Oregon through International Reforestation Supply, Eugene (345-0597). Equivalent equipment is acceptable.

1. Rain Gauge. Qualimetrics Model 6330. This is a plastic gauge with 11" capacity and 0.01" graduations, designed for post mounting.

2. Evaporation Pan. Qualimetrics Model 6821. This is a standard US Weather Bureau steel pan, 47.5" diameter by 10" deep.

3. Hook Gauge. Qualimetrics Model 6831. This is a brass gauge with 0.02" graduations.

To obtain accurate measurements, the equipment needs to be set up level and plumb in an unsheltered area near the lagoon. Equipment may have to be fenced to exclude animals.

The above list is a minimum. Various equipment needed to attain higher levels of accuracy is not listed. For example:

- Recording anemometer

- Max/min thermometers for air, for the evaporation pan, and for the lagoon surface

· Upwind and downwind evaporation pans

· Barometric pressure

If such equipment is available, its use will add precision and accuracy to the results. However, its use is not mandatory for preliminary leak tests used to screen and prioritize existing sewage treatment lagoons.

MEASUREMENTS AND CALCULATIONS

Measurements should be made on a schedule, at the same time each day, so that each set of data represents the duration of exactly one day. All measurements should be tabulated to aid calculation and reporting. We recommend using the attached form or a similar format.

Computations should be converted to compatible units of depth. Influent volume (gallons per day) is converted to inches per day through measurement of the actual water surface area. Rainfall will normally be near zero in July and August, but should be verified daily.

Evaporation will vary with wind and temperature. It should be measured daily, and the pan should be kept well filled.

Lagoon evaporation rates are invariably less than pan evaporation rates. Pan correction factors generally vary from 0.7 to 0.9. The larger the lagoon, the more its evaporation rate lags behind pan evaporation, so the smaller the numerical value of the pan correction factor.

In hot and windy summer weather, evaporation can be substantial. An erroneous pan correction factor can inject significant error. The result of computing seepage rates without any correction for pan evaporation is to overcalculate the evaporation rate. The effect of this error would be to underreport the seepage rate.

REPORT FORMAT

Leakage reports should be short and to the point. The main conclusion is to estimate the seepage rate from each lagoon cell, and from the lagoon as a whole. The methodology and equipment need to be described briefly but thoroughly. A copy of all field measurements and calculations should be tabulated and attached as supporting documentation.

Reports should be certified and signed by a registered engineer or professional hydrologist.

ANNUAL WATER BALANCE

The annual water balance prepared for each lagoon requires determinations of both seepage and evaporation. Leak tests performed according to these guidelines at average liquid depth can establish an average rate of seepage for the water balance. The rate of seepage will tend to vary with liquid level, and will remain constant if the level stays constant.

For the purpose of making water balance calculations, a monthly average evaporation rate should be obtained from local climatological records. Such records may then be applied with a suitable pan correction factor between 0.7 and 0.9, as previously described.

Rate of evaporation and pan correction factors both tend to vary throughout the year. To make accurate adjustments requires additional measurements be taken of all the pertinent factors. These include wind, water temperature, air temperature, and atmospheric pressure. Pan evaporation corrections should conform to established calculation methods, as presented in standard hydrology texts.

NEW LAGOONS

New sewage and sludge lagoons are designed to be effectively watertight and nearly leak-free. Lagoons which may jeopardize groundwater because of their contents, uses, or location are routinely installed with groundwater monitoring wells. In such applications, leak testing is not a practical or reliable alternative to direct monitoring of the groundwater.

All of the measurements in leak tests are approximations, especially liquid level, and the pan correction factor is usually a rough estimate. Consequently, seepage computed from a leak test cannot be used to prove or substantiate the existence of any actual leak. Leak testing as a basis for acceptance of lagoon construction is not feasible, too often has led to fruitless litigation, and should be discouraged.

As a practical matter, the engineer must design each lagoon for watertightness. Then the engineer must conduct thorough, intensive, and continuous construction inspection to verify that watertight construction is being attained. Inspection may include compaction, infiltrometer, smoke, and spark tests, and constant observation of workmanship and materials.

If leakage and contamination occurred from a properly inspected and certified lagoon, it would indicate a damaged liner or a failure of design. Assuming good design and inspection, the engineer's written certification of proper construction carries a presumption of watertightness. No leak testing program should be approved as a substitute for diligent construction inspection.

INQUIRIES

Inquiries about these guidelines should be directed to DEQ regional water-quality plan review engineers.

DSM:LAGOON2.TST

Orig. V.93

Rev1. VIII.94

LAGOON LEAK TEST

CITY OF ________________________

CELL NO._____ WATER SURFACE AREA__________

CELL WATER DEPTH @ TEST START________ @ TEST END____________

Date	INFLUENT (in/day)	+PRECIP (in/day)	-EVAP (in/day)	- EFFLUENT (in/day)	=NET SEEPAGE

NOTES: