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PACIFIC SALMON FOUNDATION

‘Namgis/Kuterra Closed Containment Project

Independent Environmental Monitor (IEM) Final Report for Tides Canada

August 12, 2015

The following report contains summary comments relating to the objectives of the ‘Independent Environmental Monitoring Program’ (IEMP) that was produced for this project in February, 2012. Much has been learned since the arrival of the first fish in March, 2013 and the IEMP has been adjusted to reflect the realities of the Kuterra RAS operation once in full production mode. This Final Report summarizes IEMP activities up to the completion of harvest of the 3rd cohort of Atlantic Salmon produced at Kuterra.

1. Goal of the Independent Environmental Monitoring Program (IEMP)

“The main aim of the IEMP and the duties of the Monitor (IEM) are to ensure that appropriate monitoring takes place and, where necessary, mitigation is undertaken to ensure the surrounding environment is not subjected to any unacceptable impacts from this operation.” (IEMP, Feb. 2012).

Overall, the goals of the IEMP have been met or exceeded, with some of the proposed objectives having been adapted to reflect the environmental impact realities encountered, now that the pilot facility has completed a full production cycle; i.e. Cohorts #1 - 3 having been received, reared, and processed out of the facility and Cohorts #4 – #7 presently being held.

The main focus of environmental monitoring activities has been to track the water quality of the liquid effluent at the point of discharge to the infiltration basins. The section of the Tides Canada ‘**Proposed Performance Metrics for Land-Based Salmon Aquaculture Projects’** relating to **Environment** has been used as a basis for liquid effluent monitoring. (Table 2. IEMP. February, 2012). The IEM has had access to, and routinely checked, all of the production and environmental data that has been entered into the Kuterra Production Performance Matrix.

Additional monitoring of potential impacts such as Groundwater Impacts, Surface Water Drainage/Control, Odor and Noise and Waste Management, which were brought forward as concerns during the Public Information Sessions, has also taken place throughout the duration of the IEMP. (Table 3. IEMP. February, 2012).

2. Liquid Effluent Water Quality Monitoring

2.1 Characterization of liquid Effluent

Testing of the liquid effluent that is being discharged into the infiltration basins has continued to show levels of Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Nitrogen (TN) and Total Phosphorous (TP) that are significantly lower than the predicted levels; a summary of these test parameter values and the resulting total discharge amounts of (TN), (TP) and (TSS) follows (Table 1 & Figure 1). The evident reduction, since around April, 2014, in the amounts of these nutrients being discharged with the liquid waste indicates that the improvements made to the Kuterra effluent treatment works have resulted in higher quality effluent, even as the biomass of fish in the system was increasing. Further evidence of improvements in effluent treatment is shown in the following section (Sludge Monitoring) in that the percentage of solids in the sludge has risen over the same period of time.

2.2 Review of water quality testing parameters required in the 'Performance Metrics'

The suite of water quality analysis items that are included in the 'Performance Metrics' dataset contains a number of parameters that are not considered to be essential for successful operation of the RAS fish-culture system or are not required to define the environmentally significant features of the liquid effluent being discharged. The IEM has met with Kuterra Management (C. Dinneen) and the Sr. Fish Culture Technician (J. Burton) to review the essential parameters requiring regular testing as the project moves forward; Table 2 following contains a revised list of essential test parameters for consideration. **We suggest reducing the number of water quality test parameters to include only those that are needed for fish production or environmental impact monitoring.**

Table 1 below shows that average TN, TP and TSS values in the liquid effluent are, for the most part, below the 'Estimates of Effluent Character' levels that were projected by the Freshwater Institute. (S. Summerfelt. 2011). On a few occasions the average monthly TSS levels have been slightly higher than the 29 mg/L expectation (e.g. Feb. 2014) but these elevated levels have, for the most part, resulted from occasional problems with the final waste removal system. Improvements to the final waste filtering and handling system should result in levels that fall significantly below the Estimated Effluent Character target projections.

Table 1: Kuterra RAS Liquid Effluent Water Quality Summary: Mar. 18 2013 -May 31, 2015

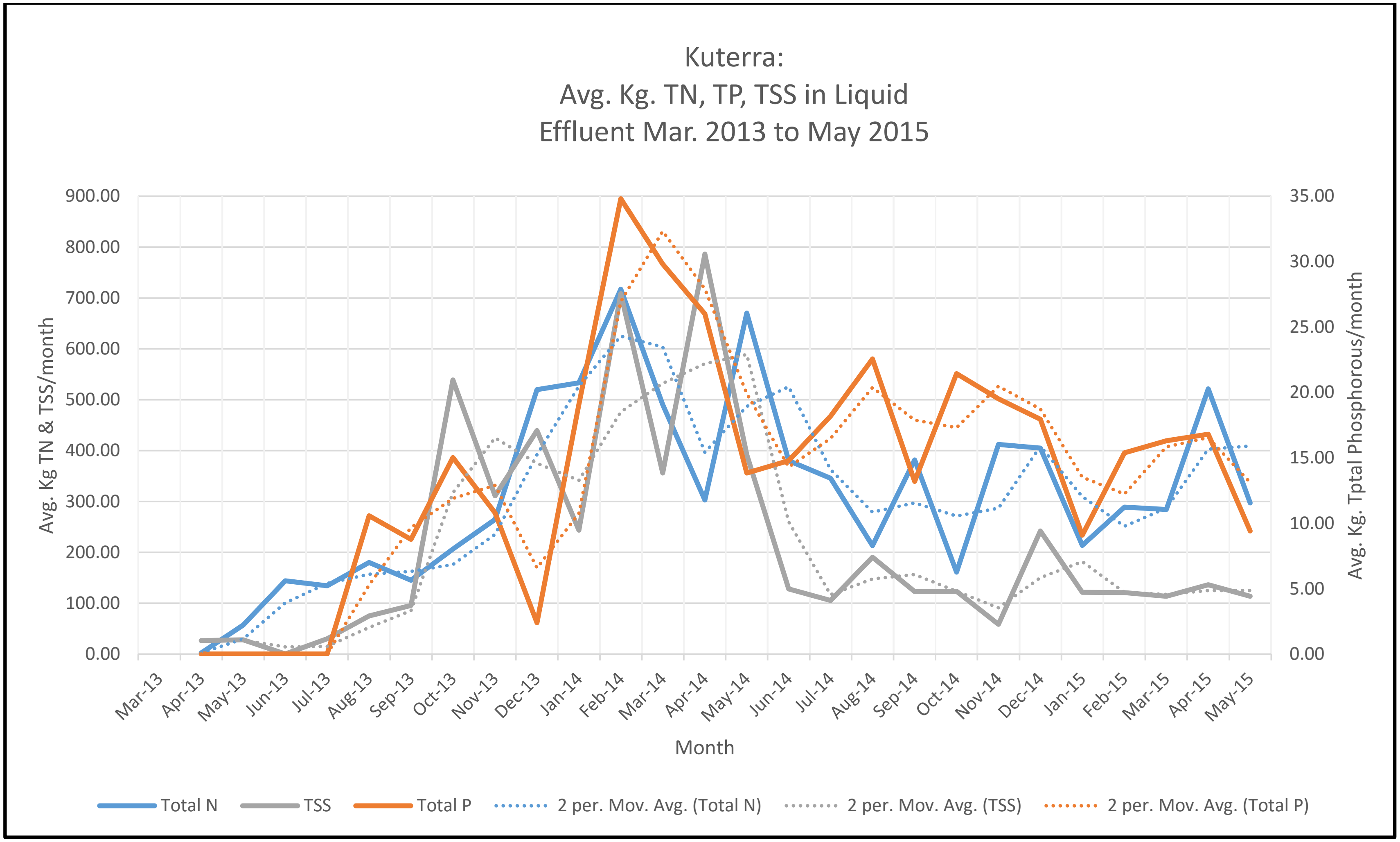
	Monthly Average Effluent Water Quality Parameters														Effluent Flows			Month Total Effluent Discharge*			TN (Kg/month)	TP (Kg /month)	TSS (Kg/month)
Month	Water °C	TAN (ppm)	TKN (ppm)	TN (ppm) (Projected max. = 99mg/L)	Nitrite (ppm)	Nitrate (ppm)	pH	Total Phos. (ppm) (Projected max. = 4.4 mg/L)	TSS (ppm) (Projected max. = 29 mg/L)	BOD (ppm)	COD (ppm)	TDS	Turb. (NTU)	Salinity (ppt)	Quar (avg. LPM)	Grow out (avg. LPM)	Total (avg. LPM)	Quar (m3)	Growout (m3)	Total (m3)			
Mar-13	10.7	0.595	0.000	0.00	0.180	0.000	7.2			<5.0				0.0	91	0	91	1844	0	1844			
Apr-13	11.3	0.230	0.060	0.87	0.136	11.000	7.2		11.0	<5.0				2.0	56	0	56	2413	0	2413	2.10	0.00	26.54
May-13	13.7	0.377	4.603	15.73	0.185	29.560	7.1		7.8	<5.0				3.4	81	0	81	3613	0	3613	56.82	0.00	28.00
Jun-13	15.1	0.763	0.000	21.70	0.077	40.333	7.0		0.0	<5.0				6.2	154	0	154	6642	0	6642	144.13	0.00	0.00
Jul-13	16.2	1.306	11.150	44.73	0.253	32.840	7.1		10.0	8.2	0.0	1071.0		1.3	67	0	67	2995	0	2995	133.99	0.00	29.95
Aug-13	16.7	1.571	6.440	39.25	18.135	80.100	7.4	2.300	16.3	12.5	0.0	1125.0		1.4	103	0	103	4593	0	4593	180.26	10.56	75.01
Sep-13	13.5	0.728	11.100	43.00	0.310	73.867	7.5	2.600	28.4	21.0	0.0			4.4	78	0	78	3370	0	3370	144.89	8.76	95.70
Oct-13	12.4	0.840	0.000	11.50	0.205	7.200	7.5	0.837	30.0		25.0			3.0	132	270	402	5910	12050	17960	206.54	15.03	538.79
Nov-13	12.5	0.913	1.730	24.00	0.320	43.733	7.3	0.979	28.3	27.0	19.0			4.0	39	216	255	1666	9350	11016	264.38	10.78	311.20
Dec-13	10.9	0.565	12.400	35.50	0.185	26.100	7.2	0.163	30.0		29.0			1.8	83	245	328	3697	10938	14636	519.57	2.39	439.07
Jan-14	12.4	0.363	1.670	36.10	0.125	35.400	7.1	1.293	16.5	11.0	61.5			3.4	69	262	331	3083	11687	14770	533.20	19.10	243.71
Feb-14	13.0	0.000	13.800	41.00	0.000	0.000	0.0	1.990	40.5	34.0	118.0			3.8	60	374	434	2419	15068	17487	716.98	34.80	708.24
Mar-14	13.6	0.830	0.000	15.85	0.497	40.750	7.0	0.964	11.5	13.0	84.5	168.0		2.9	110	583	693	4896	26034	30930	490.24	29.82	355.69
Apr-14	13.0	1.076	0.080	12.33	0.218	37.950	7.0	1.059	32.0	9.8	72.0			2.4	127	441	569	5495	19070	24565	302.97	26.01	786.08
May-14	13.5	1.717	1.397	38.15	0.100	58.150	7.1	0.787	22.3	10.5	68.5	2480		2.5	108	285	394	4838	12730	17568	670.22	13.83	391.77
Jun-14	14.3	0.573	1.030	20.81	0.375	34.200	7.1	0.809	7.0	4.6	15.5	2200	3.15	1.7	137	286	423	5904	12355	18259	380.03	14.78	127.81
Jul-14	15.7	0.579	0.620	23.00	0.060	64.900	7.1	1.210	7.0	4.1	35.0	2220	2.69	1.7	144	193	337	6425	8597	15022	345.51	18.18	105.15
Aug-14	13.0	0.917	1.380	16.80	0.070	66.250		1.779	15.0		153.0		2.68	2.2	134	150	284	5982	6696	12678	212.99	22.55	190.17
Sep-14	13.0	1.099	4.900	31.10	0.180	62.733	7.1	1.076	10.0	9.0	11.8	53	2.33	3.4	134	150	284	5789	6480	12269	381.56	13.20	122.69
Oct-14	14.0	0.781	2.375	12.72	0.150	81.567	7.8	1.690	9.8		11.9	42	2.19	5.2	134	150	284	5982	6696	12678	161.20	21.43	123.61
Nov-14	12.5	0.884	1.850	33.60	0.157	53.186	7.0	1.590	4.8	6.0	16.6	99	2.79	5.9	134	150	284	5789	6480	12269	412.23	19.51	58.28
Dec-14	13.0	1.291	3.230	25.10	0.010	76.400	7.1	1.113	15.0	8.0	61.0	232	5.78	5.0	134	228	361	5967	10168	16135	404.99	17.95	242.03
Jan-15	13.5	1.100	0.000	16.10	0.140	51.100	7.1	0.685	9.2		4.8	63	2.20	3.4	70	228	297	3105	10168	13273	213.70	9.09	121.45
Feb-15	13.0	1.000	0.600	28.80	0.090	66.800	6.9	1.533	12.1	55.0	85.0	195	1.79	2.4	21	228	249	850	9184	10034	288.98	15.38	120.91
Mar-15	13.0	0.130	#DIV/0!	22.50	0.052	49.900	7.1	1.290	9.0	8.8	50.0		1.44	3.6	55	228	283	2463	10168	12631	284.19	16.29	113.67
Apr-15	10.6	0.560	#DIV/0!	38.50	0.050	81.667	7.1	1.242	10.1	5.0	35.0		1.67	5.3	80	234	313	3446	10090	13536	521.15	16.81	136.27
May-15	10.3	0.100	#DIV/0!	26.20	0.010	0.000	7.0	0.830	10.0	5.0	30.0		2.62	5.4	65	189	254	2908	8432	11340	297.10	9.41	113.40
																			TTD	**334524**	**8269.90**	**365.65**	**5605.18**

***Notes: - Effluent chlorinated and de-chlorinated before discharge to infiltration basins**

- TN = Total Nitrogen in Suspended Solids + Disolved

xx.xx = inferred vales - no sample data available

- Previous versions of this table contained errors that resulted from inclusion of pump by-pass and purge overflows being used in the calculations.


Kuterra:
Avg. Kg. TN, TP, TSS in Liquid
Effluent Mar. 2013 to May 2015
Avg. Kg TN & TSS/month
Avg. Kg. Tptal Phosphorous/month
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
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Nov-13
Dec-13
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Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Month
Total N
TSS
Total P
2 per. Mov. Avg. (Total N)
2 per. Mov. Avg. (TSS)
2 per. Mov. Avg. (Total P)

Table 2: Kuterra Water Quality Sampling Metrics - Revised Rationale for Parameters To Be Tested - June, 2015

								Quarantine & GO Systems		Liq. Effluent	
Parameter	Reason For Testing	Recommended In-House Test Frequency	Recommended External Lab Test Frequency	Sample Collection Location	Upper Limit	Lower Limit	Optimum	Req'd. for Fish Culture (Y/N)	Reason for Exclusion from GO & Q testing	Req'd. for Effluent Characteri-zation (Y/N)	Reason for Exclusion from Effluent testing
Water °C	Feed and Growth Rate Management	Daily	n/a	Well supply water and GO & Q systems	18 C	8C	15C	Y		N	Discharged to ground at ambient temp.
TAN (ppm)	Monitoring biofilter efficiency for safe culture limits	Weekly	n/a	GO & Q Systems @ LHO's				Y		N	Discharge to ground - highly variant in shallow receivingaquifer
TN (ppm)	NH3-N + NO3-N + NO2-N + Organic N. Used with total outflow to calculate Kg/m3 and receiving environment impact	Monthly	Annually with screening of all well supplies	At final point of liquid effluent discharge to ground				N	Not critical as a test if TAN, NO3, NO2 being measured in culture systems	Y	Req'd. to determine Total Nitrogen discharged to environment
Nitrite (ppm)	Required to monitor biofilter performance	Weekly	Annually with screening of all well supplies	GO & Q Systems @ LHO's	0.5 mg/l	0 mg/l	<0.06 mg/l	Y		N	Discharge to ground - highly variant in shallow receivingaquifer
Nitrate (ppm)	Required to monitor biofilter performance	Weekly	Annually with screening of all well supplies	GO & Q Systems @ LHO's				Y		N	Discharge to ground - highly variant in shallow receivingaquifer
pH (Probe)	Needed to calculate NAOH additions	Daily - continuous	n/a	GO & Q System sumps	8.5	6.5	7.2	Y		N	WIll always be within acceptable limites (6.5-7.5)
O_2 (% Sat)	Required to ensure safe culture levels and monitor LHO performance	Daily - continuous	n/a	At outlet of each tank in GO & Q systems	120%	100%	110%	Y		N	Discharge to ground - low DO would be of concern only if discharged to surface waters
O_2 (ppm)	Required to ensure safe culture levels and monitor LHO performance	Daily - continuous	n/a	At outlet of each tank in GO & Q systems	10.0 mg/l	8.0 mg/l	>9.0 mg/l	Y		N	Discharge to ground - low DO would be of concern only if discharged to surface waters
T-Phos./TP (ppm)	Used with total outflow to calculate Kg/m3 and receiving environment impact. (?Correlation with uneaten food?)	Monthly	Annually with screening of all well supplies	At final point of liquid effluent discharge to ground	5.0 mg/l	0 mg/l	<1.0 mg/l	N	Not critical for fish culture - req'd. to determine Kg. of TP in liquid effluent	Y	Req'd. to determine Total Phosphorous discharged to environment
TSS (ppm)	Required to determine suspended organic load in culture tanks. Req'd. to calculate solids in liquid effluent discharge. Correlated to Turbidity	Monthly	Annually with screening of all well supplies	GO & Q Systems @ LHO's and at effluent outflow	100 mg/l	0 mg/l	<3.0 mg/l in culture systems; <10 mg/l in effluent	Y	Not citical if Turbidity being measured	Y	Req'd to determine TN & TP discharge to environment
CO_2 (ppm)	Ph impacts, loading density calcs. Can vary in well supplies, sometimes high.	Weekly until stable	n/a	GO & Q Systems at culture tank outlets	20 mg/l	0	<10 mg/l	Y		N	Discharge to ground - would be of concern only if discharged to surface waters
COD (ppm)	Req'd. to determine total oxygen demand of waters discharged to gorund.	Monthly	Annually with screening of all well supplies	At final point of liquid effluent discharge to ground	60 mg/l	0 mg/l	<10 mg/l	N	Not critical for fish culture if O2 levels maintained at optimum - req'd. to determine potential O2 depletion in receiving environment/aquifer	Y	
BOD (ppm)	Originally required but the BC Mun. Waste Discharge Regs. suggest COD as sufficient.	n/a	Annually with screening of all well supplies	At final point of liquid effluent discharge to ground	30 mg/l	0 mg/l	<5.0 mg/l	N	Not critical for fish culture if O2 levels maintained at optimum	N	COD a more meaningful test - background BOD widely variant in shallow receiving aquifer.
Salinity (ppt)	Ideally measure output from each production well to determine fluctuations.	Weekly	n/a	GO & Q Systems @ LHO's and at effluent outflow	20 ppt	1.0 ppt	6-8 ppt	Y		Y	More impportant to check Geothermal/monitoring wells for NaCl/effluent intrusion. Effluent salinity parallels system waters.
Alkalinity (ppm CaCO3)	Affects buffering capacity of supply waters and in culture systems	Weekly	Annually with screening of all well supplies	GO & Q Systems @ LHO's	200 mg/l	15 mg/l	>80.0 mg/l	Y		N	Not critical - gravel/sand matrix in infiltration ponds provides adequate for buffering.
Calcium Hardness (ppm)	Affects buffering capacity of supply waters and in culture systems	Quarterly	Quarterly to confirm in-house lab results	GO & Q Systems @ LHO's	120 mg/l	40mg/l	>80 mg/l	Y		N	Not critical - gravel/sand matrix in infiltration ponds provides adequate buffering.
Turbidity (NTU)	Important indicator of TSS and possibly bacteria sloughed from bio-filters. Determine correlation with TSS in effluent.	Weekly	Annually with screening of all well supplies	GO & Q Systems @ LHO's and at effluent outflow	3.0 NTU	0.0 NTU	<0.3 NTU in culture systems; <5.0 NTU in effluent	Y		Y	

Table 3: Summary of Water Quality Parameters - revised June, 2015

Inflow GO & Q Systems WQ Testing

Parameter	Water °C	TAN (am) (ppm)	Nitrite (ppm)	Nitrate (ppm)	pH (Probe)	O_2 (% Sat)	O_2 (ppm)	CO_2 (ppm)	Salinity (ppt)	Alkalinity (ppm CaCO3)	Calcium Hardness (ppm)	Turbidity (NTU)
Frequency	Daily	Weekly	Weekly	Weekly	Continuous	Continuous	Continuous	Weekly	Daily	Weekly	Quarterly	Daily

Effluent WQ Testing

Parameter	TN (ppm)	T-Phos./TP (ppm)	TSS (ppm)	COD (ppm)	Salinity (ppt)	Turbidity (NTU)
Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Bi-weekly

Note: All well sources (including geothermal wells) to have complete WQ scan at least annually

2.3 Liquid Effluent Disposal/Dispersal and Treatment

The liquid effluent that is discharged from the Kuterra RAS facility first passes through rotary drum filters to remove the larger (>40 *u*m) solid waste particles and then it flows into 3 final settling cones where smaller particles are removed from the liquid effluent stream. The clarified effluent then passes through an optional chlorination/de-chlorination system where any possible pathogens can be rendered inactive and, finally, the effluent is discharged into large infiltration basins where it is absorbed by the underlying gravel/cobble substrate.

2.3.1 Liquid Effluent Disposal/Dispersal

The effluent infiltration basins are designed to be virtually dry under most discharge conditions so that there is no 'ponding' of the effluent that could result in stagnant water that could be attractive to birds or unwanted insect growth. Over the past year or so the substrate lining the infiltration basins appears to be plugging up with fine, suspended solids and some ponding of effluent has been occurring in spite of routinely raking the surface layers of gravel. **It is recommended that occasional deeper raking (grousing) of the infiltration basin substrates take place in order to prevent effluent water ponding, thus extending the useful life of this part of the liquid effluent disposal system.**

2.3.2 Liquid Effluent Disinfection

A liquid effluent chlorination/de-chlorination system has been used at the Kuterra facility since May, 2013. Effluent disinfection was recommended as an extra-precautionary measure in the event that pathogens were detected in this waste stream. Recently completed viral assays of pre-treatment effluent waters has shown that no active viral pathogens are present and that, therefore, there is no need for continuous disinfection. (Ref. 4. below for discussion of liquid effluent and sludge viral testing). **The IEM recommends that routine liquid effluent disinfection can be discontinued but that the treatment system be kept in 'stand-by mode' so that it can be re-started if needed.**

3. Semi-solid Waste (Sludge) Monitoring and Removal

Sludge waste is collected in the final settling cones at the Kuterra facility and the accumulated sludge is regularly trucked off-site to the nearby Beaver Cove 'Sea Soil' composting facility. Normally, the sludge is removed from the site approximately every 2 weeks and the volumes removed are recorded; periodically, samples are taken of the sludge and sent to an external lab for analysis. A summary of sludge volumes removed and analysis results is shown in Table 3. It is interesting to note that the consistency of the sludge waste has changed over the past year (i.e. more solids and less water), again demonstrating the effectiveness of improvements made to that part of the waste recovery system. **We recommend that any sludge samples that are currently in the freezer be sent out for analysis and that additional samples be taken for in-house analysis of % dry, fixed and volatile constituents until consistent/reliable results are obtained.** Although reporting of dry weights of sludge removed is not presently required under Kuterra's Aquaculture Licence, the data would be useful if alternate methods of sludge disposal are being considered.

Table 4: Kuterra Sludge Disposal Record - Nov. 7, 2013 to May 31, 2015

Date	Total Vol. Removed From Site (m3)	Specific Gravity	Total Wet Weight Removed From Site (Kg.)	% Total (Dry) Solids	Total Dry Solids Removed From Site (Kg)	Total Fixed Solids (%)	Weight of Fixed Solids Removed From Site (Kg)	Total Volatile Solids (%)	Weight of Volatile Solids Removed From Site (Kg)	Total Nitrogen (% of Dry Solids)	Total N Removed From Site (Kg)	Total Phosphorous as P (g/Kg)	Total P Removed from Site(Kg)
11/7/2013	16	*1.020*	*16320*	*3.50%*	*571*	*3.59%*	*20.51*	*6.98%*	*39.88*	*5.59%*	*31.95*	*0.029*	*0.016*
12/18/2013	8.5	*1.020*	*8670*	*4.50%*	*390*	*3.59%*	*14.01*	*6.98%*	*27.24*	*5.59%*	*21.81*	*0.029*	*0.011*
12/23/2013	32	1.027	32864	3.45%	1134	1.07%	12.13	2.38%	26.98	5.12%	58.05	0.028	0.032
3/3/2014	50	1.095	54750	18.50%	10129	7.24%	733.32	11.20%	1134.42	5.43%	549.99	0.045	0.456
4/11/2014	55	1.012	55660	4.67%	2599	0.83%	21.57	3.84%	99.81	6.61%	171.82	0.017	0.044
4/23/2014	30.25	1.025	31006	14.80%	4589	4.57%	209.71	10.20%	468.07	5.60%	256.98	0.028	0.128
5/28/2014	40	*1.020*	40800	11.50%	4692	4.24%	198.94	7.29%	342.05	5.21%	244.45	0.025	0.117
6/9/2014	45	*1.020*	*45900*	*8.70%*	*3995*	*3.59%*	*143.41*	*6.98%*	*278.90*	*5.59%*	*223.44*	*0.029*	*0.114*
6/26/2014	50	1.020	51000	3.66%	1867	0.89%	16.61	2.77%	51.70	4.05%	75.60	0.033	0.062
7/14/2014	30	*1.020*	30600	*6.03%*	1845	1.17%	21.59	*4.86%*	89.68	*2.10%*	38.75	*0.024*	0.044
7/30/2014	50	*1.020*	*51000*	*7.93%*	*4045*	*3.08%*	*124.50*	*6.35%*	*256.80*	*5.09%*	*205.88*	*0.029*	*0.116*
9/10/2014	30	*1.020*	*30600*	*7.93%*	*2427*	*3.08%*	*74.70*	*6.35%*	*154.08*	*5.09%*	*123.53*	*0.029*	*0.069*
9/25/2014	30	*1.020*	*30600*	*7.93%*	*2427*	*3.08%*	*74.70*	*6.35%*	*154.08*	*5.09%*	*123.53*	*0.029*	*0.069*
10/14/2014	30	1.020	30600	3.40%	1040	27.70%	288.19	72.30%	752.21	4.20%	43.70	0.034	0.035
10/29/2014	30	1.020	30600	54.70%	16738	88.80%	14863.52	11.20%	1874.68	0.90%	150.64	0.021	0.352
11/12/2014	30	1.020	30600	29.50%	9027	73.20%	6607.76	26.80%	2419.24	2.00%	180.54	0.032	0.289
11/25/2014	20	1.020	20400	5.60%	1142	37.10%	423.83	62.90%	718.57		0.00	0.044	0.050
12/10/2014	30	1.020	30600	18.20%	5569	44.40%	2472.72	55.60%	3096.48	3.20%	178.21	0.054	0.301
12/23/2014	30	*1.020*	*30600*	*11.92%*	*3647*	*17.29%*	*630.49*	*17.30%*	*630.73*	*4.50%*	*164.03*	*0.031*	*0.113*
1/10/2015	20	1.020	20400	11.70%	2387	58.50%	1396.28	41.50%	990.52	2.90%	69.22	0.028	0.067
1/24/2015	30	1.020	30600	22.10%	6763	66.60%	4503.89	32.70%	2211.37	2.40%	162.30	0.025	0.169
2/7/2015	*30*	*1.020*	*30600*	*15.24%*	*4663*	*62.55%*	*2916.79*	*37.10%*	*1730.02*	*2.65%*	*123.57*	*0.031*	*0.144*
2/18/2015	*30*	*1.020*	*30600*	*15.24%*	*4663*	*62.55%*	*2916.79*	*37.10%*	*1730.02*	*2.65%*	*123.57*	*0.030*	*0.127*
3/4/2015	*40*	*1.020*	*40800*	*15.24%*	*6218*	*62.55%*	*3889.06*	*37.10%*	*2306.70*	*2.65%*	*164.76*	*0.031*	*0.132*
3/18/2015	*30*	*1.020*	*30600*	*15.24%*	*4663*	*62.55%*	*2916.79*	*37.10%*	*1730.02*	*2.65%*	*123.57*	*0.031*	*0.132*
4/2/2015	*20*	*1.020*	*20400*	*15.24%*	*3109*	*62.55%*	*1944.53*	*37.10%*	*1153.35*	*2.65%*	*82.38*	*0.031*	*0.132*
4/15/2015	*40*	*1.020*	*40800*	*15.24%*	*6218*	*62.55%*	*3889.06*	*37.10%*	*2306.70*	*2.65%*	*164.76*	*0.031*	*0.133*
4/29/2015	*30*	*1.020*	*30600*	*15.24%*	*4663*	*62.55%*	*2916.79*	*37.10%*	*1730.02*	*2.65%*	*123.57*	*0.031*	*0.137*
5/14/2015	*20*	*1.020*	*20400*	*15.24%*	*3109*	*62.55%*	*1944.53*	*37.10%*	*1153.35*	*2.65%*	*82.38*	*0.032*	*0.143*
5/27/2015	*30*	*1.020*	*30600*	*15.24%*	*4663*	*62.55%*	*2916.79*	*37.10%*	*1730.02*	*2.65%*	*123.57*	*0.032*	*0.144*
Total/*Avg.* **to Date**	**956.75**	*1.024*	**704170**	*12.39%*	**87023**	*21.60%*	**32852.40**	*19.18%*	**15817.48**	*4.31%*	**3074.41**	*0.031*	**2.655**

Notes:

-Values in Yellow based on actual results from North Island Labs (Maxxam).

-Other values (*italics*) inferred from lab averages. March - May /15 sample results TBA when received from lab

4. Virus Testing of System, Effluent Waters and Sludge

During April and May, 2015, considerable attention was focused towards determining whether the virus traces that were identified in most cohorts (five out of seven) during smolt screening are detectable in the final liquid effluent or in the sludge that is disposed of off-site. To that end, samples of influent, system and final effluent waters were submitted for virus presence assay at the BC Centre for Aquatic Health Sciences (CAHS) in Campbell River. Sludge samples were also sent to CAHS for target virus assay using Trizol-Chloroform-RNeasy extraction and RTqPCR methods. Water samples taken directly from Grow-out and Quarantine units returned strong positive results for virus presence but the effluent water, that was sampled immediately before the chlorine treatment system and the sludge samples, that were collected directly from the settling cones, returned either negative or very weak results (i.e. Ct values significantly higher (weaker) than the assay cut-off point. The results of the virus assays further re-enforces the conclusion that routine disinfection of the liquid effluent before discharge to the infiltration basins is not warranted. Again, **the IEM recommends that routine liquid effluent disinfection can be discontinued but that the treatment system be kept in 'stand-by mode' so that it can be re-started if needed.** The confidential lab results for all water and sludge testing, including virus assays, have been provided to Kuterra management.

The IEM recommends that samples of the final liquid effluent be submitted for RTqPCR assay at least once/year to monitor pathogen presence/absence. Hopefully, future incoming smolts will test negative for all potential pathogens and, if so, the suggested annual effluent water assays could be discontinued.

Although not of immediate concern from the point of view of potential environmental impact, consideration might be given to finding alternate disposal methods for sludge waste, regardless of the negative active virus results recently obtained. On-site sludge de-watering/drying systems would greatly reduce the volume (and cost of disposal) of this waste stream and would ensure that any potential pathogens (viruses) are rendered inactive before transport off-site.

5. Biosecurity

5.1 General Biosecurity

Biosecurity protocols are well adhered to at the Kuterra operation. Foot baths and hand wash stations are installed at the entry gate to the property and at the entries to the rearing building; additional disinfection stations are located at the entries to the quarantine and grow-out sections inside the facility and separate equipment is used in these areas. All crew and visitors are made aware of the required biosecurity practices, smolt tank trucks are sprayed down with disinfectant prior to entering onto the Kuterra property and all contractors and visitors coming onto the site are made to follow appropriate procedures.

Consideration might be given to the installation of a remote-controlled security gate with video surveillance at the entry to the site, especially if the Kuterra facility is to be expanded.

The well-head electrics on the 3 production wells are fairly exposed, although the switch mechanisms and connection boxes are padlocked. **Increasing security around the well-heads by installation of chain-link fencing should be considered, especially if the Kuterra facility is to be expanded.**

5.2 Fish Mortality Handling and Disposal

Mortalities (Morts) are routinely collected from the Quarantine and Grow-out culture tanks and these are normally stored in the lab freezer before disposal at the Beaver Cove Sea Soil composting facility. On occasion, especially after major fish-handling activities like grading or culling, plastic garbage bins of unfrozen morts have been observed either in the lab or inside, near the loading door, at the Quarantine area. Morts from the Grow-out area should not be brought into the Quarantine area and vice-versa. **We recommend that there be separate freezers for temporary mort storage and that morts not be**

stored in the lab. In fact, consideration might be given to re-locating the lab if the Kuterra facility is to expand, as it is too close to Quarantine.

5.3 Bulk Chemical Storage

Chemicals that are used for pH control (NaOH) and disinfection (Sodium hypochlorite) are presently stored in the mechanical room and this could present an environmental or work-safety concern if a bulk container was to be compromised. **A separate, heated, chemical storage unit should be installed at the site.**

6. Smolt Introductions/Screening

A critical element of ensuring that the Kuterra operation will not result in the introduction of pathogens into the receiving environment is to ensure that biosecurity protocols are followed and that the smolts brought into the facility are, in fact, free of any transmittable pathogens. All related veterinary and laboratory smolt health screening results have been provided to the IEM, up to and including records for the Cohort #7 smolts that were received April 17, 2015.

The **'Namgis Closed Containment Project Smolt Screening Protocol** was developed in February, 2013, before the selection and arrival of the first cohort of smolts and the document was included as an amendment/addition to the initial IEMP. The Smolt Screening Protocol ensures that all fish entering the facility have been screened for the standard 'DFO Schedule II' potential pathogens as per the conditions of the DFO Licence and the DFO Fish Health Protection Regulations. In addition, the Smolt Screening Protocol required all incoming smolts to be screened for ISAv, SAv and PRv, as well as Myxobacteria and Renibacteria (BKD).

The first two cohorts of smolts (1 & 2) that were received at Kuterra underwent pathogen screening at the Pfizer/Zoetis laboratory in Victoria and the subsequent cohorts (3 to 7) underwent screening at the Centre for Aquatic Health Sciences (CAHS) labs in Campbell R. All smolt screening results and any records provided by the smolt suppliers have been made available to the IEM and the project veterinarian.

All smolts received at Kuterra have been acceptable in accordance with the Smolt Screening Protocol. However, most smolts that have been brought to the site have borne fungus (*Saprolegnia*) from the supplying facilities. Fungus has been controlled using salt and/or formalin ('Parasite-S') treatments; it is likely that the higher salinity well-water source recently developed will be beneficial in reducing future fish losses from fungus.

The Kuterra Manager (C. Dinneen), the Project Veterinarian (Dr. Tyler Stitt) and the IEM have reviewed the Smolt Screening Protocol and agree that screening for some of the un-listed potential pathogens (i.e. ISAv, SAv; cost approx. $800/cohort) is not essential, in that they have not been detected or reported in BC or in non-marine environments. Given that all smolt samples that have been submitted for histological examination have returned negative for disease-related pathogens, tissue samples should be submitted for histology only if/when necropsy observations indicate a need for further diagnosis.

The IEM is also of the opinion that if future smolts are coming from a known facility and have already been subjected to routine DFO Schedule 2 screening and those results are provided by the supplier(s), there is no need to repeat that screening. However, if smolts are to be purchased from an unknown supplier, or screening records are not made available, then fish should be submitted for screening with enough advance time to make the decision to purchase well advised. In all cases the supplier(s) should provide health, mortality and vaccination records prior to any decision to accept those smolts. Screening for IHNv, IPNv, VHSv, Myxobacteria and Renibacteria (BKD) should be conducted if recent screening results are not available from the suppliers.

7. Groundwater Monitoring

7.1 Monitoring Wells

Four shallow monitoring wells were installed both on and off the Kuterra site (March, 2013), with the intention that these could be used to measure the rate and direction of travel of liquid effluent that is discharged into the infiltration galleries. Unfortunately, the four shallow wells are not deep enough (8m) to be useful for the intended purpose, with two of them going dry during non-rain periods. The two monitoring wells that are continuously wetted reveal that the waste water does travel eastward, away from the Nimpkish River or Gwa'ni Hatchery and towards Broughton Strait, as evidenced by salinity fluctuations that parallel the changes in salinity of the effluent. **Consideration could be given to installing deeper monitoring wells in the future, especially if facility expansion is proposed and drill equipment is on site.**

The two geothermal/drinking water wells that are located to the southeast and northwest of the main building are also effective monitoring points for detection of brackish effluent travel in those directions. To date there has been no significant increase in salinity detected in these two otherwise fresh water wells, confirming that the slightly saline liquid effluent is, indeed, travelling east, away from the Nimpkish R. or Gwa'ni hatchery. However, the northwest geothermal/drinking water well, located just outside the fence near the quarantine loading door, does show slightly elevated salinity levels whenever pump by-pass or purge overflows are discharged into the nearby emergency overflow pit and that well is in service. Although not of great environmental impact significance, the slightly raised salinity in this geothermal well source could have a negative impact on geothermal heat transfer equipment. **Consideration should be given to re-directing these occasion overflow surges toward the infiltration basins rather than into the overflow pit.**

7.2 Impacts on Neighbouring Water Supplies

Assessing potential impacts of groundwater extraction on the nearby Gwa'ni hatchery wells has not been possible given the tidal fluctuations that influence all the wells and the frequent (unrecorded) changes in volumes being extracted by the Gwa'ni salmon enhancement hatchery facility. Similarly, monitoring potential impacts of the Kuterra liquid effluent discharge-to-ground on the nearby Nimpkish River have not been as easy as originally proposed, again because of natural tidal fluctuations and the ever-changing water quality of the river during different flow conditions.

There have been no evident impacts on Gwa'ni hatchery well water quality or quantity since the Kuterra RAS facility began operation. (*pers. comm.* H. Nelson). Studies of the aquifer that supplies the Kuterra wells has confirmed that the direction of flow is eastward, away from the Gwa'ni facility and the Nimpkish River, so water quality changes in either hatchery wells or the Nimpkish River due to Kuterra liquid effluent discharge are unlikely to occur. (Thurber. April, 2013).

The groundwater monitoring and studies to-date have shown that the discharge of liquid effluent to ground should not negatively impact the aquifer or neighbouring Spring Hill domestic water supplies. However, it would still be desirable to conduct dye tests to further support our understanding of the direction and speed of travel of the groundwater in the area; a system of deeper and more strategically placed monitoring wells would have to be installed to make such tracking studies meaningful.

All surface waters at the Kuterra site are carried off the property through a system of well-maintained ditches that are sloped eastward, away from the Nimpkish River; there is no standing water on the site.

7.3 Pathogen Testing of Groundwater

Testing the various river and well waters that are distant from the Kuterra site for pathogen presence is not considered possible. The IEM has consulted with hydrologists and microbiologists regarding the feasibility of conducting routine examination of distant waters for pathogen (esp. viral) presence and the consensus is that conducting such tests would be a research level exercise and beyond the scope of this project both in terms of feasibility and cost. (*pers. comm.* R. Beckie, UBC; K. Garver, DFO/PBS; C. Petersmeyer, Thurber Eng.). First, the smolt screening has not revealed the presence of any known pathogens that might be released into the liquid effluent stream so the target(s) of any such investigations would be unknown. Second, the negative, or undetectable, results from the May, 2015 virus assays of untreated liquid effluent provide a level of confidence that pathogen contamination of the groundwater resulting from the discharge of liquid effluent into the infiltration galleries is not occurring.

8. Public Input

There have been no public concerns raised for the last 6 months or more. Changes to sludge removal practices have eliminated the occasional odor concerns that were raised in the past.

9. Summary of Recommendations

The following table summarizes the recommendations that are contained in this report and also includes **others** that are not discussed above in detail but might be considered. Some of the suggestions might be of more importance if the Kuterra facility is to expand.

ISSUE	DISCUSSION	RECOMMENDATION
Water Quality Parameters	Current list of water quality parameters contains items that are not critical to fish production or environmental impact monitoring	Reduce number of WQ parameters as per Table 2 above. Initiate annual virus screening of liquid effluent as discussed above
Liquid Effluent Disinfection	Liquid effluent chlorination/de-chlorination not essential given results of effluent virus testing	Discontinue liquid effluent disinfection but ensure that disinfection works remain on standby
Infiltration Basin Performance	Infiltration basin substrates are becoming plugged with waste solids causing ponding	Consider deeper raking (turning over) of gravel/cobble substrate in infiltration basins
Site Biosecurity	Security at entry gate and around well heads could be improved, especially if expansion of the facility is being considered	Consider installing a remote controlled gate with video surveillance. Consider fencing around well-head electrical control boxes
Mortalities storage and handling on site	Morts should not be stored in the lab, quarantine or grow-out areas	Consider installation of mort. freezer(s) that are away from the lab and fish culture areas
Bulk Chemical Storage	Bulk chemicals (e.g. NaOH) are currently stored in the mechanical room where there is a risk of un-contained spillage/leakage	Recommend a separate chemical storage unit with temperature control
Smolt Screening	The current list of potential pathogens that are being tested for includes some that may not be essential	Reduce smolt screening requirements as in **6.** above if fish are from a known source and screening records are provided by supplier.
Other:		
Groundwater Monitoring	Off-site groundwater monitoring wells not adequate	Consider developing additional and deeper off-site groundwater monitoring wells, especially if expansion takes place
Purge and Pump by-pass Discharge Flows	Purge and pump by-pass flows discharging into emergency overflow pit	Re-direct occasional high-volume flows directly to infiltration basins to avoid salt intrusion into geothermal/drinking water wells
Sludge Handling	Trucking sludge off-site is cumbersome and very costly	Investigate alternate systems for sludge disposal including possible drying/bagging
Sludge Sampling	Determination of dry weights of material removed from site would be useful if alternate sludge handling/disposal options are to be considered	Conduct additional sludge sampling and testing to obtain dry, volatile and fixed residue data that has acceptable levels of confidence/reliability

10. Acknowledgements

The Kuterra RAS Pilot Project has developed with the utmost concern for protection of the environment around the facility and beyond. The achievements related to environmental protection are, in large part, a result of the cooperation and dedication of many organizations and individuals who have worked to meet the goals of the IEMP. Acknowledgement and thanks (in no particular order) are due to:

- ‘Namgis First Nation Chiefs and Councillors, past and present, for ensuring that the protection of the wild salmon and other resources within the Traditional Territories come first and foremost and for bringing forward many of the concerns that shaped the Independent Environmental Monitoring Program (IEMP);
- Catherine Emrick and Tides Canada for all the assistance in developing and supporting the IEMP since the beginning, over 4 years;
- Eric Hobson and the Save Our Salmon Foundation for putting the wild salmon first and for ensuring that the goals of the IEMP were/are given high priority as the project has developed;
- Garry Ullstrom (CEO) and the Kuterra Board of Directors for putting environmental protection at the top of the priority list as the Kuterra project has evolved;
- Jackie Hildering (2012 – 2014) and Jo Mrozewski (2014-15) for assisting with fielding all of the public inquiries and responses and for their great work in publicizing the importance of the IEMP as a critical component of the Kuterra project;
- Cathal Dinneen (Manager), Pam Chalmers and John Burton (Sr. RAS Technicians) and the rest of the Kuterra Crew for supporting the IEM in the execution of the IEMP, notwithstanding the daunting task of raising happy and healthy Kuterra Salmon and all that entails while doing so!

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