Memo

Stantec

To:	Tony Brcic, P.Eng. Capital Regional District	From:	Bob Dawson Victoria BC Office
File:	149009002	Date:	May 13, 2010

Reference: Core Area Liquid Waste Management Program – Management of Wet Weather Flow at Clover Point

1. Background

All sewage flows generated in the North East Trunk and East Cost Interceptor system are currently discharged to the marine environment via the Clover Point Outfall which extends offshore approximately 1100 metres terminating in a multi port diffuser at a depth of approximately 65 metres. All flows are currently screened using 6 mm mechanically cleaned screens prior to discharge. In the future, the wet weather flows during storm periods could be as high as 8 times the predicted 2030 ADWF of 54.4 ML/d. Currently the storm flow discharges at Clover Point do not reach this high flow because the main trunk sewer system does not have the hydraulic capacity to handle those peaks entirely and some overflows occur via short outfalls at several locations.

The continuous discharge of raw sewage at Clover Point has been occuring since parts of the Victoria's core were serviced in 1895 when the first short Clover Point outfall was constructed. The current Clover Point outfall was constructed in 1980. These discharges resulted in the contamination of the marine sediments with many compounds attributed to the sewage effluent being discharged. They include heavy metals, phenolic compounds, PAH's, chlorinated organics, and semivolatile and volatile organics. In particular, some heavy metals are above the levels indicated in the BC Ministry of Environment Contaminated Site Regulations. This contamination is most severe close to the outfalls but radiates outwards from the outfalls for several hundred metres. This information has been obtained during marine sediment sampling and analyses programs carried out by CRD staff.

Similarly, there are specific organic priority contaminants that have also been detected at levels that do not conform to the Contaminated Site Regulations. These exceedences were reported in the June 2006 Scientific and Technical Review Report by SETAC and were one of the reasons that influenced the Minister of the Environment to require treatment for CRD Core Area sewage flows.

The CRD has also been conducting water column testing for the key wastewater characterization parameters such as BOD, TSS and NH_3 but because of the high dilution occurring (e.g. 300 to 800 times initial dilution), as the wastewater plume rises these key indicators have not exceeded critical levels.

Microbiological testing for fecal coliform levels is carried out monthly by the CRD at about 32 surface sampling locations radiating out from each of the outfall terminus sites at Clover Point and Macaulay Point. For most of the year, the effluent plume is trapped at a considerable distance below the surface of the sea as predicted by wastewater plume mathematical modeling. The surface water testing has shown that, even at a distance of 100 metres from the outfall terminus, the fecal coliforms measured are usually much less than 200 cfu/100 mL which is the body contact recreational standard. However, two or three times a year, the coliform levels have been in the hundred to thousands of cfu/mL. Often this is during winter storms when the temperature and salinity stratification do not occur and is usually associated with a storm flow.

The Ministry of Environment has recognized that at some time in the future, the organic, microbiological, and metal loads could become so high that the water column would become contaminated. Initially, it was presumed that a trend in water quality would be recognizable and a trigger level of contamination would determine when primary and secondary treatment would be necessary. However as suggested by SETAC and the Ministry of the Environment, that at our current level of marine environmental knowledge, there is a risk that damage to the ecology and habitat could occur as the trigger points are approached. Therefore, it was recommend that removal of a high level of the organic, solids and metal loads should be achieved prior to discharge similar to the levels achievable by secondary treatment.

2. Initial Proposal for Treatment of Wet Weather Flow

The main thrust of the wastewater treatment planning and conceptual design studies to date has concentrated on providing secondary treatment for flows and loads up to and including 2 x ADWF for each of the future effluent streams. This is a requirement of the Municipal Sewage Regulations. For flows in excess of 2 x ADWF and up to flows occurring during a wet period with a return period of 5 years, the regulation states that a minimum of primary treatment should be provided. Initial options for wastewater treatment in the Clover Point sewered area included:

- A small Saanich East plant in the vicinity of the University/Haro Woods areas for an ADWF of 14.1 ML/d (reduced from 16.6 ML/d), which would consist of an advanced biological treatment plant using membrane bioreactor (MBR). For flows in excess of 2 x ADWF, chemically enhanced primary treatment would be provided. The flows from the primary treatment and from the MBR portions of the plant would be combined and this effluent would be discharged via a new outfall. Biosolids generated by this plant are to be discharged via the sewer system to Clover Point;

- At Clover Point, flows up to 2 x ADWF or 75.6 ML/day would be diverted to secondary wastewater treatment facilities at Mcloughlin Point or on the West Shore, and

- Also at Clover Point, flows between 2 x ADWF and 4 x ADWF would be screened (6 mm screens) then receive primary treatment through a chemically enhanced lamella plate primary treatment plant before being discharged to the ocean via the existing Clover Point outfall.

This wet weather primary treatment plant would be a very small footprint facility constructed in rock at a very high capital cost of about $27 million. This plant would only operate for a very small percentage of the time. It would be very difficult to start up and shut down this plant for individual storms and wet weather events.

3. Impact of Storm Events on Clover Point Flows

Kerr Wood Liedel has generated a typical hydrograph of a 5 year return period storm for Clover Point flows based upon their modeling and calibration with historical flow measurments in the system. This hydrograph is shown as **Figure 1**. From this hydrograph, it was possible to predict the impact on flows discharged at Clover Point for diversions of 2, 3 and 4 times the ADWF to a plant at Mcloughlin Point, in the Upper Victoria Harbour or the West Shore. The diversion levels of 3 and 4 x ADWF have been plotted as lines on this graph to show how the volume of the of excess flow is small in comparison to the bulk of the 5 year return period wet weather event.

The hydrograph of a typical storm as shown on Figure 1 represents the flow discharge at Clover Point with a plant and outfall constructed for the Saanich East catchment area thus diverting a portion of the flow that currently discharges at Clover Point.

It was realized quite early on that when flow diversions referenced above are provided prior to fine screening of excess flows, the annual load of pollutants BOD, TSS, metals and organics associated with the solids would be significantly decreased. This load is also further impacted by the fact that during the wet periods, the strength of the wastewater in terms of BOD and TSS, and most metals would decrease approximately in inverse proportion to the flow increase. Of course there would be periods following an extremely long dry period that during the first flush of the first sizable rainy period the concentrations would be high but in terms of the annual load on the seabed, this would be small. It was also realized that if a reasonable amount of storage were provided in the sewer system in the range of 5000 m^3 to 15000 m^3, that the flow, frequency of excess flow discharges , length of discharge period and hence the annual load would be further reduced.

4. Impact of Treatment on Solids Discharge at Clover Point

Table 1 summarizes the KWL modeling results of annual excess flow quantities, annual number of hours of discharge, and average concentration of BOD and TSS during these excess flow occurrences for various scenarios combining flow diversion levels and storage facility capacity. Using this information, it was possible to estimate the impact of the following scenarios for treatment, flow diversion and storage on the annual TSS loads on the seabed in the vicinity of the Clover Point outfall:

- Status quo-raw sewage discharge at Clover Point;
- Diversion of 2 x ADWF to a treatment facility, no storage at Clover Point and screening of excess flows before ocean discharge;
- Diversion of 2 x ADWF, screening of excess flows and primary treatment for wet weather flow (between 2 x ADWF and 4 X ADWF);
- Diversion of 2 x ADWF, 15000 m^3 of storage at Clover Point, screened discharge of excess flow;
- Diversion of 3 x ADWF, no storage at Clover Point, excess flow screened/discharged;
- Diversion of 3 X ADWF , 5000 m^3 of storage at Clover Point, excess flow screened and discharged to the ocean;
- Diversion of 4 X ADWF , no storage, excess flows screened/discharged, and
- Diversion of 4 X ADWF, 15000m^3 of storage screening and discharge.

The calculations in this table are representative of the overall system Option $1A^{Prime}$ where the diverted flows would be treated at a secondary treatment plant at the McLoughlin Point site with discharge of effluent via an upgraded Macaulay Point outfall.

For the above scenarios, the decrease in the calculated annual loads of TSS discharged at Clover Point is shown in **Table 2**. Several things are apparent from this tabulated information:

- If no treatment was provided at Clover Point except for fine screening (i.e. current conditions), then the total annual solids discharge to the seabed would be 2690 tonnes per year assuming a TSS concentration of 177 mg/L applied to the annual average flow of 41.6 ML/day.This is representative of the status quo projected to 2030;

- Diverting 2 x ADWF results in an accumulated overflow of 567 ML per year over 465 hrs (20 days), which would result in annual discharged TSS levels of 45 tonnes per year. This means that the seabed in the vicinity of Clover Point would experience a TSS reduction and hence a probable reduction of most of the metals of concern, of about 98.3%;

- Applying advanced primary treatment using chemically enhanced primary techniques to the excess flows above 2 x ADWF would reduce the annually discharged TSS load to about 15 tonnes per year for an overall reduction of 99.4%, and

- Increasing the amount of storage and diverted flows continues to reduce the hours of excess flow discharge and provides a small incremental improvement to the TSS load reduction such that 3 x ADWF and 4 x ADWF diversions both achieve greater than 99 % annual TSS load reductions.

It is interesting to compare these scenarios to what 2 x ADWF diversion versus secondary treatment of all flows up to 4 x ADWF would achieve: this would be about 86% assuming a secondary effluent containing 25 mg/L of TSS.

In **Table 3**, this analysis has been extended to compare the incremental TSS load improvements with the associated capital costs of installing the various levels of diversion pumping, transmission lines tunnels and treatment facilities. Providing diversion of up to 2 x ADWF to Mcloughlin Point where primary and secondary treatment would occur, is a significant cost of about $41 million. Providing a wet weather flow primary plant for excess flows on top of this only achieves an incremental TSS load improvement of about 1.1% at an added capital cost of about $27 million and annual operating costs of $0.6 million. From an environmental improvement point of view for the TSS and associated metals and some organics components, the extra costs to achieve compliance with the regulation is not cost effective when considering the small improvement in impact on the seabed.

Note that diverting 3 x ADWF would cost about $49 million and would remove 99.4% of the TSS loading which represents a 1.1% incremental improvement over diverting 2 x ADWF.

5. Microbiogical Impact – Current Conditions

The populations of fecal coliform organisms in raw wastewater are always very high with concentrations of million cfu/100 mL being the average. Over the last couple of years, with the current screened raw sewage discharge, the monthly sampling has shown periodic excursions above the body contact recreational standard of 200 cfu/100 mL. About 32 surface sampling locations radiating out in concentric rings from the Clover and Macaulay Point outfalls and commencing at 100 metres from the points directly above the diffuser have been routinely taken and analyzed for fecal coliform concentrations. As well, one control seawater surface sample is taken at a remote location as a control for those stations within the zone of potential plume influence. These sampling locations are shown on **Figure 2.**

In 2008, for 9 months, all samples showed concentrations less than 200 cfu/100 mL. On two occasions significantly higher counts were observed. In July 2008, 9 out of 32 samples within 250 metres of the outfall terminus showed counts ranging from 1400 to 12000 cfu/100 mL. Also, in November 2008, 23 of the 32 samples were above the 200 cfu/100 mL standard at points within 400 metres of the outfall terminus with 18 samples ranging from 520 to 970 cfu/100 mL.

Similar results of sampling analyses were recorded for 2009 with 7 of the monthly sampling episodes registering fecal coliforms well below the 200 cfu/100 mL limit and many passing the 14 cfu/100 mL acceptable for water overlying shellfish beds. Of the 456 samples analyzed that year, 406 were below the body contact recreation limit. In October, there was one sampling session recorded where 18 of the 37 samples were between 520 to 937 cfu/100 mL and 5 were between 230 to 400 cfu/100 mL. Most of these non-conforming samples were within 400 metres of the outfall terminus.

Past modeling of the effluent plume emanating from Clover Point has shown that during the summer months, when the seawater is overlain by brackish water spreading out under the influence of the Fraser River, there is a strong stratification as a function of depth of the seawater in terms of salinity, temperature and density. During this period, the effluent plume is usually trapped at 15 to 20 metres below the surface. For a large percentage of the time during these summer conditions, the fecal coliform concentrations range around 10 to 20 cfu/100 mL at the surface. However, even during the summer period particularly during slack tide and during storm flow runoff periods, the counts rise above 100 to 200 to several thousand cfu/100 mL for short periods within the initial plume and there is periodic breakthrough to the surface. Modeling has shown that the maximum initial dilution under current discharge conditions is limited to about 800 times.

During the winter time, the stratification is very much weakened and modeling predicts that the plume rises for much of the time to a shallower depth with more frequent breakthrough of the plume to the surface again during stormy weather, wet weather high flows and slack tidal conditions. Flow diversion of 2 to 4 x ADWF only decreases the mass load in proportion to total and diverted flow, which at 3 x ADWF might be 2.5 million cfu/100mL. It should be noted that compliance with the Municipal Sewage Regulation of 200 cfu/100 mL is based on geometric mean of 5 samples per month.

6. Microbiological Modeling of Future Conditions

Microbiological modeling was carried out by Seaconsult. Their report is included in **Appendix A** and is summarized in this section. Initial dilution calculations were carried by out by Seaconsult for six scenarios described in **Table 4**. These can be summarized as follows:

- Scenario 1 - Pumping 3 x ADWF to the treatment plant at McLoughlin Point and discharge treated effluent at Macaulay Point; screened sewage flow in excess of 3 x ADWF discharged at Clover Point.
- Scenario 2 - Pumping 2 x ADWF to the treatment plant at McLoughlin Point and discharge treated effluent at Macaulay Point; screened sewage flow in excess of 2 x ADWF discharged at Clover Point.
- Scenario 3 - Pumping 2 x ADWF to the treatment plant at McLoughlin Point;, providing a wet weather plant at Clover Point for 2 to 4 x ADWF and discharge screened sewage in ecess of 4 x ADWF at Clover Point

The primary objective of the modeling was to determine the likelihood of plume surfacing above the Clover Point diffuser, and the dilution of effluent, and hence fecal coliform bacteria, at the point of maximum rise or the boundary of the initial dilution zone (IDZ).

For the three scenarios where the treated effluent is discharged at Clover Point together with the excess wet weather flow (scenarios 1, 2 and 3), the modeling indicates that under certain conditions, the plume will rise to the surface and the fecal coliform concentration will be in the range of 1000 to 2800 cfu/100 mL.

However this is based on a conservative set of assumptions (worst case scenario):

- Largest storm flow rate for the East Coast Interceptor;

- Minimum winter stratification in the receiving waters;
- Lowest current speeds on the turn of the tide, and
- All of the above factors occurring at the same time.

These assumptions are reasonable because the high storm flows can persist for several hours as can weak tidal currents. Thus high outfall flows can coincide with slack currents, but it is equally likely that high flows could occur during the hours of strong tidal currents. In that case trapping would be deeper in the water column with surfacing of effluent unlikely.

It is also important to note that the predictions of receiving water bacterial concentrations of about 1000 cfu/100 mL at the water surface are associated with isolated storm events, lasting for only a few hours. These results do not imply that the receiving water quality standard of 200 cfu/100 mL would automatically be exceeded based on the geometric mean of five samples over a 30-day period.

7. Conclusions

For Option 1A^{Prime}, diversion of flows of up to 3 x ADWF from the Clover Point catchment area and discharge of wet weather flows above this level following fine screening to the sea via the Clover Point outfall reduces annual loadings by over 99% compared with levels that would be experienced in 2030 if raw sewage discharge would continue. Reduction in heavy metal loadings and some of the organics of concern would parallel these TSS load reductions. Providing advanced primary treatment to those wet weather flows in excess of 3 x ADWF would make only a small incremental improvement of about 1% in reduced load and at a cost of $27 million for capital expenditure, and an annual O&M cost of $0.6 million.

From a microbiological point of view, the effluent plume initial dilution and dispersion has shown that during wet weather periods the discharge of excess flows directly to the sea will result in trapping of the plume for a significant period of the year at depths of 5 to 20 metres. Infrequently and for short periods that occurs during slack tide and the wet weather storm discharge events, surface fecal coliforms will exceed the body contact recreation standard of 200 cfu/100 mL and reach into the 1,000 cfu/100 mL range. However, these excursions will be infrequent and will only last a short time. **The MSR Regulation, which specifies a limit of 200 cfu/ 100 mL based on the geometric mean of 5 samples per month, is expected not to be exceeded**.

It is therefore recommended that the discharge of flows in excess of 3 x ADWF during storm events be discharged via the Clover Point outfall following fine screening without disinfection. Continued monitoring of accumulation of metals and of selected organics on the seabed in the vicinity of the outfalls should continue. Also, the surface sampling fecal coliform monitoring program should be continued to insure compliance with MSR monthly requirement for fecal coliform.

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Attachments: Tables 1 to 4
Figures 1 to 2
Appendix 1 – Report from Seaconsult

Tables 1 to 4

Table 1
Clover Point Stormflow Control Strategies
TSS and Metal Load Reduction Efficiency

Diversion x ADWF	Storage (m^3)	Overflow Duration (Hrs)	Discharge/Overflow Volume (ML)	** Average Overflow TSS conc (mg/l)	Overflow Load TSS (Tonnes/yr)	TSS Load Reduction %
0	0	8760	15176	177	2690	0
2	0	465	567	79	45	98.3
2	APT*	465	567	25	15	99.4
2	15000	189	378	99	37	98.6
3	0	110	202	75	15	99.4
3	5000	71	185	81	15	99.4
4	0	48	68	62	5	99.7
4	15000	22	46	65	3	99.9

* APT Advanced Primary Treatment - 70% TSS removal
** Adjusted for WS Transfer from Saanich East

Table 2
Clover Point Stormflow Control Strategies
Relative Cost of TSS and Metal Load Reduction Strategies

Diversion x ADWF	Storage (m^3)	Overflow (ML/yr)	TSS Load (tonnes/yr)	% TSS Load Reduction	*% Incremental Improvement	Infrastructure Capital $ x 10^6	** Incremental Capital $ x 10^6
0 (raw discharge)	0	15176	2690	0	n/a	n/a	n/a
2	0	567	45	98.3**	98.3	41.2	n/a
2 APT	0	567	15	99.4	1.1	68.5	27.3
2	15000	376	38	98.6	0.3	64.4	23.2
3	0	202	15	99.4	1.1	49.8	8.6
3	5000	185	15	99.4	1.1	59.1	17.9
4	0	88	6	99.7	1.4	58.7	17.5
4	15000	46	3	99.9	1.6	68	26.8

* % incremental improvement compared to diversion of 2XADWF - no storage
** incremented cost compared to 2 x ADWF - no storage
APT - Advanced Primary Treatment - 70% removed TSS

Table 3
Clover Point Stormflow Control Strategies
Estimated Cost of TSS and Metal Load Reduction Efficiency

Scenario	Handling of Wet Weather Flow	Cost of Pumping & Conveyance	Cost of Storage (m3)	Cost of Wet Weather Plant	Total Cost	Incremental TSS Load Improvement
1	2 x ADWF Pumping Only	$41,160,130			$41,160,130	98.3
2	2 x ADWF & Wet Weather Plant	$41,160,130		$27,297,270	$68,457,400	99.4
3	2 x ADWF & 15,000 m3 of storage	$41,160,130	$23,244,350		$64,404,480	98.6
4	3 x ADWF Pumping Only	$49,762,200			$49,762,200	99.4
5	3 x ADWF &5,000 m3 of storage	$49,762,200	$9,297,740		$59,059,940	99.4
6	4x ADWF Pumping Only	$58,718,400			$58,718,400	99.7
7	4x ADWF & 5,000 m3 of storage	$58,718,400	$9,297,740		$68,016,140	99.9

Notes:

1 Assumes current level of I&I control

2 The cost of providing additional capacity in the primary clarifiers at WWTP is negligible

Table 4
Design Flows (ML/d) for Microbiological Modeling

Scenario 1 – 3 x ADWF Pumped to a WWTP facility at McLoughlin Point

- Plant in East Saanich
- 3 x ADWF pumped from Clover Point to a WWTP facility at McLoughlin Point
- 4 x ADWF pumped from Macaulay Point to a WWTP facility at McLoughlin Point
- All flow treated at the WWTP is discharged at Macaulay Point

	From Clover Point	From Macaulay Point	Totals
ADWF	37.2 – after diversion of portion of flow at Saanich East plant	56.5	93.7
Raw Sewage Pumped to McLoughlin Pt	Up to 3 x ADWF = 111.6	Up to 4 x ADWF = 226	337.6
Sewage Receiving Primary Treatment	Up to 3 x ADWF	Up to 4 x ADWF	337.6
Sewage Receiving Secondary Treatment	2 x ADWF	2 x ADWF	184.4
Treated Effluent Discharged at Clover Outfall			None
Screened Sewage Discharge at Clover Outfall	> 3 x ADWF		Flows in excess of 111.6 ML/d from Clover Point catchment area

Scenario 2 – 2 x ADWF Pumped to a WWTP facility

- Plant in East Saanich
- 2 x ADWF pumped from Clover Point to a WWTP facility at McLoughlin Point
- 4 x ADWF pumped from Macaulay Point to a WWTP facility at McLoughlin Point
- All flow treated at the WWTP discharged at Macaulay Point

	From Clover Point	From Macaulay Point	Totals
ADWF	37.2 – after diversion of portion of flow at Saanich East plant	56.5	93.7
Raw Sewage Pumped to McLoughlin Pt	Up to 2 x ADWF = 74.4	Up to 4 x ADWF = 226	300.4
Sewage Receiving Primary Treatment	Up to 2 x ADWF	Up to 4 x ADWF	300.4
Sewage Receiving Secondary Treatment	2 x ADWF	2 x ADWF	184.4
Treated Effluent Discharged at Clover Outfall			None
Screened Sewage Discharge at Clover Outfall	> 2 x ADWF		Flows in excess of 74.4 ML/d from Clover Point catchment area

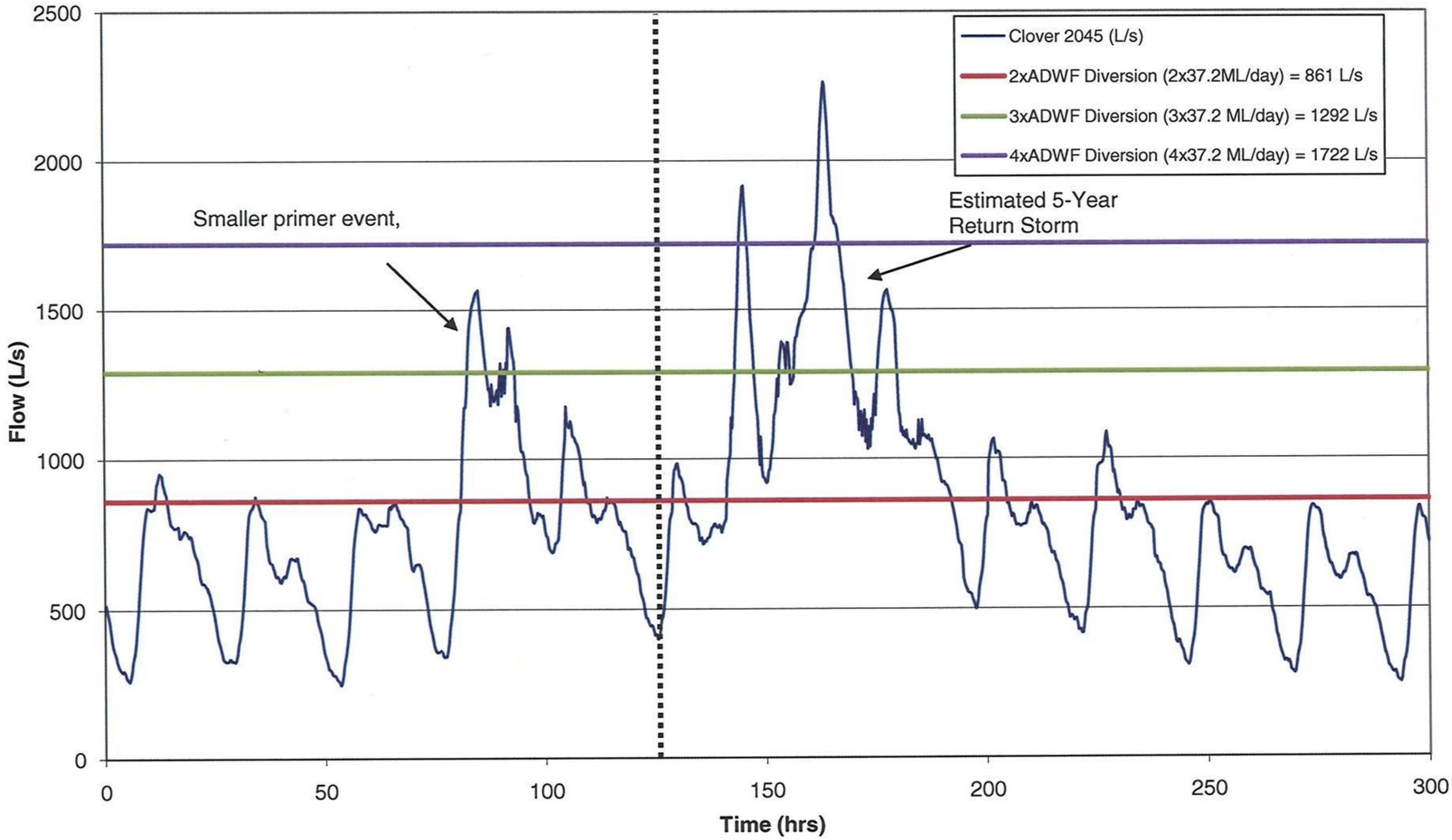
Scenario 3 – Wet Weather Flow Plant at Clover Point

- Plant in Saanich East
- 2 x ADWF pumped from Clover Point to a WWTP facility at McLoughlin Point
- Wet weather flow plant at Clover for flows between 2 x ADWF and 4 x ADWF
- 4 x ADWF pumped from Macaulay Point to a WWTP facility at McLoughlin Point
- All flow treated at the WWTP discharged at Macaulay

	From Clover Point	**From Macaulay Point**	**Totals**
ADWF	37.2 – after diversion of portion of flow at Saanich East plant	56.5	93.7
Raw Sewage Pumped to McLoughlin Pt	Up to 2 x ADWF = 74.4	Up to 4 x ADWF = 226	300.4
Sewage Receiving Primary Treatment at McLoughlin Point	Up to 2 x ADWF = 74.4	Up to 4 x ADWF = 226	300.4
Sewage Receiving Primary Treatment at Clover Point and discharged at Clover Poiint	Up to 2 x ADWF = 74.4		74.4
Sewage Receiving Secondary Treatment	2 x ADWF	2 x ADWF	187.4
Screened Sewage Discharge at Clover Outfall	> 4 x ADWF		Flows in excess of 148.8 ML/d from Clover Point catchment area

Figures 1 & 2

Figure 1
Synthetic Clover Point Storm Hydrograpah in 2045
Assumes Saanich East Treatment Plant or 12,000 m3 of Storage is built, water conservation and 1% I&I reduction/year



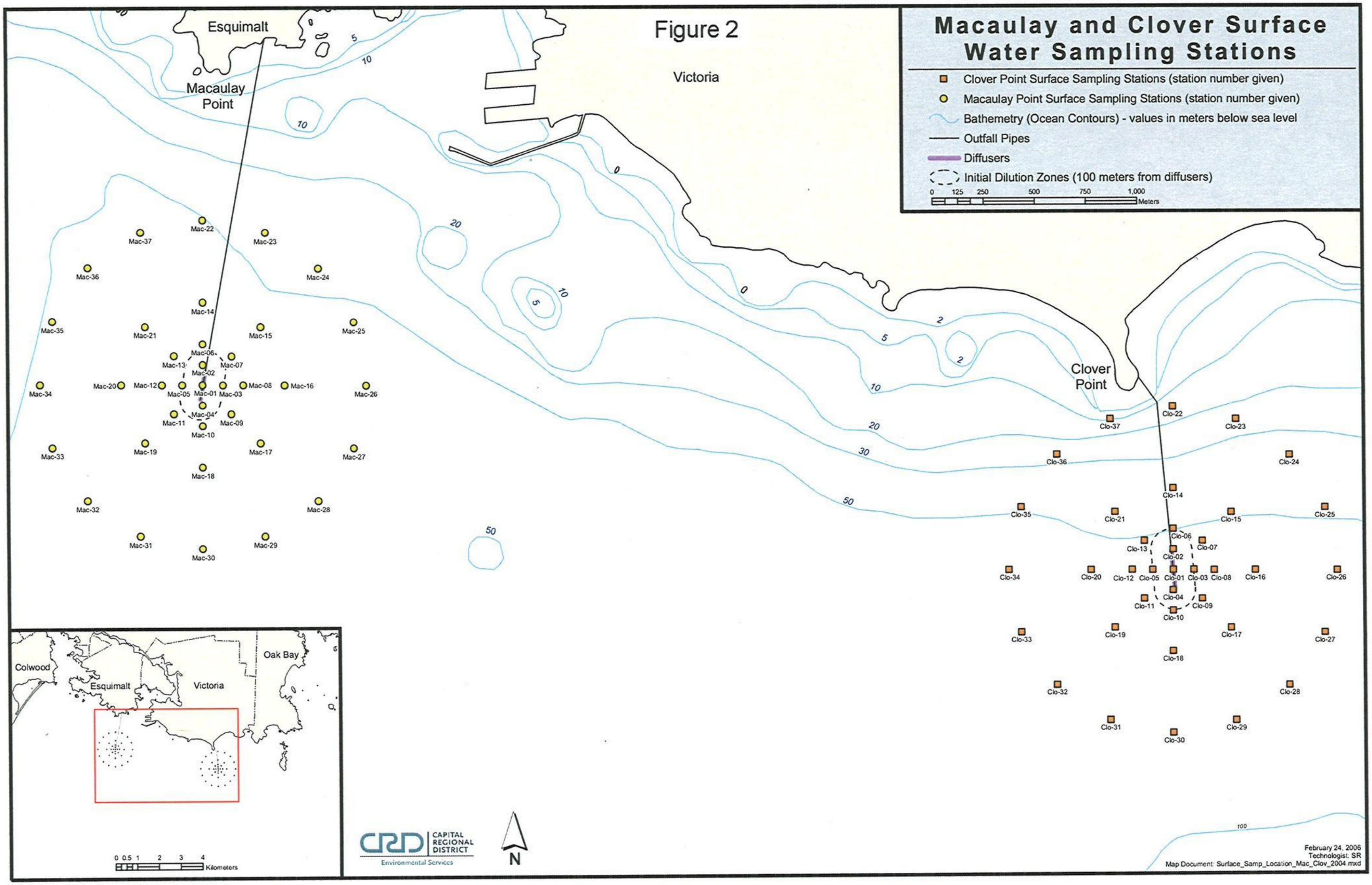


Figure 2
Macaulay and Clover Surface Water Sampling Stations
Clover Point Surface Sampling Stations (station number given)
Macaulay Point Surface Sampling Stations (station number given)
Bathemetry (Ocean Contours) - values in meters below sea level
Outfall Pipes
Diffusers
Initial Dilution Zones (100 meters from diffusers)
0 125 250 500 750 1,000 Meters
Esquimalt
Macaulay Point
Victoria
Clover Point
Colwood
Oak Bay
0 0.5 1 2 3 4 Kilometers
CAPITAL REGIONAL DISTRICT
Environmental Services
N
February 24, 2006
Technologist: SR
Map Document: Surface_Samp_Location_Mac_Clov_2004.mxd

Appendix A

TECHNICAL MEMORANDUM

To: Bob Dawson, Gilbert Cote, Stantec Consulting
From: Donald Hodgins, Ph.D., P.Eng., Seaconsult
Subject: Dilution calculations for various treatment options
Date: May 14, 2010

1.0 Purpose

Initial dilution calculations were carried out for three wastewater treatment options involving different diversions of flow from Clover Point, and one option with primary treatment of some of the overflow at Clover Point (Table 4, Stantec, revised May 13, 2010. The primary objective was to determine the likelihood of plume surfacing above the Clover Point diffuser, and the dilution of effluent, and hence fecal coliform bacteria, at the point of maximum rise or the boundary of the initial dilution zone (IDZ).

The calculations correspond with worst-case flow conditions in the East Coast Interceptor, as represented by a 2045 synthetic hydrograph supplied by Kerr Wood Leidel (Fig. 1). By way of comparison, actual flows recorded during a storm in November 2008 are also plotted in Fig. 1; peak flows are nearly equivalent in both events although the specific histories differ.

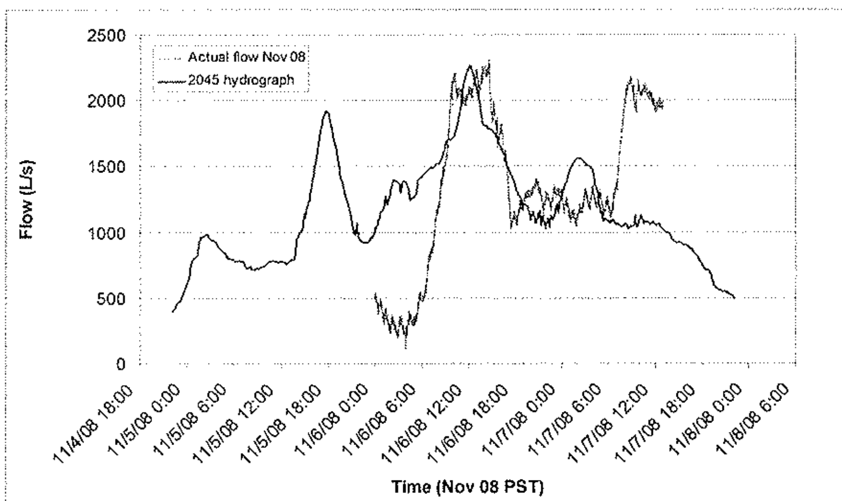


Figure 1 Synthetic storm hydrograph and an actual storm flow record from November 2008.

2.0 Methods

The dilution calculations were made with the US EPA buoyant plume model UM for multi-port diffusers (Baumgartner et al., 1993).[1]

The following assumptions and basic input data were used:

[1] Baumgartner, D.J., W.E. Frick and P.J.W. Roberts, 1993. Dilution Models for Effluent Discharges 2nd Ed., Report EPA/600/R-93/193, US Environmental Protection Agency. This model is the predecessor of the UM3 model currently available in the US EPA suite VPLUMES and is equivalent in terms of its basic physics and key assumptions. For the present application it provides equivalent results.

1. A peak flow of 2264 L/s.
2. Clover ADWF[2] of 431 L/s (37200 m^3/d).
3. Macaulay ADWF of 654 L/s (56500 m^3/d).
4. Coliform concentrations will decrease with increasing wastewater flow (through dilution) according to $Fe=5E+09Qe^{-1.0199}$, where Fe is the concentration in the East Coast Interceptor and Qe is the corresponding flow in L/s. The same relation is assumed to apply to flows from the Macaulay catchment.
5. Coliforms will be removed by treatment at the following levels: primary 50%, secondary 98.6%.
6. Winter oceanographic conditions (minimum stratification as shown in the Aquametric dataset for November and December).
7. Current speeds corresponding to slack tide (predicted using measured data near the Clover Point diffuser at depths of 29 and 49 m).
8. Clover Point diffuser specifications assuming 41 (existing) and 55 (maximum available) ports are open and functional.

3.0 Results

In all scenarios considered here none of the wastewater diverted to the McLoughlin Point WWTP is returned for discharge at Clover Point. Consequently, the discharge at Clover Point consists only of storm water overflows that remain after diversion. In scenario 3, some of this overflow (between 2xADWF and 3xADWF) is provided with primary treatment prior to discharge. The treatment leaves the flow rate unaltered, but reduces the bacterial concentrations by 50% (the assumed level). In this particular example, all of the overflow is captured by the treatment range; thus, no screened wastewater is discharged.

Because these overflows are well within the range of storm water flows at Clover Point, the existing diffuser with 41 operational ports is assumed for the analyses. In addition, the effect of increasing the number of ports to the maximum 55 that are available is considered.

The results obtained from the UM model are shown in Table 1. The terms used in Table 1 have the following meaning:

1. Final effluent flow Qf – flow rate of the storm water overflow to the outfall.
2. Final effluent fecal coliform concentration Ff – coliform concentration in the final effluent, reflecting the removal rates for treatment of part or all of the flow to the outfall.
3. Trapping depth T – depth at which the rising plume achieves neutral density and is ultimately dispersed by currents.
4. Dilution at trapping Dt – bulk dilution of the plume at the trapping depth. Note that this dilution is less than achieved by the plume as it initially rises past the trapping depth.
5. Maximum rise depth R – depth to which the plume rises by virtue of its vertical momentum. This depth is always less than the trapping depth. If ambient stratification is strong the trapping depth and maximum rise depth will be relatively close together. When stratification is weak, as it is in this analysis, the plume will rise well above the nominal 'trapping' depth since there is no force to counteract the vertical momentum. When R is noted as 'sfc' in Table 1 it signifies that the effluent plume is very likely to reach the water surface. Here this is a consequence of the high flow rate in the outfall combined with weak winter stratification in the ocean and minimum current speeds.
6. Dilution at R – bulk dilution of the plume at the maximum rise depth. This is the most useful estimate of dilution within the IDZ and should be used to infer expected coliform concentrations in the receiving waters.

[2] Average dry weather flow

7. Fecal coliform concentration IDZ – the value ranges given here were calculated as Ff/D. It is important to appreciate that the dilution is a kind of average that applies over the area affected by the plume. Within that area there are likely to be concentrations that are higher, and some that are lower, than given strictly by Ff/D. In addition, the maximum rise depth is at the very final stage of the behaviour of a submerged plume, when the plume itself has become large through entrainment, and various assumptions in the model are breaking down. Consequently the estimates of dilution are quite approximate, and should be treated as providing an order of magnitude estimate. For this reason, the concentrations are shown as a range rounded to the nearest hundred.

   The overflow rates considered here (at the storm peak) are relatively high, ranging for example, from 1.5 to more than 2 times the current ADWF. These flows are likely above the optimal range for diffuser performance and as shown in Table 1, the plumes are predicted to rise to, or close to, the surface for all cases except scenario 1 with 55 operational ports. In these cases dilutions are likely to be in the range of about 700:1 to 1000:1, and it is reasonable to expect coliform concentrations of the order of 1000 cfu/100 mL in the IDZ at the peak of the storm. We would not expect to see concentrations as high at 10000, nor as low as 100, under these conditions. Greater precision should not be read into these results.

   Increasing the number of ports to 55 from 41 does provide a benefit in terms of trapping depth and dilution, but not enough to eliminate plume surfacing under these particular oceanographic conditions.

4.0 Conservative Assumptions

The above results represent a conservative set of assumptions (worst case scenario):

1. largest storm flow rate for the East Coast Interceptor;
2. minimum winter stratification in the receiving waters;
3. lowest current speeds on the turn of the tide;
4. all of the above factors occurring at the same time.

These assumptions are reasonable because the high storm flows can persist for several hours (see e.g. Fig. 1), as can weak tidal currents. Thus high outfall flows can coincide with slack currents, but it is equally likely that high flows could occur during the hours of strong tidal currents. In that case trapping would be deeper in the water column with surfacing of effluent unlikely.

It is also important to note that the predictions of receiving water bacterial concentrations of about 1000 cfu/100 mL are associated with isolated storm events, lasting for only a few hours. These results do not imply that the receiving water quality standard of 200 cfu/100 mL would automatically be exceeded based on the geometric mean of five samples over a 30-day period.

Table 1: Results obtained from the UM buoyant plume model for six scenarios.

		Final Effluent		*Dilution Model Results*				
	Discharge		***Fecal Coliform***	***Trapping***	***Dilution***	***Max Rise***	***Dilution***	***Fecal Coliform***
Scenario	***Method***	***Flow***	***Concentration***	***Depth***	***at T***	***Depth***	***at R***	***Concentration***
		Qf	***Ff***	***T***	***Dt***	***R***	***D***	***IDZ***
		(L/s)	***(cfu/100 mL)***	***(m)***		***(m)***		***(cfu/100 mL)***
1	single diffuser, 41 ports	973	1.9E+06	23	600	~5 - 10	1000	1800 to 1900
1	single diffuser, 55 ports	973	1.9E+06	31	630	18	1200	1500 to 1600
2	single diffuser, 41 ports	1403	1.9e+06	18	460	sfc	~700	2700 to 2800
2	single diffuser, 55 ports	1403	1.9e+06	22	560	~5 to sfc	~900	2100 to 2200
3	single diffuser, 41 ports	1403	9.5E+05	18	460	sfc	~700	1300 to 1400
3	single diffuser, 55 ports	1403	9.5E+05	22	560	~5 to sfc	~900	1000 to 1100