

Appendix E

Job _____

Project No. 51-00070007.00

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Description Mass Balance of dissolved non-reactive constituent around one segment pair

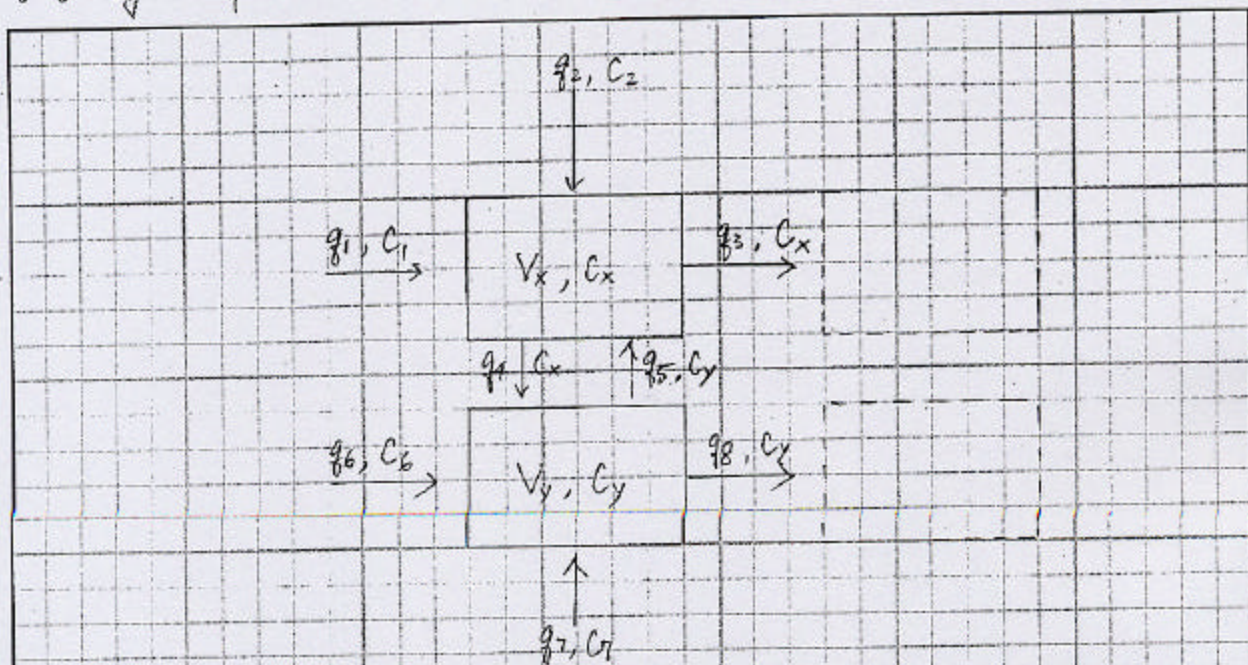
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Mass Balance Around Water Column:

$$\frac{d(V_x C_x)}{dt} = g_1 C_1 + g_2 C_2 - g_4 C_x + g_5 C_y - g_3 C_x \quad (1)$$

Mass Balance Around Benthic Layer:

$$\frac{d(V_y C_y)}{dt} = g_6 C_6 + g_4 C_x - g_5 C_y + g_7 C_y - g_8 C_y \quad (2)$$

Where

g_2 = Groundwater flow through stream bank

g_1, g_3 = surface water flow

g_4, g_5 = pore water flow through surface water-sediment interface

g_6, g_8 = pore water flow

C_x = Concentration of dissolved constituent in water column

C_y = Concentration of dissolved constituent in benthic layer

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At Steady State:

Eqn (1) becomes:

$$\begin{aligned}
 g_1 C_1 + g_2 C_2 - g_4 C_x + g_5 C_y - g_3 C_x &= 0 \\
 (g_4 + g_3) C_x - g_5 C_y &= g_1 C_1 + g_2 C_2 \quad (3)
 \end{aligned}$$

Eqn (2) becomes:

$$\begin{aligned}
 g_6 C_6 + g_7 C_x - g_5 C_y + g_7 C_7 - g_8 C_y &= 0 \\
 -g_5 C_x + (g_5 + g_8) C_y &= g_6 C_6 + g_7 C_7 \quad (4)
 \end{aligned}$$

Therefore C_x , C_y are obtained by solving the following matrix:

$$\begin{bmatrix} g_4 + g_3 & -g_5 \\ -g_5 & g_5 + g_8 \end{bmatrix} \begin{bmatrix} C_x \\ C_y \end{bmatrix} = \begin{bmatrix} g_1 C_1 + g_2 C_2 \\ g_6 C_6 + g_7 C_7 \end{bmatrix}$$

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$$\text{Let } a = g_4 + g_2$$

$$b = -g_5$$

$$c = -g_4$$

$$d = g_5 + g_8$$

$$e = g_1 C_1 + g_2 C_2$$

$$f = g_6 C_6 + g_7 C_7$$

Sub a, b, c, d, e, f into Eqn (3) and (4)

$$a C_x + b C_y = e \quad (5)$$

$$c C_x + d C_y = f \quad (6)$$

Multiply (5) by d and (6) by b :

$$ad C_x + bd C_y = ed$$

$$bc C_x + bd C_y = bf$$

and subtract to obtain

$$ad C_x - bc C_x = ed - bf$$

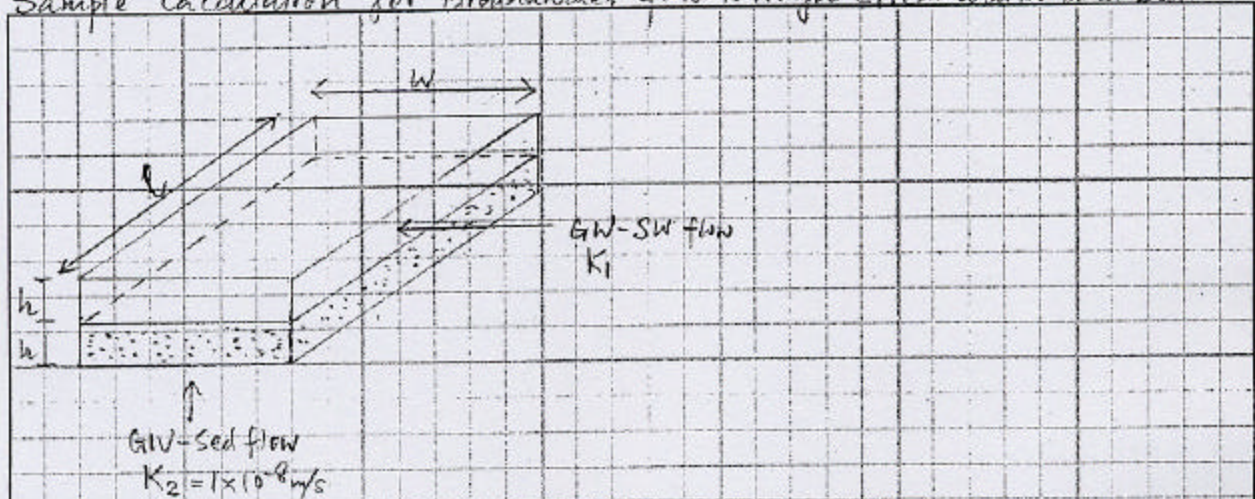
$$C_x(ad - bc) = ed - bf$$

$$C_x = \frac{ed - bf}{ad - bc}$$

Similarly, multiplying (5) by c , (6) by a and subtracting yields

$$C_y = \frac{af - ce}{ad - bc}$$

Sample Calculation for Groundwater flow through streambank and sediment Reference



For segment pair 1,2:

$$\begin{aligned} h &= 2 \text{ ft} \sim 0.6 \text{ m} \\ W &= 50 \text{ ft} \sim 15.24 \text{ m} \\ L &= 99.8 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{GW-SW Seepage Area} &= h \times L \\ &= 0.6 \text{ m} \times 99.8 \text{ m} \\ &= 61 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{GW-SW } \frac{dh}{dL} &\sim 0.25 \\ K_1 &= 1 \times 10^{-8} \text{ m/s} \end{aligned}$$

$$\begin{aligned} \text{GW-SW flow} &= K_1 A \frac{dh}{dL} \\ &= (1 \times 10^{-8} \text{ m/s})(61 \text{ m}^2)(0.25) \\ &= 1.52 \times 10^{-7} \text{ m}^3/\text{s} \end{aligned}$$

$$\begin{aligned} \text{GW-Sed Seepage Area} &= L \times W \\ &= 99.8 \text{ m} \times 15.24 \text{ m} \\ &= 1521 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{GW-Sed } \frac{dh}{dL} &\sim 0.001 \\ K_2 &= 1 \times 10^{-8} \text{ m/s} \end{aligned}$$

$$\begin{aligned} \text{GW-Sed flow} &= K_2 A \frac{dh}{dL} \\ &= (1 \times 10^{-8} \text{ m/s})(1521 \text{ m}^2)(0.001) \\ &= 1.52 \times 10^{-8} \text{ m}^3/\text{s} \end{aligned}$$

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Description

Sample Calculation for

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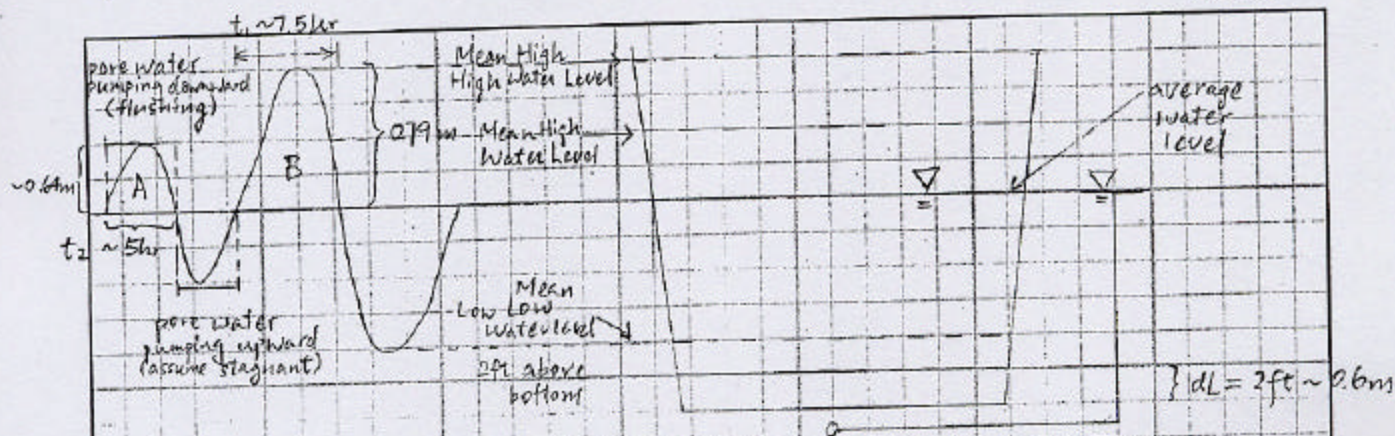
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porewater flow due to tidal pumping

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Date

Reference



porewater flow:

$$q = KA \frac{dh}{dL} \left(\frac{\frac{1}{2} \text{ cycle of high water}}{\text{tide cycle}} \right)$$

$$K = 1 \times 10^{-8} \text{ m/s}$$

$$A = 152.1 \text{ m}^2 \quad (\text{Segment pair 1, 2})$$

$$dL = 0.6 \text{ m}$$

$$\text{Time Averaged } dh = \frac{\text{Area A} + \text{Area B}}{t_1 + t_2}$$

$$\text{Assume Area A} = \frac{1}{2} (5 \text{ hr} \cdot 0.64 \text{ m})$$

$$= 1.6 \text{ m} \cdot \text{hr}$$

$$\text{Assume Area B} = \frac{1}{2} (7.5 \text{ hr} \cdot 0.79 \text{ m})$$

$$= 2.96 \text{ m} \cdot \text{hr}$$

$$\therefore dh = \frac{(1.6 + 2.96) \text{ m} \cdot \text{hr}}{(7.5 + 5) \text{ hr}} = 0.37 \text{ m}$$

$$\therefore q = \left(1 \times 10^{-8} \frac{\text{m}}{\text{s}} \right) (152.1 \text{ m}^2) \left(\frac{0.37 \text{ m}}{0.6 \text{ m}} \right) \left(\frac{1}{2} \right)$$

$$= 4.7 \times 10^{-6} \text{ m}^3/\text{s}$$

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Modeling Results Summary for Zinc																				
Segment	GRID 8			GRID 7	GRID 6	GRID 5	GRID 4	GRID 3	GRID 2	GRID 1	GRID 0									
	1,5	3,4	5,6																	
Conc. in Groundwater, mg/L	53	63	63	7,8	9,10	11,12	13,14	15,16	17,18	19,20	21,22	23,24	25,26	27,28	29,30	31,32	33,34	35,36	37,38	39,40
C _g , ug/L	2,7E-03	9,4E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03	8,1E-03
C _g , ug/L	2,7E-03	2,0E-02	1,1E-02	8,2E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03	8,0E-03
C _g , ug/L	2,0E-02	2,0E-02	2,5E-01	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02	1,6E-02
C _g , ug/L	4,1E-02	4,1E-02	4,1E-02	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3	6,3
Conc. in Groundwater, mg/L	0	0	0	1,1E-03	2,8E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03	3,4E-03
C _g , ug/L	0	0	0	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03
C _g , ug/L	0	0	0	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03	2,8E-03
Conc. in Groundwater, mg/L	0	0	0	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02
C _g , ug/L	0	0	0	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02
C _g , ug/L	0	0	0	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02	2,0E-02
Conc. in Groundwater, mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C _g , ug/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C _g , ug/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conc. in Groundwater, mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C _g , ug/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C _g , ug/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conc. in Groundwater, mg/L	0	0	0	0	0															

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Surface Elev., m/s	3.0E+00	2.0E+00	1.0E+00	0.0E+00	-1.0E+00	-2.0E+00	-3.0E+00	-4.0E+00	-5.0E+00	-6.0E+00	-7.0E+00	-8.0E+00	-9.0E+00	-1.0E+01	-1.1E+01	-1.2E+01	-1.3E+01	-1.4E+01	-1.5E+01	-1.6E+01	-1.7E+01	-1.8E+01	-1.9E+01	-2.0E+01	-2.1E+01	-2.2E+01	-2.3E+01	-2.4E+01	-2.5E+01	-2.6E+01	-2.7E+01	-2.8E+01	-2.9E+01	-3.0E+01	-3.1E+01	-3.2E+01	-3.3E+01	-3.4E+01	-3.5E+01	-3.6E+01	-3.7E+01	-3.8E+01	-3.9E+01	-4.0E+01	-4.1E+01	-4.2E+01	-4.3E+01	-4.4E+01	-4.5E+01	-4.6E+01	-4.7E+01	-4.8E+01	-4.9E+01	-5.0E+01	-5.1E+01	-5.2E+01	-5.3E+01	-5.4E+01	-5.5E+01	-5.6E+01	-5.7E+01	-5.8E+01	-5.9E+01	-6.0E+01	-6.1E+01	-6.2E+01	-6.3E+01	-6.4E+01	-6.5E+01	-6.6E+01	-6.7E+01	-6.8E+01	-6.9E+01	-7.0E+01	-7.1E+01	-7.2E+01	-7.3E+01	-7.4E+01	-7.5E+01	-7.6E+01	-7.7E+01	-7.8E+01	-7.9E+01	-8.0E+01	-8.1E+01	-8.2E+01	-8.3E+01	-8.4E+01	-8.5E+01	-8.6E+01	-8.7E+01	-8.8E+01	-8.9E+01	-9.0E+01	-9.1E+01	-9.2E+01	-9.3E+01	-9.4E+01	-9.5E+01	-9.6E+01	-9.7E+01	-9.8E+01	-9.9E+01	-1.0E+02	-1.1E+02	-1.2E+02	-1.3E+02	-1.4E+02	-1.5E+02	-1.6E+02	-1.7E+02	-1.8E+02	-1.9E+02	-2.0E+02	-2.1E+02	-2.2E+02	-2.3E+02	-2.4E+02	-2.5E+02	-2.6E+02	-2.7E+02	-2.8E+02	-2.9E+02	-3.0E+02	-3.1E+02	-3.2E+02	-3.3E+02	-3.4E+02	-3.5E+02	-3.6E+02	-3.7E+02	-3.8E+02	-3.9E+02	-4.0E+02	-4.1E+02	-4.2E+02	-4.3E+02	-4.4E+02	-4.5E+02	-4.6E+02	-4.7E+02	-4.8E+02	-4.9E+02	-5.0E+02	-5.1E+02	-5.2E+02	-5.3E+02	-5.4E+02	-5.5E+02	-5.6E+02	-5.7E+02	-5.8E+02	-5.9E+02	-6.0E+02	-6.1E+02	-6.2E+02	-6.3E+02	-6.4E+02	-6.5E+02	-6.6E+02	-6.7E+02	-6.8E+02	-6.9E+02	-7.0E+02	-7.1E+02	-7.2E+02	-7.3E+02	-7.4E+02	-7.5E+02	-7.6E+02	-7.7E+02	-7.8E+02	-7.9E+02	-8.0E+02	-8.1E+02	-8.2E+02	-8.3E+02	-8.4E+02	-8.5E+02	-8.6E+02	-8.7E+02	-8.8E+02	-8.9E+02	-9.0E+02	-9.1E+02	-9.2E+02	-9.3E+02	-9.4E+02	-9.5E+02	-9.6E+02	-9.7E+02	-9.8E+02	-9.9E+02	-1.0E+03	-1.1E+03	-1.2E+03	-1.3E+03	-1.4E+03	-1.5E+03	-1.6E+03	-1.7E+03	-1.8E+03	-1.9E+03	-2.0E+03	-2.1E+03	-2.2E+03	-2.3E+03	-2.4E+03	-2.5E+03	-2.6E+03	-2.7E+03	-2.8E+03	-2.9E+03	-3.0E+03	-3.1E+03	-3.2E+03	-3.3E+03	-3.4E+03	-3.5E+03	-3.6E+03	-3.7E+03	-3.8E+03	-3.9E+03	-4.0E+03	-4.1E+03	-4.2E+03	-4.3E+03	-4.4E+03	-4.5E+03	-4.6E+03	-4.7E+03	-4.8E+03	-4.9E+03	-5.0E+03	-5.1E+03	-5.2E+03	-5.3E+03	-5.4E+03	-5.5E+03	-5.6E+03	-5.7E+03	-5.8E+03	-5.9E+03	-6.0E+03	-6.1E+03	-6.2E+03	-6.3E+03	-6.4E+03	-6.5E+03	-6.6E+03	-6.7E+03	-6.8E+03	-6.9E+03	-7.0E+03	-7.1E+03	-7.2E+03	-7.3E+03	-7.4E+03	-7.5E+03	-7.6E+03	-7.7E+03	-7.8E+03	-7.9E+03	-8.0E+03	-8.1E+03	-8.2E+03	-8.3E+03	-8.4E+03	-8.5E+03	-8.6E+03	-8.7E+03	-8.8E+03	-8.9E+03	-9.0E+03	-9.1E+03	-9.2E+03	-9.3E+03	-9.4E+03	-9.5E+03	-9.6E+03	-9.7E+03	-9.8E+03	-9.9E+03	-1.0E+04	-1.1E+04	-1.2E+04	-1.3E+04	-1.4E+04	-1.5E+04	-1.6E+04	-1.7E+04	-1.8E+04	-1.9E+04	-2.0E+04	-2.1E+04	-2.2E+04	-2.3E+04	-2.4E+04	-2.5E+04	-2.6E+04	-2.7E+04	-2.8E+04	-2.9E+04	-3.0E+04	-3.1E+04	-3.2E+04	-3.3E+04	-3.4E+04	-3.5E+04	-3.6E+04	-3.7E+04	-3.8E+04	-3.9E+04	-4.
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CALCULATION OF ESTIMATED SOIL-GROUNDWATER DISTRIBUTION COEFFICIENTS

Soil Sample ID	Copper in Soil (mg/kg)	Zinc in Soil (mg/kg)	Groundwater Sample ID	Copper in Groundwater (mg/L)	Zinc in Groundwater (mg/L)	Copper Kd (L/kg)	Zinc Kd (L/kg)
SSB1-4	43	100	SSB1-GW : 0-0.5	<0.005	0.17		588
SSB2-4	4.7	24	SSB2-GW : 0-0.5	<0.005	<0.01		
SSB3-4	130	210	SSB3-GW : 1-1.5	0.012	0.13	10,833	1,615
SSB4-4	5.2	320	SSB4-GW : 1-1.5	0.017	0.042	306	7,619
SSB5-3	290	94	SSB5-GW : 4-4.5	2.4	5.9	121	16
SSB6-4	10	130	SSB6-GW : 1-1.5	0.015	0.038	667	3,421
SSB7-3	190	130	SSB7-GW : 4-4.5	0.027	0.35	7,037	371
SSB8-4	4.8	3.5	SSB8-GW : 0-0.5	0.017	0.022	282	159
SSB10-4	32	87	SSB10-GW : 4-4.5	<0.005	<0.01		
SSB11-4	160	120	SSB11-GW : 3-3.5	0.012	1.9	13,333	63
SSB12-4	210	110	SSB12-GW : 0-0.5	<0.005	0.026		4,231
					Average	4,654	2,009