

Appendix C. Appendix 4 Estimation of Salinity in Ortega River, Florida

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1. Introduction

Members of the Wetland Vegetation Working Group requested help estimating mean salinity in the Ortega River from the mouth to Collins Road for comparison with salinity levels of soils that they collected in this reach. They further requested estimates of salinity changes from a 155 and 262 mgd withdrawal in the adjacent St. Johns River. Increased salinity near the mouth of the Ortega River will increase salinity in the Ortega River during periods when and where the Ortega River is influenced by ocean salt. Estimates were made using the EFDC WSIS hydrodynamic model to simulate salinity at the mouth of the Ortega River in conjunction with a simple steady-state pseudo-empirical model having a functional form of a solution to the advection-diffusion equation for salt transport. The salinity estimates provide daily salinity for the period 1996 – 2005 at any location between the mouth of Ortega River and Collins Road.

2. Observed Data

Observed salinity data were available at Collins Road in Ortega River and at two locations near the confluence of Ortega River with the St. Johns River (Figure C-1). Observed salinity data are also available in the Cedar River just to the north of the Ortega River, but these data are not considered here. Observed discharge data are available at two locations.

Discharge was observed by USGS at two locations: Ortega River at Jacksonville (02246300) and Ortega River at Kirwan Road (02246318). Discharge was measured at 02246300 from Jan. 1965 through April, 2003. The gauge 02246318 has been in operation since March 2002. The overlapping period of record for these two gauges was used to create a linear regression to make a single discharge record for Kirwan Road. The overlapping records contain 390 matched pairs of discharge and are highly correlated (Figure C-2). The linear regression equation has a slope of 1.218, indicating that the new gauge location has about 22% greater discharge than the old gauge location.

The combined record over the period 1995 – 2007 had a mean discharge of $1.75 \text{ m}^3\text{s}^{-1}$ with a standard deviation of $4.31 \text{ m}^3\text{s}^{-1}$. Discharge is strongly skewed right; the median discharge was $0.88 \text{ m}^3\text{s}^{-1}$ and the maximum discharge was $123.6 \text{ m}^3\text{s}^{-1}$.

Salinity data at the three locations shown in Figure C-1 are summarized in Table C-1.

Table C-1. Summary of salinity data observed in and near Ortega River.

Station	Distance from Mouth	NRECS	POR	MIN	MAX	Median	Mean	STDEV
OR83	0.0	157	9/1993-8/2001	0.06	23.5	3.6	6.0	5.9
ORTRM	1.2	142	6/1993-8/2001	0.03	21.6	5.2	6.7	5.7
ORTCR	12.0	152	7/1995-8/2010	0.03	12.1	0.09	0.7	2.0

Salinities at OR83 and ORTRM, near the mouth of the Ortega River, are quite similar. Salinity at Collins Road (ORTCR) is usually fresh, the median salinity is 0.09, but experiences high salinity events of up to 12, about 1/3 ocean salinity.

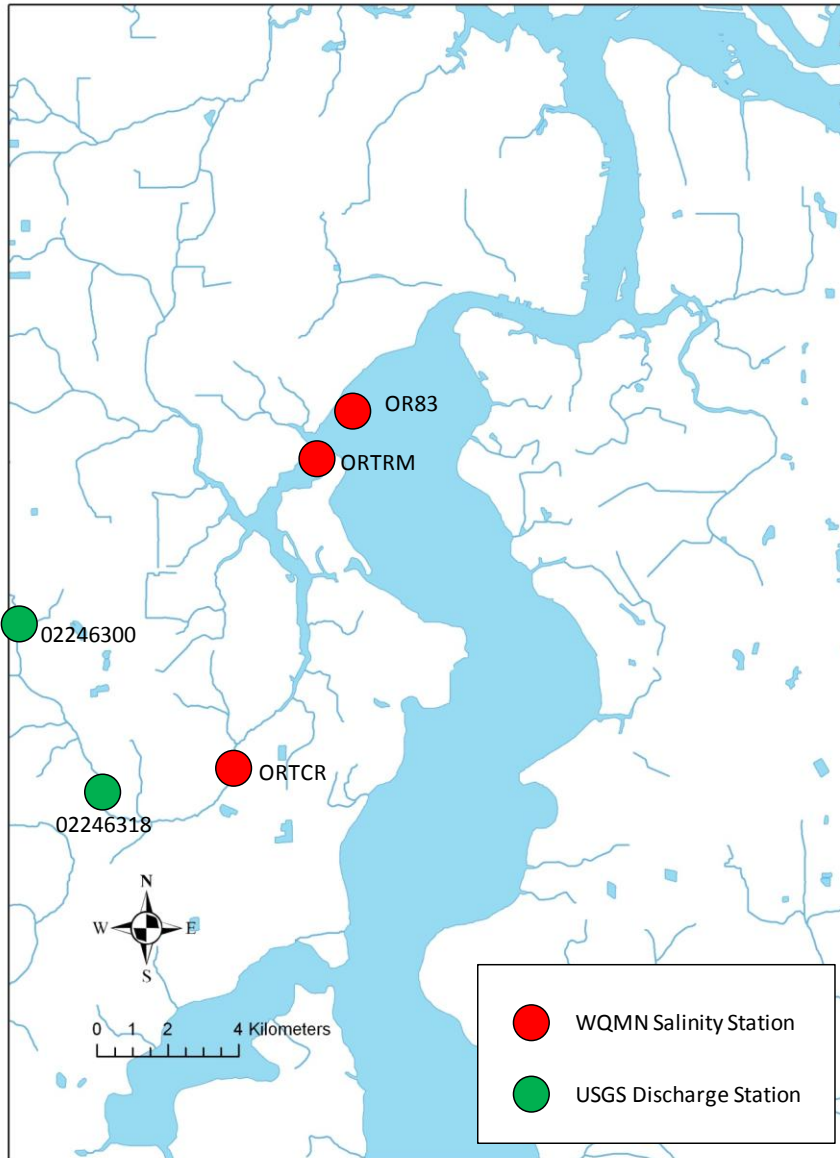


Figure C-1. Study area and location of observed salinity and observed discharge in and near the Ortega River.

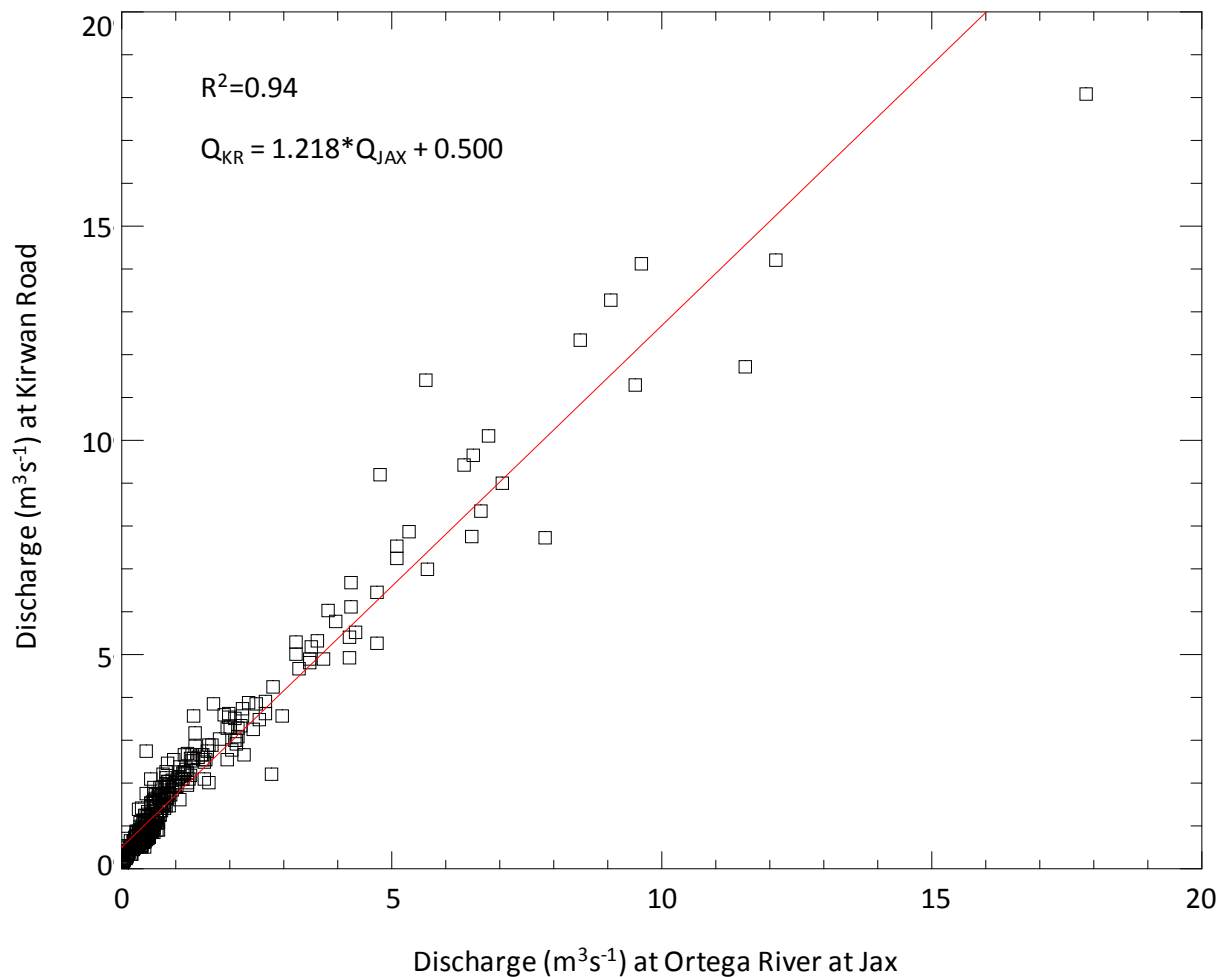


Figure C-2. Linear regression between discharge observed at Ortega River at Jacksonville and Ortega River at Kirwan Road.

3. Salinity Estimation Method

The salinity records were examined at Collins Road and the downstream stations to identify times when coincident salinity were observed on the same day. There were six of these paired values identified. I added two additional high observations of salinity (6/5/2000 and 6/10/2002) at Collins Road and estimated salinity at the mouth from the EFDC WSIS model. The eight pairs of salinity were also matched with the previous 30-day averaged discharge (Table C-2).

Table C-2. Matched pairs of salinity at Collins Road and the mouth of Ortega River with previous 30-day averaged discharge.

Date	Salinity at Collins Road	Salinity at Mouth	Previous 30-day averaged discharge (m ³ s ⁻¹)
10/24/1995	0.052	0.281	6.92
2/27/1996	0.090	0.915	0.99
4/30/1996	0.082	0.376	1.22
6/4/1999	4.59	14.0	0.56
8/18/1999	0.262	9.4	0.75
6/5/2000	10.7	17.0	0.54
8/29/2001	0.133	3.6	1.51
6/10/2002	12.15	16.5	0.20

A steady-state estimate of the distribution of salinity within Ortega River for these eight days was assumed to have to form:

$$S(x) = S_0 e^{-kQx}, \quad (1)$$

where Q is the 30-day averaged discharge, x is distance along the Ortega River (0 – 12 km), S_0 is the salinity at the mouth, and k is a net diffusion coefficient.

This form of a solution is based on the advection-diffusion equation:

$$\frac{dS}{dt} = U \frac{dS}{dx} + E \frac{d^2S}{dx^2},$$

where Q (discharge) in the first equation is assumed to be linearly proportional to velocity and all linear conversions, units conversions, and diffusion parameterization is consumed by the exponent k .

Equation (1) can be solved for k for each day using the input parameters shown in Table C-2. This results in the following eight k -values: 0.025, 0.2, 0.1, 0.17, 0.4, 0.075, 0.18, 0.13. Given the crudeness of the approach, the k -values are reasonably well-constrained and have a mean value of 0.16.

Daily values of salinity at Collins Road were next predicted using a constant k of 0.16, observed 30-day averaged discharge, and simulated salinity at the mouth from the EFDC WSIS model. The predicted salinity at Collins Road was matched with all 95 observations of salinity at Collins Road for the period 1996 – 2005. The constant k -value was then fine-tuned to minimize the sum of the squares of the residuals between simulated and observed values. The final k -value was 0.165.

Observed and simulated salinity at Collins Road are moderately correlated ($R^2 = 0.77$) and the mean of the salinity residuals is -0.13 with a standard deviation of 1.0. Principle sources of error are the lack of dynamics inherent in the steady-state solution and the assumption of spatially-constant velocity over the length of the river. Dynamics of importance likely include temporally-varying river discharge, tidal waterlevel and tidally-varying discharge within the river, and spatially- and temporally-varying horizontal turbulent diffusion parameters.

Although crude, the estimation method provides (a) a means for estimating a 10-yr salinity record at any location in the Ortega River between the mouth and Collins Road, and (b) a means for estimating changes to salinity in Ortega River by propagating simulated salinity for the mouth obtained from the EFDC WSIS model scenarios.

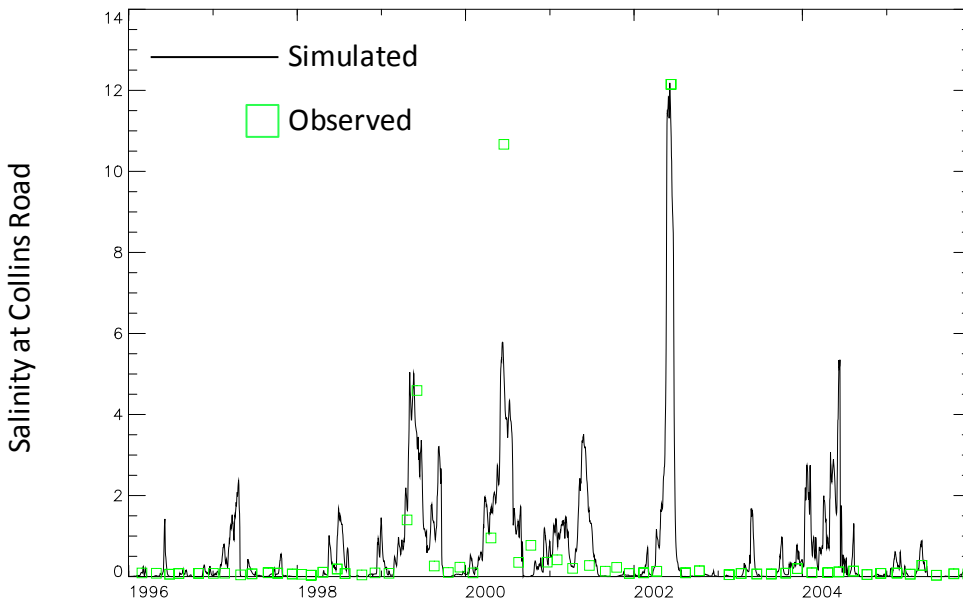


Figure C-3. Comparison of observed and predicted salinity at Collins Road (1996 – 2005).

Results

Mean salinity in 1 kilometer intervals progressing upstream in the Ortega River are predicted for a Base Scenario, 155 mgd withdrawal scenario, and 262 mgd withdrawal scenario in Table C-3. Mean salinity differences are in Table C-4.

Table C-3. Predicted mean salinity in Ortega River at 1 kilometer intervals from the mouth for a Base Condition, and 155 mgd and 262 mgd withdrawal scenarios.

Distance From Mouth (KM)	Base Salinity	Salinity for 155 mgd withdrawal	Salinity for 262 mgd withdrawal
0	2.54	2.74	2.91
1	2.20	2.37	2.52
2	1.92	2.07	2.20
3	1.69	1.82	1.93
4	1.49	1.60	1.70
5	1.32	1.42	1.51
6	1.18	1.26	1.34
7	1.05	1.13	1.20
8	0.94	1.01	1.07
9	0.84	0.91	0.96
10	0.76	0.82	0.86
11	0.69	0.74	0.78
12	0.62	0.67	0.70

Table C-4. Predicted mean salinity differences in Ortega River at 1 kilometer intervals from the mouth between a Base Condition, and (a) 155 mgd Scenario and (b) 262 mgd Scenario. Positive differences indicate increasing salinity in the Scenario compared with the Base.

Distance From Mouth (KM)	Salinity Difference for 155 mgd Scenario	Salinity Difference for 262 mgd Scenario
0	0.20	0.37
1	0.17	0.32
2	0.15	0.27
3	0.13	0.24
4	0.11	0.21
5	0.10	0.18
6	0.09	0.16
7	0.08	0.14
8	0.07	0.13
9	0.06	0.11
10	0.06	0.10
11	0.05	0.09
12	0.04	0.08

4. Summary Statistics for Predicted Salinity at E.S. Monitoring Locations

Table C-5. Summary statistics for predicted salinity at E.S. monitoring locations for Base Run.

Distance from Station 1 (km)	Mean	Stdev	MIN	1	2	5	10	25	50	75	90	95	98	99	MAX
0.0	0.55	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.56	1.56	2.70	4.03	5.17	11.81
0.5	0.58	1.29	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.59	1.64	2.83	4.21	5.41	11.96
1.0	0.61	1.33	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.64	1.73	2.98	4.40	5.64	12.12
1.21	0.62	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.66	1.78	3.03	4.48	5.74	12.18
1.5	0.64	1.37	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.69	1.85	3.11	4.62	5.90	12.28
2.0	0.67	1.42	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.73	1.96	3.21	4.82	6.17	12.44
2.5	0.71	1.46	0.00	0.00	0.00	0.00	0.00	0.01	0.09	0.78	2.06	3.38	5.01	6.45	12.61
3.0	0.75	1.51	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.84	2.16	3.57	5.24	6.74	12.78
3.5	0.79	1.56	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.89	2.29	3.75	5.45	7.04	12.94
4.0	0.83	1.61	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.96	2.43	3.93	5.72	7.36	13.12
4.5	0.87	1.67	0.00	0.00	0.00	0.00	0.00	0.02	0.13	1.02	2.58	4.13	5.91	7.58	13.29
5.0	0.92	1.73	0.00	0.00	0.00	0.00	0.00	0.02	0.14	1.09	2.72	4.36	6.09	7.89	13.47
5.5	0.97	1.79	0.00	0.00	0.00	0.00	0.00	0.03	0.16	1.17	2.88	4.58	6.37	8.23	13.64
6.0	1.03	1.85	0.00	0.00	0.00	0.00	0.00	0.03	0.18	1.25	3.06	4.75	6.64	8.60	13.82
6.5	1.09	1.92	0.00	0.00	0.00	0.00	0.00	0.04	0.19	1.35	3.26	4.99	6.96	8.99	14.01
7.0	1.15	2.00	0.00	0.00	0.00	0.00	0.00	0.04	0.21	1.45	3.47	5.22	7.28	9.39	14.19
7.5	1.22	2.08	0.00	0.00	0.00	0.00	0.00	0.05	0.23	1.57	3.68	5.55	7.60	9.81	14.38
8.7	1.40	2.29	0.00	0.00	0.00	0.00	0.01	0.07	0.30	1.89	4.28	6.23	8.43	10.90	14.84

Table C-6. Summary statistics for predicted salinity at E.S. monitoring locations for 155 mgd withdrawal.

Distance from Station 1 (km)	Mean	Stdev	MIN	1	2	5	10	25	50	75	90	95	98	99	MAX
0.0	0.59	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.62	1.66	2.84	4.24	5.40	12.23
0.5	0.62	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.66	1.76	3.00	4.39	5.62	12.39
1.0	0.65	1.39	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.71	1.86	3.14	4.60	5.87	12.56
1.21	0.67	1.41	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.72	1.91	3.21	4.69	5.97	12.62
1.5	0.69	1.44	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.75	1.97	3.30	4.82	6.13	12.72
2.0	0.72	1.48	0.00	0.00	0.00	0.00	0.00	0.01	0.09	0.81	2.10	3.44	5.05	6.41	12.89
2.5	0.76	1.53	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.87	2.22	3.60	5.25	6.70	13.06
3.0	0.80	1.58	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.93	2.34	3.78	5.51	7.00	13.23
3.5	0.84	1.63	0.00	0.00	0.00	0.00	0.00	0.01	0.12	1.00	2.46	3.97	5.71	7.32	13.41
4.0	0.89	1.69	0.00	0.00	0.00	0.00	0.00	0.02	0.14	1.07	2.60	4.17	5.90	7.65	13.59
4.5	0.94	1.75	0.00	0.00	0.00	0.00	0.00	0.02	0.15	1.14	2.76	4.38	6.21	7.90	13.77
5.0	0.99	1.81	0.00	0.00	0.00	0.00	0.00	0.02	0.16	1.22	2.91	4.60	6.42	8.20	13.95
5.5	1.04	1.88	0.00	0.00	0.00	0.00	0.00	0.03	0.18	1.30	3.09	4.86	6.71	8.57	14.13
6.0	1.10	1.94	0.00	0.00	0.00	0.00	0.00	0.03	0.20	1.40	3.27	5.05	7.02	8.94	14.32
6.5	1.17	2.02	0.00	0.00	0.00	0.00	0.00	0.04	0.22	1.49	3.48	5.33	7.33	9.34	14.51
7.0	1.24	2.10	0.00	0.00	0.00	0.00	0.00	0.04	0.24	1.61	3.73	5.52	7.62	9.76	14.70
7.5	1.31	2.18	0.00	0.00	0.00	0.00	0.00	0.05	0.27	1.73	3.95	5.85	7.93	10.20	14.90
8.7	1.51	2.40	0.00	0.00	0.00	0.00	0.01	0.07	0.36	2.07	4.55	6.57	8.88	11.33	15.38

Table C-7. Summary statistics for predicted salinity at E.S. monitoring locations for 262 mgd withdrawal.

Distance from Station 1 (km)	Mean	Stdev	MIN	1	2	5	10	25	50	75	90	95	98	99	MAX
0.0	0.63	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.66	1.79	2.98	4.36	5.60	12.36
0.5	0.66	1.39	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.70	1.89	3.13	4.56	5.85	12.52
1.0	0.69	1.44	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.76	1.99	3.29	4.77	6.08	12.69
1.21	0.70	1.45	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.78	2.03	3.36	4.85	6.19	12.75
1.5	0.73	1.48	0.00	0.00	0.00	0.00	0.00	0.01	0.09	0.82	2.11	3.45	4.99	6.36	12.85
2.0	0.76	1.53	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.88	2.23	3.62	5.21	6.64	13.02
2.5	0.80	1.58	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.95	2.36	3.79	5.47	6.94	13.20
3.0	0.85	1.63	0.00	0.00	0.00	0.00	0.00	0.01	0.12	1.01	2.48	3.99	5.69	7.26	13.37
3.5	0.89	1.69	0.00	0.00	0.00	0.00	0.00	0.02	0.14	1.08	2.62	4.19	5.94	7.57	13.55
4.0	0.94	1.75	0.00	0.00	0.00	0.00	0.00	0.02	0.15	1.16	2.76	4.40	6.22	7.80	13.73
4.5	0.99	1.81	0.00	0.00	0.00	0.00	0.00	0.02	0.17	1.24	2.91	4.63	6.51	8.14	13.91
5.0	1.05	1.87	0.00	0.00	0.00	0.00	0.00	0.02	0.18	1.33	3.06	4.88	6.72	8.51	14.09
5.5	1.11	1.94	0.00	0.00	0.00	0.00	0.00	0.03	0.20	1.41	3.27	5.11	6.99	8.88	14.28
6.0	1.17	2.02	0.00	0.00	0.00	0.00	0.00	0.03	0.22	1.50	3.46	5.34	7.32	9.28	14.47
6.5	1.24	2.09	0.00	0.00	0.00	0.00	0.00	0.04	0.24	1.61	3.69	5.59	7.60	9.70	14.66
7.0	1.31	2.18	0.00	0.00	0.00	0.00	0.00	0.05	0.27	1.73	3.93	5.81	7.94	10.14	14.86
7.5	1.39	2.26	0.00	0.00	0.00	0.00	0.00	0.05	0.30	1.87	4.17	6.10	8.30	10.60	15.05
8.7	1.60	2.50	0.00	0.00	0.00	0.00	0.01	0.07	0.39	2.24	4.79	6.91	9.23	11.77	15.53