Resource Management Associates

User Information for 34 North Polygon Weighting Program

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Program Objective

The objective of the program described here is to determine how a given set of polygons covering the waterways of the Sacramento-San Joaquin Delta should be weighted in order to best interpolate water quality data measured at discrete stations to the entire Delta system. The problem can be stated as: given polygon locations and station locations where water quality data is collected, determine which stations should be used to calculate interpolated water quality values for any given polygon, and how the values from those stations should be weighted.

Input Files

Below is a description of the input files required to run the program. These files should all be placed in the same directory.

weights_program.exe Main program executable.

Delta_poly.ply Text file listing the nodes and node connectivity of the polygons where station weights are needed. This file must be named "Delta_poly.ply" and must be given using the standarized .ply file format[1]. In this format, several header lines are followed by a listing of vertex locations, which are then followed by a listing of vertex indices for each polygon.

Stations.txt Text file listing the stations for which weights will be calculated. The first line lists the number of stations, n_{stat}. The next n_{stat} lines give UTM Zone 10 Easting and Northing values for each station.

Delta_34North_SWA3_ro.geo RMA grid file needed for the solution scheme. It should usually not be necessary to modify this file.

Output Files

These files are created each time the program is run.

polygon_weights.txt Polygon weighting file. Each row of the file shows weights for an individual polygon. The first column is the polygon number. This is simply the number of the polygon in the order in which it was given in the .ply file. The weights are then listed out on the row, from left to right for stations 1 to n_{stat}, in the order they were listed in Stations.txt file. The last number in each row specifies the number of RMA grid points that are located within each polygon. This number may be useful for error checking.

calcweight.log Text file that outputs grid, polygon, and station file information, and program warnings and errors. It may also be useful in error checking.

[1] http://www.mathworks.com/matlabcentral/fx_files/5459/1/content/ply.htm

How the progam works and an example

The program generates the weights for each station by solving a Laplace equation over the RMA grid and averaging the results to the given polygons. A seperate computation is carried out for each station, using an internal boundary condition of one at the station's location and values of zero at all other station locations. This is analogous, in a physical sense, to the steady-state diffusion through the Delta of a water quality variable having a value of one at the station point.

Input files are first read into the program. If any of the files are missing, an error message is displayed and the program stops. The maximum allowable number of vertices per polygon is set in the program as 60 (for memory allocation purposes). If any polygon listed in the .ply file has more than 60 vertices listed, an error message will be displayed and the program will stop.

An abridged example of a Delta_poly.ply file is shown below. The full file contains data for 1959 polygons and is included with this documentation. The data and file were provided by 34 North.

```
ply
format ascii 1.0
element vertex 11225
property float x
property float y
property float z
element face 1959
property list uchar int vertex_index
end_header
653020.715731 4171375.798525 0.000000
652938.290822 4171375.798525 0.000000
652900.546286 4171461.436657 0.000000
```

... (total of n_{vertex} lines; 11225 in this example)

```
615504.883655 4241885.656279 0.000000
616468.731769 4241718.788621 0.000000
616479.315970 4241218.515030 0.000000
6 0 1 2 3 4 5
5 6 7 8 9 10
6 11 12 13 14 15 16
```

... (total of $n_{polygon}$ lines; 1959 in this example)

```
6 11206 11207 11208 11209 11210 11211
6 11212 11213 11214 11215 11216 11217
7 11218 11219 11220 11221 11222 11223 11224
```

An abridged example of a Stations.txt file is shown below. The complete file is included with this documentation. Data for this sample file was obtained from the California Data

Exchange Center (CDEC) website[2] and converted to UTM Zone 10 Easting and Northing values using the CorpsCon program[3], distributed by the US Army Corps of Engineers.

```
Number of stations:  50
1 605157.353 4208489.328 ANH
2 605268.806 4237112.330 BKS
3 612164.574 4209692.390 BLP
```

... (total of n_{stat} lines; 50 in this example)

```
48 635802.146 4185056.336 TWA
49 629439.657 4192600.687 VCU
50 621876.414 4292632.197 VON
```

Figure 1 shows a plot of the example polygons and CDEC stations. Following input file reading, the centroids of each polygon are calculated (Figure 2), and all of the RMA grid points lying within each polygon are located (Figures 3,4). If any polygon centroid is located beyond 1 km from the closest RMA grid point, a warning message is displayed and written to the .log file. The polygons enclosing the station points are located next. If the Easting/Northing values listed for a given station do not fall within a polygon, the polygon with the closest centroid location is chosen as the station polygon.

A Laplace solver is then run for each of the stations, in batches of five stations per run. An internal boundary condition of one is set at the RMA grid point closest to the station polygon centroid. Internal boundary conditions of zero are set at all other station polygon centroids, and the solver computes the steady state solution. Once the run is complete, values at all RMA points within each polygon are averaged to determine the polygon weight. These weights are then normalized so that the maximum weight occurs at the station polygon and has a value identically equal to one. This process is repeated for every station in order to generate $n_{polygon} \times n_{nstat}$ weights. The final weights are re-normalized for each polygon, so that the sum of all the weights for a given polygon is exactly equal to one. The final weights are output in the polygon_weights.txt file, an example of which is shown below.

1 0.000000 0.000000 0.000000 ...   0.000000 0.000000 0.000000 2
2 0.000000 0.000000 0.000000 ...(n_{stat} float values) 0.000000 0.000000 0.000000 3
3 0.000000 0.000000 0.000000 ...   0.000000 0.000000 0.000000 4

... (total of $n_{polygon}$ lines; 1959 in this example)

1957 0.000000 0.006261 0.000000 ...   0.000000 0.000000 0.000000 17
1958 0.000000 0.006265 0.000000 ...(n_{stat} vals) 0.000000 0.000000 0.000000 9
1959 0.000000 0.006270 0.000000 ...   0.000000 0.000000 0.000000 10

Figure 5 shows polygons in the vicinity of the Antioch CDEC station, color coded according the computed weights.

[2]http://cdec.water.ca.gov/

[3]http://crunch.tec.army.mil/software/corpscon/corpscon.html

Additional comments

1. Weights are calculated assuming diffusion through the Delta waterways. This approach is not valid for plotting meteorological variables, which are not constrained to travel within the channels. This is also not a valid approach for interpolation around locations with a highly unidirectional flow. In this case, the scheme may result in assigning a significant weight to a polygon upstream of a station point. Since water quality variables cannot physically diffuse upstream through strong unidirectional flow, assigning a nonzero weight for that station may be physically unfounded. However, for most of the Delta during most of the interpolation period of interest, this effect should be considered small.

2. During all diffusion simulations, the Delta Cross Channel is assumed to be closed and thus acts as a boundary for diffusion through that channel.

3. The program may produce incorrect results when there is no polygon within the vicinity of a station location. For example, the CDEC station DWS (Sacramento Deep Water Ship Channel) is located within the RMA Delta grid boundaries. However, no polygons listed in the .ply file cover the ship channel and, as a result, the program will use the closest polygon (located in the Yolo Bypass) to assign an internal boundary condition of one. Consequently, weights are calculated as if the station was located on the east side of the Yolo Bypass instead of in the ship channel and, for this reason, the DWS station was removed from the sample Stations.txt file.

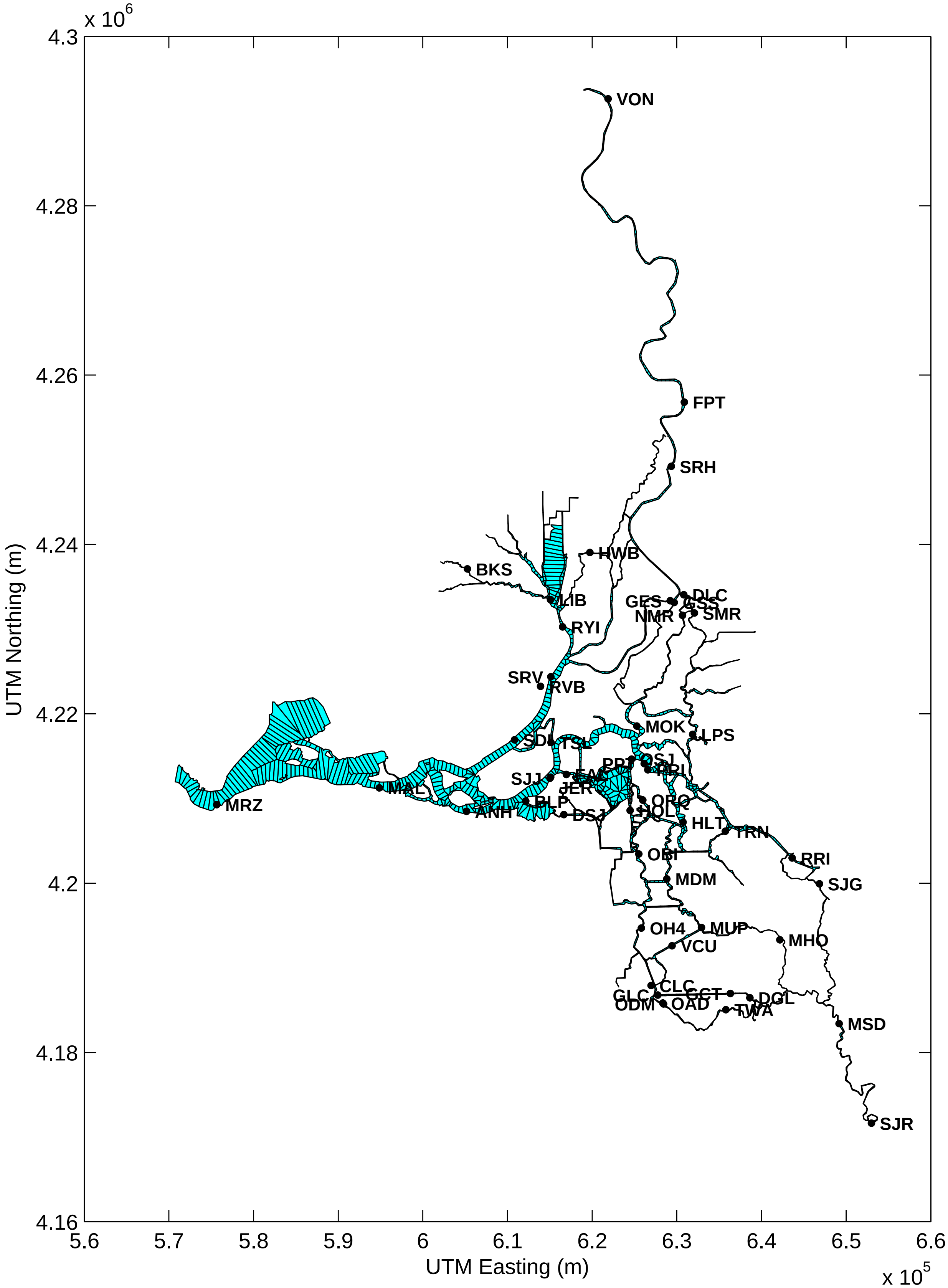

Figure 1: Example polygon and CDEC stations

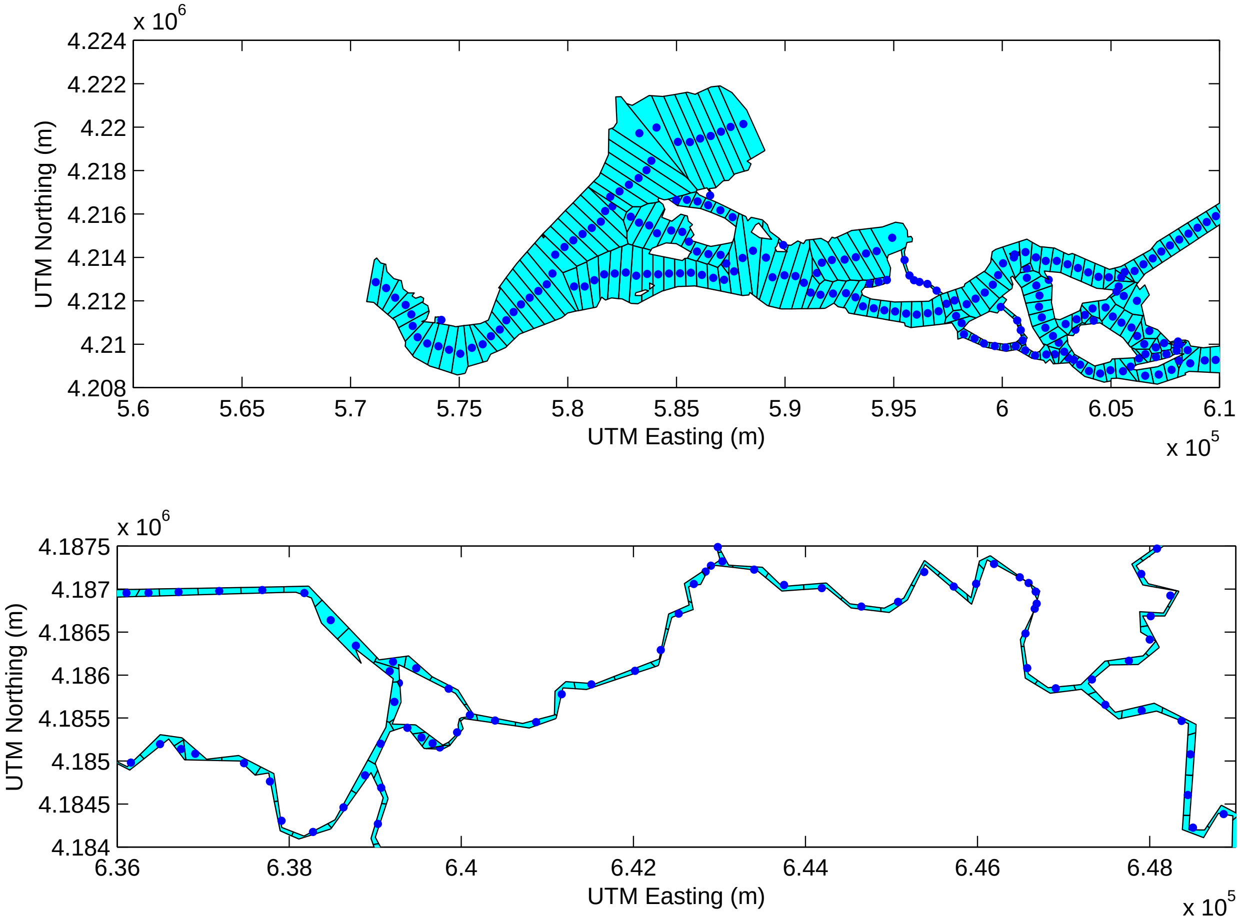

Figure 2: Polygon centroid locations in the vicinity of Suisun Bay [top panel] and Grant Line Canal, Doughty Cut, and Old River [bottom panel]

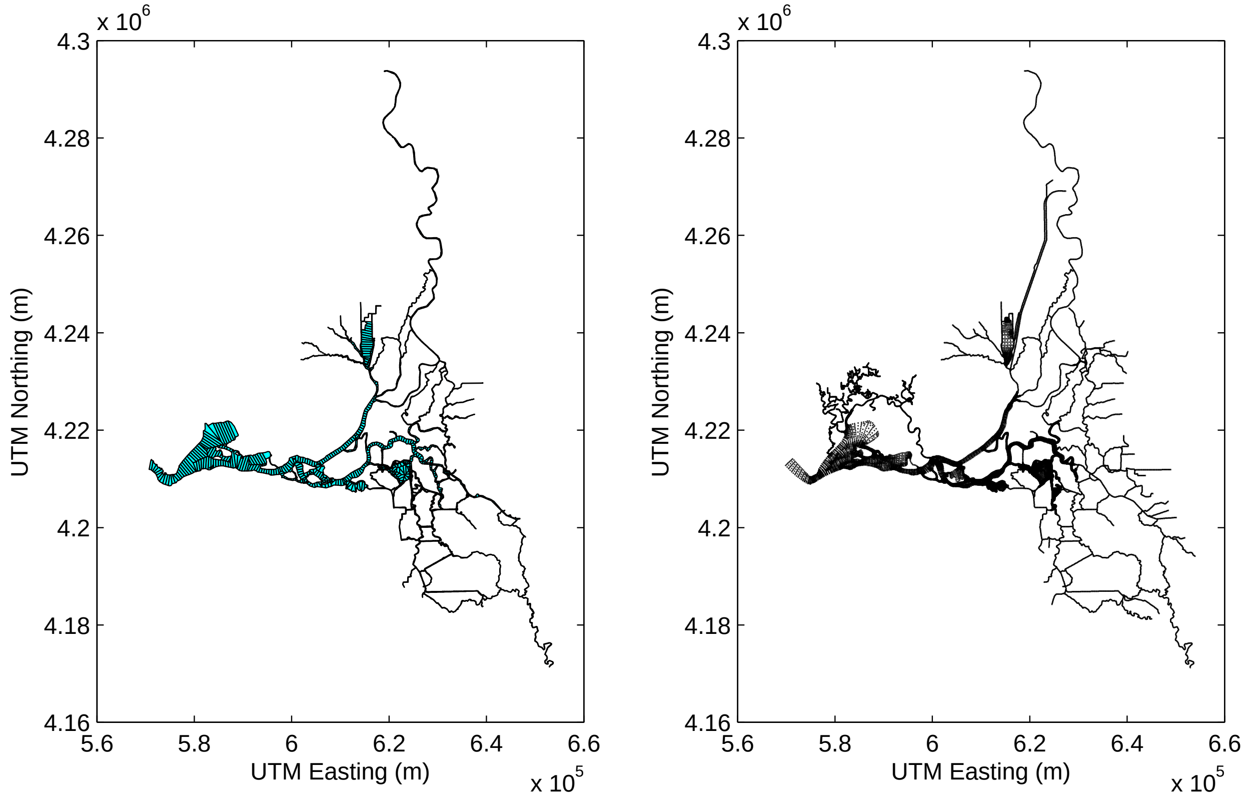

Figure 3: Spatial extent of polygons [left panel] and RMA grid points [right panel]

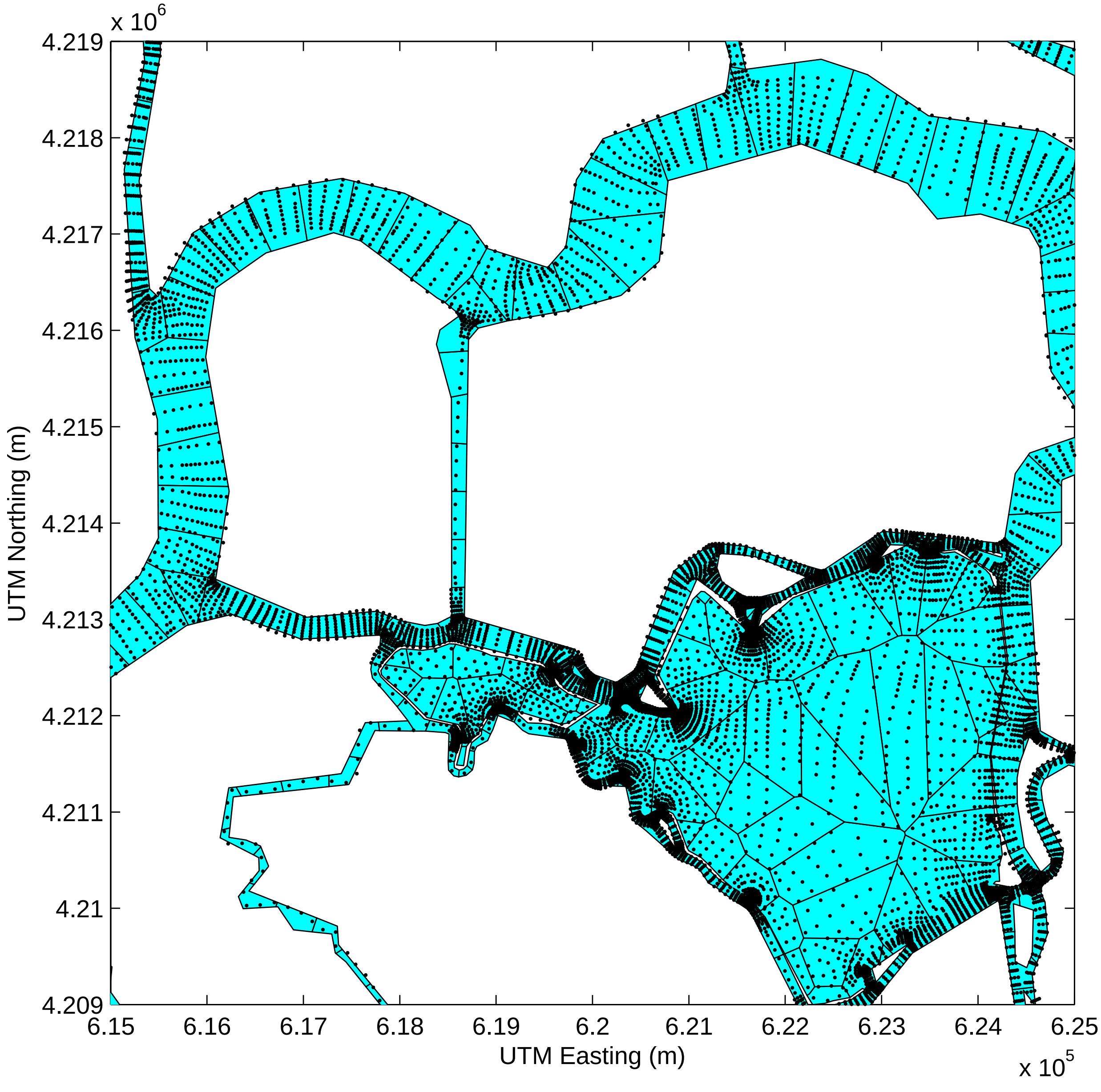

Figure 4: Polygons and RMA grid points in the vicinity of Franks Tract

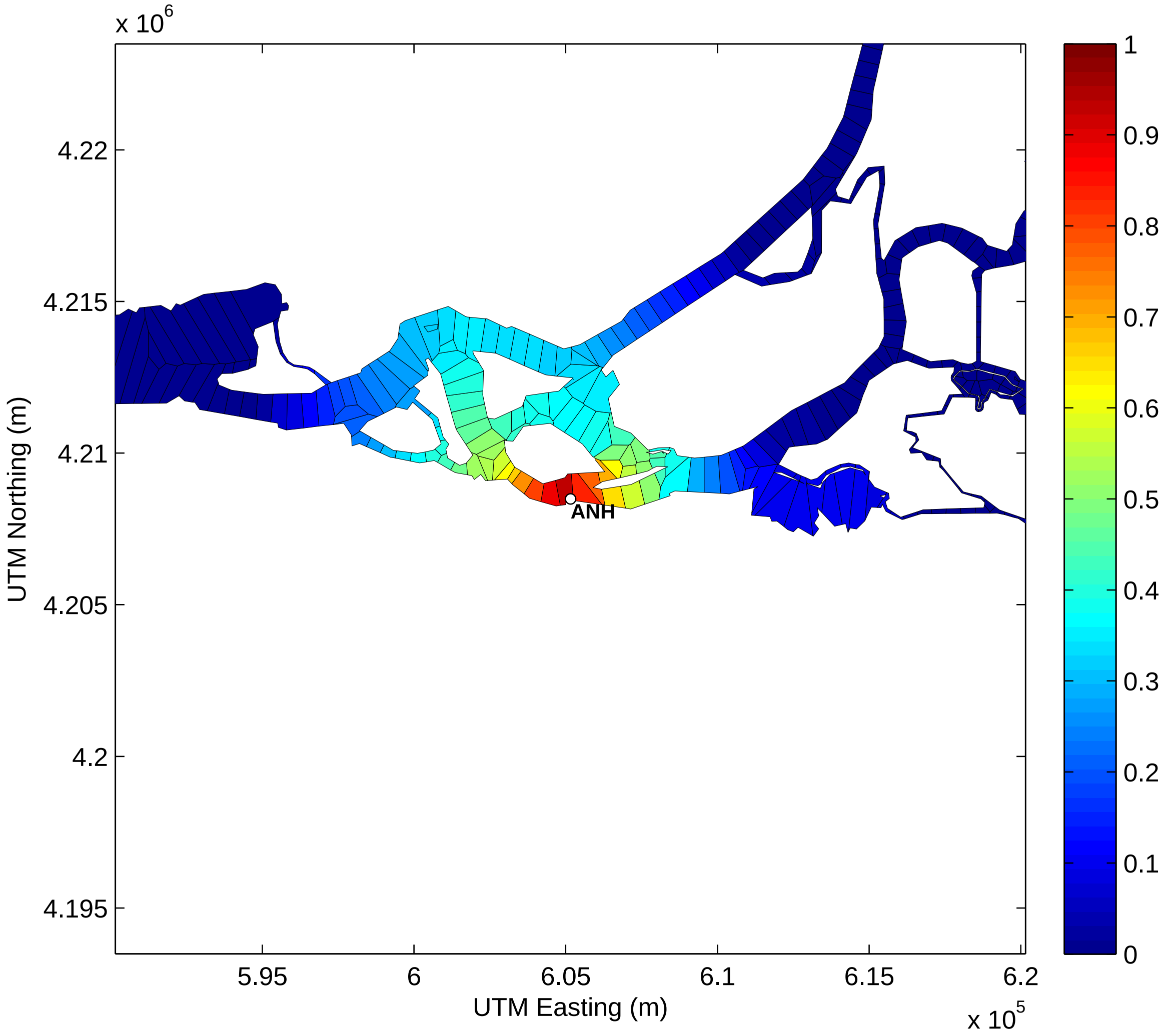

Figure 5: Computed polygon weights for the CDEC station ANH (Antioch)