Modernizing the Mapping of the Edmonds Memorial Cemetery

Project Report

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Western Washington University

Sustainable Communities Partnership

About SCP

Western's SCP program focuses the energy and ideas of faculty and students upon the issues that cities face as our society transitions to a more sustainable future. SCP partners with one community each academic year, facilitating a program in which many Western courses complete service-learning projects that address problems identified by the partner.

Sustainable
Communities
Partnership

www.wwu.edu/scp
SCP@wwu.edu
360-650-3824

SCP Partner for Academic Year 2016 - 2017: The City of Edmonds, WA

SCP is proud to partner with the City of Edmonds, Washington, during the program's inaugural year. Eleven courses at Western will tackle ten projects identified in collaboration with city staff.

Acknowledgment

The Association of Washington Cities (AWC) has provided invaluable assistance during the launch of the SCP program. AWC provided seed funding, guidance regarding program design, help with promotion of the program, and advice regarding selection of the inaugural partner.

SCP is housed within Western's Office of Sustainability

PREFACE

Throughout winter and spring quarters, 2017, work took place to develop a modern GIS map of the Edmonds Memorial Cemetery, together with a web interface that would support public exploration of the cemetery. An intern conducted the great bulk of the work, with assistance from eight students. The main product of the effort is the digital files delivered to Edmonds, with this document of secondary importance. Numerous visits were made to Edmonds to meet with officials, discuss the scope of work, and conduct field work. A presentation regarding the project was given on June 9, 2017, to an audience of interested officials and citizens.

Western Team

GIS Intern:	Alice Lazzar-Atwood
Student field team:	Henry Haro, Claire Anderson, Gary Boba, Allison Joy, Amanda Gale, Garrett McHugh, Zoe Carter
Computer science student:	Austin Corotan
Supervisor:	David Davidson

Edmonds Staff

Carrie Hite	Director, Parks, Recreation & Cultural Services
Rich Lindsay	Park Maintenance Manager
Cliff Edwards	Sexton
David Rohde	GIS Analyst

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MODERNIZING THE MAPPING OF THE EDMONDS MEMORIAL CEMETERY

By Alice Lazzar-Atwood & David Davidson

Introduction

This manual will provide information on the development of a spatial database for the Edmonds Memorial Cemetery (EMC) and instructions for the maintenance of the database in the future. The spatial database consists of three feature databases: Cemetery_Units, Columbarium_Units, and Cemetery_POIs. All were developed using ESRI software. All features were built in the projected coordinate system NAD 1983 State Plant Washington North FIPS 4601 Feet.

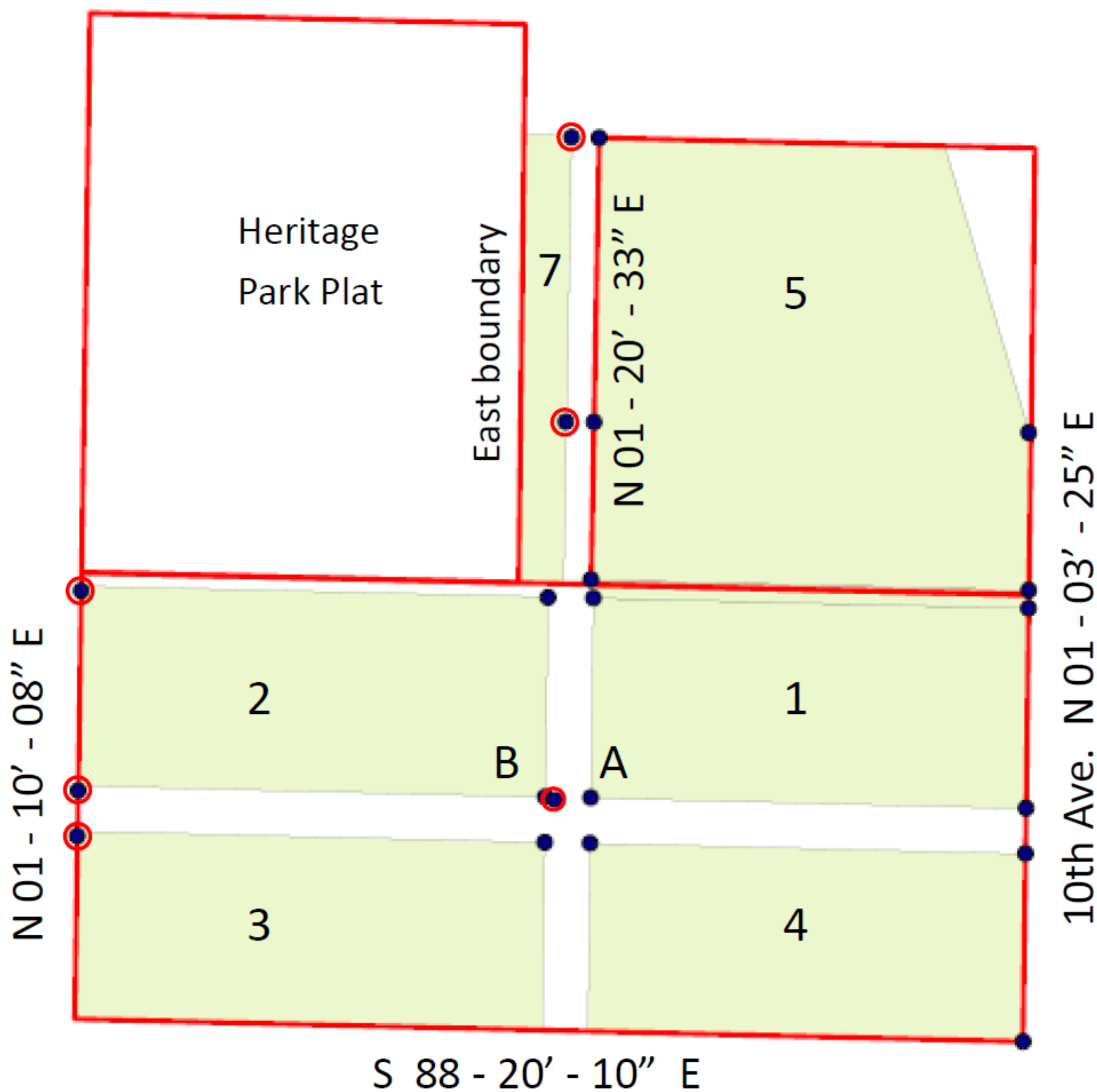
Development of the Spatial Database

Inputs

Figure 1 helps illustrate the manner in which the geodatabase was constructed. I used six main inputs to develop this geodatabase:

1. A 1990 survey conducted by Reid-Middleton. This survey provided bearing and distance information for blocks 1-5 in EMC, as well as the outermost property boundaries of EMC. This survey did not provide bearing and distance information for Heritage Park Plat, but rather included Heritage Park Plat in the boundaries of EMC.
2. A second survey conducted by Reid-Middleton of Heritage Park Plat (a neighboring residential subdivision). Notably, this survey provided bearing and distance information on the boundary lines of EMC that were shared with Heritage Park Plat.
3. A plot map of EMC. This map had written information on the size and location of lots and graves in all blocks, and further information on distances between blocks. It also showed the position of cement features that bounded some lots in EMC.
4. A color-coded plot map of EMC. The map color-coded every grave in EMC based on size. There were 9 different sizes.
5. A point feature class including 21 points from throughout the cemetery (see Figure 1). The points were generated by Edmonds staff using accurate GPS equipment to measure the location of rebar pins placed by Reid-Middleton in 1990. The pins are placed at the corners of the main five blocks, with some corner pins missing. Three pins were <u>not</u> placed at corners of the platted blocks, but rather are remnants of a series that was intended to help Edmonds do wayfinding within the cemetery. They appear to be associated with Block 7, but in actuality are not aligned with the edge of that block.
6. A legacy MS Access database that is the primary management system for EMC.

Figure 1.



Property Boundaries

I used bearing and distance information from the R-M surveys of EMC and Heritage Park Plat to first generate property boundaries (bold red lines in Figure 1). The four major bearings provided by R-M are shown on Figure 1, and R-M also provided edge-lengths for each edge of Blocks 1 through 5. To develop the property boundaries, I used the GPS coordinates of the SW corner of Block 1 (point "A" in Figure 1) as the overall anchor. I chose that anchor because of its central location, as well as the obvious nature of its pin, as well as the lack of nearby foliage—it is believed to be one of the more accurate GPS locations provided by Edmonds. From that anchor, I generated a line the appropriate bearing and distance to the east EMC boundary (SE corner of Block 1), and then generated lines extending counter-clockwise around the original EMC tract (which encompasses Blocks 1 through 4), arriving back at the SE corner of Block 1. Those lines closed to within a few inches, a minor amount. I forced closure by altering the final edge, thus producing a polygon encompassing Blocks 1 through 4. From the NE corner of that tract, I then generated lines to bound Block 5 (a parcel annexed to the original EMC parcel), again relying on the R-M survey of the EMC.

Prior to relying solely on the R-M survey data (as described above), I first attempted to use the GPS coordinates provided by Edmonds to directly define property boundaries, as well as block edges. The resulting polygons were inaccurate, though, when comparing derived edge lengths/bearings to the R-M survey. It became apparent that the precision of the GPS coordinates was poor in comparison to the precision of the R-M survey data. This is likely due to issues inherent to GPS, such as the presence of overhead foliage and/or adjacent structures, which tend to interfere with the satellite signals.

Blocks

Following development of the property boundaries, I created a polygon feature class containing all seven blocks in EMC. This feature class again relied solely on bearing and distance information from R-M, and again was anchored upon point "A." R-M provides data (distance/bearing) for the edges of each block, as well as precise widths of the aisles that separate the blocks, so it was a simple matter to create polygons matching the provided data. Blocks 1, 4, and 5 are built eastward from anchor point "A," and blocks 3 and 4 are built eastward from the west property boundary.

Blocks 6 and 7 were a little trickier, as these blocks were both newer and had less clear information. I used the east boundary of the Heritage Park Plat for the west edge of block 7, and the bearing of the west edge of block 5 for the east edge of block 7. This results in a trapezoidal block 7, which is wider at the north than at the south. This distortion is not reflected in the legacy plot maps, which imply a consistent width throughout the block. However, the road between blocks 5 and 7 was a consistent width. Therefore, I accepted this distortion, but built block 7 from the south up, so the south end is of a width that matches the legacy map, while the north end is wider. Since I had no specific edge-length information for block 7 from R-M, I referred to the plot map for sizing. However, given the non-parallel edges of the block, the south and east edges match the map, while the north and west edges are both slightly longer to account for the difference.

Block 6 is a 12-foot wide strip located between block 1 and block 5. While blocks 1, 5, and 6 are shown to be flush at the west end in legacy plot maps, block 5 actually extends 1.6 feet further west than block 1. After conferring with Cliff Edwards, I determined that this was accurate, and that block 6 also extended this extra amount. Therefore, I used the same bearing information as I had with blocks 5 and 1, but I used the south edge of block 5 as the north edge of block 6.

Applying a grid conversion

After the development of the blocks, I noted that there appeared to be a uniform rotational skew of all the blocks in comparison to the GPS points. Although I had determined that the GPS points were not as accurate as the Reid-Middleton survey, the skew was still informative. It existed because I had not applied a grid conversion before building the polygons. The state plane projected coordinate system provides specific projections for regions of the US, but even within a given region, there is distortion as one moves farther away from the central meridian. I developed a set of block-edge bearings based upon the GPS coordinates, and a corresponding set based upon the R-M survey. By comparing the bearings for a given edge as derived by these two methods, an angular rotation factor can be derived. Such factors were derived for nine edges, and the average of the factors amounted to 17' 54" (see table below). I rotated the polygon features counter-clockwise by that amount, which resulted in a much better correspondence between polygon vertices and GPS corner coordinates. Close examination of the polygon corners revealed that a small translation within the X-Y plane would yield an even better match between vertices and GPS points, so the entire polygon layer was shifted such that the SE corner of block 2 (point "B" in Figure 1) is aligned with the corresponding GPS coordinates of that corner pin. I.e., point B became the de facto anchor point. After the rotation and X-Y translation, the average distance of a polygon vertex to its corresponding GPS pin is 1.7 inches, and the worst-case separation is 3.4 inches. Those values are based upon 15 of the GPS points, with the six red-circled points on Figure 1 omitted. The points at the west end of the cemetery are beneath heavy foliage, resulting in displacements of greater than 3 feet. The points at the east edge of block 7 are omitted because they don't correspond to any vertex within block 7 (recall that they were remnants of a wayfinding method developed by R-M).

Edge	R-M Bearing	GPS Bearing	Difference
S of Blk 5	88:20:10	88:36:46	0:16:36
N of Blk 1	88:20:10	88:38:57	0:18:47
S of Blk 1	88:20:10	88:36:15	0:16:05
N of Blk 4	88:20:10	88:38:44	0:18:34
E of Blk 1	1:03:25	0:44:03	0:19:22
W of Blk 1	1:03:25	0:42:51	0:20:34
E of Blk 2	1:03:25	0:44:57	0:18:28
W of Blk 5	1:20:33	1:04:10	0:16:23
W of Blk 5	1:20:33	1:04:14	0:16:19
		Avg. of 9 values:	0:17:54

Lots

Within each block are lots. After discussion with Cliff Edwards, I learned that there are three varieties of lots. There is an original "lot" that typically consists of 8 full sized graves. Then, to the east, there is a "road lot", that was later added when more space was needed, and to the south there is an "aisle lot," that again was added later. I hereafter use the term "mega-lot" to refer to a collection consisting of a lot, together with its associated road lot and aisle lot.

To produce lot polygons, I used the ArcGis "Split Polygon" tool to dissect blocks into mega-lots, as based upon the lot and grave dimensions shown on the legacy plot map. The splits were done with lines parallel to the edges of the encompassing blocks. I then used the same tool to split each mega-lot into its three constituent zones ("lots," "road lots," and "aisle lots"), again with lines parallel to the edges of the mega-lots.

It was necessary to produce a polygon for each of the three zones within each mega-lot, because the legacy Access DB contains "lot" records, with one such record for each zone within each mega-lot. I.e., there are three Access DB "lots" associated with each mega-lot. There was also a legacy numbering scheme used in the DB, as follows: An original 8-grave lot was represented by just its number (ex: "32"), a road lot as the original number with the block number as the first digit (eg: "132" if the road lot is in mega-lot 32 in block 1). For an aisle lot, a letter follows the original lot number, with the letter denoting the block (eg: "032a" if the aisle lot is in mega-lot 32 in block 1). In block 5, there are more than 100 mega-lots, so the road lots extend beyond "5XX." Eg. "612" is a road lot that has a main lot number of 112 and is located in block 5.

I found that with all of the blocks, the dimensions shown on the legacy plot maps were not perfectly consistent with the block sizes. Again, since the blocks were based upon survey-grade data, I assumed these were more accurate. The result was that there is some distortion in lot size. I began creating the lots from the center of the EMC outwards toward the edges. In other words, I started creating lots from the SW corner of block 1, the SE corner of block 2, the NE corner of block 3, the NW corner of block 4, and the SW corner of block 5. Therefore, any mismatches between polygon dimensions and legacy lot dimensions are found in the lots at the outer edges. Most notably, I found that blocks 2 and 3 were 0.5-0.85 feet too short, relative to what the plot maps indicated. Cliff Edwards is aware of this issue, and has historically accounted for the problem at the western edge of these blocks. I.e., the lots and graves that border the west edge are as much as 0.85 feet shorter than the plot maps indicate.

Blocks 6 and 7 technically do not have lots. In the Access DB, some of the graves in these lots were labeled as being lots, each with one grave, and some where labeled as just being a grave with no lot. In place of lots, I digitized graves for each of these lots.

Graves

The process I used to develop the graves in EMC was extremely similar to the process I used to develop lots. The "Split Polygon" tool was used to split each lot into the appropriate number and sizes of graves according to the legacy maps. Again, discrepancies in grave sizes (as compared to legacy maps) were relegated to the graves at the outer edges. Again, the most notable difference was in the west edge of blocks 2 and 3.

When comparing the Access DB to the graves, I realized that the Access DB assumed that block 6 had three rows (108 graves), but all plot maps showed block 6 as having two rows (72 graves). After discussion with Cliff Edwards, we found that block 6 was originally created with 108 graves, but past documentation had been unclear. Since there were people buried in all three rows in the Access database, I gave block 6 three rows of graves that were 4 ft x 8 ft, instead of two rows of 6ft x 8 ft graves (as is shown on the legacy plot maps).

Graves that were 8 ft are considered "full" graves, meaning that a casket could be buried in them, in addition to up to 8 urns (which are interred in a grid of small plots slightly above the underlying casket). Graves that were less than 8 ft could not accept a casket, and are considered "ash" graves. In the Access DB, full graves simply were assigned a number (ex: "3"), and ash graves had an "A" in front of their number (ex: "A3"). I gave the graves number attributes accordingly.

Polygon attributes have been created for the mega-lots, the three zones of lots within each meg-lot, and the graves within each lot, such that polygons can be linked to the Access DB.

Developing Hierarchical Topological ID's

When developing these feature classes, it became clear that there was no sort of unique but meaningful identifier for lots, graves, or people. The unique ID's that existed in the Access database appeared to be random, simply generated automatically as each new entry was put in. I needed an easy way to join the Access DB and the geodatabase together, and developing a unique and meaningful ID scheme was the most logical way. I developed the following scheme:

1	**043**	**2**	**0**	**3**
Block	*Lot*	*Lot Type*	*Grave Type*	*Grave*

In this scheme, a lot gets a 5-digit number, and a grave gets a 7-digit number. The high-order digit represents the block number, which can be 1-7. The next three digits represent the mega-lot number. Three digits are needed because in block 5, there are over 100 lots. In addition, for the sake of consistency in applying ID's, graves in block 6 and 7 were considered each as lots, so these blocks also have over 100 lots. The fifth digit designates lot type. A "1" represents an original lot, a "2" represents an aisle lot, and a "3" represents a road lot. The sixth digit designates a grave type. There can be two types of graves: Full and Ash. Full graves are represented by a "0", and ash graves are represented by a "1". Finally, the seventh digit represents the grave number. This number can range from 1-8, depending on how many graves are in a given lot.

Using Python script in ArcMap's Field Calculator, I used the attributes I had developed in the feature classes to generate these unique ID's as a new field. Meanwhile, Austin Corotan (a computer science student) developed a JavaScript utility program to generate the same ID's for all entries in the Access DB. The development of this unique ID scheme would allow for easy joins between the two databases.

People

I developed a "people" point feature class in order to account for the fact that multiple people can exist in the same grave, and yet ArcMap cannot support many-to-one joins. In other words, a single grave polygon cannot have multiple external database entries (i.e., people) associated with it. I derived this people feature class directly from the Access DB. This was made possible by the unique ID's we developed. Because each person was an individual point, I added a lowest-order eighth digit to the ID scheme.

1	**043**	**2**	**0**	**3**	**4**
Block	*Lot*	*Lot Type*	*Grave Type*	*Grave*	*Person*

As can be viewed above, the eighth digit represents the person number. A person can have a number from 1-9. These numbers designate the location of a person within a grave. The "1" is the casket position in a full grave. 2-9 represent the 8 possible urn burials on top of the casket.

To assign geographic coordinates to these people, I generated X-Y centroids for each grave polygon and exported the centroid values as an Excel table. The JavaScript utility developed by Corotan (described later) joins these X-Y coordinates to the Access DB using the grave IDs. The result is a table that contains a separate entry for each person who is either buried in EMC, or has purchased a grave in EMC. In addition to the information already in the Access DB (e.g., name, dates of birth/death, etc.), these entries also have X-Y coordinates associated with them, and a JPEG file name if applicable (see the "Headstone Photos" section).

This table can be imported into ArcGIS as a point feature class. I added an attribute to the Graves table called "Availability", and populated it based on whether or not a given polygon contains any "people" points.

To convert this table into a point feature class, I added it into ArcMap, and displayed it as XY data. The projection ArcMap will use is the projection of the data frame, so if it is not set to State Plane Washington North, make sure to do that manually, as the northings and eastings in the table are based on this projection. Once the XY data is displayed, it appears as an "Events" layer. Export this data into the desired GDB to save it as a permanent point feature class.

Calculating "Availability"

I added an attribute to the Graves table called "Availability", and populated it based on whether or not a given polygon contains any "people" points. To do this, I first used the ArcGIS "field calculator" to assign every polygon as "Available". Then, I used "Select by Location" to select the graves (target layer) that contained any part of the source layer (people). I then used field calculator again to assign only the selected polygons as "Not available".

I later created a second availability attribute, AvailavilityHS. For this, I introduced a third category, "HeadstonePresent", for those graves that were available (as indicated by the legacy Access DB), but had a headstone present on the grave. Initially, I used field calculator to populate "AvailabilityHS" with the same values as "Availability". Then, I used a "Select By Location" to select all graves (target layer) that contained any part of a headstone (source layer). As described below in the "Surveyed Headstones" section, this only evaluates the NW corner of each headstone. Using field calculator on just the selected features, I assigned the string "HeadstonePresent" to all of the features that were labeled as "Available". Note that "Not available" graves may have headstones, but are labeled the same as unavailable graves without headstones. For the web map and the wall map, I used the symbology tab in the graves layer properties to symbolize the graves by the "AvailabilityHS" attribute.

Revisions to Legacy Access DB

A goal of the project was to support linkage of information between the Access DB and the GIS map. Although Edmonds intends to purchase cemetery-management software in the future, the existing Access DB is the available resource at this time, so work was done to support a linkage. There are two main data tables within the Access DB—"lots," and "graves." Information about individual people is recorded within rows of the "graves" table, and that information is transferred to the GIS by way of the method discussed immediately above—the "people" table that is imported as a point feature class into the GIS. The underpinning of the linkage is the use of the hierarchical topological person ID values.

The “lots” table is coupled to the GIS in a different manner. Recall that within each mega-lot are three zones. It is those distinct zones that correspond to data in the Access DB “lots” table, with one row in the table pertaining to each such zone in the EMC. Given this one-to-one correspondence between the zone polygons and the rows of the “lots” table, it is possible to directly join that DB table to the GIS. However, to support that join, revisions had to be made to the Access DB. We earlier noted that “under the hood” of the Access DB, numeric values unrelated to topology were used as the “keys” that link a given “lot” to the set of “graves” included within the lot. We had to replace those keys with new numbers consistent with the lot-ID, grave-ID and people-ID scheme described above. We broke the linkage between the two data tables in the Access DB, erased the legacy key values, put in place new 5-digit key values consistent with our scheme, and rebuilt the linkage between the tables. This resulted in a key value for each row of the “lots” table that is identical to a unique topological 5-digit value associated with a given zone polygon. The modified Access DB was delivered to Edmonds in April and has been in use since then.

Headstone Photos

In mid-March 2017, a field team took a photo of every headstone present in EMC at that time. At this point, we had developed our ID scheme, and assigned everyone in the Access DB a number. We printed out the database, so we had reference sheets with names and ID’s on them.

We went row by row, using ropes to create an obvious border between the rows of lots, to make finding the appropriate headstones easier. This was important, because when we took a picture of a headstone, we used the app “FilePhoto” to name the photo according to the corresponding person ID. This meant that we had to go in order of lot number, so that finding people on the reference sheet to obtain their ID number would be as simple as possible. In addition to naming each photo with its 8-digit person ID number, we appended 3 more digits to each photo name: we graded the degree of weathering of each headstone on a 5-point likert scale (first appended digit), then appended either a 1 or a 2 to indicate a flat headstone or an upright headstone, and finally appended either a 1 or a 9 to indicate a single person headstone or a multiple person headstone. This resulted in each photo having an 11 digit file name.

We encountered many problems while taking these photos. There were some headstones that did not have any names that were on our reference sheets. In contrast, there were some people on the reference sheet that did not have a headstone. If we found a headstone that did not exist on the reference sheet, we assigned it a person ID based on its relative position.

After taking photos of every headstone, we manually checked each photo against the Access DB. For every photo that had a “9” (indicating it represented a multi-person headstone), we duplicated it so each person on the headstone had a photo, and edited the person ID so it matched the person ID in Access. We changed the first instance of the photo to end in a “1” instead of a “9”, and any following instances to a “0” instead of a “9”. The purpose of this was to provide an easy way to tally how many headstones existed in EMC.

After checking all of the photos, a second utility program provided by Corotan was used to dissect each photo’s name. It removed the appended three digits from each file name, leaving a name that simply represented the person’s ID. It then produced an Excel sheet that contained the new file name, and then produced new fields for the Likert reading, upright/flush designation, and headstone tally.

Cement Enclosures

I digitized a polygon feature class that represents all of the cement features that enclose various lots in EMC. These features are interesting. They were meant to enclose the 8 graves that comprise each original lot. However, many of them were not installed that way. Cliff Edwards had evaluated all of them, and drawn their relative positions onto one of the plot maps. Going on site to obtain accurate spatial data on where each cement feature was located was beyond the scope of this project. Instead, I used Cliff's plot map to digitize each enclosure.

As mentioned previously, the plot map did not perfectly correspond with the Reid-Middleton survey information. In addition, it appeared to have ripped in the middle, and then been taped back together. This made digitization a little more complicated. For each block, I re-georeferenced the plot map to get the blocks to line up as best as possible. Then, I digitized each cement enclosure drawn in by Cliff.

I ran into the most problems for block 5. Because of its angled nature, the polygon I developed from the R-M survey was especially different from the block drawn on the plot map, and this was also a place where the plot map had been ripped and taped back together. For the digitization of these cement features, I relied most heavily on relative positions. I noted which graves each cement enclosure cut through, and drew them accordingly. I felt that this was the most effective way to handle these features, because when Cliff initially drew them on the map, this is likely the way he handled them. While it needs to be emphasized that these cement features have a low level of spatial accuracy compared to the blocks, lots, and graves, they do follow the relative positions of the cement features on the plot map well. In other words, they match (and are limited by) the accuracy of the plot map.

Columbarium Terraces/Niches and Communal Grave

Edmonds also desired to have mapping and database-linkage for the Columbarium. This posed difficulties in that a columbarium is a *vertical* structure, with niches aligned one atop another, whereas the remainder of the cemetery is a horizontal arrangement of lots and graves. If traditional mapping (within the X-Y horizontal plane) was performed for niches and the corresponding persons, the mapped points would overlay one another. In discussion with David Rohde, a decision was made to create a 2-D representation of the terraces and niches in the horizontal plane (i.e., as if the wall of niches was tipped over and lying flat on the ground), meaning that the mapped locations of persons/niches are not geospatially accurate.

8	**016**	**7**	**10**	**2**
	Terrace	*Row*	*Column*	*Person*

The 8-digit topological numbering scheme described earlier was augmented to include persons in the old Columbarium, the new Columbarium, and the Communal Grave. For such persons, the highest-order digit is "8" (recall that elsewhere in EMC, that digit is used to represent the Block number, a value from 1 through 7). The next three digits specify a terrace of niches (001 – 016 equate to terraces A – P). The next digit is the row (range 1 - 7), and the next two digits are the column (range 1 – 10). Those 7 leading digits specify a niche, and the final digit specifies the person within the niche (1 or 2). For the old columbarium, the north wall is coded as

“8017” and the south as “8018” with the next three digits specifying the niche (range 1 – 24) and the final digit the person within the niche (1 or 2). The communal grave is coded as “801900x1” where the “x” can range from 1 – 7 to match the “grave” numbers in the Access DB. Corotan’s maintenance utility correctly builds 8-digit ID numbers for all persons in the columbariums and communal grave, and such persons are correctly assigned to niches in the web map and the GIS database.

Surveyed Points of Interest (POIs).

Edmonds desired that various EMC features and amenities be accurately mapped (e.g., light poles, trash receptacles, buildings). This was accomplished by use of a Total Station (a surveyor’s instrument). The same team that acquired headstone images in mid-March also performed feature mapping, gathering point-data that could later be used to draw features. For example, dozens of individual points were gathered along the edges of the asphalt road, which enabled me to accurately map the road’s location with reference to the grid of graves. The points were directly measured in the WA State Plane coordinate system, as the Total Station was deployed directly over R-M pins, for which we had precise coordinates. Points measured in this manner are quite accurate—i.e., to within +/- two inches of the absolute location.

I used these points to digitize the seven feature classes in the Cemetery POI feature dataset (the eighth feature class is a collection of the points unedited). I created point feature classes for lights and amenities such as trash cans and bathrooms; line features for benches; and polygon features for buildings, structures, water features, and road features.

Surveyed Headstones.

Edmonds desired that the location of each headstone be accurately mapped. We chose to again use Total Stations to accomplish this task, because of the higher degree of accuracy and the rapidity of data collection, relative to the use of GPS. A five person team worked in early June to collect data, which consisted of a single X-Y coordinate per headstone, taken at the NW corner of the stone. This headstone data is not closely integrated into the feature layers described earlier (i.e., the “persons” point feature set, or the “headstones” image set). Those data sets are suitable for use in the public web map, as they conceptually show persons and headstones as present within certain graves. The headstone-location points would be confusing to the casual user, as they are off-center within a grave, or even present in an adjacent grave to where a person is buried (i.e., the headstone might extend beyond the edge of the grave that was meant to contain it). The value of these mapped points is the accurate portrayal (+/- two inches) of where headstones lie, in comparison to the platted grid of graves.

Inconsistencies that arose

We encountered inconsistencies, as discussed below:

Headstones that did not exist

As mentioned, we found that some people in the Access database seemed to have missing headstones. This means that a person that was marked as having a headstone in the database did not have a headstone on site. There were a few explanations for these inconsistencies:

1. The headstone was overgrown. EMC is large and old. In photographing headstones, we encountered one that was almost entirely overgrown. We discovered it by accident, when I noticed a tiny opening in the grass that was strangely shiny. This led us to believe that other headstones might have been overgrown.
2. The headstone was unreadable. We encountered some headstones that we ranked as a "1" on the Likert scale. In other words, we could not read the name on the headstone. In these cases, if there was a person missing in the area, we assigned that headstone to that person. If there wasn't, we did not take a photo. It is possible that the headstone may still be associated with a person, and is in a different place than where the person is actually buried.
3. The headstone was out for maintenance. It took us five days to obtain these photos, and business at EMC continued as usual. If a headstone had been removed for maintenance during this time, we would not have found it.

In general, this was not an issue that we addressed. If we could not find a headstone, we did not have a photo to associate with the person.

People that did not exist

We found a number of headstones that were for people that did not exist in the Access database. Again, after conferring with Cliff Edwards, there seemed to be multiple reasons for this inconsistency.

1. The headstone is a memorial. Often, we would encounter this issue on double headstones. Two people were on the headstone, but only one of those people was in the Access database. Often, when one person in a married couple dies, they are buried with a double headstone that has the names of both people on it. However, the remaining person may not actually be buried there when they die, explaining their absence in the Access database. However, since people would still likely want to come to this headstone to honor both people listed on the headstone, we added these people into the system.
2. They were never recorded. The other main trend with people who were missing was that they lived a long time ago. It's likely that records were not perfectly maintained, and since it was so long ago, current management has no knowledge of what actually happened. In these cases, we also added these people into the system. Again, we assumed that the location of the headstone is where people would want to go to honor the names on the headstone.

Graves 9 and 10

There were a small number of people who were recorded as being buried in graves 9 and 10 within a given Lot, but according to the conceptual layout of EMC, graves 9 and 10 don't exist. These records were a result of previous management mis-recording burials. Cliff Edwards evaluated all instances of headstones that were for people buried in graves 9 and 10, and fixed them accordingly. This is an involved process, as it sometimes involves editing multiple people's locations within the lot. Therefore, Cliff was not able to assess every single grave 9 and 10 in the Access database. As time goes on, these issues will come up, and should be assessed and edited as they do.

Lot that didn't exist

There was an instance in which a lot was recorded in the Access database that did not theoretically exist on site. In block 4, lot 32 had a type "4", when lots can only have types 1-3. This was because this particular area of block 4 is heavily populated, and therefore the road lot (type 3) was split into two in order to fit all of the people into the Access database. For the sake of simplicity, I edited the lot polygons so that lot 40323 was split into lot 40323 and lot 40324

Maintenance: Adding People and Photos

At some point, Edmonds will purchase cemetery-management software and migrate data (from both the GIS and the legacy Access DB) to the new software. Meanwhile, Edmonds needs a means to continue cemetery operations with the DB and GIS. This section describes methods and tools to be used for ongoing operations.

Access DB. Cliff Edwards should continue use of the Access DB in the same manner as always. He can add data to all fields in all tables, recording new burials and sales.

Headstone photos. As headstones are placed, each can be photographed. Initially, the photos can be placed in a TEMP folder and given names corresponding to the person's name (e.g., "Joe Smith 7 June 17"). During the update process described below, the photos can be renamed and uploaded to the Edmonds GIS server.

Periodic GIS update. We have provided a utility program that can be run periodically to make new data available within the GIS applications. The utility accepts three Excel files as input:

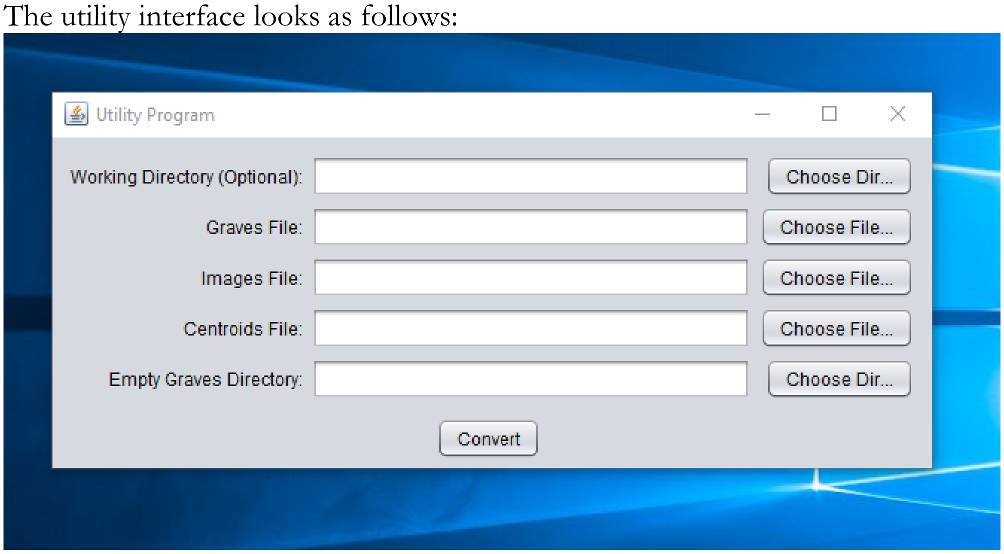
- Centroids. This file identifies the centroid of each grave/niche within EMC. It should never be altered, as it matches the topology of the mapped grid of graves. The entries within this file are sorted (and MUST be sorted) in ascending order of 7-digit grave IDs. The utility program reads this file, but does not alter it.
- Graves. The user must export this file from the Access DB. Within Access, use menu options to display the entire "Graves" table in a "Table" display (rather than as a "Form"). Select the entire table (i.e., so that all ~10,000 rows are selected), and then export the table as an Excel sheet. Use the option to maintain formatting, and the option to export only the selected rows. Place the exported Excel file into the working folder used by the utility program. **Ensure that the file is sorted in ascending order of LotID.** If queried by Excel, choose the option to sort "anything that looks like a number as a number." The utility program reads this file and modifies it, adding four columns of data for each "grave" (row). The first added column contains an 8-digit PersonID, which is based upon the 7-digit ID of the grave within which the person is buried. The next two columns are an X (Easting) and Y (Northing) value of where the person is buried, based upon the centroid file and the 7-digit grave ID. The final column (if present) is the name of a JPEG file that shows the associated headstone. For many entries (i.e., people that have purchased a plot but are not yet deceased) there is no JPEG image, as there is no headstone. If there IS a headstone, the appropriate file name is fetched from the "Images" Excel file described below. After the utility has run, the altered Graves file can be imported into the GIS (and the web map) as a point feature set, using the X-Y values to provide coordinates with which to plot the points. To perform the import, within ArcMap right-click on the sheet and select "Display XY

data." Make sure the X and Y fields are assigned correctly, and that the projection is State Plane Washington North FIPS 4601 US Feet. This will produce a temporary event layer. To make this a permanent feature class, right click on the Events layer and select "Export Data". This will result in the creation of a "people" point feature class.

- Images. This Excel file must be manually modified by the user. The file contains rows that show the correspondence between persons (in the above-described Excel file) and headstone photos. For each new headstone photo to be incorporated, a row must be inserted into the file. The user must specify the Person ID, the file name of the JPEG image, the attributes of the headstone (stone-condition likert reading, upright/flush designator, and tally value), and the X-Y coordinates of the headstone. Recall that the first 7 digits of a Person ID are the Grave ID within which the person is buried. Reference the Centroids file and find the X-Y coordinates of the centroid of the given grave; copy/paste the appropriate coordinates into the Images file. X coordinates equate to "Easting" and Y coordinates equate to "Northing." **Before submitting this file to the utility, ensure that it is sorted in ascending order of Person ID.** If queried by Excel, choose the option to sort "anything that looks like a number as a number." **AND, set every value in the "Refcount" column to zero.** The utility program uses that column to indicate how many times it has associated a given photo with a person. After the utility runs, every value in that column should be a "1," meaning that every photo was referenced once and only once.

There's a chicken-egg issue. A Person ID must be put in one column of the Images file, but that ID is generated by the Utility program that reads both the Images and the Graves files. A user sufficiently confident of their understanding of how the person-numbering scheme relates to the legacy Lot ID and Grave # values can calculate the Person ID for a new entry (row) within the Graves file, and then assign that Person ID to the headstone photo within the Images file, prior to running the utility. A second alternative is to run the utility program twice in a row. The first time through, it will process new persons (rows) of data from the Access DB and will compute person-ID values for each person. On that run, the utility will not yet notice a photo, because the user will not yet have inserted a row into the Images file. After the first run, find the Person ID values of the newcomers, and edit the Images file to include new rows of persons and associated photos. Remember to set the Refcounts in the Photos file back to zero. Run the utility a second time and it will attach image names to corresponding persons.

The utility interface looks as follows:



The utility is delivered within a folder titled "Updating" which in turn contains folders titled "Working Directory" and "UtilityProgram2." Within the latter folder are the utility itself, named "UtilityProgram2.exe" and a folder named "bin." This entire folder assemblage should be copied intact to the user's hard drive, and the utility is run by activating the .exe file in the folder where it is located – it needs access to files within the "bin" directory in order to work.

It is recommended that the user place the three input files into that Working Directory, and that the path to that directory be specified in the first line. In the next three lines, the names of the input files are specified. They can be chosen by mouse, or entered by keyboard. If an input file is within the working directory specified in the first line, a path name can be omitted. Alternatively, the user can opt not to provide a working directory and to instead specify full path names for all files (and can have the files located at arbitrary locations within the file system). In the final line, the user provides the name of an output file. As the utility runs, it processes the Graves file, row by row. Each row is EITHER modified to contain the four new columns of data (as described earlier), OR is shunted out of the Graves file and into an "Empty Graves" output file. Once done running, a new, shorter Graves file is present, referencing only those graves that contain non-null data. Also present is an EmptyGraves file, with thousands of "empty" graves – rows that had null data in all important fields.

> ***NOTE: The utility modifies the Graves file! If running the utility twice in a row, to solve the "chicken-egg" problem noted earlier, discard the Graves file produced after the first run, and use a fresh copy of the Graves file exported from Access for the second run.***
>
> ***NOTE: The utility is able to read only .xlsx files, which are the newest internal file format of Excel files. It will not work on older .xls files.***

List of Delivered Products

- This report.
- A modified version of the legacy MS Access database, incorporating the new 5-digit "LotID" values as keys for "under the hood" linkage of "Lots" to "Graves," and also fixing numerous inconsistencies. This DB can be used in the customary manner for management of the cemetery. The "Lots" table can also be directly joined to the EMC Lots polygon feature layer within the GIS geospatial database.
- An Excel sheet listing the centroids of the polygons (graves and niches) within the GIS.
- An Excel sheet showing the correspondence between headstone images, persons, and locations of persons (using X-Y values based on centroids).
- An Excel sheet linking surveyed locations of headstones to persons.
- A utility program that generates an Excel sheet of persons and their associated locations (based on centroids) within the cemetery. The sheet generated by the utility can then be imported into the GIS to show mapping of persons within the cemetery.
- A PDF file of a wall-size map intended to help with cemetery management. The map uses the surveyed headstone data to show where headstones lie in relation to graves.
- A PDF file of an 8.5 X 11 map intended for distribution to the public.

- A folder of about 2,600 JPEG images of headstones in the cemetery (as of late March 2017).
- A web-map interface that runs on the Edmonds server.
- Geospatial databases that contain the following layers:

  Cemetery Units

  - EMC Boundaries – Property parcel boundaries - polygons
  - EMC Blocks – Boundaries of five major blocks - polygons
  - EMC MegaLots – Boundaries of "mega-lots" – polygons
  - EMC Lots – Boundaries of all Lots (original, road, aisle) – polygons – attributes include both our 5-digit topological ID, as well as legacy Lot identifiers
  - EMC Graves – Boundaries of all graves – polygons – attributes include our 7-digit topological ID, as well as legacy lot/grave identifiers, as well as "availability"
  - EMC People – Locator of person within cemetery – points – attributes include JPEG of headstone (if present) and legacy attributes such as name, date of death
  - EMC Vertices – Locations of surveyor's monuments, relative to our grid of graves - points
  - EMC Headstones – Location of NW corners of headstones – points – attributes include name, date of death
  - EMC Cement Borders – Locations of cement borders enclosing original lots – polygons – hand-digitized from scanned hardcopy cemetery map
  - Edmonds Cemetery Survey Points – GPS points provided by Edmonds

  Columbarium Units

  - EMC Terraces – Portrayal of terraces in new Columbarium – polygons – not geospatially accurate
  - EMC Niches – Portrayal of niches in new Columbarium – polygons – not geospatially accurate

  Cemetery POIs. Points of Interest that Edmonds wanted mapped. All mapping based on points gathered with Total Stations (surveyor equipment), and later processed.

  - Lights
  - Amenities
  - Buildings
  - Benches
  - Structures
  - Road
  - Water Feature
  - TS Points – the full set of gathered points.