

Creating a Pavement Management System Using GIS

Problem Definition

As is the case with many cities, the city of La Cañada Flintridge is responsible for a large system of public roads. At last count, the city maintains 88 centerline miles of paved roads and alleys, or approximately 11.5 million square feet of pavement (Pavement Management Unit, 2012). In the 2011-12 fiscal year, the city of La Cañada Flintridge projected expenses of approximately \$1.29 million to maintain and resurface public roads under the city's jurisdiction, approximately 1/10th of all general fund expenditures for that year (The City of La Cañada Flintridge, 2012). However, despite the size of the infrastructure and the large expenditure of funds, city staff has little means to directly analyze and prioritize the work being done.

In part this is due to the organizational structure of the city's public works department. As a contract city, La Cañada Flintridge obtains the bulk of its road maintenance through a contract with the county of Los Angeles department of public works. The contract also includes consultation on pavement management practices in the form of an annual pavement condition report, which provides information on the status of the city's roads.

Additionally, the public works department has had little concern with obtaining the funds needed in order to maintain the roads. However, with the start of a number of large-scale infrastructure projects in the past year, public works staff is having greater difficulty in obtaining the necessary funds to do required street maintenance. The Fiscal Year (FY) 2012-13 budgeted road-resurfacing program is \$690,500, almost ½ of the total FY 2011-12 budgeted amount (The City of La Cañada Flintridge, 2012).

As a result, city public works staff is beginning to consider ways in which to effectively prioritize the work to be done in any given year. In addition, staff members are concerned with ways to better communicate the work of the street maintenance program to elected officials, other departments, and the general public (Kwan & Parseghian, 2012). Through initial discussion, I was able to explain to the

city engineer, Ying Kwan, and a public works management Analyst, Arabo Parseghian, how I might be able to use geographic information systems to organize and store data on the city's system of roads, streets, and alleys. In addition, I explained that I could create maps that could assist in prioritizing future maintenance work and more effectively communicate the work that has been done in the past.

Data

In discussions with Mr. Parseghian and Mr. Kwan, I found that the most pressing issue was that most data is dispersed or undigitized. The planning division holds the city's sole Arc-GIS license, but is too understaffed to provide GIS support to other departments. As a result, their GIS database lacks most information on the city's roads and public works projects. However, I was able to obtain shapefiles of the city's roads, the current parcels within the city limits, and the highways that run through the city, as well as separate shapefiles of major landmarks including parks and water features. These shapefiles provided the basic geographic framework for all future data that I came across. In particular, the road shapefile was key, as I regularly mapped multiple datasets including pavement quality rankings and traffic counts upon this shapefile. However, as will be discussed shortly, this was not without issues.

Through my associates in Public Works, I was also able to obtain the most recent copy of the city's pavement condition report in Microsoft Word format. In addition, I acquired an Excel file of the street inventory that the county used to create their pavement condition report. Initially, I had hoped to obtain this data in a single shapefile from the county, through my associates in our public works department. However, either due to lack of effort on their part, or lack of interest on the part of the county, I have yet to receive any such shapefile.

Unfortunately, the way in which the city segmented the streets proved very different from the way in which the county segmented streets. As a result, I spent a large amount of time formatting the city's street shapefile and the county's street inventory spreadsheet in order to join the two sets of data. This included creating

entries for specific subsections of city streets, removing spaces from fields, and putting applicable numbers into a number format (see figures 1 and 2 below for examples). In addition, I created a column of data in the streets shapefile labeled “Section_ID”, which was a duplicate of the “Section ID” column in the street inventory excel file. These duplicate records allowed me to join the two data sets in ArcGIS.

Figure 1 - The County's Street Inventory Before Reformatting

	A	B	C	D	E	F	G	H
1	Funct Class	Section ID	Street*	Limits	PaveWidth(ft)	Length(ft)	Area(ft^2)	PCI
2	Local	RD1000761	ALMINAR_AV	DALERIDGE RD - BAPTISTE WY	34	635	21500	68
3	Local	RD1000762	ALMINAR_AV	BAPTISTE WY - 0100 N REVLON DR	32	1450	46400	68
4	Local	RD1000950	ALVEDO RD	LAMOUR DR - VIRO RD	26	1345	34970	66
5	Local	RD0176709	BAPTISTE_WY	HAMPTON RD - VINETA AV	40	380	15200	79
6	Local	RD1005264	BAPTISTE_WY	CROWN AV - BURGGOYNE LN	32	720	23040	68
7	Local	RD1005265	BAPTISTE_WY	BURGGOYNE LN - VIRO RD	32	655	20960	68
8	Local	RD1005656	BELITA LN	LAMOUR DR - VIRO RD	26	1015	26300	66
9	Local	RD1007141	BURGGOYNE LN	BAPTISTE WY - KIRST ST	26	540	14040	80
10	Local	RD1007142	BURGGOYNE LN	KIRST ST - 0295 N KIRST ST	22	295	6490	80
11	Local	RD1007177	BURNING TREE DR	MEADOWVIEW DR - STARLT CREST DR	26	2620	68120	68
12	Local	RD1008118	CARMEL RD	SAN JUAN WY - SANTA INEZ WY	22	1315	28930	71
13	Local	RD1007921	CNON DE PRISO LN	1320 W SANTA INEZ WY - 0650 W SANTA INEZ WY	22	670	14740	77
14	Local	RD1007922	CNON DE PRISO LN	0650 W SANTA INEZ WY - SANTA INEZ WY	30	650	19500	77
15	Local	RD1010382	CROWN AV	FOOTHILL BL - NANCY WY	36	970	34820	100
16	Local	RD1010383	CROWN AV	BAPTISTE WY - SANTA INEZ WY	36	1450	52200	100
17	Local	RD1010384	CROWN AV	SANTA INEZ WY - NOREN ST	32	1210	38720	78
18	Local	RD1010385	CROWN AV	NOREN ST - 0215 S STARDUST RD W	26	550	14300	78
19	Local	RD1010386	CROWN AV	0215 S STARDUST RD W - STARDUST RD W	29	215	6235	78
20	Local	RD1010387	CROWN AV	STARDUST RD W - STARLT CREST DR	32	1110	35520	78
21	Local	RD1010613	DALERIDGE RD	FOOTHILL BL - BAPTISTE WY	32	1675	53600	74
22	Local	RD1010614	DALERIDGE RD	BAPTISTE WY - 0350 N BAPTISTE WY	22	350	7700	74
23	Local	RD1011132	DEL MONTE RD	SAN JUAN WY - SANTA INEZ WY	22	1490	32780	68

Figure 1 - The County's Street Inventory after Reformatting

	A	B	C	D	E	I
1	Funct Class	District	Section_ID	Street	Limits	PCI
2	Local		1 RD1000761	ALMINAR_AV	DALERIDGE_RD-BAPTISTE_WY	68
3	Local		1 RD1000762-3	ALMINAR_AV	BAPTISTE_WY-0100_N_REVLON_DR	68
4	Local		1 RD1000762-2	ALMINAR_AV	BAPTISTE_WY-0100_N_REVLON_DR	68
5	Local		1 RD1000762-1	ALMINAR_AV	BAPTISTE_WY-0100_N_REVLON_DR	68
6	Local		1 RD1000950	ALVEDO_RD	LAMOUR_DR-VIRO_RD	66
7	Local		1 RD0176709	BAPTISTE_WY	HAMPTON_RD - VINETA_AV	79
8	Local		1 RD1005264-1	BAPTISTE_WY	CROWN_AV - BURGGOYNE LN	68
9	Local		1 RD1005264-2	BAPTISTE_WY	CROWN_AV - BURGGOYNE LN	68
10	Local		1 RD1005265-1	BAPTISTE_WY	BURGGOYNE LN - VIRO_RD	68
11	Local		1 RD1005265-2	BAPTISTE_WY	BURGGOYNE LN - VIRO_RD	68
12	Local		1 RD1005265-3	BAPTISTE_WY	BURGGOYNE LN - VIRO_RD	68
13	Local		1 RD1005656	BELITA LN	LAMOUR_DR - VIRO_RD	66
14	Local		1 RD1007141	BURGGOYNE LN	BAPTISTE_WY - KIRST ST	80
15	Local		1 RD1007142	BURGGOYNE LN	KIRST ST - 0295 N KIRST ST	80
16	Local		1 RD1007177	BURNING_TREE_DR	MEADOWVIEW_DR - STARLT_CREST_DR	68
17	Local		1 RD1008118	CARMEL_RD	SAN_JUAN_WY - SANTA_INEZ_WY	71
18	Local		1 RD1007921	CNON_DE_PRISO LN	1320_W_SANTA_INEZ_WY - 0650_W_SANTA_INEZ_WY	77
19	Local		1 RD1007922	CNON_DE_PRISO LN	0650_W_SANTA_INEZ_WY - SANTA_INEZ_WY	77
20	Local		1 RD1010382-1	CROWN_AV	FOOTHILL_BL - NANCY_WY	100
21	Local		1 RD1010382-2	CROWN_AV	FOOTHILL_BL - NANCY_WY	100
22	Local		1 RD1010383-1	CROWN_AV	BAPTISTE_WY - SANTA_INEZ_WY	100
23	Local		1 RD1010383-2	CROWN_AV	BAPTISTE_WY - SANTA_INEZ_WY	100
24	Local		1 RD1010384-1	CROWN_AV	SANTA_INEZ_WY - NOREN_ST	78

The third data set that I obtained was the city's 2009 engineering and traffic study. This study offers the most recent average daily traffic count of 100 street segments within the city. Unfortunately, the study was in PDF and hard copy formats only, meaning that I had to physically enter the information into an excel spreadsheet. In addition, since the report provides traffic counts for only a sample of the city's streets, I have had to estimate the traffic counts for some street segments.

Map 1 - District 1



Due to the large amount of data processing involved throughout the course of this project and the time constraints in place, I unfortunately had to narrow my scope to a small section of La Cañada Flintridge. I focused on the area that the county has labeled District 1, which is bounded by Foothill Boulevard to the South, Gould Avenue to the West, and city boundaries to the North and East (see Map 1 to the left).

This district does not include Foothill Boulevard, Angeles Crest Highway, or any private roads, as those roads are either out of the city's jurisdiction or are subject to requirements or considerations that are standard local roads are subject to.

Synthesis of Information

In my initial contact with public works staff members regarding this project, I found some individuals uncertain of how GIS software could be used to assist their work. Given such reservations, I felt that the best strategy to implement my program was to show some immediate results with the project. As a result, once the data was

available, I immediately went to work creating a series of maps that could be used immediately by public works staff.

The first map that I created was a map that displays the streets resurfaced in District 1 during the fiscal year 2011-12 Street Resurfacing project (see Map 2 to the right). According to at least one associate of mine, this map is needed in order to communicate the locations of such projects to residents and the staff members of other departments in a quick convenient manner. In part, this is because local property owners whose property resides along such streets are restricted from having certain work done to their homes that could negatively affect the newly resurfaced streets. In particular, this is meant to deter property owners from installing utilities to their location.

To create this map, I first used the “Select by Feature” query to isolate the street segments within District 1 that have a score of 100 on the County’s pavement condition index. According to the pavement condition report (Pavement Management Unit, 2012, p. 3), this score symbolizes “a brand new pavement in excellent condition”. Such a score makes perfect sense considering that the evaluation occurred directly after the FY 2011-12 street resurfacing project completed. Once the street segments with this score were selected, I then exported the records to a separate map layer. This new map layer became the source records for a “Select by Location” query of all parcels within 50 feet. I performed this query in order to select and isolate the parcels located directly adjacent to the recently resurfaced street segments. Once selected, I exported the records for these parcels

Map 2 - Fiscal Year 2011-12 Street Resurfacing Project

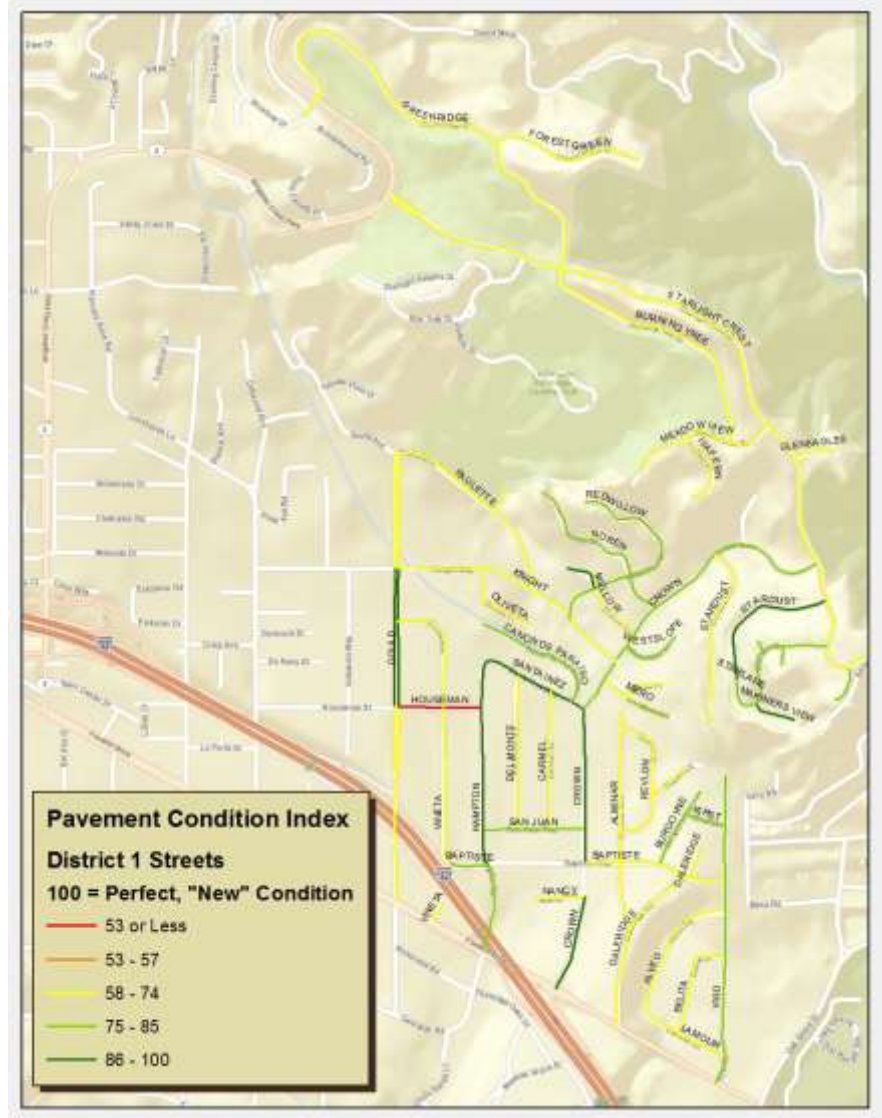


to a separate shapefile. I then removed all extraneous shapefiles from the map, added labels and a legend, and exported the map to a “.JPEG” file.

In addition to this map,

Map 3 - District 1 Pavement Condition Index Scores

my associates in the public works department requested a map that displays the current condition of streets. This request came about in part because the current maps issued by the county use a color-coding scheme that is somewhat unclear, and leads to confusion among members of the public (see Figure 3 below). As discussed above, the process for creating this was very time-intensive, involving the creation and formatting of multiple street segments throughout District 1. However, despite the time investment it proved relatively simple to create a chloropleth map based on the



county’s pavement condition index and condition categories. However, to simplify the map for the reader’s sake, I used a 2-color continuum, where red symbolized poor road quality and green represented good quality.

CONDITION CATEGORY	
	PCI = 100 - 86 (Excellent)
	PCI = 85 - 75 (Good)
	PCI = 74 - 58 (Fair)
	PCI = 57 - 40 (Poor)
	PCI = 39 - 0 (Failed)

Figure 3 - County Categories

With these maps in place, I then set about using current data on the conditions of roads and the 2009 traffic count as a means to analyze where future projects could be of most use. Based upon initial

Map 4 - High Traffic & Maintenance Needed



conversations with the public works staff, there was little interest in attempting to look at records of past capital improvement projects. Instead, public works staff was most interested in attempting to maintain or improve service levels in some manner. As a result, I attempted to create a suitability map that would target the more heavily trafficked segments of street in District 1, which also have low enough pavement condition index scores that maintenance work is required. I did this by first creating a shapefile of all streets with traffic counts. This shapefile also contained records on the pavement condition index

score of the individual street segments. Using the “Statistics” function, I found that the mean average daily traffic count for streets in District 1 was approximately 2,644 vehicles. From there, I used the “Select by Attributes” function to locate street segments with a greater than average traffic count and a pavement condition index score of 74 or less, as roads with such scores require resurfacing. This query located two street segments that with such attributes, a street segment along Gould Avenue and a street segment along Starline Crest Drive (see Map 4).

With a sight selected, I was then able to create a project area. Based upon my conversations with my counterparts in the public works department, I was aware that the proximity of one site to another is an important factor, as it can help to minimize the overall costs of a capital improvement project. With this factor in mind, I used the “Select by Feature” function to find other street segments that required street resurfacing located within a 500-foot radius of each

Map 5 - Possible Project Sites



high traffic site. I then created my final map which displays two possible project sites (see map 5).

Conclusions

Ultimately, the maps above should provide a concrete argument for the ways in which the City of La Cañada Flintridge public works department can utilize GIS software to better prioritize and disseminate pavement management information. In creating a prioritization scheme for such projects, staff provides senior management and policy makers a greater understanding of the drivers of such a program (cost, service level). At the same time, in identifying specific neighborhoods via maps, I believe that we can create a stronger visual association with the actual residents and neighborhoods being affected by the funding level.

Were I to have more and better information, I feel that I would be able to provide a stronger case for utilizing GIS software for pavement management. One example of this: The fact that the 2009 traffic study does not provide figures for every street in the city somewhat diminishes the validity of my suitability study. Another factor that reduces the efficacy of the work is the fact that this study is based upon information in one district, a subsection of the city of La Cañada Flintridge, which could be far different from other areas in the city.

If given additional work time and support, I would continue to digitize all of the information in the county's 2012 pavement condition report, as well as the information from past reports. Firstly, this would hold county staff more accountable for the information that they provide. In the course of this project, I have found a number of street segments for which no record could be accounted, and other records that are obvious errors or duplications. Although I have found only a handful of records with such factual errors, it could prove to be the rule rather than the exception in other places of the report. The second reason that I plan to continue working on this is because I believe that in expanding the scope of the project I could gain additional insight into factors that could improve the efficiency or service-delivery of the City's street resurfacing program.

Works Cited

Kwan, Y., & Parseghian, A. (October 4, 2012). (C. Castruita, Interviewer)

Pavement Management Unit. (2012). *City of La Cañada Flintridge Pavement Condition Report*. County of Los Angeles Department of Public Works, Geotechnical & Materials Engineering Division. La Cañada Flintridge: County of Los Angeles.

The City of La Cañada Flintridge. (July 16, 2012). *City Budget*. Retrieved November 18, 2012 from The City of La Cañada Flintridge Website: <https://sites.google.com/a/lcf.ca.gov/city-of-la-canada-flintridge-site/city-budget-1>