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GEOB472

Uncovering Vancouver's Sewer Systems – a humbling experience

The Project

There is a complex process behind the simple act of flushing a toilet or turning on a tap, and that process lies underground in our sewer systems. Every day about 1 billion litres of wastewater is collected through a region-wide network of sewers and taken to wastewater treatment plants. While the majority of wastewater, or "used" water, comes from any source that drains from our homes and businesses, such as taps and toilets, stormwater comes from rainfall or any water that is not absorbed into the ground. (Sewers, Rainwater & Drainage, City of Vancouver). Currently in the City of Vancouver, all stormwater and wastewater run in one pipe to the Iona Wastewater treatment plant in Richmond, BC. Stormwater does not need to be treated so sending it to the treatment plant takes up valuable space and energy. Due to the anticipated intensity of rainfall events as a result of climate change, the City of Vancouver is working towards being better prepared, with an aim to eliminate combined overflows by 2050. When there is an intense rainstorm, sewer systems become overloaded and overflow can end up in the ocean. Replacing combined sewer systems with separated sewer systems will not only free up space at the treatment plant, but also prevent used water from entering natural water systems.

Currently, the city uses an online database system, VanMap, to visualize the sewer network. A hindrance of this system is in order to see details such as direction of flow of sewer pipes, you must be zoomed in to the scale of a block. This makes it difficult to take into account the overall catchment during planning sessions. The purpose of this project is to create large scale maps (one catchment filling a paper map sized 24” x 36”) for the 19 catchments in metro Vancouver to better visualize the sewer network. These maps will help educate the city of Vancouver staff, councillors and the public on better understanding how the sewer systems in Vancouver work.

The Visualization Pipeline

The priority of these maps was to create a transferable product, “design transferability is about leveraging one or more aspects of an existing design for a new application or map use situation” (Griffin et al. 2017 p. 93). Because these maps would mostly be used in combination with VanMap, most of our design decisions were fueled by this objective.

Acquire

“The acquisition step involves obtaining the data” (Fry 2008 p. 7).

We acquired our data from our community partner at the City of Vancouver; they provided us with the catchment boundaries and flow arrows. The rest of the data we retrieved from the city’s open data portal. These files included; sewer network package, road network, parks, property parcels and block boundaries.

Parse

“After you acquire the data, it needs to be parsed—changed into a format that tags each part of the data with its intended use” (Fry 2008 p.8).

We did not need to parse our data, for it was already in shape file format and prepared to use in ArcMap.

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Filter

This "step involves filtering the data to remove portions not relevant to our use" (Fry 2008 p. 9).

Filtering the data was completed in the acquisition process. We downloaded the relevant packages and only used data files relevant to this project. In the sewer network package, we only used the sewer mains, sewer trunks and manholes. The road network package ended up being too dense for our purposes, and we ended up asking for a simpler data set from our community partner.

Mine

"This step involves math, statistics, and data mining" (Fry 2008 p. 9).

Our data did not require mining. At one point during the representation process, we did apply a definition query on the sewer mains to only display pipes that had a diameter of 450 and greater, however this ended up not being beneficial for our community partner.

Represent and Refine

"This step determines the basic form that a set of data will take" (Fry 2008 p. 9).

"Graphic design methods are used to further clarify the representation by calling more attention to particular data (establishing hierarchy) or by changing attributes (such as color) that contribute to readability" (Fry 2008 p. 11).

These two phases were the epitome of trial and error. The data we were tasked to visualize all overlapped. Main sewer lines, trunk lines, flow arrows and roads all lie atop each other, and each piece of information does not rank over another with regard to a visual hierarchy. As Tufte (1990) states, "confusion and clutter are failures of design, not attributes of information" (p. 53), thus we took great pains to remedy the data clutter. Tufte (1990) suggests utilizing colour and value, as well as subtraction of weight when layering data, such as visual activation of negative areas of white space. He states this will "enhance representation of both data dimensionality and density on flatland" (Tufte 1990 p.60). All our thematic data lie along the road network, so we decided to activate the white space to highlight this important information. By colouring in the block and property parcels in a light yellow and outlining them in grey, the resultant white space allowed the dense sewer network system to come to the forefront.

The distinction between different sewer types and the density of flow arrows were two major issues surrounding these maps. In regard to sewer types, we were faced with some limitations. While Tufte mentions that colour can enhance and visualize certain layers, we were constrained to colours used in the City of Vancouver's online system, VanMap. MacEachren (1995) articulates these limitations, however phrasing them as filters;

> "On cartographer's side of the system, these filters include objectives, knowledge, and experience, abilities, attitudes, external considerations such as client demands, as well as the abstraction processes by which information is put into map form (e.g., projection, simplification, generalization, classification, symbolization, etc.). For map use, the following factors were identified as filters: the perceptual and spatial abilities of the readers, understanding of the symbol system (e.g., training or ability to understand the legend), goals, attitudes, viewing time, intelligence, prior knowledge, and preconceptions" (p. 5).

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The limitations, or filters, for visualizing the different sewer mains fall into three of the aforementioned categories; objectives of the map, our abilities to visualize the different pipe systems and our client demands. Our design decisions also took into account how these maps would be used, as MacEachren stated above, it was important that the user of this map understood the symbol system. And a filter applied in doing so would be comparison with VanMap.

The objective behind these maps is to be used in conjunction with VanMap, so pipes have to be the same colour to be easily identified when moving back and forth between the online platform and the static map. Our abilities were limited to the system we were using, ArcMap; while colours were already predefined, we could only symbolize different pipes using different stroke weight, transparency, or hashed lines. However, due to so many pipes overlapping, the use of transparency did not work, falling into Josef Albers *1 + 1 = 3 or more* principle, discussed by Tufte (1990), creating more noise. When we used transparency, we fell into the problem where “surplus visual activity is non-information, noise, and clutter” (Tufte 1990 p. 61). The overlapping transparent pipes created a new colour, exasperating the original problem. We attempted to offset the pipes using the offset feature in ArcMap, however this ended up separating pipes instead of moving them uniformly. Perhaps if we had better knowledge of python we could have created a code to remedy this. We also attempted to solve this issue in Adobe Illustrator, however, due to the minute details of the overall map, certain aspects were lost in translation. We could not incorporate the two systems seamlessly. This ties into the third limitation, our client demands. We wanted to create a process that could be replicated, and thus using only ArcMap was a priority. Our client demands also fall into the colours of the pipes (magenta for combined, red for sanitary, and green for storm) and how they can be visualized. The “understanding of the symbol system” (MacEachren 1995 p.5) was extremely important for the use of the map. As noted, transparency was not a way around this, so another option could be hashed lines. However, hashed lines are used as a symbol for ‘sanitary force’, thus would be confusing if we used the same symbology for another pipe.

We ended up using a slightly wider stroke for storm pipes, as the majority of overlap occurred with storm and sanitary pipes. Laying the slightly narrower sanitary pipes on top was the only way to create a sense of visual hierarchy, while at the same time conforming to the objective of the map and how it will be used.

We ran into similar problems dealing the flow arrows. Each pipe had corresponding flow arrows, and as pipes overlapped each other, there were many duplicate arrows creating a visual mess. As Dodge et al. (2008) propose, “geographic visualization exploits the mind’s ability to more readily see complex relationships in images, and thus provide a clear understanding of a phenomenon, reducing search time and revealing relationships that may otherwise not have been noticed” (p. 2). The purpose of the flow arrows on these maps is to better understand the relationship between pipes. So, for example, if there was a spill, a map would help to quickly visualize where the resulting pollutants would flow too. Our ability to create clarity was again hindered by the system we were using; we lacked an understanding of how to create a more efficient labeling code. We applied certain tools, such as the ‘disperse marker tool’ in ArcMap, but this resulted in the arrows being uniformly spread out regardless of their relationship to the pipe. We also attempted to use the pipes to symbolize flow by creating a network layer using the Network Analyst tool. This takes into account how each pipe was drawn; the direction the pipe was drawn from node to node created a similar network to the flow arrows. However, the length of pipe between each node was just as dense as the separate flow arrows layer, and did not solve the problem. We also colour coded arrows to match its corresponding pipe yet this just added more complexity to the map. We ended up manually deleting arrows in ArcMap to reduce the arrow noise. Although our community partner stated that this was an inefficient use of our time and deemed not necessary. While we did manage to clean up some of the arrows, we were deleting valuable data points resulting in a counterintuitive method for the strict planning use of these maps. As Tufte (2006) states, “analytical presentations ultimately stand or fall depending on the quality, relevance, and integrity of their content” (p. 136). While these maps are not analytical, deleting important data results in these maps losing integrity and trustworthiness. Our community partner would look at the map and wonder whether there was important flow information missing. I also experimented with using contours to visualize flow, however this was ineffective due to the nature of our data, an underground pipe system that does not always flow true to the contour of the earth. Our final design decision was to leave all the arrows the same colour (black), and we placed them above the pipes. This set them apart from the coloured pipes, and also created a stark contrast with the underlying white space.

The roads names, again, fell on top of all the above information. As noted above, the first road network dataset we used was far too detailed for the purpose of these maps. We only really needed important cross sections and main streets. Initially we were going to add these in manually. Our community partner ended up finding a simpler road network data set which suited our needs. We used the typeface outlined in the City of Vancouver style guide and added a white halo to allow identification over the noise of the pipes and flow arrows.

Finally, we decided to add a transparent layer to irrelevant catchment boundaries. As Cairo (2013) asserts, “the higher the contrast between two adjacent patches of color, the more likely they will be identified as belonging to different entities. The lower the contrast (or the blurrier the edges), the harder the brain must work to distinguish between them” (p. 112). While I agree with Cairo (2013) on the importance of contrast, we wanted to tone down the visual noise to not overwhelm a map user, but still highlight the catchment of interest. To accomplish this used a white overlay over the neighbouring catchments to subtly lower them in the visual hierarchy. We also used transparency to still allow the user to see the pipe and flow network, if needed. I did experiment using black to create more contrast (Figure 1), but our team decided that white was the most useful.

In the end, our final maps did not visualize the pipe systems as well as we would like. However, the scale and size of the map (24” x 36”) will aid in remedying this problem. How our maps fall along Cairo’s (2013) visualization wheel can be seen in Figure 2, and a zoomed in sample of one final map can be seen in Figure 3.

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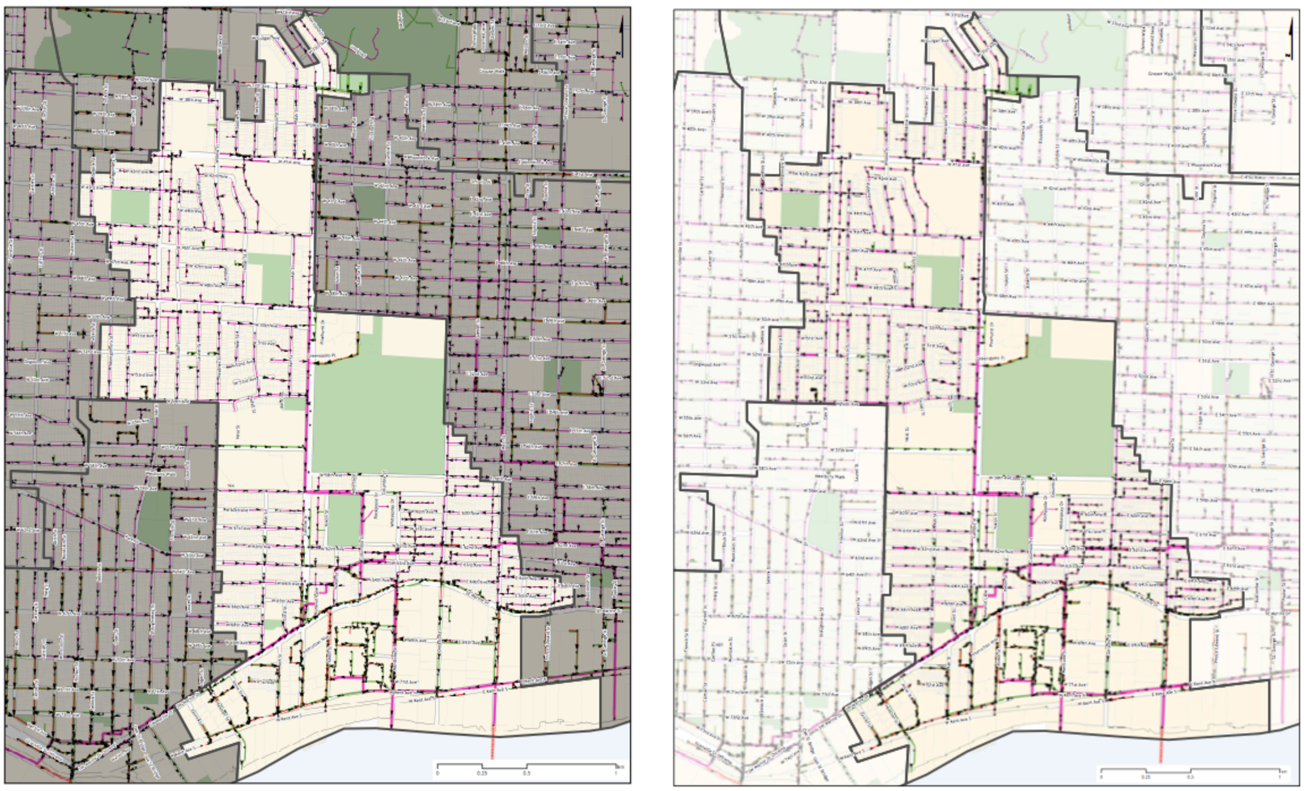

Figure 1. Comparing black and white overlays.

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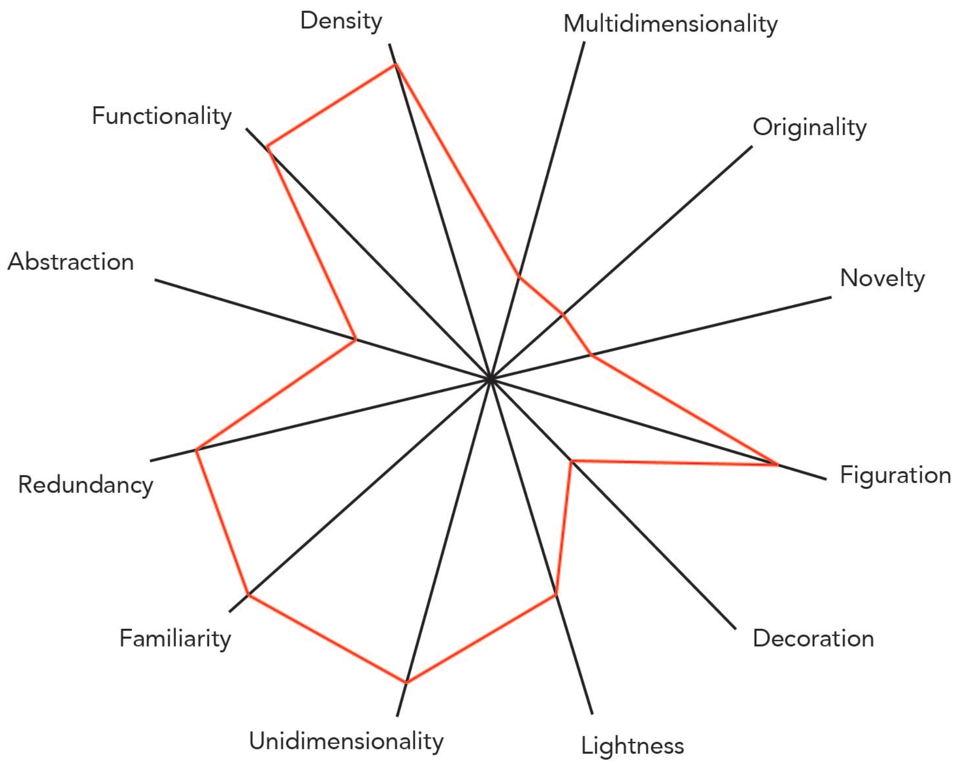

Figure 2. Cairo's (2013) visualization wheel for final sewer maps.

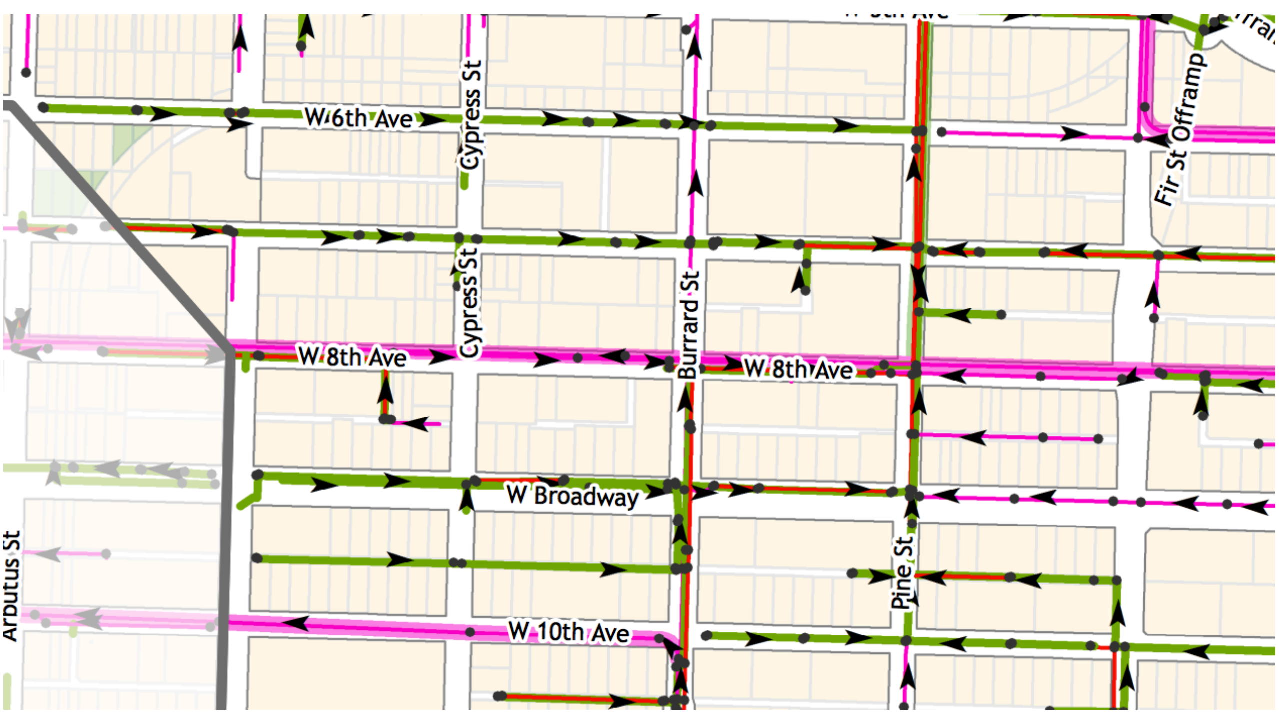

Figure 3. Representation of the scale of printed map.

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Working with a Community Partner

Working with a community partner was an incredible and humbling learning experience. I was enthusiastic to be part of a project that was helping to prepare Vancouver for more extreme weather events. It was also interesting to gain a better understanding our city's sewer system. However, it was a struggle for my artistic side. I was soon struck with the reality of working for an evolving business where data is compiled over years, and by different individuals. After the first meeting with our partner, my brain was full of different ways to create beautiful and functional maps. I soon realized that we would be restricted to certain colours, and I grew frustrated with the inability to create a product that was in my mind. The idea behind this process was the ability to be easily replicated, thus utilizing the power of ArcMap was preferred. Attempting to recreate a dense data set within Adobe Illustrator was decided to be an inefficient use of energy. The colour scheme and the state of the data was an issue for everyone involved, including our community partner, but this was the reality we had to work with. I was a little disappointed to not be able to work more with the infographic, as this was where the creative side of my brain could have soared. Although, my skills with ArcMap were better utilized to create the catchment maps and through this process my skill set was pushed and strained.

All in all, I think this was a great lesson in working within the confines of very specific requirements.

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