GSI implementation along the Sammamish river in Kenmore

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The city of Kenmore has experienced tremendous growth and development over the last decade. Drainage problems are common in the region, and stormwater runoff has been deteriorating the already damaged Kenmore basin. Fauna that depend on the Sammamish river are also threatened. Implementation of GSI along the shoreline of the river can reduce the stream pollution and assist on the preservation of several species of animals. Thus, this research begs the question, ***where along the Sammamish river should GSI be implemented first?***

1. *Introduction*

Sammamish river and the salmon; a indicative of environmental conditions

A good portion of the Kenmore basin has been severely degraded (figure 1), as well as the Sammamish river. The river is of great importance to over 30 species of fish that use the stream for rearing, migration and colony (City of Kenmore, 2010, p.11).

However, the river has high concentrations of fecal coliform bacteria, low concentration of oxygen and high temperatures in the summer – all factors that affect the livelihood of the fauna dependent on the river.

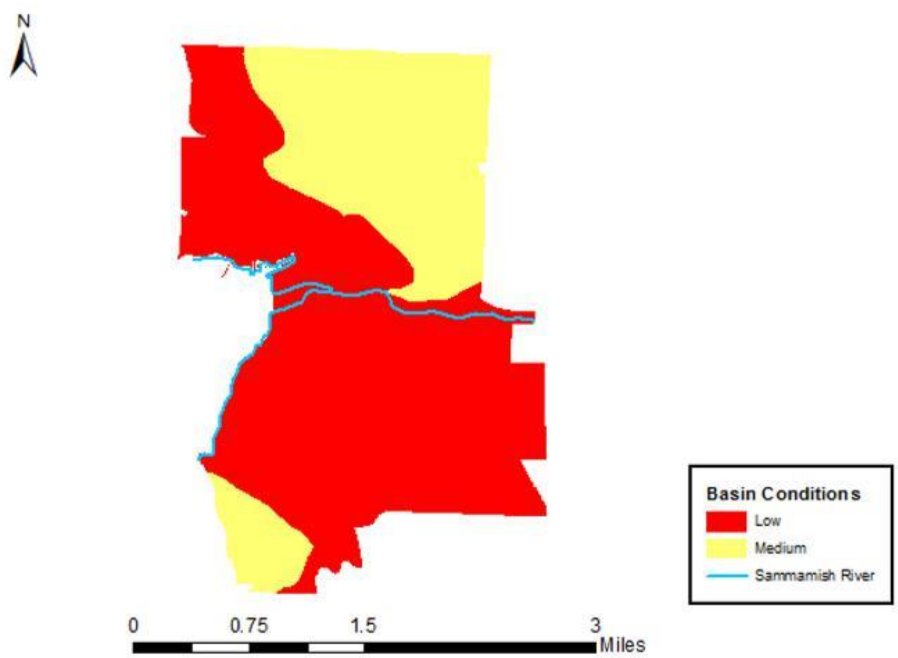

Figure 1. Kenmore basin conditions.

Stormwater runoff from developed areas where surface is impervious is to blame, along with gray stormwater infrastructure that dumps drainage water directly into water bodies.

When precipitation is abundant, the stormwater system might be combined with raw sewage, causing combined sewage overflow (CSO). This is why there is a high concentration of fecal coliform in the river, as well as high concentrations of phosphorus and nitrogen, which increase algae and deplete oxygen.

Moreover, clearing of vegetation along the shoreline removes important canopy cover that is mutually important for fish and riparian trees. The trees provide cooler temperatures during the summer, food and fallen trees provide places of rest for salmonids swimming upstream.

Because of this interconnectivity, salmon is a keystone species, that tells us much about the health of the environment they inhabit. The presence of salmon has diminished greatly in the basin, and several species that roam the area are threatened or endangered.

Mitigation approach

While understanding that runoff water knows no boundaries, and that the source points for surface runoff water may be far from the proposed area of focus, this research focus on mitigating the problem at its final stage, as opposed to approaching a solution focused on the source.

The reason for that approach is twofold; acting as a last barrier for runoff water before it enters the basin, vegetation along the coast will not only work as a drainage device, but also mitigate other environmental problems caused by development, such as providing shade and refugee to fauna dependent on the waterway.

Finally, the latest assessment available on the focus area of this study (City of Kenmore, 2010) provided by local government officials, served as stepping stone and guide for this project, particularly in the early stages. The information regarding pollutant levels and riparian vegetation situation made up for the lack of spatial data we encountered through the process.

Research question and structure

Having defined the background and scope of the case study, we state that our intention is to design a geodatabase that will serve to mitigate and restore the deterioration of the Kenmore basin, with a focus on protecting the fauna reliant on the Sammamish river, its major waterway. In order to do so, we seek to define **where should GSI be implemented along the Sammamish river within the boundaries of the city of Kenmore.**

The findings of such research could be used to assist policy design – tax/water charge rebates for owners of parcels that implement GSI, or land use zoning ordinances for example – and in other efforts concerned with the health of basins and waterways. Therefore, it would mostly be of interest to local and federal government agencies, and those involved in the stewardship of resources.

The following sections will describe our project methods, results, findings, conclusions and recommendations for future efforts of the same nature.

2. *Methods*

We relied heavily on the literature available on GSI. After becoming more familiar with the subject and exploring some possibilities, we moved on to developing a preliminary question, determined what data was relevant, performed data collection, defined subtypes and topologies, constructed a data schema and analyzed the data to refine our focus and research question.

Literature review

We examined some of the literature available and will be drawing particularly from four sources that guided us through the process of geodatabase design; one is a study focused on the coast of Louisiana (Brown, 2014). The study provides a lot of visual information on GSI and examines in depth some species of plants and trees, taking in consideration much more than merely drainage capacity or erosion mitigation capabilities; instead, it describes how GSI addresses other issues along with drainage, particularly shoreline mitigation.

The city of Seattle produced a similar work, in the form of a compendium with several articles and case studies of GSI applications from around the US (She, Char, 2008), many of them addressing land-use-specific solutions, which guided us on what kind of infrastructure to suggest for specific areas. That provided another rich source of information and reference for our research, providing information on several areas ranging from policy design to actual implementation of the assets.

Another work that influenced this project, particularly when electing the best types of GSI for specific sites, examines the feasibility of such projects alongside roads and residential neighborhoods, with the community as central focus (Emerson, Rottle, 2012).

Assessment of the Kenmore basin conditions

Before we even decided what data to collect, we performed archival research and acquired some information on the conditions of the basin from secondary sources. The Kenmore Shoreline Master Program provided the information that set us off to a specific area and methods.

It informed us of the high level of pollutants in the water, the implications for its fauna and what kind of species depended on the health of the river. This information served as stepping stone and guide through the project.

Development of a preliminary research question

Our research question arose from the fact that the basin in poorest condition is the one where the Sammamish is located. Swamp Creek was an option, but we decided to address Sammamish for its poorer condition, relevance to several species and for being of major importance for salmon – an endangered species.

Feature classes and datasets

Such project demands a good understanding of water presence and its behavior; the **hydro** dataset is crucial to understand these patterns. Feature classes included are the water streams and floodways within Kenmore boundaries, as well as bodies of water that receive the discharge and the conditions of the basins.

The **utility_network** dataset was created for the same reason, particularly in understanding how much drainage water is diverted directly to the basin (drainage network), instead of being treated along with raw sewage (combined network). Information obtained from analyzing laterals connected to mainlines could also reveal the impact of GSI if implemented in private property (such as downspouts diverting stormwater to raingardens, instead of the grey water system). Reports of problems with the drainage system were also included as a feature class, as they point to areas where CSO is likely to happen.

The **RoadNetwork** feature dataset has two feature classes: **Roads_Kenmore** & **Routes_Kenmore**. The road network is essential in understanding the effect of impervious surfaces runoff combined with runoff of automobile pollutants in relation to the shorelines. There are not any freeways running through Kenmore. However, there is a lot of traffic on Bothell Way (RT 522) that is used as a connector between highway accesses in Shoreline and Bothell, with delays an everyday occurrence around rush-hour.

The **LandUse** feature dataset has three feature classes: **Neighborhoods_Kenmore**, **Parcel_Kenmore**, and **Zoning_Kenmore**. These feature classes are useful in determining areas of industrialization, parks, and residential neighborhoods. Each of these areas have different impacts on runoff and are therefore included to assist in the analysis.

The **canopy_cover** feature is a raster file produced by the U.S Forest Service, derived from LIDAR. It shows land covered with levels from 0-100, from no canopy presence to 100% canopy cover.

The **Kenmore_elevation** feature dataset has no feature classes because it is a raster dataset, but it has information divided up on a black to white scale with different colors on the gray scale meaning different elevation heights based on how the raster measures the distance. This is a 10x10 raster dataset as well in terms of the scale of the pixels in what they represent.

Finally, we used **impervious_cover** derived from LIDAR to identify the level of permeability of the surfaces studied.

Software and other resources

ArcMap and ArcDiagram were the main software used for this project. Google Drive was used for remote collaboration, since most of the work was performed that way.

Some assistance was provided by staff from the City of Seattle, an organization that has been very successful in the implementation of GSI and stormwater management. This assistance was limited to some light guidance, for example in explaining what the reasoning behind the construction of their geodatabase was.

Finally, some GIS fieldwork was performed by one of the group members. Pictures of trouble areas helped us focus in certain areas, and gave us an idea of the seriousness and scope of the problem (figure 2).

Figure 2. Picture by Sean Fisher.

Data collection, manipulation and challenges

Data for Kenmore is difficult to find, and is often inaccurate or outdated. Thus, we looked for data at bigger agencies and consortium portals. Our sources were the King County GIS Portal, the University of Washington Earth and Space Sciences GIS Data Portal and the Multi-Resolution Land Characteristics Consortium (MLR).

Because the data was never specific to the municipality, the first step for all data handling was clipping it to a base layer called **Kenmore_boundaries** – nothing more than a polygon representing the legal boundaries of the city.

Almost all data had to have its symbology altered to better portray the data and for analysis; **basin_conditions** and **zoning** had unique values assigned different colors. Raster data had color schemes simplified to fewer values – from over a hundred to fewer than 10.

No topology was set, but subtypes were defined for **Roads_Kenmore**.

We first attempted a site suitability study, by stacking layers that gave us information about zoning/land use, hydrology conditions and where drainage complaints originated.

We then intersected these features, processing data in a manner that would give us areas where the conditions of the basin were bad and drainage problems were reported. Later we added the raster files to identify areas with low tree canopy cover and high impervious surface area. Unsurprisingly, these two raster looked pretty much the same; there will not be trees where there is no pervious surface. However, because trees offer refugee to fishes and reduce water temperature during summer, it was important to identify how much riparian canopy was present.

Challenges had mostly to do with the scarcity of data available for Kenmore. Our gray storm water infrastructure layer had merely the geometry – georeferenced from maps provided by the city of Kenmore. With no data available to work with, spatial analysis and processing was not an option; worst yet, the distinction between drainage pipes, sewage and combined lines was not specified. Without knowing what lines are going to dump water into water bodies, the analysis of suitability becomes a bit less meaningful. Water that is directly discharged into the river is of most concern, as it is untreated and adds pollutants to the water.

With that data, we would be able to better use elevation data, to identify trouble spots where water would accumulate and be drained to the drainage pipes. The elevation data, though processed and ready to be used, did not lead to any significant findings, but with that data in hand, it certainly could.

Finally, since the feature class that represented drainage complaints would be one of the major factors in the study of site suitability, it was important that the data would be robust. It was not, unfortunately, due to poor domain choices – or lack of thereof – that made the data difficult to interpret and use. That severely slowed down our analysis. A “drainage” problem for example, could have been caused by a CSO occurrence or a beaver. The only way to sort it out was by reading the “comments” field, where no domains where set, other than a 254-character limit.

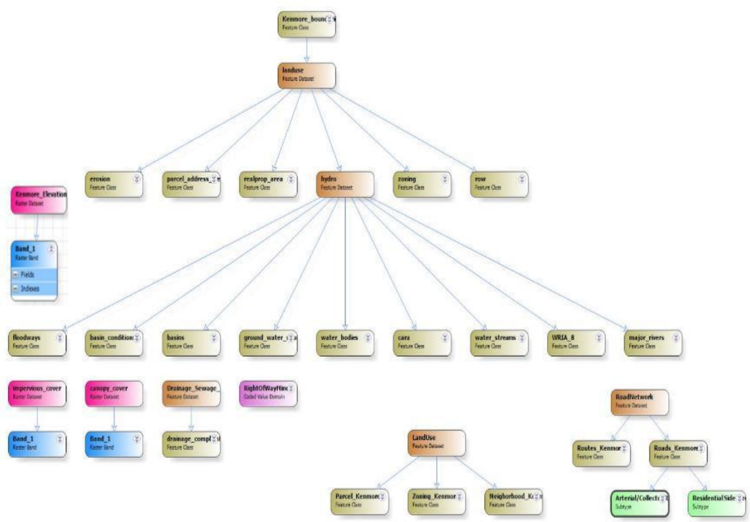

Figure 3. The raw geodatabase design for this project. Not all data was found or worked as intended.

Metadata however, was always available, complete and well explained. The King County GIS Portal had a spreadsheet file with keys to all datasets provided. Good descriptions and contact information were provided with it. For this study, no refinement of metadata was needed, but we certainly used it to interpret the data and understand some fields of most feature classes.

3.1 Results

The analyses described above lead us to three conclusions regarding the case study (figure 4). First, almost all drainage complaints along the river originated from either single-family or industrial/commercial parcels.

Second, though most of the area along the river is dedicated to single-family housing, the critical areas – those with most impervious surface, least canopy and where drainage complaints originated – where industrial/commercial parcels.

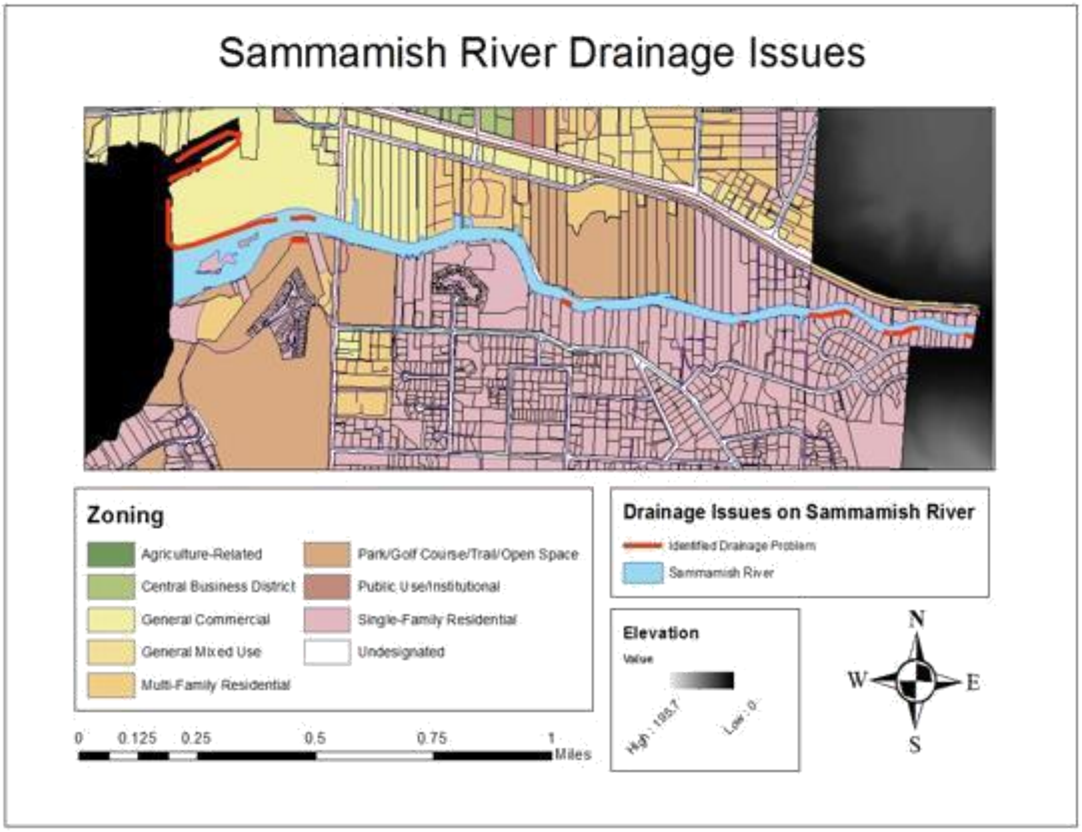

Figure 4. Intersection analysis showing areas that demand the most attention.

Third, there is very little canopy cover along the west side of the river, where most complaints also originated. Unsurprisingly, this is also the area with the most impervious surface immediately next to the river.

3.2 Discussion of results

Regarding the geodatabase design, we agree that we took several steps in the right direction by picking the data we did, but several feature classes end up not being used.

Some of them were not used for the lack of other relevant data – as aforementioned in the case of the drainage network – and others simply did not have the relevancy that we anticipated, such as roads and routes.

In spite of the lack of data and some issues with the data available, we were able to draw some relevant conclusions from the analysis that could be applicable in real-world decisions.

4.1 Conclusions

The Kenmore Shoreline Master Program (2010) lists several mitigation strategies to protect and repair the Sammamish river. Assuming a limited budget and time, we proposed a scenario where implementation had to be fast, cheap and as effective as possible, so short-term results could be achieved.

Our conclusions regarding our geodatabase design and its efficiency boil down to the need for more data. A good analyses regarding the preservation/restoration of the riparian buffer was not possible, because we lacked data on the vegetation cover type along the river. Much has been said about the negative effects caused by invasive species, which is a concern expressed in the Kenmore Shoreline Master Program. A site suitability study identifying where to plant trees and perhaps, where to remove them is necessary for this study.

We also concluded that many feature classes were not useful, at least not in this context. Some issues of duplicated data that performed the same task, but with different names and sources arose a couple of times.

Overall, the geodatabase works better with a different research question; perhaps something more directly involved with policy design, such as **what kind of land use parcel should be prioritized when implementing GSI,** for example.

Though the geodatabase does answer our original question to an extent, it falls short in addressing our goal of mitigating stormwater runoff **and** the issue of loss of habitat that is caused by the clearing of riparian trees.

Finally, we spent too much time collecting data that was not necessarily relevant at the end, and did not make it into the final geodatabase design. We believe this mistake is related to generalizing feature datasets too broadly, and not entirely thinking of feature classes and datasets as "nouns" related to the case study.

4.2 Recommendations; designing a better geodatabase and moving forward

If this work were to be continued, there are three major steps that should be taking in the design of a better geodatabase.

First, reliable and up-to-date drainage and waste water network data must be acquired. It must allow the users to perform spatial analyses, and it should clearly have distinctions of sewage and drainage mainlines. The information regarding the laterals stemming from private parcels is also important, since CSO usually occurs during heavy rains; knowing that a residential parcel has several downspouts connected to the drainage line instead of dumping the water in a bio-retention cell is a good starting point in reducing the amount of water diverted to the drainage network, which in the long run has the potential of avoiding/minimizing the occurrence of CSOs.

Second, place specific geological and vegetation cover data is necessary in building a case and plan for riparian buffer protection and restoration. Merely knowing the amount of tree canopy cover does not lead to robust results.

Third, hydrology layer must be updated, as it is six years old. Basin conditions and new drainage complaints are a must.

With these datasets in hand, elevation data would have much better applications, and could be used as one of the factors in identifying critical areas.

Moreover, some time must be spent with the conceptualization of what constitutes a "critical area," or a "suitable site" for example, particularly in the early stages, when the geodatabase is being design. In other words, knowing what will indeed be relevant, can save a lot of time.

Our process was one of trial and error, where we collected as much data as possible and then analyzed what would be relevant. This approach is less time consuming in the early stages than a more careful geodatabase design, but costs much more time in the long run.

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5. References and annotated bibliography

Brown, D., & Louisiana Sea Grant College Program Content Provider. (2014). Using Plants for Stormwater Management A Green Infrastructure Guide for the Gulf South. Baton Rouge: LSU Press.

The study provides a lot of visual information on GSI and examines in depth some species of plants and trees, taking in consideration much more than merely drainage capacity or erosion mitigation capabilities; instead, it describes how GSI addresses other issues along with drainage and taking in consideration potential challenges that certain trees and vegetation might bring, such as the infiltration of roots in pipes and sidewalks (16-17). Though focused on an area much different than Seattle – which entails much different species-, the study is a good reference guide to what to look for in specific species to maximize benefits, while being careful not to introduce new problems.

City of Kenmore. (2010). City of Kenmore Shoreline Master Program Restoration Plan.

We were mainly guided by the City of Kenmore Shoreline Master Program: Restoration Plan to identify the goals, opportunities, potential actions, and how future restoration can be implemented. This is done in compliance of the requirements for the Washington State Shoreline Management Act which also works in tandem with the Inventory and Analysis that we looked at below.

City of Kenmore. (2010). Kenmore Shoreline Master Program Update Inventory and Analysis.

This analysis investigated the causes and solutions to many issues surrounding water and water flow in Kenmore. Using this analysis along with the City of Kenmore Shoreline Master Program: Restoration Plan presents the opportunity to understand the shoreline issues of Kenmore, the history of the different shorelines and their development, and possible restoration actions that can provide the city with a better green infrastructure.

Emerson, P., & Rottle, Nancy. (2012). The social feasibility of roadside raingardens : A compendium of siting, design and engagement tools. University of Washington.

This work also provides a comprehensive history of drainage assets in Seattle (13-16), as well as recent efforts – and challenges – regarding the implementation of GSI in the city (17-19). However, the main reason why this work is included as a reference to this project is that it examines the social impact of GSI implementation as well as the limitations it might bring, instead of merely proposing them based on levels of storm water runoff and basin conditions. In one example, it examines how roadside raingardens would potentially prohibit the implementation of bike lanes in the future, as well as reducing sidewalk space for pedestrians, or parking for cars in short blocks (51-52, 54).

She, Nian, & Char, Michael. (2008). Start with the Soil: Changing Construction Site Soil and Vegetation Management in Washington. Low Impact Development for Urban Ecosystem and Habitat Protection, 1-4.

A compendium with several articles and case studies of GSI applications from around the US. Filled with quantitative data, the compendium has examples citing the efficiency of GSI in controlling stormwater and pollutants carried by it. In one case study in Nashville, bioretention planters installed in a Walmart parking lot not only reduced the impervious area and stormwater flowing down the drainage system, but also reduced the amount of phosphorus and other pollutants present in the water that did entered the grey system substantially (p 891-893).That will served as another rich source of information and reference for our research, providing information on several areas ranging from policy design to actual implementation of the assets.

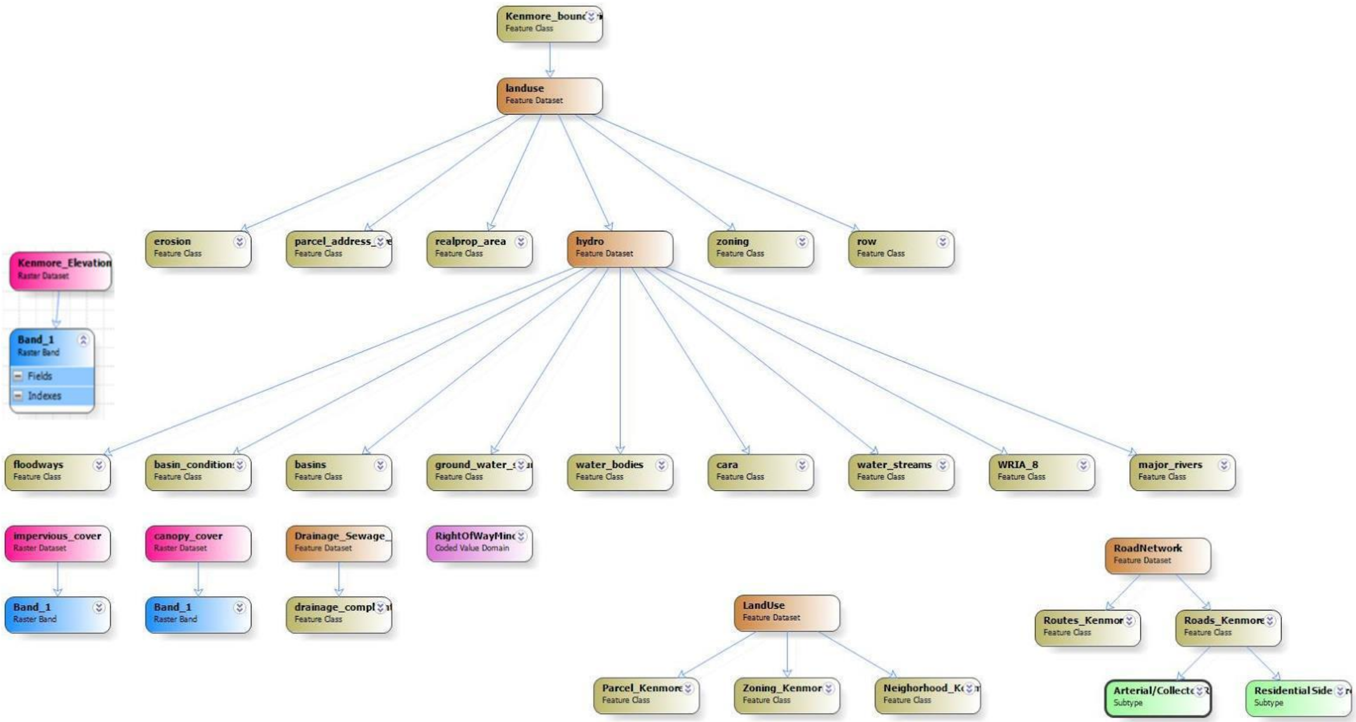
6. Appendices

Geodatabase Design:

Feature Dataset	Feature Class / Raster	Shape and Description	Table	Source
hydro	water_streams	Lines. Rivers and streams within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
hydro	floodways	Polygons. Floodways within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
hydro	ground_water_source	Point. Ground water source within Kenmore boundaries	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
hydro	basins	Polygons. Basins within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
hydro	basin_conditions	Polygons. Basin conditions from low(poor) to high (pristine)	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
utility_network	Mainlines	Lines. Pipes in the right-of-way, both drainage and sewage.	N	Georeferenced from City of Kenmore Portal. Retrived from ArcOnline. http://www.kenmorewa.gov/content/stormwater-inventory-maps
utility_network	Laterals	Lines. Private drainage and sewage infrastructure.	N	Georeferenced from City of Kenmore Portal. http://www.kenmorewa.gov/content/stormwater-inventory-maps
utility_network	Junctions	Points. Rubber couplers, fittings, valves, clean-outs and other pipe junctions.	N	Georeferenced from City of Kenmore Portal. http://www.kenmorewa.gov/content/stormwater-inventory-maps
utility_network	GSI	Polygons. Green stormwater infrastructure. Rain-gardens, bioretention planters.	N	Georeferenced from City of Kenmore Portal. http://www.kenmorewa.gov/content/stormwater-inventory-maps
utility_network	drainage_complaints	Polygons. Sources of complaints regarding the drainage system.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
RoadNetwork	Roads_Kenmore	Lines: Arterial & Residential Roads within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/ Subtypes include: Arterial/Collector Roads & Residential Side Streets.
RoadNetwork	Routes_Kenmore	Lines: Major Arteries within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/

LandUse	Neighborhood_Kenmore	Polygons: Identified Neighborhoods within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
LandUse	Parcel_Kenmore	Polygons: Tax parcels within Kenmore boundaries.	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
LandUse	Zoning_Kenmore	Polygons: Zoning designations with Kenmore boundaries	Y	King County GIS Portal http://www5.kingcounty.gov/gisdataportal/
	canopy_cover	Pixels/Raster: Shades of green depict percentage of canopy land cover from 0-100%.	Y	Multi-Resolution Land Characteristics Consortium (MRL) http://www.mrlc.gov/nlcd11_data.phpC
	kenmore_elevation	Pixels/Raster: The raster is on grayscale going from black to white to represent the different elevation levels based on a scale of the raster.	Y	University of Washington Earth and Spaces Sciences GIS Data Portal http://gis.ess.washington.edu/data/raster/tenmeter/byquad/index.html
	impervious_cover	Pixels/Raster: Impervious surface area, ranging from 0-100% imperviousness.	Y	Multi-Resolution Land Characteristics Consortium (MRL) http://www.mrlc.gov/nlcd11_data.phpC

Diagrams:


Kenmore_bound
Feature Class
landuse
Feature Dataset
erosion
Feature Class
parcel_address_
Feature Class
realprop_area
Feature Class
hydro
Feature Dataset
zoning
Feature Class
row
Feature Class
Kenmore_Elevation
Raster Dataset
Band_1
Raster Band
Fields
Indexes
floodways
Feature Class
basin_condition
Feature Class
basins
Feature Class
ground_water_
Feature Class
water_bodies
Feature Class
cara
Feature Class
water_streams
Feature Class
WRIA_8
Feature Class
major_rivers
Feature Class
impervious_cover
Raster Dataset
canopy_cover
Raster Dataset
Drainage_Sewage_
Feature Dataset
RightOfWayMinc
Coded Value Domain
RoadNetwork
Feature Dataset
Band_1
Raster Band
Band_1
Raster Band
drainage_compl
Feature Class
LandUse
Feature Dataset
Routes_Kenmor
Feature Class
Roads_Kenmore
Feature Class
Parcel_Kenmore
Feature Class
Zoning_Kenmor
Feature Class
Neighorhood_K
Feature Class
Arterial/Collecto
Subtype
Residential Side
Subtype

Attributes and Metadata

ObjectID and Shape are not listed. Shape has been specified earlier (see **Geodatabase Design** table). Fields where all data is <Null> are not included, as they are not relevant to this work (e.g, **comment** field in **water_bodies** dataset). Shape length and area shape were also omitted. All data listed in this section was retrieved from KCGIS Portal.

drainage_complaints

Item	Description	Domain
TRACKERID	The Tracking ID from the WLR Division's database.	*Range Min:* 741832.00000000 *Range Max:* 774099.00000000
COMP_NO	The complaint number from WLR Division's database.	
PROBLEM	Type of problem.	***ACS*** Access ***BEAV*** Beavers ***BSR*** Bioswale Retrofit ***CDT*** Commercial determination ***DCA*** Development/Construction ***DDM*** Drainage Miscellaneous ***DES*** Drainage - erosion/sedimentation ***DLE*** Drainage-landslide/ earth movemetn ***DTA*** Drainage Technical Assistance ***ERQ*** Earthquake 2001 ***FEAS*** Capital Project Feasibility Study ***FRE*** Facility Retrofit ***GRT*** Grant Program ***INQ*** General Drainage Inquiry ***IRG*** Irrigation ***L2ME*** Maintenance Enforcement Level 2 ***LSP*** Landscaping ***MFD*** Maintenance - Facility Dumping ***MFR*** Maintenance - Fence Repair ***MMA*** Mainenance - Aesthetics ***MMF*** Maintenance - Flooding ***MMG*** Maintenance - General ***MMM*** Maintenance - Mowing ***MNM*** Needs Maintenance ***MNW*** Maintenance - Noxious Weeds ***MSQ*** Mosquitos ***NWD*** New Discounts ***RCD*** Residential/Commercial Determination ***REC*** Recreation Facility ***REM*** Remeassure ***RET*** Retrofit ***RFD*** Residential Flooding ***RFN*** Runoff From Neighbor ***RVC*** Road Vacation ***SFTD*** 65/10 Discount ***SGN*** Sign ***SKH*** Sinkhole ***STR*** Storage ***SWF*** SWM Fee Questions ***TRE*** Tree Removal ***UTI*** Utility Installation ***VAND*** Vandalism ***WQAI*** Water Quality Audit Inspection ***WQAP*** Water Quality Audit in Progress ***WQB*** Water Quality - BMP (Best Management Practice ***WQD*** Water Quality - Dumping ***WQDC*** Water Quality - Dumping Commercial ***WQDR*** Water Quality - Dumping Residential ***WQI*** Water Quality - Illicit Connection ***WQO*** Water Quality - Other ***WQP*** Water Quality Permit ***WQPD*** Water Quality - Audit Permit Driven ***YRD*** Yard Extension
RECD	The date the complaint was received.	*Range Min:* 19000101 *Range Max:* 20091208
CLOSED	The date the complaint was closed.	*Range Min:* 19000101 *Range Max:* 20070621
COMMENTS	Comments about the complaint.	

basin_conditions

Item	Description	Domain
OBJECTID_1	Internal feature number.	Sequential unique whole numbers that are automatically generated.
Condition	Environmental Condition Value	***Low*** Areas with high development intensity (e.g., reduced forest cover, many roads crossing aquatic areas and wetlands, significant amounts of impervious surfaces, and extensive amount of armoring and structures along shorelines) and a low biological value (e.g., the little presence or low use by critical species or little or no presence of rare, endangered or highly sensitive habitats). ***Medium*** Areas with either high or moderate development intensity and moderate or low insignificant biological value. ***High*** Areas with low development intensity (e.g., substantial forest cover, relatively few roads crossing aquatic areas and wetlands, low amounts of impervious surfaces, and low amounts armoring and structures along shorelines) and a significant biological value (e.g., the presence or high use by critical species or the presence of rare, endangered or highly sensitive habitats).
WRIA_Name	Water Resource Inventory Area Name	
Study_Unit	Drainage Catchment Name	
WRIA_Num	Water Resource Inventory Area Number	

basins

Item	Description	Domain
WTR_NAME	Water Course Name	Full name of water course
BASIN_ID	Basin ID number	Integer identifying number - first or first two digits indicate WRIA; next two digits indicate WATERSHED; final two digits indicate BASIN
WRIA_NO	WRIA ID Number	***5*** Stillaquamish ***7*** Snohomish ***8*** Cedar-Sammamish ***9*** Duwamish-Green ***10*** Puyallup-White ***11*** Nisqually ***12*** Chambers-Clover
WRIA_NAME	WRIA Name	Full name of WIRA
WTRSHD_NAME	Watershed Name	Full name of watershed
WTRSHD_ID		

water_streams

Item	Description	Domain
WTR_NAME	Water Course Name	Full name of water course
BASIN_ID	Basin ID number	Integer identifying number - first or first two digits indicate WRIA; next two digits indicate WATERSHED; final two digits indicate BASIN
WRIA_NO	WRIA ID Number	***5*** Stillaquamish ***7*** Snohomish ***8*** Cedar-Sammamish ***9*** Duwamish-Green ***10*** Puyallup-White ***11*** Nisqually ***12*** Chambers-Clover
WRIA_NAME	WRIA Name	Full name of WIRA
WTRSHD_NAME	Watershed Name	Full name of watershed
WTRSHD_ID		
RTE_ID	Route Identification Number	Unique identifier for each stream
BASIN_NAME	Basin Name	Full name of basin
STR_LVL	A measure of stream hierachy	
SOURCE_NAME	Source of Stream Location	

floodways

Item	Description	Domain
FLOODPLAIN	Areas designated as floodways.	***Floodway*** The area regulated by Federal, state, or local requirements to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as set by the National Flood Insurance Program) within the 100-year floodplain.

water _bodies

Item	Description	Domain
FEATURE_ID	Unique identifier for each feature	Unique and persistent, non-sequential positive integer
NAME	Name of geographic feature	Mixed case name of feature, where known; otherwise blank
CREATE_USER		
CREATED_DATE		
EDIT_USER		
EDITED_DATE		
SUBSET_CD	Integer value that classifies larger, more significant lakes and rivers	***0*** Wtrbdy all ***1*** Bigwater river ***2*** Bigwater waterbody
SUBSET	String value that classifies larger, more significant lakes and rivers	***Wtrbdy all*** Feature not part of BIGWATER cartographic set ***Bigwater river*** A significant double-banked stream or river that is part of BIGWATER cartographic set. ***Bigwater waterbody*** A significant lake or pond that is part of BIGWATER cartographic set.
TYPE_CD	Integer value for type of water feature or non water feature	***101*** Reservoir ***106*** Fish hatchery or farm ***107*** Residential or industrial water impoundment ***109*** Sewage Disposal Pond ***116*** Bays, estuaries, gulfs, oceans ***400*** Rapids ***401*** Falls ***412*** River or stream ***414*** Ditch or channel ***415*** Aqueduct ***416*** Flume ***421*** Lake or pond ***423*** Sand or gravel ***902*** Fresh water island

ground_water_source

Item	Description	Domain
GW_ID	Groundwater Database table record ID number.	*Range Min:* 1 *Range Max:* 9462
EQUIS_ID	Groundwater Database unique identifier for each groundwater source.	Unique ID made up of letters and numbers - format varies.
LOC_NAME	Name of a well owner or water system.	Text string of location name, sometimes using property owner's/water district name.
SRC_TYPE	Type of groundwater source.	***A*** Public water system (well) Group A: 15 or more connections as recorded by the WA Department of Health. ***B*** Public water system (well) Group B: 2 to 14 connections, as recorded by the WA Department of Health. ***D*** Domestic
LOC_SRC	Method used to collect data, indicating accuracy of data location.	***GPS*** This site has been GPSed. The error of location can be less than 1 foot. ***map*** This site has been located via a map or aerial photography. The error of this location can be up to 100 feet. ***Parcel*** This site has been located within the parcel of interest. The error of this location can be up to 200 feet (or more). ***QTRQTRSEC*** This site has been placed by on the Township/Range/Section/Quarter/Quarter placement. The error of this location can be up to 500 feet. ***Unknown*** The error of this location is unknown.
SURF_ELEV	Land surface elevation in feet, not top of casing elevation.	*Range Min:* -2.64200000000 *Range Max:* 3003.07007000000
DATA_SRC	Initial source of location information.	***Historic - unknown source*** Historical source. ***King County DNRP*** King County Department of Natural Resources. ***King County WLRD*** King County DNRP Water & Land Division. ***Seattle - KC Health*** Seattle and King County Public Health Department. ***U.S. Geological Survey*** United States Geological Survey. ***WA Ecology*** Washington State Department of Ecology. ***WA Health*** Washington State Department of Health.
WRIA	Water Resource Inventory Area.	***00*** WRIA not defined/unknown. ***07*** Snohomish WRIA. ***08*** Cedar-Sammamish WRIA. ***09*** Green-Duwamish WRIA. ***10*** Puyallup-White WRIA. ***15*** Kitsap WRIA.
BASIN_NAME	King County DNRP Water & Land Division basin name	Text string representing the King County WLRD hydrobasin name from DRNBASIN.
BASIN_ID	King County DNRP Water & Land Division basin ID code.	Text string of 4 letters representing the code for the King County WLRD hydrobasin.
PIN	PIN of the parcel that contains the location.	10 digit Parcel Identification Number.
CITY	City that contains location.	Text string representing incorporated area name or for unincorporated locations, the county name.
ZIPCODE	Zipcode that contains the location.	Five-digit zipcode.
TOWNSHIP	Township that contains the location.	2 digit 1 letter PLSS Township.
RNG	Range that contains the location.	2 digit and 1 letter PLSS Range.
SECTN	Section that contains the location.	2 digit PLSS Section number.
QS	Quarter or quarter-quarter section that contains the location.	PLSS quartersection (2 letters) sometimes followed by forward slash and 2 letters indicating quarter-quartersection.
LOC_NUM	USGS Well ID number.	USGS ID [format: Township/Range - 2 digit number, letter, 2 digit number).
LOC_TYPE	Type of groundwater source.	***Other*** Other groundwater source. ***Spring*** A spring is a point where groundwater flows out of the ground, and is thus where the aquifer surface meets the ground surface. Depending on how constant the source of the water is - rainfall or snowmelt that infiltrates the earth - springs can be ephemeral (intermittent), perennial (continuous) or artesian. When they leave the ground they may forms pools or streams. ***Surface*** All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water. ***Unknown*** Groundwater source type is unknown. ***Well*** A pit, hole, or shaft sunk into the earth to tap an underground source of water. ***Wellfield*** An area containing more than one pumping well that provides water to a public water supply system or single owner.
WELL_DEPTH	Depth of wells (springs and surface = 0) in feet.	*Range Min:* 0.00000000000 *Range Max:* 3200320.00000000000
WADOE_TAG	ID assigned by the Washington Department of Ecology.	3 letters followed by 3 digits, or unsure
CARA_CODE	Critical Aquifer Recharge Area code.	***1*** Any portion of a well head protection area where there is high susceptibility OR any portion of a sole source aquifer where there is high susceptibility. ***2*** Any portion of a well head protection area where there is medium susceptibility OR any portion of a sole source aquifer where there is medium susceptibility, OR any remaining high susceptibility areas. ***3*** Vashon/Maury areas not classed as category 1 or 2. ***none*** Groundwater Source is not in an area covered by the CARA
WQ_YN	Availability of groundwater quality data.	***0*** No water quality data available. ***1*** Water quality data is available.

Zoning_Kenmore

Item	Description	Domain
CURRTEMP	current zoning codes without P, SO, or DPA codes	***(no value)*** no value ***A-10*** Agricultural, one DU per 10 acres ***A-35*** Agricultural, one DU per 35 acres ***CB*** Community Business ***F*** Forest ***I*** Industrial ***M*** Mineral ***MIT*** Muckleshoot Indian Tribe ***NB*** Neighborhood Business ***O*** Office ***R-1*** Residential, one DU per acre ***R-4*** Residential, four DU per acre ***R-6*** Residential, six DU per acre ***R-8*** Residential, eight DU per acre ***R-12*** Residential, 12 DU per acre ***R-18*** Residential, 18 DU per acre ***R-24*** Residential, 24 DU per acre ***R-48*** Residential, 48 DU per acre ***RA-2.5*** Rural Area, one DU per 5 acres (That 5 is not a typo) ***RA-5*** Rural Area, one DU per 5 acres ***RA-10*** Rural Area, one DU per 10 acres ***RB*** Regional Business ***UR*** Urban Reserve, one DU per 5 acres
CURRZONE	Feature geometry.	Coordinates defining the features.
USERID	Length of feature in internal units.	Positive real numbers that are automatically generated.

Parcel_Kenmore

Item	Description	Domain
MAJOR	First six characters of the parcel identification number (PIN)	Six character code derived from PLSS or plat number. eg 092503 for section 9 in township 25, range 3.
MINOR	Last four characters of the parcel identification number (PIN)	4 characters or numbers
PIN	Parcel Identification Number	Ten character concatenation of the Major and Minor field
COMMENTS	Additional information	Free text
SITETYPE	Internal code used to adjust the symbology of the site within the backoffice software	See metadata for ADDR_SITETYPE_LUT. http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=addr_sitetype_lut
Alias1	This is an alternate name that has been applied to the street that the site is located on	Free text
Alias2	This is a secondary alternate name that has been applied to the street that the site is located on	
SITEID	Unique identifier	*Range Min:* 7.0 *Range Max:* 2954765.0
ADDR_HN	House number	Number as a string
ADDR_PD	Prefix directional	String, e.g., E, N, NE, NW, S ...
ADDR_PT	Prefix street type	String, e.g., AVE, DR, HWY, LN, PL, RD, ST, STHY
ADDR_SN	Street name	String, all capital letters, such as 101ST, LINDEN, QUEEN ANNE
ADDR_ST	Suffix street type	String, e.g., ACRD, ALY, AVE, BLVD, ... VIA, VIS, WALK, WAY
ADDR_SD	Suffix street directional	String, e.g., E, N, NE, NW, S, SE, SW, W
ADDR_NUM	House number	Integer
ADDR_FULL	Complete address with house number, street name, street type, and directional	String, e.g., 103RD AVE SW, 4135 FAUNTLEROY WAY S
FULLNAME	Complete street name with type and directional, but no house number	String, all capital letters, such as: 83RD AVE NE, YUKON AVE S, ZURS ST
ZIP5	Five digit ZIP code	String
PLUS4	Plus 4 or add-on code to complete 9 digit ZIP code	String
LAT	Latitude coordinate	*Range Min:* 47.14117122

Neighborhoods_Kenmore

Item	Description	Domain
NEIGHBORHOOD_NAME		
NEIGH_NUM	Number of neighborhood	

Roads_Kenmore

Item	Description	Domain
TLINK_ID	Uniquely identifies a transportation link	*Range Min:* 1 *Range Max:* 173949
CREATEDATE	Date on which the transportation link is created	*Range Min:* 18991230 *Range Max:* 20061024
EFFEC_DATE	Date on which the transportation link is active	*Range Min:* 18991230 *Range Max:* 20061024
DB_MD_DATE	Date on which the record was modified	*Range Min:* 18991230 *Range Max:* 20061031
END_DATE	Date on which the record is no longer active	***18991230*** ***20030305*** ***40000101*** ***40010101***
KC_FCC_ID	King County road class codes	***C*** Collector Arterial ***F*** Freeway ***L*** Local Arterial ***M*** Minor Arterial ***P*** Principal Arterial
KC_FCC_ID	King County road class codes	***C*** Collector Arterial ***F*** Freeway ***L*** Local Arterial ***M*** Minor Arterial ***P*** Principal Arterial
CFCC_ID	Census feature class codes	***A00*** Road, major and minor categories unknown ***A01*** Road, unseparated ***A02*** Road, unseparated, in tunnel ***A03*** Road, unseparated, underpassing ***A04*** Road, unseparated, with rail line in center ***A05*** Road, separated ***A06*** Road, separated, in tunnel ***A07*** Road, separated, underpassing ***A08*** Road, separated, with rail line in center ***A1*** Primary highways with limited access ***A10*** Primary highways with limited access, major category ***A11*** Primary highways with limited access or interstate hwy, unseparated ***A12*** Primary highways with limited access or interstate hwy, unseparated in tunnel ***A13*** Primary highways with limited access or interstate hwy, unseparated underpassing ***A14*** Primary highways with limited access or interstate hwy, unseparated rail line in center ***A15*** Primary highways with limited access or interstate hwy, separated ***A16*** Primary highways with limited access or interstate hwy, separated in tunnel ***A17*** Primary highways with limited access or interstate hwy, separated underpassing ***A18*** Primary highways with limited access or interstate hwy, separated rail line in center ***A2*** Primary road without limited access ***A20*** Primary road without limited access, major category ***A21*** Primary road without limited access, unseparated ***A22*** Primary road without limited access, unseparated in tunnel ***A23*** Primary road without limited access, unseparated underpassing ***A24*** Primary road without limited access, unseparated rail line in center ***A25*** Primary road without limited access, separated ***A26*** Primary road without limited access, separated in tunnel ***A27*** Primary road without limited access, separated underpassing ***A28*** Primary road without limited access, separated rail line in center

TYPE_L	Transportation link name type code as identified by USPS left	***AcRd*** AccessRoad ***Aly*** Alley ***Ave*** Avenue ***Blvd*** Boulevard ***Brg*** Bridge ***Cir*** Circle ***Cres*** Crest ***Ct*** Court ***Cto*** Cutoff ***Dr*** Drive ***Expy*** Express Way ***Ext*** Extension ***Fwy*** Freeway ***Holw*** Hollow ***Hwy*** Highway ***Ky*** Key ***Ln*** Lane ***Loop*** Loop ***Mall*** Mall ***Opas*** Over Pass ***Park*** Park ***Pkwy*** Parkway ***Pl*** Place ***Ramp*** Ramp ***Rd*** Road ***Rise*** Rise ***St*** Street ***Stair*** Stair ***Ter*** Terrace ***Trl*** Trail ***Tunl*** Tunnel ***Vis*** Vista ***Walk*** Walk ***Way*** Way ***Rail*** Rail