

Building Missoula: Interactive Permit & Development Data Dashboards

An Initiative for Enhanced Accessibility & Insights
from Permit Data

A Data Engineering Project by Luke Wyman



Project by Luke Wyman of the University of Montana in Collaboration with
City of Missoula Community Planning, Development & Innovation

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Executive Summary

The City of Missoula Community Planning, Development, and Implementation (CPDI) department is focused on improving the efficiency, transparency, and responsiveness of its development review and permitting processes. Currently, permit data is gathered at various intervals using ad hoc methods, which creates challenges in data accessibility, consistency, and usability. This data, which includes information on residential and commercial new construction and remodels, helps the city understand development trends, market fluctuations, and the overall health of the community's growth.

Currently, there is no unified, consistent system for tracking and analyzing historical building permit data, which limits the ability of both internal and external stakeholders to fully explore and understand the data. While CPDI staff possess a solid working knowledge of permit volumes and timelines, there are few opportunities for both the CPDI team and external stakeholders—such as builders, contractors, and developers—to interact with the data in a comprehensive and meaningful way. In municipalities across the country, access to permit data presented in dashboard formats can provide users with valuable insights into community development trends, permit processing volumes, and opportunities for operational improvements. Without such systems in place, there is no straightforward way to identify emerging patterns, forecast future development needs, or optimize the permit review process, leaving key opportunities for strategic decision-making and operational efficiency largely unexplored.

This project aims to develop interactive dashboards that will provide both CPDI staff and the public with better access to permit data. By centralizing and organizing historical building permit data, these dashboards will allow users to explore trends, monitor permit volumes, and gain insights into the efficiency of the permit review process. The goal is to empower CPDI staff, builders, contractors, and developers with the tools they need to make informed decisions, streamline operations, and foster greater transparency in the development review and permitting process.

Introduction

The rapid expansion of large municipalities has elevated the importance of having development review and permitting processes that are both transparent and efficient. Economic pressures such as rising living costs, housing shortages, and increased development demands make the monitoring and analysis of building permits essential to maintaining growth. These permits serve as crucial indicators of community development trends, market dynamics, and growth patterns.

In Missoula specifically, development activity continues to accelerate, yet the city lacks a unified system to organize and analyze permit data effectively. This absence creates a significant gap in the CPDI team's ability to generate accessible insights and respond to changing conditions. By addressing this deficiency, Missoula officials would gain the tools needed to make data-driven decisions, streamline operations, and respond more effectively to community needs as they evolve over time. Without such systematic analysis, the city risks missing important signals about development patterns, potentially resulting in misaligned policies and resources. A comprehensive approach to permit data not only benefits city planners and officials but also provides

valuable transparency to residents, developers, and businesses seeking to understand and participate in Missoula's growth trajectory.

This project, done in coordination between the University of Montana and the City of Missoula CPDI department, seeks to address these challenges by developing a small suite of interactive dashboards that centralize and streamline access to building permit data. These dashboards will provide both internal and external stakeholders with valuable insights into permit volumes, processing timelines, and community development trends.

By leveraging these tools, the CPDI team will be better positioned to improve efficiency, transparency, and responsiveness in the development review and permitting process. Additionally, the public will benefit from access to real-time permit information, allowing residents to track current developments. This democratization of permit data represents a significant step toward fostering a more informed and engaged citizenry, ultimately strengthening the collaborative relationship between Missoula's government and the community it serves.

Solution Overview

The proposed solution I came up with centers on the development of interactive data dashboards designed to transform how Missoula processes and visualizes building permit information. The data exists in the Acella database, as well as in Excel spreadsheets derived from Acella reports after having an audit done. The dashboards I create in this project draw inspiration from municipalities that have obviously spent resources to develop highly informative permit dashboards. Drawing from these data sources using carefully designed Python and SQL scripts, I create data sets that are effective for dashboard filtering and development.

<TBD Flow diagram showing data sources, methods, transformations, dashboards, experiences TBD>

Technology Selection

While collaborating with the CPDI team as an external resource, I navigated specific technology constraints that shaped the project implementation. The city's data environment presented two primary sources: the Acella Enhanced Reporting Database and various Excel Workbooks maintained by department staff. This hybrid data landscape required two data engineering approaches—SQL scripts for database queries and Python Jupyter Notebooks for processing Excel-based information.

For visualizations and user interface development, the CPDI team determined that ArcGIS dashboards would serve as the optimal platform. This selection aligned strategically with the city's existing technology ecosystem, where ArcGIS already powers their GIS data management, city mapping, parcel information, and related spatial services. Though initially unfamiliar with this platform, I was able to use my previous experience in PowerBI and Domo to work through the logic to develop high-impact dashboards.

The ArcGIS implementation ultimately delivered highly functional, visually compelling dashboards that the city staff can maintain independently after project completion. Equally important, was that I learned a new skill. Once the data was hosted on the platform, I had to use ArcGIS's data expression language, Arcade, to shape the data for my data visualization needs.

Data Sources & Integration

To stay consistent with the team's resources and general workflows for data management, many technology decisions supporting the dashboards were determined by the CPDI team. Given accessibility, learning curve, and time constraints to the CPDI team's data environments, my primary focus was developing scripts that automated data extraction and transformations. I aimed to maximize automation within my accessibility constraints, while attempting to be forward-thinking about dashboard maintenance throughout future lifecycles.

When the project is completed, I will conduct a session with the CPDI team's technical stakeholders to ensure they are equipped with the knowledge needed to maintain and update the dashboards moving forward. During this session, we will review the standard operating procedures for managing the data pipelines, ensuring that data updates are seamless, and the dashboards remain accurate and reliable over time. This will include discussions on data acquisition, processing, and visualization, as well as troubleshooting steps to address potential issues. By providing clear and structured procedures, the CPDI team will be empowered to manage the dashboards independently.

Sub-Projects/Dashboards

To better manage my time and resources, I chose to break the initiative for enhanced accessibility and insights from permit data into several sub-projects. This strategy allowed me to focus on each component more effectively, ensuring that each piece had clear objectives and deliverables. By dividing the initiative into smaller, manageable sub-projects, each resulting in its own dashboard, I was able to work more independently. This approach helped me avoid potential delays, such as waiting on process diagrams or access to the database, while still advancing the overall project efficiently.

- 01 [Building Permit Metrics](#): Create automated visualizations of key building permit process metrics like processing times, resubmittals, and volumes.
- 02 [Building Permit Operational Insights](#): Design a dashboard to enhance internal operations by providing metrics on team-specific workflow activity related to building permits.
- 03 [Community Development Snapshots](#): Provide long-range, filterable reporting on building and other permits to help the community analyze growth patterns in city development.

01 Building Permit Metrics

In this sub-project, I built a data pipeline that transformed raw back-end SQL database tables from the Acella Enhanced Reporting Database into dashboard-ready datasets. In the dashboard, users can find fully automated visualizations of metrics such as permit processing times, volumes, and more. These visualizations are designed to update daily as new data populates within the system, ensuring people always have access to current information. Public-facing metrics were developed

to improve overall transparency and help the public better understand the permit process and lifecycle. The result of this solution is a fully automated, filterable dashboard that requires little-to-no oversight that the city can release for the public.

<TBD Screenshot Linked to the Completed Dashboard TBD>

Requirements Gathering

Before developing solutions for this project, I took the time to understand the building permit processes and stakeholder needs to ensure my approach aligned with the team's vision for the new dashboard. One of the primary purposes of the dashboard was to streamline the permit application workflow, making it crucial to clearly understand each stage involved.

Since I was unfamiliar with the building permit process, I requested a diagram, which I then refined to highlight key touchpoints and the flow of information essential for the dashboard. This step was critical as it formed the foundation for developing the logic needed to structure the data to meet the dashboard's needs. The visual representation helped clarify the project's goals and allowed me to define a permit cycle in the data, specifically identifying key hand-offs between the city and the applicant throughout the process.

Since there wasn't an existing dashboard to reference, I first investigated dashboards from other municipalities

<TBD Simplified Building Permit Process Diagram TBD>

to better understand best practices and key features. I worked with the CPDI team to develop and understand the visualizations that were to be shown in the dashboard. This research and preparation helped shape my approach to structuring the data effectively, especially since I was not familiar with the native database tables that contained this information, in one way or another.

Proper data structuring required balancing granularity with usability. The challenge was to track permits throughout their entire lifecycle while ensuring the data format supported intuitive filtering, aggregation, and meaningful insights for stakeholders. To achieve this, I created visualization requirements list that allowed me to theoretically plan the dataset by predefining key features. I then worked closely with the CPDI team to identify the relevant native database tables and fields needed to build the logic for querying the data effectively.

Data Acquisition and Preparation

<TBD Currently being worked on. TBD>

Dashboard Development

<TBD Extensively prepared for dashboard development. I have a list of requirements that will be built with attributes/filters already scoped. TBD>

Results & Capabilities

<TBD TBD>

Data Updates

<TBD Automatically updated daily. Query/ies will be given to GIS team to configure data feed. TBD>

Risks

<TBD TBD>

02 Building Permit Operational Insights

In this sub-project, I built a data pipeline that transformed raw back-end SQL database tables from the Acella Enhanced Reporting Database into dashboard-ready datasets specifically designed for internal permit processing teams. This dashboard focuses on team-specific metrics, providing detailed visualizations of workflow efficiency, processing bottlenecks, and workload distribution across departments. Internal staff can track how long permits spend at each review stage and identify

where delays commonly occur within their specific team's process. These visualizations update daily as new data populates the system, ensuring the CPDI team has current information for operational decision-making.

<TBD Screenshot Linked to the Completed Dashboard TBD>

The result of this solution is a fully automated, filterable dashboard that requires little-to-no oversight that the city can release for internal teams.

Requirements Gathering

<TBD TBD>

Data Acquisition and Preparation

<TBD Comes from Acella ERD. Needs to be developed, but is highly like 01 data, only with internal team reference points for permit process. More than likely will duplicate scripts from 01 and modify. TBD>

Dashboard Development

<TBD Needs to be developed, but is highly like 01 dashboard, only with internal team reference points for permits points for permit process. More than likely will duplicate dashboard from 01 and modify. TBD>

Results & Capabilities

<TBD TBD>

Data Updates

<TBD Automatically updated daily. Query/ies will be given to GIS team to configure data feed. TBD>

Risks

<TBD TBD>

03 Community Development Snapshots

In this sub-project, I developed scripts that transformed audited data from Acella, which had been compiled into monthly reports in Excel workbooks, into dashboard-ready datasets. These scripts automated the extraction and standardization of historical permit information from multiple years, creating a unified data repository. The resulting dashboard consolidates long-term data, empowering users to discover new insights about city development patterns. Users can now visualize and analyze development trends, seasonal fluctuations, and growth patterns that were previously difficult to identify when the data existed only in separate monthly reports without on-demand visualizations and navigation across time.

<TBD Screenshot Linked to the Completed Dashboard TBD>

Requirements Gathering

Before developing solutions for this project, I assessed the existing data, processes, and stakeholder needs to make sure what I was working with aligned with the team's vision for a new dashboard. The main inspiration for this dashboard comes from a consolidation of the monthly, quarterly, and yearly analyses for the City of Missoula's development data on their [website](#). Upon reviewing these reports, I found that the monthly development report was the primary tool used to communicate development data to the public. However, it lacked interactive visualizations and other engaging features. Conducting long-term analysis or generating filterable reports required manually consolidating data from multiple monthly reports.

After becoming familiar with the data, I met with the CPDI team to determine the key functionalities they needed in a dashboard. They wanted to analyze the same development data while seamlessly navigating between different months. Additionally, they were concerned about public complaints regarding the lack of calendar year-to-date consolidations, as only fiscal year-to-date data was provided. The dashboard needed to maintain the same reporting format while enabling the team to more efficiently access and analyze long-term trends.

Data Acquisition and Preparation

The team and I tried to solution the data by considering using a new data report coming out of Accela. However, given the scope and timeline for this project, we wanted to ensure that the data pull wasn't an issue for me. To acquire the data, we ended up using the Fiscal Year Development Report Workbooks from 2021 through 2025. Since there were multiple departmental changes and changes that happened to the monthly report around 2021, we decided that this would be a good range of data to use for the dashboard.

There are three primary components to be considered in these workbooks and each component has its own sheet for any given month. Here are the components:

1. **Data Dumps:** This is monthly building permit data that comes out of Accela and is audited by the team. There are two tables on this sheet, one is the main table, and one is the set of permit revisions that were made to previously reported permits. Each row represents a single building permit completed that month.
2. **Five Reports:** This is monthly all-type permit data that is pulled from Accela. There are five tables on this sheet, and each contains varying information about all consolidated permits, ranging from permit volumes to revenue collected from permits.
3. **Report:** This is the monthly report as seen on the [website](#). Specific cells reference values from the **Data Dumps** or the **Five Reports**, depending on a wide variety of conditions. The top of the report is mainly sourced from the **Data Dump** while the bottom of the report is mainly sourced from the **Five Reports**.

It should be noted that the YTD consolidations take the current month's values and then consolidate by summing with the previous month's YTD consolidations, which could lead to many downstream reporting errors.

Given the time I had to understand this data and report this data effectively, I decided that two datasets were necessary to support the dashboard. At a high-level, here are the data sets that I created:

1. **BuildingPermitDataAll.csv**: This data set supports visualizations inspired by the top of the monthly **Report**. It's important to note the data is sourced by directly pulling the permit data from the **Data Dumps**. In my script, there are a wide range of functions developed to pull the data appropriately, clean it, define the building permit type, and pull it all together across multiple years.
2. **PermitDataAll.csv**: This data set supports visualizations inspired by the bottom of the monthly **Report**. It's important to note the data is sourced by directly pulling data from the **Reports** sheet, not the Five Reports sheets. While the permit type categorization rules were relatively clear for building permits, the data was in too raw of a form in the **Five Reports** for me to confidently report financials and quantities for all permits. As such, the data comes directly from the already-compiled monthly **Report**, which has already been reviewed and released by the CPDI team.

The team should be highly aware that I am using the **Data Dumps** data for the **BuildingPermitDataAll.csv** and the **Reports** data for **PermitDataAll.csv**. The CPDI team should continue performing their monthly audits and report building as they have for the past few years. When new data is uploaded to the dashboard, they should verify that the month's data aligns with what was reported in the monthly report. If specific values are off, it is likely that logic used in the script needs to be modified or the actual rows in the data need to be modified. For example, the script attempts to remove duplicates, but if one is missed, it could be worth deleting the row from the data dump.

It's important to emphasize that the goal of this project is not to alter the existing data processing workflow but to consolidate historical data into an interactive and accessible dashboard. While the process may be more detailed, it ultimately opens greater opportunities for exploring long-term development data.

Dashboard Development

The two data sets developed above are inputs to the dashboard and have been optimized to best support various dashboard functionalities. Dashboard tables mimic the values found in the monthly report. Some visualizations required further consolidations, like finding YTD cumulative sums (for things like quantities, units, valuations, and revenue) for any given month on both fiscal and calendar years. These consolidations are performed in Arcade data expressions and used in multiple serial charts on the dashboard.

Results & Capabilities

The completed dashboard successfully consolidates Missoula's development data into an interactive and user-friendly interface. By integrating data from monthly, quarterly, and yearly reports, the dashboard eliminates the need for manual data aggregation, significantly improving efficiency. Users can now seamlessly navigate between different months, compare trends over time, and filter data based on specific criteria, allowing for more in-depth analyses.

A key improvement is the inclusion of both fiscal and calendar year-to-date consolidations, addressing a major concern raised by the CPDI team. This addition enhances transparency and aligns reporting with public expectations. Additionally, the dashboard introduces several year-over-year visualizations, making it easier to identify patterns and insights immediately.

By preserving parts of the existing reporting format, the dashboard ensures continuity in how data is presented while providing new tools for exploration and decision-making. This solution improves public access to Missoula's development data, making long-term trends easier to explore and understand.

Data Updates

To update the dashboard with the latest data, the CPDI team should continue following their current process for pulling and formatting the data as consistently as possible. The script used to generate the dashboard data is designed to recognize the common formats from previous monthly reports, so any changes to the data format could prevent the script from processing the data correctly.

Once the monthly reports are audited and finalized, the team can update the development workbook in the folder where all reports are stored. Running the script will generate two new CSV files which can then be uploaded to the GIS platform. The datasets should be uploaded as to overwrite the previous table instances. To ensure the update works smoothly, it's critical to manage the script carefully and avoid making changes to the schema, as this could cause the upload to fail.

Risks

There are a few risks associated with this project, mainly due to the complex nature of the data ingestion and permit type declaration. At the completion of this project, the following aspects of this solution pose as future risks to the deliverability of the dashboard:

- The workbooks must be maintained in the same structure and format as they have been previously. During the auditing process, the team should be cautious about where data is entered and how calculations are performed. If the data output appears incorrect or inconsistent, it may be worth reviewing the workbook for issues that could affect the script's processing. Problems within the workbook—such as misplaced data or calculation errors—could lead to unexpected results when the script runs.
- The data schema must remain identical with every data upload to the GIS platform. Any changes to the schema between uploads will cause the data upload process to fail. This makes it challenging to add new features to the dashboard, as the addition of new fields or functionality could alter the schema. If new features are necessary, they must be incorporated carefully and in a way that does not disrupt the existing structure of the data, ensuring compatibility with the GIS platform.
- Processing does not end with the Python code used to generate the data; sometimes, Arcade data expressions are needed to transform the data for visualizations or metrics. While powerful, these expressions can be challenging to manage for those unfamiliar with the Arcade language. It's important to have a solid understanding of how these expressions work, as errors in these scripts can affect how data is displayed or calculated within the dashboard. Equally important, is assuring that all filters are applied to the appropriate visualizations to display accurate information.

Discussion

Key Results & Capabilities

<TBD when dashboard work is done TBD>

Key Risks

<TBD when dashboard work is done TBD>

Future Development

<TBD when dashboard work is done TBD>

Key Takeaways from the Lead Developer

<TBD when dashboard work is done TBD>

Closing Remarks

Summary of Achievements: Recap the project's primary goals, solutions, and results.

Final Thoughts: Offer concluding remarks that tie together the importance of the project and its contribution.

Acknowledgements: Thank CPDI for working with me and acknowledge professionalism and giving me platform to develop important project.