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

Table of Contents

EXECUTIVE SUMMARY **2**

INTRODUCTION **3**

SOLUTION OVERVIEW **4**

- Technology Selection 5
- Sub-Projects/Dashboards 5

01 BUILDING PERMIT METRICS **6**

- Requirements Gathering 6
- Data Acquisition and Preparation 7
- Dashboard Development 8
- Results & Capabilities 8
- Risks 9

02 BUILDING PERMIT OPERATIONAL INSIGHTS **10**

- Requirements Gathering 10
- Data Acquisition and Preparation 10
- Dashboard Development 11
- Results & Capabilities 11
- Risks 12

03 COMMUNITY DEVELOPMENT SNAPSHOTS **13**

- Requirements Gathering 13
- Data Acquisition and Preparation 14
- Dashboard Development 15
- Results & Capabilities 16
- Data Updates 16
- Risks 16

DISCUSSION **18**

- Key Results & Capabilities 18
- Challenges & Limitations 18
- Future Development 17

CLOSING REMARKS **19**

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 collected at varying intervals using semi-standardized methods. This inconsistency in how and when data is gathered creates challenges in ensuring the data is consistently accessible, reliable, and useful for analysis or informed decision-making. For instance, if data reveals a seasonal spike in permit applications, CPDI can work proactively with the public to manage expectations and adjust internal workflows to reduce delays. 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 around commercial and residential developments.

Currently, there is no unified, consistent system for tracking and analyzing historical building permit metrics data, which limits the ability of both internal and external stakeholders to understand what's happening around building permits for the city. 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 is presented in dashboard formats that 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 insights derived from 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 around building permits. The CPDI staff can use the dashboards to help identify any bottlenecks and develop KPIs against the dashboard. Finally, this as a great opportunity to provide transparency in the development review and permitting process, fostering more trust between CPDI and the community it serves.

Introduction

The rapid growth 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 key indicator of community's 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.

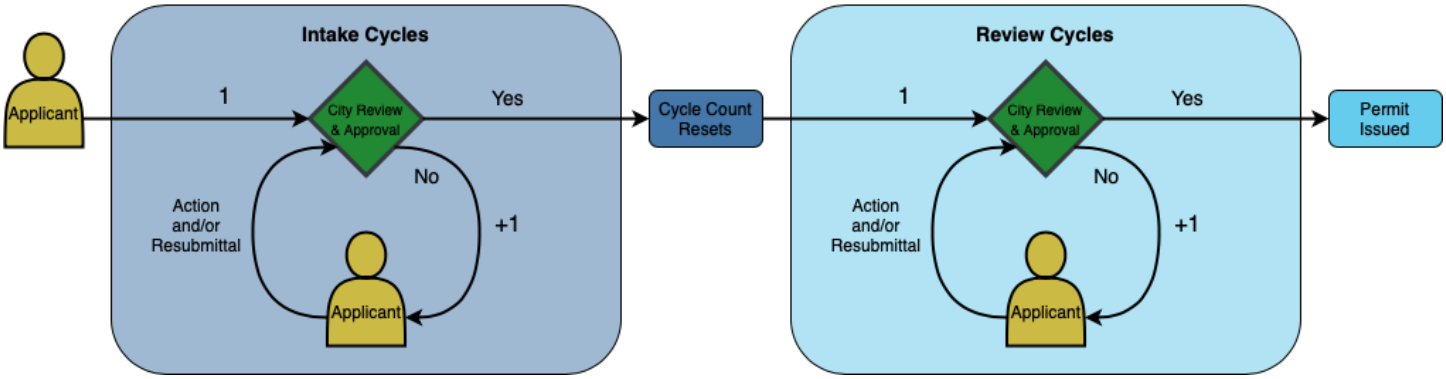
By leveraging these tools, the CPDI team will be better positioned to improve efficiency, transparency, and responsiveness in the development review and permitting process. Additionally, the public will benefit from access to real-time permit information, allowing residents to track current developments. 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 solution I propose centers on the development of several interactive data dashboards designed to transform how City of Missoula CPDI processes and visualizes building permit information. The data exists in their database platform called Acella, which is a Microsoft Azure database, and in Excel spreadsheets derived from Acella reports following an audit. The dashboards I create in this project draw inspiration from municipalities that have spent resources to develop highly informative permit dashboards. Drawing from these data sources using carefully designed SQL and Python scripts, I create data sets that are effective for dashboard filtering and development.

The underlying data comes from building permit records, which reflect a wide range of construction activity in Missoula. When a property owner or developer decides to build a new home, remodel an apartment complex, install a new roof, or construct a garage, they must apply for a building permit through the city. That application initiates a complex, collaborative review process that often involves multiple city departments such as engineering, environmental health, fire safety, zoning, and planning.

As the permit moves through these phases, it may pass through multiple cycles. A cycle begins when the applicant addresses a specific action item, such as paying a fee or providing additional details. The permit will continue circulating between the applicant and various city departments until all required approvals are obtained. Once the review process is complete and all reviewers have signed off, the permit is issued and followed by final inspections. For new dwellings, the post-review process also includes approvals for temporary certificates of occupancy (TCO) and certificates of occupancy (CO).



These cycles can vary widely in number and duration, depending on the complexity of the project. As the permit passes through each stage, whether being reviewed by the city or the applicant, this data is recorded by both manual and automated processes in Accela. While the system provides a detailed activity history, it doesn't indicate how long the city or applicant is responsible at each step.

Extracting this information isn't straightforward. Accela's data tables are complex and often abstract, especially to those unfamiliar with the system. Gaining meaningful insights requires both a deep understanding of the data structure and a clearly defined pipeline using common table expressions.

To address this, I built a series of well-structured SQL queries and Python scripts that extract and transform raw permit and process data into clean, structured datasets. The goal is to produce a dataset that makes dashboard development straightforward. With the right structure, the data supports dynamic filtering and helps reveal patterns in permit review timelines. It also highlights which departments are involved, tracks how many cycles each permit goes through, and shows how responsibility shifts between the city and the applicant.

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.

Sub-Projects/Dashboards

To better manage my time and resources, I chose to break this initiative into several sub-projects for enhanced accessibility and insights from permit data. 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 researched and decided upon with the goal of improving overall transparency and helping the public better understand the permit process and lifecycle. The result of this solution is a fully automated, filterable dashboard that requires minimal oversight that the city can release for the public.

Requirements Gathering

Before developing solutions for this project, I took the time to thoroughly understand the building permit processes and the needs of stakeholders to ensure my approach aligned with the team's vision for the new dashboard. As I was informed, the team lacked automated reporting for permit processing and cycle review timelines. Given that one of the primary goals of the dashboard was to streamline the permit application workflow, it was essential to gain a clear understanding of each stage in the process.

Since I was new to the building permit process, I asked for a diagram outlining a generalized process flow for issuing a permit. This visual reference was essential for understanding how to structure the data effectively. It

provided the foundation for developing the logic needed to support the dashboard's requirements. By mapping out each step, the diagram helped clarify the project's goals and made it possible to define what constitutes a permit cycle in the data; When I was viewing the raw permit data, I then had enough background to identify key indicators of hand-offs between the city and the applicant throughout the process.

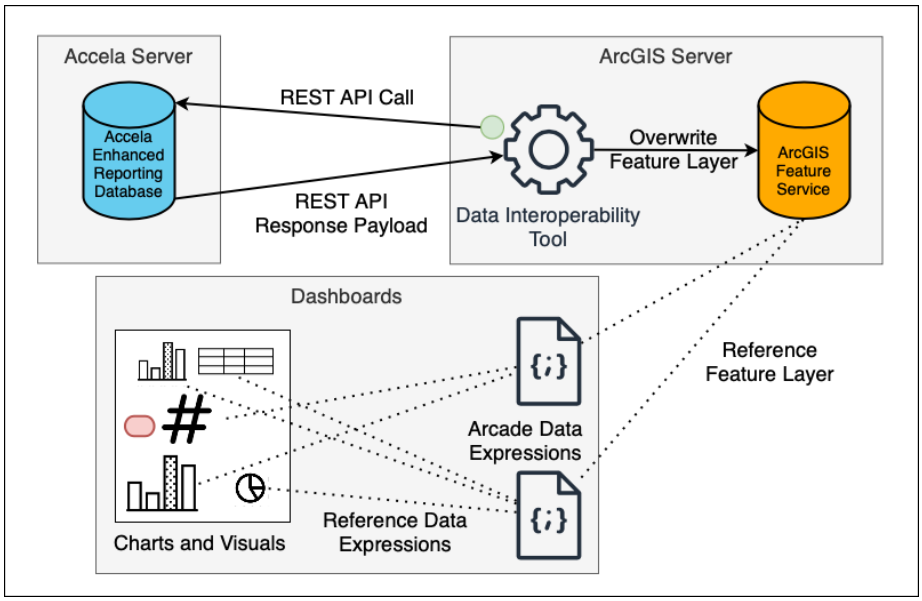
Since there was not an existing dashboard to reference, I studied dashboards from other municipalities to better understand best practices and key features. I worked with the CPDI team to develop and understand the visualizations that were to be shown in the dashboard. This research and preparation helped shape my approach to structuring the data effectively, since I was not familiar with the native database tables that contained this information.

Data Acquisition and Preparation

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.

With our requirements in place, I built a test dataset that included the fields needed to display the requested information in the dashboard. From there, it was a matter of locating these fields in the database and structuring the data to fully support filtering and drill-down functionality in the visualizations.

Once I had access to the database, I developed an initial query using a few test building permits. This helped guide my decisions on how to merge tables and perform calculations in SQL. Initially, the query produced a satisfactory table, but I encountered significant performance issues, with processing times reaching about a minute and a half per permit. Given that over 6,000 permits were relevant for this dashboard, this was not feasible. I revisited the query, leveraging my improved understanding of the relevant data tables. By carefully scripting and optimizing the SQL, I was able to reduce the processing time from 90 seconds per permit to just 12 seconds for the entire table.



To make the data accessible for analysis, the CPDI team helped set up a connection between the backend SQL database and ArcGIS using a REST API. This connection allowed us to automate scheduled data updates, ensuring that permit data from Accela was regularly pulled into ArcGIS without requiring manual effort. As a result, the dashboards always reflected the most up to date

information. This automation was essential for maintaining real-time insights and keeping stakeholders informed as new data entered the system.

Dashboard Development

Because of the time and effort invested upfront in gathering requirements and understanding the permit process, building the dashboards became more about exploring the capabilities of ArcGIS Dashboards than wrestling with the data itself. The foundational work, such as defining cycles, clarifying hand-offs, and shaping the dataset around stakeholder needs, ensured the data was already well-structured and aligned with the dashboard's goals. While the dashboard relied on a single dataset, I developed several data expressions within the platform to filter, group, and aggregate the data as needed. These expressions powered the visualizations and allowed the dashboard to remain flexible without adding complexity to the underlying data pipeline.

Results & Capabilities

The dashboard supports a wide range of use cases and provides insights into various aspects of building permit data that were not previously available on demand. Users can filter the data by project type (addition/remodel or new construction), permit type (commercial or residential), permit subtype, pre-issuance cycle, year, and month. These filters are applied only to the visualizations and metrics where they are relevant, ensuring the dashboard remains intuitive and focused on meaningful analysis.

Depending on the filters applied, the meaning of certain metrics and visualizations may change. For example, applying a month filter adjusts the yearly permit trends and processing time charts to show year-over-year values for that specific month, allowing for more targeted comparisons.

Beneath the filter bar, users will find high-level metrics that display the number of permit applications received and issued, shown across both yearly and monthly timeframes. This section also includes a key performance indicator: the median number of days it takes for a permit to move from application to issuance.

Further down, the dashboard presents data on how long it typically takes an application to move through each pre-issuance cycle, broken down by whether the city or the applicant is responsible. This area highlights the number of review and resubmittal cycles required before a permit is issued, offering insight into where time is spent in the review process. Additional visualizations related to both pre- and post-issuance phases can be accessed through the navigation bar.

On the far right, users can view information related to open applications. These are applications currently under review or awaiting action from an applicant. his section allows users to track each application’s status by its original submission date and see where it currently stands in the process. For the city, this view serves as a practical tool for managing the permit pipeline, helping staff identify applications that have stalled and may need to be followed up on, renewed, or voided.

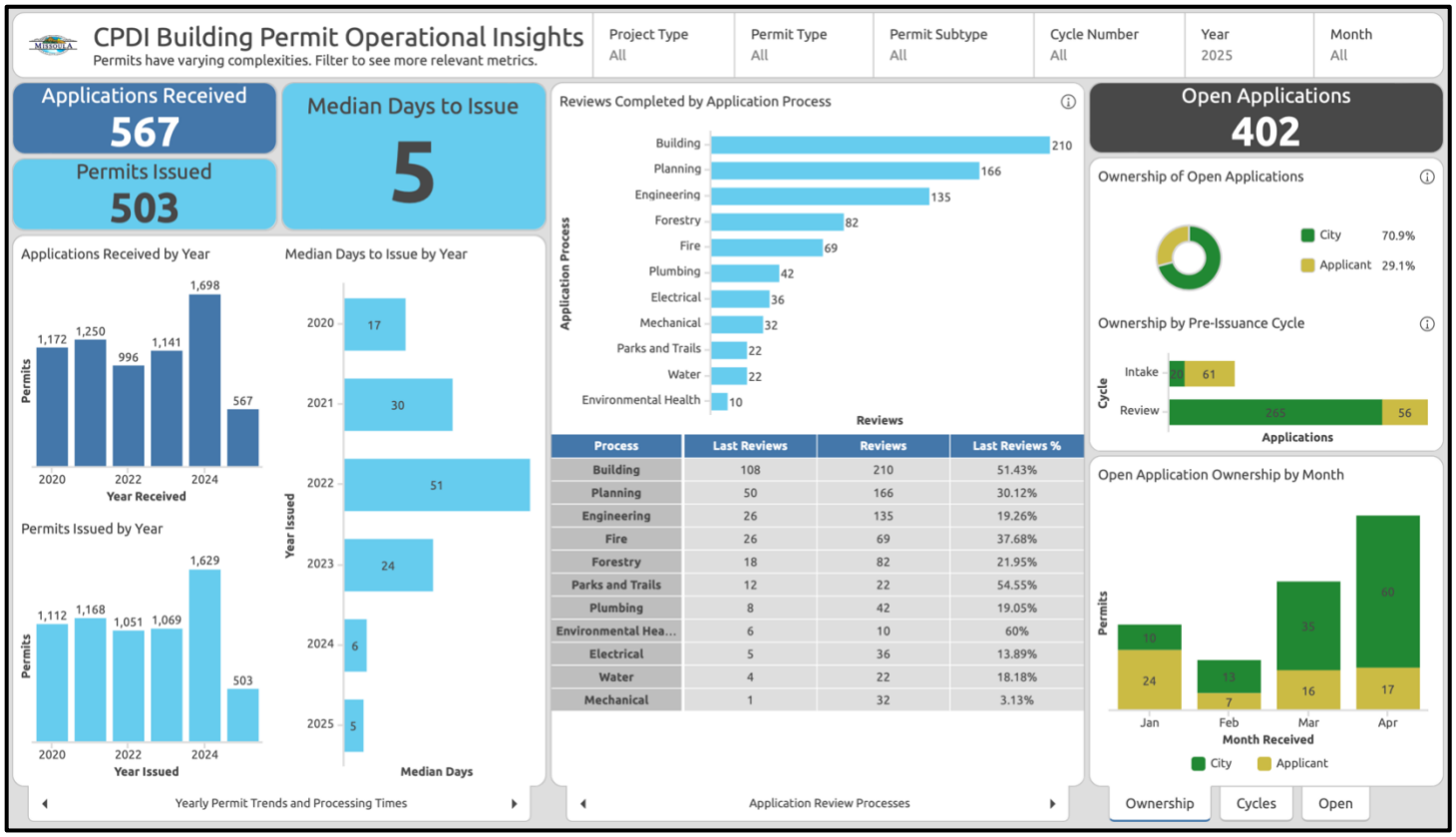
Risks

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

- The building permit process can be complex due to the involvement of multiple teams reviewing various permits. As the process evolves—whether simplified or made more intricate—there is a risk that the indicators used in the query may no longer capture key inflection points accurately. Therefore, if the CPDI team decides to modify the process in the future, the query will need to be revisited and adjusted to ensure it accurately reflects the updated workflow.
- Given the reliance on backend database tables, on major risk lies in the accuracy and completeness of the data. Missing or inaccurate data could undermine the dashboard's reliability. Ensuring the data extraction process is regularly monitored for discrepancies is essential to avoid misleading insights.
- The usefulness of the dashboard depends on how well users understand and apply the available filters. There is a risk that some users may overlook important filter options, such as permit type, leading to inaccurate interpretations. For example, a user might assume that review times for new residential homes are very short, when in fact the data is skewed by many simple permits like reroofing, which move through the process much faster.

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 stay in 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. The result of this solution is a fully automated, filterable dashboard that requires minimal oversight that the city can release for internal teams.



Requirements Gathering

The requirements gathering for this dashboard was relatively straightforward compared to other sub-projects. Many of the metrics and visualizations included in this dashboard are also found in the building permit metrics dashboard. This overlap was intentional, as these metrics are essential for understanding the broader context of the review process analysis. By reusing familiar metrics, the dashboard ensures consistency, enabling users to easily interpret and compare city review data across permit issuances.

The guidance provided for this dashboard was limited, with the main request focused on understanding the average number of days a review team takes to process applications and how frequently they complete their

processes. Given this limited guidance, I had the flexibility to design additional visualizations. I experimented with the data, trying out various metrics and visualizations until I identified around eight fully-filterable ones that I believed would offer the most valuable insights for the team.

Data Acquisition and Preparation

The data for the Operational Insights dashboard follows a similar process to the Building Permit Metrics dashboard, with some key distinctions. While the Building Permit Metrics dashboard relies on a single dataset, the Operational Insights dashboard incorporates both this dataset and an additional one. Users will notice many familiar metrics and visualizations from the Building Permit Metrics Dashboard appear here as well. This intentional overlap allows users to compare the number of processes completed against the number of permits issued, providing insight into the efficiency of permit processing workflows.

After optimizing the database query, it was forwarded to the CPDI team who created the feature layer as part of their standard workflow. The data is refreshed through an automated daily REST API call using the Data Interoperability Tool, which processes and either publishes new or overwrites existing data in the ArcGIS Online Feature Service. This automation ensures the dashboard always displays current permit information. As with the Building Permit Metrics dashboard, data expressions are applied when necessary to transform the raw data into meaningful metrics that power the dashboard's visualizations and metrics.

Dashboard Development

Since many of the necessary metrics were already developed for the Building Permit Metrics dashboard, I chose to use that dashboard as a foundation for this project. I duplicated the original, removed metrics and visualizations that were not relevant to operational analysis, and integrated the new dataset. Because this dashboard is intended specifically for the City of Missoula CPDI team, I focused on adding visualizations that support internal evaluation and help uncover insights to improve the efficiency of review processes.

I had greater flexibility in developing the metrics and visualizations for this dashboard, which allowed me to explore different ways of shaping the data to best communicate meaningful insights. By leaving in metrics from the other dashboard, users are already oriented to the format and can easily dive into the data.

Results & Capabilities

This dashboard follows the general layout of the Building Permit Metrics dashboard, with many of the same metrics and visualizations carried over. These elements support the primary goal of this tool, which is to help the City of Missoula CPDI team closely examine the review process and identify where delays may be occurring.

The filter bar at the top is structured similarly but includes an additional filter for cycle number, referring to how many times a permit moves through the city's internal review process. Since the focus here is strictly on internal reviews, there is no need to include a filter for pre-issuance stages.

Familiar metrics like permit volume and open applications are positioned on the left and right sides of the dashboard. New content appears in the center, offering insight into the review process itself.

Users can explore metrics showing how many application review processes were completed and how often those reviews resulted in approval. The dashboard also displays how frequently a review process was the final step in a given cycle, as well as the median number of days each team took to complete its review. With the cycle number filter, users can examine how review times shift across multiple cycles, offering insight into how repeated reviews may impact the overall time to issuance.

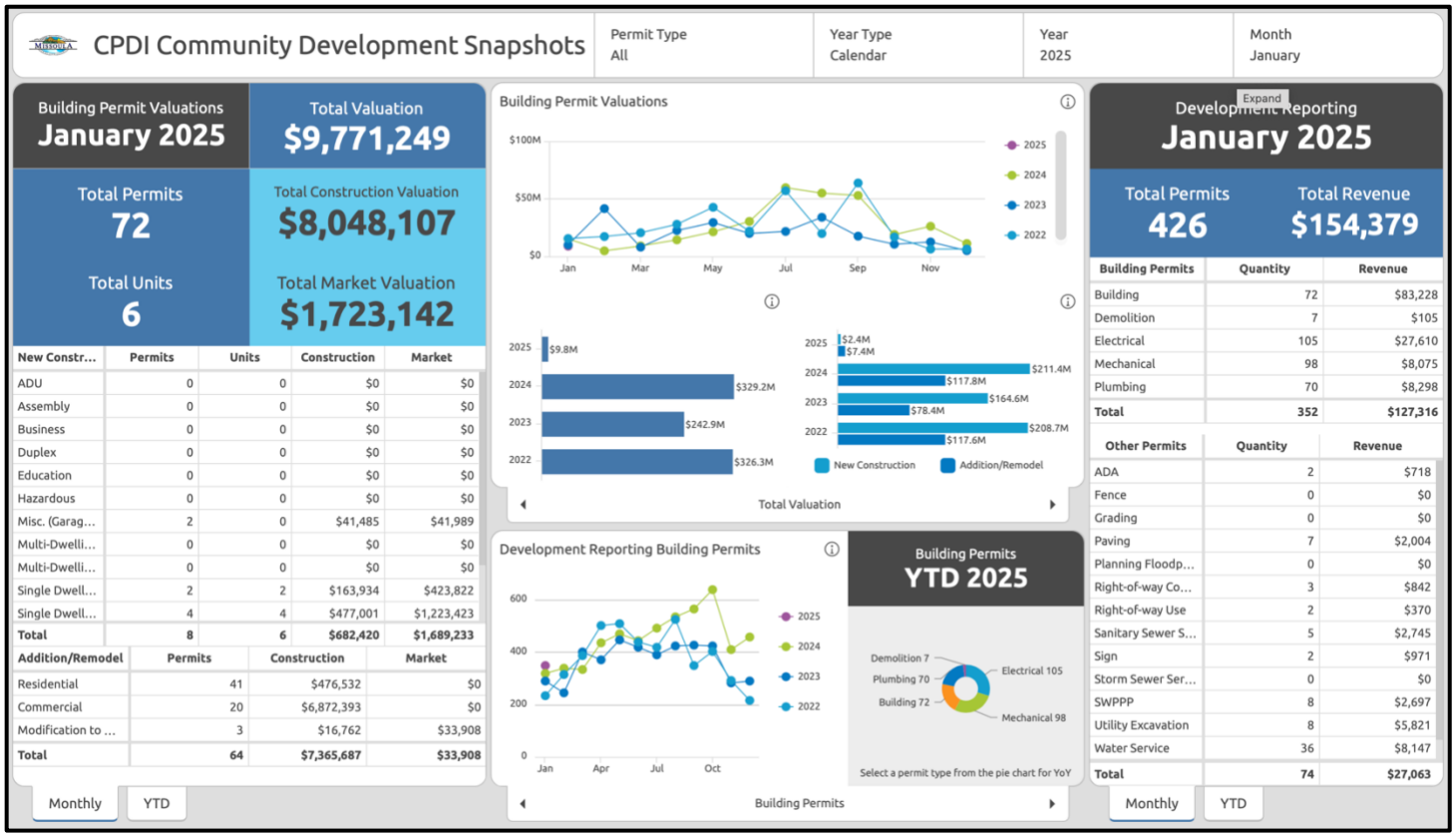
Risks

While the Operational Insights dashboard offers significant value for internal analysis, several risks and limitations should be considered:

- While the dashboard focuses on quantitative metrics like review time and approval rates, there is a risk of oversimplifying the permitting process. Not all delays indicate inefficiency—some may result from legitimate complexities or sequencing dependencies. For example, a specialized department like Fire may not be pulled into a review until another team has completed their portion and identified the need for further evaluation.
- Although the dashboard is currently low maintenance thanks to automation, future changes to the database schema, review processes, or ArcGIS platform may require updates to the query logic or data expressions. The CPDI team should remain familiar with how the query generates and reports metrics and consider how any modifications to the review process might impact data accuracy and interpretation.
- The dashboard focuses exclusively on the city-managed portions of the review process, omitting delays or inefficiencies caused by the applicant. This creates a limited view of the full permit lifecycle, lacking context around rejections, applicant-driven delays, or other factors that could offer a more comprehensive understanding of the review process. To improve insight, the team might consider incorporating the notes from rejected processes to better understand what leads to further review cycles.

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.



Requirements Gathering

Before developing solutions for this project, I assessed the existing data, processes, and stakeholder needs to ensure 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. It was hard to see from this report any trends

happening without diving in and looking at the numbers. 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 first considered a new set of queries for the data report coming out of Accela to be uploaded to the GIS platform. However, given the scope and timeline for this project, we wanted to ensure that the data pull wasn't an issue. To acquire the data, we used 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 consider in these workbooks and each component has its own sheet for any given month. The components include:

1. **Data Dumps**: This is monthly building permit data that comes out of Acella and is audited by the team. There are two tables on this sheet, one is the main table, and the other 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 Acella. 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 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.

COMMUNITY PLANNING, DEVELOPMENT AND INNOVATION MISSOULA

Feb-25 — Fiscal Year '25

Building Permit Valuation	THIS MONTH - FY2025 QTY.	UNITS	VALUATION	THIS MONTH - FY2024 QTY.	UNITS	VALUATION	YTD - FY2025 QTY.	UNITS	VALUATION	YTD - FY2024 QTY.	UNITS	VALUATION
Single Dwelling Attached*	4	4	$ 390,515.24	4	4	$ 324,433.30	11	11	$ 886,877.96	16	16	$ 1,316,500.22
Single Dwelling Detached	7	7	$ 734,241.28	6	6	$ 619,666.76	67	67	$ 8,439,368.85	50	50	$ 6,426,623.95
Duplex	0	0	$ -	0	0	$ -	3	6	$ 421,465.70	1	2	$ 99,285.44
Multi-Dwelling Apt	0	0	$ -	0	0	$ -	19	200	$ 17,537,766.74	5	63	$ 2,531,965.68
Multi-Dwelling Condo	0	0	$ -	0	0	$ -	2	27	$ 1,669,573.20	1	4	$ 807,724.80
TED** Single Dwelling	2	2	$ 195,956.64	0	0	$ -	8	8	$ 683,530.64	11	11	$ 567,074.74
TED Two Unit	0	0	$ -	0	0	$ -	6	6	$ 489,518.00	4	4	$ 365,712.00
TED 3+	0	0	$ -	0	0	$ -	30	30	$ 2,876,358.49	3	3	$ 172,033.20
Misc. (Garage, Shed, etc.)	0	0	$ -	2	2	$ 21,073.80	12	12	$ 116,330.49	16	16	$ 300,737.51
Assembly	0	0	$ -	0	0	$ -	1	1	$ 23,500.00	0	0	$ -
Business	1	1	$ 22,275.96	3	3	$ 175,340.70	13	13	$ 16,537,843.47	19	19	$ 15,255,956.93
Education	0	0	$ -	0	0	$ -	0	0	$ -	0	0	$ -
Hazardous	0	0	$ -	0	0	$ -	0	0	$ -	0	0	$ -
Institutional	0	0	$ -	0	0	$ -	0	0	$ -	0	0	$ -
Total New Construction	**14**	**14**	**$ 1,342,989.12**	**15**	**15**	**$ 1,140,514.56**	**172**	**381**	**$ 49,682,133.54**	**126**	**188**	**$ 27,843,614.47**

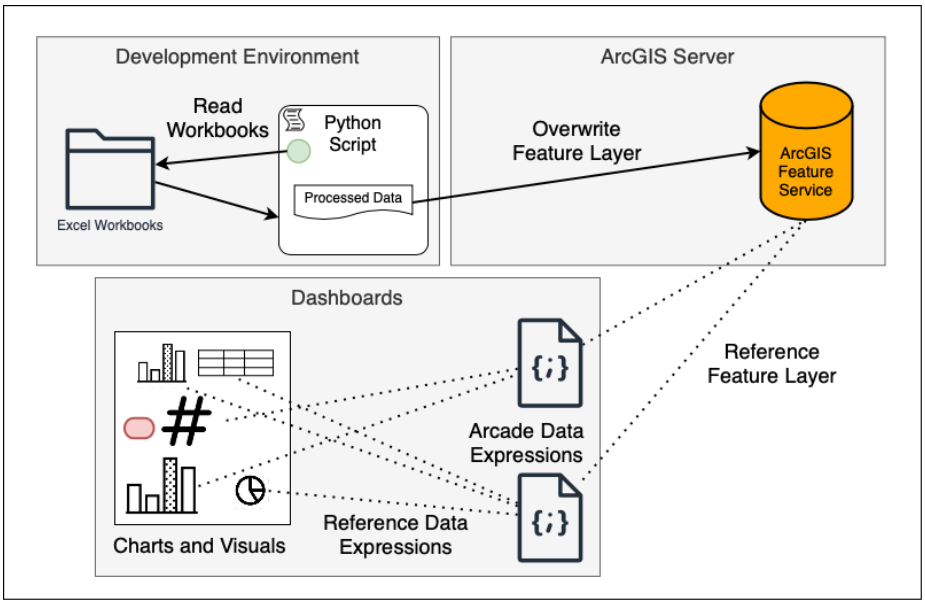
Addition/Remodel	QTY.	VALUATION	QTY.	VALUATION	QTY.	VALUATION	QTY.	VALUATION
Residential	30	$ 763,400.38	25	$ 649,086.80	798	$ 19,472,869.75	376	$ 10,768,612.53
Commercial	10	$ 1,972,459.00	9	$ 701,461.00	208	$ 77,168,805.22	139	$ 28,174,410.89
Modification to work in progress	2	$ -	3	$ 22,838.00	24	$ 2,038,012.02	15	$ 4,299,831.01
Total Addition/Remodel	**42**	**$ 2,735,859.38**	**37**	**$ 1,373,385.80**	**1030**	**$ 98,679,686.99**	**530**	**$ 43,242,854.43**

Dwelling Units	MO ADUs	MO Total Units	MO ADUs	MO Units	YTD ADUs	YTD Total Units	YTD ADUs	YTD Total Units
Total Change in Dwelling Units	**0**	**13**	**3**	**13**	**4**	**359**	**9**	**162**

Permits and Construction Valuation	MO Permits	MO Valuation	MO Permits	MO Valuation	YTD Permits	YTD Valuation	YTD Permits	YTD Valuation
Total Permits and Construction Valuation	**56**	**$ 4,078,848.50**	**52**	**$ 2,513,900.36**	**1202**	**$ 148,361,820.53**	**656**	**$ 71,086,468.90**

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 is 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 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 the month's data aligns with what was reported in the monthly report. If specific values are off, the logic used in the script likely 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 is important to emphasize that the goal of this sub-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 in 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 Is 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 is 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

The dashboards developed for the City of Missoula's CPDI team have delivered several meaningful results and capabilities for both internal operations and the broader community. For CPDI staff, the automation of data collection and visualization has significantly improved operational efficiency by reducing the time spent on manual reporting and allowing more focus on resolving application bottlenecks. With access to historical permit data, process review teams can now better understand application trends and proactively allocate resources during periods of high activity. Additionally, the dashboards have enabled the development and tracking of key performance indicators (KPIs), such as average permit review times and open application backlog volumes, helping the team set measurable goals. By making real-time performance metrics publicly accessible, the city also reinforces its commitment to transparency and continuous improvement.

For the community, these dashboards provide greater visibility into the permitting process. Stakeholders now have access to clear, up-to-date information on permit volumes, types, and processing timelines, which improves predictability for builders and developers planning future projects. Real-time data helps applicants better anticipate standard review durations, reducing the likelihood of unnecessary status inquiries and improving communication between the city and applicants. Furthermore, the broader community gains insight into long-term development trends, empowering residents to engage more meaningfully in public meetings, planning discussions, and decisions that shape growth for the city of Missoula.

Challenges

I'd like to quickly highlight some of the key challenges I faced during development. Understanding the data was a significant hurdle. Between data located in the database and data spread out across the excel workbooks, I spent a lot of time understanding data points and validating my work matched up to the team's needs. Building these data sets from scratch without a data dictionary added complexity, and many decisions had to be revisited as my understanding of the data evolved.

I also had to optimize SQL queries to ensure efficient data retrieval. I spent extra effort to optimize my SQL queries so they can be ran in seconds, instead of hours which allows the data to be updated daily. Since I didn't know the data well, I had to revisit my queries to fix them based on requirements that weren't initially communicated to me.

Additionally, processing data from Excel workbooks using a Python script was another challenge that introduced a lot of back and forth trying to validate data requirements. The workbooks that have all of the data do not always appear to use consistent aggregation rules, so I had to make assumptions about how to assign permits to categories. Understanding niche requirements, such as permit statuses and attributions, required careful attention to detail.

This was my first experience working with ArcGIS dashboards. While I am satisfied with how these dashboards turned out, I believe building the dashboards in a more familiar platform would have accelerated development the development of metrics and visualizations within the dashboards. For future projects, I would consider using

ArcGIS Experience Builder, which would enable me to create a more narrative-driven presentation and integrate commentary alongside visualizations and metrics.

Limitations

Despite my best efforts, there were some limitations to my project. One of the main limitations is the manual processing required for development snapshots. This involves running a Python script and uploading data. I provided a detailed set of instructions as to how I update the data in my production environment, but I am not sure how they will continue with updating the data. However, I see a lot of value in what I've created with the Development Snapshots dashboard through the ability to see the data in a long-term context.

I also received many requests for features, and I tried my best to address all the requests, building data sets that would best support the requested features. If the team wants to expand to see more visualizations or metrics, the queries and output data sets might not support what they want to see. So, they could have to develop more queries or data sets to support future enhancements to the dashboard.

Lastly, these dashboards can be memory-intensive, which may lead to slow performance on lower-end computers. To improve accessibility, the city could consider creating a streamlined version that isolates key metrics and visualizations, ensuring all users can access critical insights regardless of their device's performance.

Closing Remarks

The completion of this project marks a significant step forward for the City of Missoula's CPDI department, equipping the team with the tools to better manage, interpret, and act on building permit data. With the development of real-time, interactive dashboards, CPDI now has a reporting system that supports data-driven decision-making and increases public visibility into development activity. These dashboards reduce the burden of manual reporting, enhance internal operational awareness, and foster transparency and trust by making key metrics accessible to the public.

For CPDI staff, the dashboards offer a clearer view of review timelines, potential bottlenecks, and shifting permit volumes, enabling them to adapt more effectively. External stakeholders gain greater transparency into the review process and where delays might occur. While no dashboard can capture every nuance, these tools provide a strong foundation for CPDI to improve processes and accelerate permit issuance—without compromising quality.

I would like to thank everyone who supported this project: the City of Missoula CPDI team for their collaboration, data access, and technical guidance throughout; the University of Montana College of Business faculty for their valuable direction and feedback; the GIS team, whose expertise was instrumental in implementing the visualizations; and a special thanks to the project team members who participated in weekly meetings and provided thoughtful feedback. I'm excited to see the impact of this work unfold and look forward to hearing how the team continues to build on it.