School of Earth and Planetary Sciences

A Brokering Approach to Federating Spatial Data in a Semantic Web Environment

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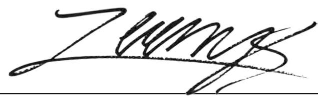
Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: 

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ABSTRACT

This thesis proposes a broker approach to federate Australia and New Zealand's spatial data using Semantic Web technologies and ontologies. The proposed approach improves the current methods of integrating and accessing spatial data in Australia and New Zealand by enabling on-demand access to concurrent data, removing the need for a data warehouse to maintain and store the integrated data, and allowing the semantic reconciliation of heterogeneous spatial datasets.

While an ideal solution is to make use of a common schema for all spatial data, this solution relies on the transformation of current spatial data to a standard schema which requires a lot of time and resources. Instead, a broker approach is a more immediate solution that can improve the current spatial data integration systems in Australia and New Zealand. The broker approach makes use of an ontology developed reusing W3C and OGC ontologies. This thesis explained how the ontology was developed and the steps used in implementing the broker system and its evaluation.

As an integral part of a broker, this thesis also investigated how to integrate spatial data based on both non-spatial and spatial criteria. It was determined that filtering the geometry type of feature types is significant in finding similar ones. However, further research to find similarities in geometries of similar feature types was inconclusive. Nonetheless, numerous unaccounted variables were determined to be the cause of the inconclusive results. These variables cannot be determined from the data alone and their inclusion in this thesis was deemed out of scope.

To evaluate the broker, datasets from the specific Web services were selected from both Australia and New Zealand. The evaluation used a ground truth which is based on hand-selected queries and datasets. Using the same queries with the broker, the results were compared to the ground truth. The evaluation showed that the broker can be successfully utilised to query heterogeneous Web feature services using a single query from one unified view.

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PUBLICATIONS RELATED TO THIS THESIS

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LIST OF ABBREVIATIONS

AIXM - Aeronautical Information Exchange Model
API - Application Programming Interface
FSDF - Foundation Spatial Data Framework
FTP - File Transfer Protocol
GIS - Geographic Information System
GML - Geography Markup Language
HTTP - HyperText Transfer Protocol
ID - Identifier
IRI - International Resource Identifier
OGC - Open Geospatial Consortium
OWL - Web Ontology Language
OWS - OGC Web Service
SDSC - Spatial Data Supply Chain
SMTP - Simple Mail Transfer Protocol
SWS - Spatial Web Service
URI - Uniform Resource Identifier
URL - Uniform Resource Locator
W3C - World Wide Web Consortium
WCS - Web Coverage Service
WFS - Web Feature Service
WKT - Well-Known Text
WMS - Web Map Service
WPS - Web Processing Service
XML - Extensible Markup Language
XSLT - Extensible Stylesheet Language Transformations

CHAPTER 1

INTRODUCTION

1.1 Research Overview

Spatial data in Australia are heterogeneous and disparate by nature. They are owned by the various States and Territories which gather and represent data differently. These different representations are known as semantic heterogeneities (Hakimpour & Geppert, 2005; Halevy, 2005; Hull, 1997). Semantic heterogeneities cause issues where different datasets cannot be directly integrated without first undergoing some kind of transformation.

In Australia, integrating spatial data from multiple sources often has to be manually achieved (Woodgate et al., 2017). This is inefficient and time consuming. The user is also heavily relied on to properly interpret and transform the data themselves while manipulating the necessary technical aspects of such tasks (Box, Simons, Cox, & Maguire, 2015). Imposing these responsibilities on the users causes duplication of efforts and impedes data consumption as the users might not have the required technical skills to understand or use the data. Differently, the data warehouse model used in Australia (PSMA Australia Limited, 2014) relies on a third party to transform the data from different data sources and store them in a central repository. This model is difficult to scale as the data gets duplicated, and much time is required for updates from the data sources to propagate to the users (Widom, 1995). Data warehouses also use static rules to match remote schemas to the common schema leading to complex manual maintenance and the possible removal or modification of metadata that do not fit in the schema. Further, the user still needs the expertise to extract the data they require. An alternative method is to allow a third party with the necessary skills to extract the data instead. A more efficient solution to access and integrate disparate heterogeneous spatial datasets in Australia is required.

Spatial data can be accessed through Web services, but these services are often isolated from one another. Geoportals can be used to improve access to these Web services. Geoportals provide a central repository where Web services end-points are gathered. However, they do not integrate the data but only metadata, which make data easier to find. Further, search engines, that geoportals use, offer minimal functionality often only supporting metadata keyword search. The tasks of understanding, unifying, and extracting the needed data are still left to the users. Even though the discovery of datasets is made easier with geoportals, the selected Web services are few and the geoportal end-points have to be manually chosen, i.e. a user must have prior knowledge about the existence and the exact Web-location of the catalogue. As a result, geoportals are not cross-discoverable—a geoportal and their selected Web services cannot be discovered from another geoportal.

A more efficient solution to integrate and access heterogeneous spatial data is by using a federated schema for all spatial data to align to. However, this method requires all current data to be transformed, often manually, to the new schema which is costly and time consuming. Halevy (2005) states that the success of using standard schemas to resolve semantic heterogeneity only applies where the incentives to transform the existing data to the new schema are very strong.

An implemented spatial federated schema can be found in Europe (INSPIRE Thematic Working Group, 2012). It required a change in legislation to ensure that the data providers adhere to the common schema. This process takes a long time as various parties must be involved and constant schema updates are required making its maintenance costly.

In this thesis, a brokered approach is proposed as a solution to federate the spatial data in Australia. Different to the current data warehousing approach used, a broker is more scalable as it does not store the transformed datasets, but instead fetches and integrates them on-the-fly which reduces data duplication. To resolve data heterogeneities, the reconciliation of their semantic differences is required (Srivastava, Sridhar, & Dehwal, 2012). To achieve this, Semantic Web technologies and ontologies are used. Ontologies resolve semantic discrepancies by semantically describing data and enabling the on-the-fly integration of data (Hasani, Sadeghi-Niaraki, & Jelokhani-Niaraki, 2015). Ontologies can also be used as a global model to provide a unified view over Web services allowing their federated querying.

As data integration is part of a broker, this thesis also explores methods to compare spatial features from disparate datasets using both spatial and non-spatial criteria. This can help data consumers and domain experts to align the semantic discrepancies in spatial data. While there are multiple research projects dedicated to finding the similarity between heterogeneous datasets, few are focused on spatial data. In this thesis, spatial feature types are analysed for similarity based on their metadata and geometry. To this aim, different data providers that contain similar feature types are used as use-cases. The feature types explored are from Web feature services from Australia and New Zealand. Although New Zealand's spatial data do not need to be federated, they are included in this thesis because of their close relationship with Australia.

1.2 Research Objectives

The main objective of this thesis is to examine a broker approach to improve the current integration of and access to spatial data in Australia and New Zealand by using Semantic Web techniques. To achieve this goal, the following key objectives are identified:

Objective 1: Review the usage of Semantic Web techniques in data integration and its potential application in a broker system;

Objective 2: Implement Semantic Web technologies to use in the broker system;

Objective 3: Explore methods to facilitate the integration of heterogeneous spatial data;

Objective 4: Implement methods for on-the-fly data retrieval; and

Objective 5: Implement a broker prototype over which multiple datasets can be queried from and evaluate the prototype.

1.3 Overview of the Broker System

A broker is a mediator which facilitates the transactions between users and data end-points. In this thesis, the proposed broker system makes use of an ontology as a global model. The ontology provides a unified view over disparate Web services by describing them semantically. The ontology stores information such as the schema of features, and the methods to send requests to a Web service. In this manner, a user does not require the technical knowledge to query each Web service as they are all queried based on the ontology model. The ontology developed in this thesis is the Web Service Ontology (WSO) and is described in chapters 3 and 4.

Once a Web service has been described semantically and stored in the ontology, the heterogeneous datasets are reconciled. While this process is best achieved manually, it is time consuming and laborious, hence this thesis investigates methods which can facilitate this process by comparing feature types spatially and non-spatially. In chapter 5, non-spatial comparison techniques are investigated, and in chapter 6, the geometries of feature types are compared for their similarity.

As only the schemas of the datasets are stored in the broker system, the filtering of datasets need to be executed by the Web sources. To allow this, any filter that the user specifies is transformed and included in the request calls made to each Web service. As such, a user request must be decomposed into two sub-queries. The first sub-query requests information that can be answered by the broker's ontology such as:

1. Web services that can answer the query requested by the user;
2. The addresses of the relevant Web services; and
3. The mapping from the ontology to each Web service.

The second sub-query contains the filters that the user wants to apply on the retrieved datasets and can only be processed by the Web services. These filters are used when constructing a request to a Web service. The described work-flow is presented in figure 1.1.

1.4 Choice of Research Methodology

This thesis is identified as being concerned with applied research because it requires the novel creation and implementation of technologies to solve an immediate problem. Other types of research are explained and contrasted in section 2.14, justifying the approach taken. As this research aims at investigating and implementing a solution, the chosen approach to follow is a science and engineering approach, more precisely a software engineering approach.

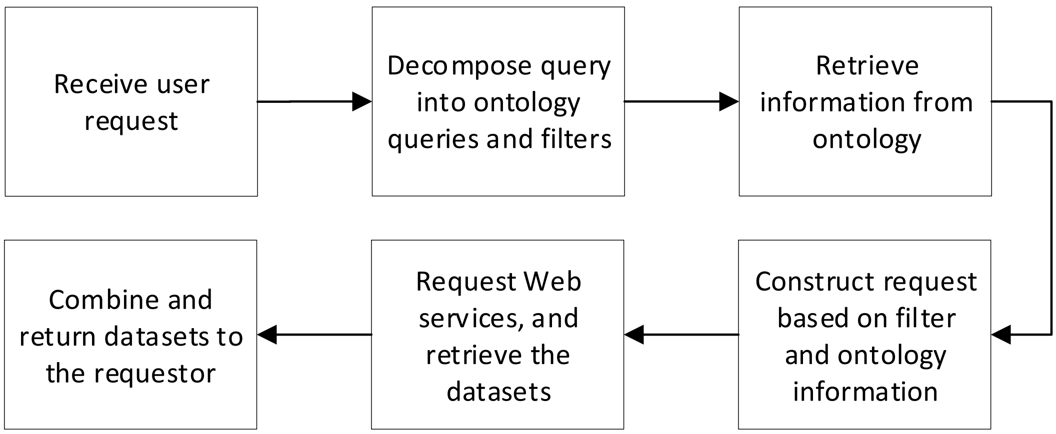


Figure 1.1: Broker Work-flow Overview

The engineering approach consists of multiple stages where the engineer (researcher in this case), develops a product iteratively comprising of multiple cycles. To allow for flexibility the engineering methodology used will be based on an agile methodology called Scrum. The Scrum methodology aims at improving the flexibility of software development by making use of sprints (Schwaber, 1995). A sprint is a term used in the agile methodology to signify a specified amount of time where the product is developed, wrapped, evaluated, and modified (Schwaber, 1995). During the lifetime of a product creation, multiple sprints happen until the deadline or a satisfactory result is reached. For this research, varying sprints of 1 week to 2 weeks have been used, where results are reported, evaluated, and the next sprint is planned for. This methodology is flexible and appropriate for this research, as it is comprised of unforeseeable events that is frequent in any research and software development project.

Given this research is of academic and not of engineering origin, the different components developed have to be in unison with reviewed literature. Each sprint consists of literature review, followed by an evaluation of whether the literature can be applied to the research, if so it gets implemented (which may last over a few sprints), and then further planning happens for the next phase.

For the relevant research for the thesis, a prototype is implemented and evaluated to see whether it can be part of the final product. If not, sub-components can be reused, otherwise new research and a new sprint is carried out.

The prototypes have been implemented with free and open source programs in conjunction with Semantic Web standards and conventions. Additionally open data have been used for the testing phase: Web services from the statutory authority in charge of property and land information in Western Australia (Landgate), the Department of Environment, Land, Water and Planning (DELWP) in Victoria, Australia, the Land and Property Information (LPI) from New South Whales, Australia, and Land Information New Zealand (LINZ).

1.5 Significance of this Thesis

A broker approach to data integration resolves many existing issues within the data warehouse model used in Australia. First, an integration method is implemented using ontologies where the data sources are not duplicated but kept at their source. This allows the users to have on-demand access to concurrent data and to query disparate data sources as a unified entity, minimising the issues of outdated and duplicated data. Moreover, reuse is an important facet of ontologies as their development is a community driven process. To stay true to this characteristic, the OWL-S, GeoSPARQL, vCard, and HTTP ontologies, which are World Wide Web Consortium (W3C)[1] and Open Geospatial Consortium (OGC)[2] ontologies, are reused in the implementation of the broker. Doing so can encourage the semantic community to implement existing ontologies instead of building new ones, propelling the move towards a Web of semantics.

Another aspect of this research is enabling the querying of disparate datasets from a single gateway to ease access to and querying of the data sources. By using Semantic Web technologies and OGC-compliant Web services, this thesis provides a solution allowing users to query a single system but receive datasets from multiple sources. The technical requirements that are characteristic of spatial Web services are executed internally by the broker, and hence this burden is removed from the user.

A further problem addressed in this thesis is the manual intervention required in data integration. In this thesis, methods are explored facilitating the matching of similar feature types from different data sources. By doing so, tools can be made to help domain experts to consolidate heterogeneous spatial datasets in a semi-automated fashion.

Although there have been a number of disparate and ongoing research activ-

[1] The W3C is the main international standards organisation for the World Wide Web.

[2] OGC is an international organisation who creates open standards for the geospatial community.

ities on data integration and semantics, there is less research activity exploring the combination of these two topics under a real-world use-case. This is more prevalent in the area of the Semantic Web, where various ontologies have been created but fewer used in conjunction. In this thesis, existing tools and research have been used as much as possible to explore whether existing disparate tools and ideas can be integrated in a novel functional solution.

Finally, by using open datasets from Australia and New Zealand as a focal point, the implementation of the broker solution provides a centralised access to public cross-jurisdictional data. This means that less time is spent on transforming the data, and data usage can be more productive. This aspect is important in Australia and New Zealand, as current data integration methods are labour intensive (Woodgate et al., 2017).

1.6 Scope of this Thesis

This thesis investigates a broker approach to access and integrate disparate datasets on-the-fly within the context of spatial information infrastructure in Australia and New Zealand. To achieve this, the main concepts explored are: Semantic Web technologies, geospatial Web services, and on-the-fly retrieval processes.

Regarding Semantic Web technologies, ontologies are the main focus. Ontologies are defined as the explicit specification of a knowledge domain and concept and their relationships (Gruber, 1993; Partyka, Alipanah, Khan, Thuraisingham, & Shekhar, 2008; Pedro, 2009; Uschold, Gruninger, Uschold, & Gruninger, 1996). Ontologies allow concepts to be modelled, reasoned and inferred over. The Resource Description Framework (RDF) (Schreiber & Raimond, 2014), and the Web Ontology Language (OWL) (McGuinness & Van Harmelen, 2004) are explored. Specific ontologies used include OWL-S (Martin et al., 2004), HTTP (Koch, Velasco, & Ackermann, 2017a), vCard (Iannella & McKinney, 2014), and GeoSPARQL (OGC, 2012).

In regards to Web services, only Web services standardised by OGC are examined, more specifically, Web Feature Service (WFS) version 1.0.0 (OGC, 2005). WFS provides data at the most basic level and other Web services such as Web Map Service (WMS) and Web Coverage Service (WCS) can be derived from it. WMS data can be obtained by rendering WFS data into a map image, and WCS combines a set of spatial data, which have not been rendered to images, over specific geographic locations. Although this thesis experiments with one type of OGC Web service, the concepts outlined in this thesis can be extended to other standard compliant Web services.

To implement the broker system, the Python programming language (Python Software Foundation, 2018) alongside the Django framework (Django Software Foundation, 2016) are utilised. With the numerous Python libraries available, a quick implementation of the system's back-end could be achieved. To properly store and query ontologies, the Stardog program (Stardog Union, 2018) is used primarily due to its limited but functional implementation of GeoSPARQL[3] (OGC, 2012) and its fast querying time.

For the evaluation of the system, only functional tests are conducted. Stress testing was not possible due to resource limitation, and comparative testing was not implemented because at the time of the completion of this thesis, there were no other known systems that use the same technologies as specified in this thesis.

As such, this thesis proposes the novel application of ontologies in a broker system for the on-the-fly integration of and access to spatial data. This research provides a functional application of Semantic Web technologies that can be reproduced in other domains and applications. As a lot of spatial data integration relies on the user, multiple methods are also investigated to facilitate the finding of similar spatial feature types based on their characteristics. The implemented broker uses disparate spatial datasets from data providers in Australia and New Zealand.

1.7 Thesis Structure

The structure of this thesis is as follows:

Chapter One introduces the research background for this thesis. It provides an overview of the current issues of data heterogeneities and the proposed solution to solving it. Current methods are identified and reasons for further research in that aspect justified. The scope, motivation, objectives, research methodology used, and significance of this thesis are stated in this chapter.

Chapter Two reviews relevant research in the area of the integration of se-

[3]GeoSPARQL is an OGC standard to describe and query spatial features using ontologies.

mantic spatial data and provides an analysis of existing solutions related to solving disparate heterogeneous spatial datasets. The advantages and disadvantages of these systems are given, alongside an explanation of why they are not ideal for Australia and New Zealand. The choice of a broker solution is justified, and further investigations regarding the issues of and other possible solutions to data heterogeneity are reviewed. Further, important concepts and technologies that are used within this thesis are also explained in chapter two.

Chapter Three examines the usage of a global ontology as the core technology for a federated solution to spatial data in Australia and New Zealand. It describes the methods employed in designing the global ontology, and explains its structure and its justifications.

Chapter Four describes an approach to automatically populate the global ontology based on Web feature services. The structure of Web feature services are first described followed by their modelling into the developed ontology. The automatic process is explained and an evaluation of its functionalities is executed.

Chapter Five investigates non-spatial methods to facilitate the matching of similar feature types using their metadata. It provides an explanation of how each component of a Web feature service can be used to identify similar feature types. The approach used is explained and applied. Afterwards, it is evaluated and the results are discussed.

Chapter Six explores a method to find similar feature types spatially based on their geometries. The distribution of the geometries for each feature type is computed and compared to one another. The similarities and differences between the distributions are recorded and a discussion is provided about the implications of geometries in discriminating feature types.

Chapter Seven explains the implementation of the proposed broker solution. It describes the advantages and disadvantages of the broker system, alongside the different processors used in the system and their functionalities.

Chapter Eight evaluates the broker system. The methodology used for evaluation and the selection of the ground truth are described. The broker is then evaluated and the results discussed.

Chapter Nine concludes this thesis, and discusses the proposed solution. It details the limitations of the proposed solution, and identifies future work related to this thesis.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

Since the formulation and progressive advancement of the Web, the importance of spatial data and Geographic Information Systems (GIS) has grown. What were static maps in the early stages quickly developed into dynamic information increasing in accuracy as better tools are created (Hart & Dolbear, 2007). Moreover, due to the accessibility of the Web, users are now able to both consume and produce information. The creation of spatial data has evolved to include end-users, which are often not familiar with GIS, as part of its supply chain. OpenStreetMap (OpenStreetMap contributors, 2018) is one such example. Its maps are based on a crowd-sourced platform allowing the public to both create and maintain spatial data.

However, alongside the Web boom, one persistent issue remains. As more spatial data get created, the lack of a standardised platform has allowed those disparate data to become heterogeneous. When one real world entity is represented differently, data heterogeneities are formed and the data cannot interoperate. Although data heterogeneity has been an issue since the introduction of databases (Litwin, 1987), it is still relevant today (Jirkovský, Obitko, & Mařík, 2017; Li, 2017).

To ease the sharing of disparate and heterogeneous spatial data, solutions such as, the Infrastructure for Spatial Information in the European Community (INSPIRE) (INSPIRE Thematic Working Group, 2012), the EuroGEOSS broker (EuroGEOSS, 2016), and the Public Sector Management Agency (PSMA) (PSMA Australia Limited, 2016) in Australia, have been implemented. INSPIRE and EuroGEOSS are approaches where the data providers need to follow certain standards and schemas to integrate successfully with a central repository. In contrast, PSMA uses a data warehouse approach where the responsibility to unify the data rests on a mediator (e.g. PSMA) and not on the data providers.

However, these solutions are not ideal for Australia and New Zealand. The INSPIRE and EuroGEOSS approaches would require a lot of time to be fully implemented because the different States and Territories would need to agree to a common schema to adopt, or a change in legislation would be required. As for the current data warehouse approach used by PSMA (Box et al., 2015), it has problems pertaining to data duplication, scalability, and outdated data (Widom, 1995).

A solution that resolves PSMA's issues and does not require nation-wide agreement is to use a broker. A broker is characterised by its ability to integrate datasets on-the-fly (Zhu et al., 2004) which means that users have access to concurrent data (resolving the issue of outdated data), and the data do not get duplicated, making this solution more scalable.

To enable the on-the-fly integration of data, ontologies can be used (Hasani et al., 2015). Ontologies can also reconcile the semantic differences of spatial data, which is important to resolve data heterogeneity (Jirkovský et al., 2017; Srivastava et al., 2012). Further, Zhao, Zhang, Wei, and Peng (2008) mentions that the root of heterogeneities in spatial data is the lack of semantics in their structure. Ontologies can fill this gap by expressing the semantics of spatial data, as well as, enabling users to form more expressive queries.

Thus, a broker approach using Semantic Web technologies is explored in this thesis. To fully capture the intent of this research, chapter 2 presents a literature review pertaining to the various aspects of a broker system and ontologies. Spatial Web services are first discussed, followed by a review of five spatial data supply chain patterns alongside implemented systems that make use of them. Afterwards, the broker approach used is examined and justified. Then, work in relation to data heterogeneities are reviewed: causes of the problem and existing solutions to them. The notion of Semantic Web techniques to solve data heterogeneities are introduced after, followed by a review of existing research methodologies and this chapter's conclusion.

2.2 Spatial Web Services

In the current cyber era, the Internet is the primary method used to connect distributed data, allowing users to access them remotely. Two main ways to achieve these are *via* protocols used on the Internet such as the HyperText Transfer Protocol (HTTP) and the File Transfer Protocol (FTP). FTP allows direct transfer of files from one machine to another while HTTP is the main protocol used to access the Web. The end-points that make use of HTTP for data access are called Web services. They are 'self-contained, self-describing, modular applications that can be published, located, and invoked across the Web' (OGC, 2018).

In the spatial domain, Spatial Web Services (SWSs) are Web services that publish spatial data on the Web. SWSs are required for users to consume the data, either directly through SWS end-points or *via* mediators such as geoportals. Due to the necessity to standardise this approach, various organisations have developed and published Web services standards. One of the most well known groups is the Open Geospatial Consortium (OGC) (`http://www.opengeospatial.org/`).

OGC has published widely utilised spatial Web services standards such as Web Feature Service (WFS), Web Map Service (WMS), and Web Coverage Service (WCS). These Web services provide a standardised way to publish data by specifying how the Web service calls are made and structured. The Web services describe their capabilities and the services they offer using eXtensible Markup Language (XML). The inputs and outputs for a particular request call are also described, allowing precise HTTP calls to be made to the Web service. As they are used on the Web, they can also be accessed world wide.

With WFSs, geographical features can be retrieved and manipulated. WMSs allow the requests of static cartographic representation of data, and WCSs offer continuous geographical coverage of unaltered data.

While these services have their uses, it is identified that WFSs provide data at the basic feature level. As the data WFSs serve are at the feature level, WMSs and WCSs data can be derived from them. WMS data are obtained by transforming WFS data into a static map image, and WCS data is a collection of feature data over particular regions. Therefore, it is reasonable to focus on WFS in this thesis.

2.2.1 Web Feature Services

A WFS is an OGC compliant Web service that allows the retrieval of geographical data from an underlying data store. The OGC standard defines eleven operations for WFS (OGC, 2018):

1. *GetCapabilities*;
2. *DescribeFeatureType*;
3. *GetPropertyValue*;
4. *GetFeature*;
5. *GetFeatureWithLock*;
6. *LockFeature*;
7. *Transaction*;
8. *CreateStoredQuery*;
9. *DropStoredQuery*;
10. *ListStoredQuery*; and
11. *DescribedStoredQuery*;

The three operations focused on in this thesis are *GetCapabilities*, *DescribeFeatureType*, and *GetFeature*. *GetCapabilities* provides an XML document which describes the operations and datasets that are served by the WFS. The feature types available and operations supported are outlined in the XML document. *DescribeFeatureType* describes a specific feature type by stating its schema and structure. *GetFeature* returns the feature instances of the requested feature type. The *GetFeature* operation allows the filtering of the features according to both, spatial and non-spatial conditions.

2.3 Spatial Data Supply Chain Patterns

Spatial data supply chain patterns are patterns that help in distributing data from data providers to data consumers. Derived from the definition of a supply chain from the Oxford dictionary (Oxford University Press, n.d.), a spatial data supply chain (SDSC) is 'the sequence of processes involved in the production and distribution of [spatial data]'. The data providers are often the same entities as the data collectors, and commonly distribute their data through spatial Web services. In order for users to access the data, five spatial data supply chain patterns are identified by Box et al. (2015):

1. The Anarchic Pattern

The anarchic pattern relies on the users to directly interact with the data providers. The users are in charge of negotiating the access, extraction, loading, interpretation, manipulation, and harmonisation of the datasets. In this pattern, there is no mediator to aid the users with such tasks. The anarchic pattern has the disadvantage of duplication of efforts, and requires the user to have GIS knowledge.

2. The Centralised Pattern

The centralised pattern relies on one national data distributor for all spatial data collectors. There is only one point of data access. Examples are the Australian Bureau of Statistics (ABS), and the Australian Bureau of Meteorology. Although this method works for specific needs (e.g. statistics), it does not cater for data unification from multiple heterogeneous data sources.

3. The Aggregated Pattern

This pattern includes a mediator (the aggregator) which manipulates and combines data from multiple data providers into a unified product for user consumption. This pattern creates data duplication as both the original data and the combined data are stored separately. An example of an aggregator in Australia is PSMA. They unify disparate spatial data together at the national level. This method relies on a centralised data warehouse to capture and store the transformed data.

4. The Brokered Pattern

This pattern is a variation of the aggregated pattern, where instead of storing the transformed data, data retrieval and transformation is done on-the-fly. It does not have the issue of data duplication, but retrieving the data on-the-fly is mostly dependent on the speed of the data providers. An example of a brokered approach is EuroGEOSS (EuroGEOSS, 2012) which aims for cross-discipline data integration acting as a mediator between INSPIRE (INSPIRE Thematic Working Group, 2012) and GEOSS[1].

5. The Federated Pattern

The federated pattern relies on a global schema to which all data providers must adhere. By doing so, no structural heterogeneity occurs. This pattern relies on the data providers to provide their data in the specified schema, and thus on their participation. Unless there are strong incentives to transform the existing data to the new schema, the adoption of global schemas is unlikely (Halevy, 2005).

An example of federated supply chain pattern is INSPIRE (INSPIRE Thematic Working Group, 2012), where the European Union enacted a directive stating that the data providers need to represent their data using the INSPIRE standards (The European Parliament and the Council of the European Union, 2007). This solution pushes the task of standardising the data to the data providers and depends on the data providers voluntarily and consistently publishing high quality data in the specified format. Reed (2017) also mentions that as technology progresses, INSPIRE needs to constantly evolve their technologies while making sure not to jeopardise their existing infrastructure.

Additionally, implementing a nation wide federated system needs legislation and policies to be enacted by the government. This requirement deviates from the infrastructure's objective of user adoption to an implementation. INSPIRE for example evaluates their progress based on the European Parliament's goal of progress rather than content and user adoption (Masser, 2017). This change of focus defeats the purpose of the federated system and care must be taken for better user focus while implementing it. As Hendriks, Dessers, and van Hootegem (2012) state, for an infrastructure to serve its initial purpose it should be developed with the users in mind.

2.3.1 National SDSC Patterns in Australia and New Zealand

Anarchic, centralised, and aggregated patterns are used nationally in Australia. The anarchic pattern refers to users having direct access to SWSs. Specialised spatial

[1]GEOSS allow multiple independent Earth observation, information and processing systems to coordinate, interact, and expose diverse information to a wide range of users (`https://www.earthobservations.org/geoss.php`).

data, such as statistical and meteorological data, are used in a centralised pattern, however this pattern cannot be applied to unify other data providers. This pattern relies on one central schema for all data, and thus does not consider heterogeneous datasets (Box et al., 2015).

The main pattern used for national coverage of spatial data in Australia is aggregation. PSMA is Australia's aggregator to unify disparate spatial data at the national level. This method relies on a centralised data warehouse to capture and store the transformed data. Although it has been successfully utilised, this method is difficult to scale as it causes data duplication, and requires considerable human effort to maintain. Further, detecting a change at the data sources and cascading it to the data warehouse is an inherent issue: too many update checks result in degraded performance, and the opposite leads to outdated data (Widom, 1995).

As Widom (1995) states, a data warehouse can be seen as a materialised view. The data from the sources are transformed to a view for user consumption. Rather than manipulating and updating the data directly, the inclusion of a view makes the process more challenging, and it is not a scalable option (Litwin, 1987).

The federated approach is unlikely to work in Australia and New Zealand as the spatial data is owned by the different States and Territories. They have no obligation to conform to a global schema. Given that transforming existing data from one form to another is resource intensive, there is not much incentive to do so. The lack of incentives and the resources required renders a global schema adoption less plausible (Halevy, 2005).

The remaining pattern is the brokered approach. This pattern uses a mediator to consolidate the varying datasets on-the-fly. By doing so, the users gain access to concurrent data, and because the data are kept at their source, data duplication and scalability issues are minimised. Further, this method does not require any data provider to change their existing models or to adopt any new policies or standards. Therefore, the brokered approach is a preferable solution for a more immediate federation solution for Australia and New Zealand's spatial data.

According to Box et al. (2015), no national brokered pattern is known to be used in Australia. Although the Northern Territory Land Information System states that they use a spatial data broker, their approach is local to the Northern Territory and, at the time of writing this thesis, no details regarding the integration process

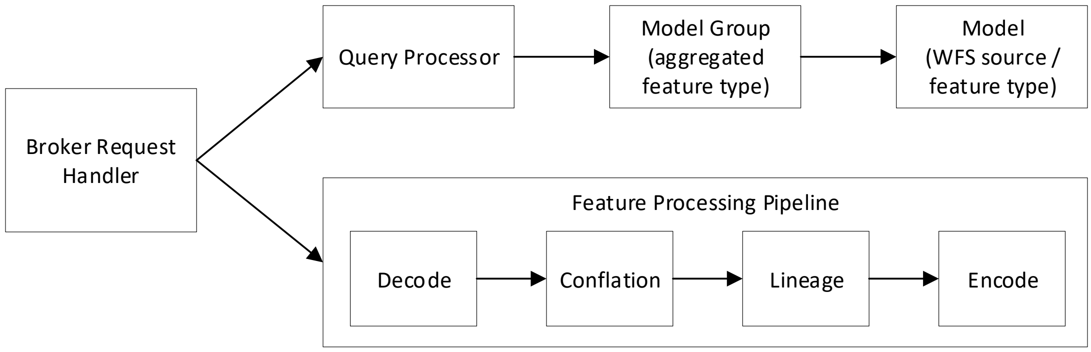


Figure 2.1: Component Architecture of the Data Broker from the OGC Testbed 11 (OGC, 2015)

could be found.

2.4 The Brokered Pattern

A broker is described as a mediator used to facilitate the transactions between the users and data providers (Radwan, Alvarez, Onchaga, & Morales, 2004). A broker's main characteristic is its ability to integrate data in real time (Zhu et al., 2004). Such a system is known as a lazy system since the information is extracted only when queried (Widom, 1995). Widom (1995) states that a lazy system is appropriate for dynamic information, and queries spanning over a large volume of data. These are characteristics of spatial data. An additional benefit of broker systems is that they can be used to track the usage of Web services to alienate good performing Web services from lesser performing ones (Yang, Cui, Liu, & Ouyang, 2008).

The spatial community has considered the brokered approach. OGC (2015) reports on the OGC testbed 11 work regarding a data broker system using the United States Federal Aviation Authority data. The scope of their work includes the implementation of a broker to unify datasets from the aviation domain. Figure 2.1 demonstrates the various components of the data broker. It includes the querying, aggregation, conflation, and insertion of lineage of the data.

The OGC testbed 11 scope was limited to the composition of WFS, and using the Aeronautical Information Exchange Model (AIXM). They provide practical recommendations in implementing a spatial broker system, and agree that a broker system using WFS can be practically used to align OGC-compliant Web services. The weakness in their approach is the focus on one specific domain (the aviation domain) which already uses a standardised schema: AIXM. AIXM specifies feature types pertaining to particular aeronautical features such as *aixm:AirportHeliport* and *aixm:Airspace*.

Further, the testbed does not cover the possibility that two features from different sources can refer to the same concept; the report states that this scenario is out of scope. As such, in the report, the assumption that each feature can be uniquely identified is made.

A mature example of a broker system in the spatial domain is the EuroGEOSS broker (EuroGEOSS, 2016). EuroGEOSS builds on top of INSPIRE and provides interdisciplinary access to drought, forestry, and biodiversity datasets (Pearlman et al., 2011). Each theme's vocabulary is specified by the INSPIRE directive, and the EuroGEOSS broker mediates between these vocabularies and GEOSS (EuroGEOSS, 2012). However, this method relies on an already established federated system for each theme.

This research differs from EuroGEOSS by federating data irrespective of their themes. Instead of integrating spatial data based on their theme (where each theme already uses a common schema), Semantic Web techniques are used to describe spatial data and integrate them on-the-fly.

2.5 Heterogeneities

Heterogeneities can be broadly grouped into system and information heterogeneities (Sheth, 1999). System heterogeneities involve differences between two systems that prevent seamless interoperability (Hull, 1997; Sheth, 1999), and information heterogeneities are described as incompatibility between similar data due to differences and dissimilarities in interpretation (Deen, Amin, & Taylor, 1987; Srivastava et al., 2012).

2.5.1 System Heterogeneity

System heterogeneity refers to differences in the workings of systems. Sheth (1999) mentions that system heterogeneity occurs due to differences in hardware, systems, and software. Although Box et al. (2015) refer to communication protocols as technical interoperability, it can be considered as part of system heterogeneity because proper communication protocols are required for two systems to interoperate. System heterogeneity is referred by Hull (1997) as platform heterogeneity, and includes database management systems, and Application Programming Interface (API) support.

Although system heterogeneity was an issue in the earlier days of computing, much of it has been resolved through standards, and common practices. As an example, the HyperText Transfer Protocol (HTTP), File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP) are used by a majority of systems communicating with one another remotely through the Internet. Due to these reasons, interoperability at the system level can be considered resolved and is not expanded in this thesis.

2.5.2 Data Heterogeneity

Data heterogeneity happens when different bodies represent the same real world entity in different ways (Halevy, 2005). It differs from system heterogeneity as the differences are at the data level rather than system level. Due to different syntaxes and formats, and a lack in shared understanding, these data cannot work together before an integration process takes place. Uschold et al. (1996) identify four related issues caused by the lack of shared understanding:

1. Poor communication among the different parties;
2. Limited interoperability;
3. Limited potential for sharing and reuse; and
4. Wasted effort in duplicated efforts.

Data heterogeneities is an issue still being researched today, with semantic heterogeneity being the most important to solve (Halevy, 2005; Jirkovský et al., 2017; Li, 2017; Srivastava et al., 2012).

Various causes of data heterogeneity have been identified. Deen et al. (1987) identify missing data, conflicting values, and name, scale, type, semantic, and structural differences as categories. Hull (1997) articulates semantic or logical perspective as representing data models, schemas, and data types. Box et al. (2015) and

Sheth (1999) categorise data heterogeneity as syntactic, structural, and semantic, while Halevy (2005) uses semantic heterogeneity in the same context as structural heterogeneity.

In this thesis, the types of data heterogeneities will be categorised as syntactic, structural, and semantic. These three categories are commonly used together and have distinct different interoperability levels (Brodaric & Gahegan, 2006).

2.6 Syntactic Heterogeneity

Bishr (1998) and Lutz and Kolas (2007) describe syntactic heterogeneity as the discrepancy between different data models. He (2010) gives the example of using a relational model vs an object-oriented model, or raster vs vector representations, where the same object is stored in different file formats.

This type of heterogeneity is more important for machine parsing, than for human consumption; for two datasets to be integrated, the formats used need to be parsed and understood by the machine first. This issue has been mostly resolved *via* the use of standard data formats such as XML.

In the geospatial domain, specific file formats are used to enable syntactic interoperability. The most common ones being Geo-JavaScript Object Notation (GeoJSON), Geography Markup Language (GML), Well-Known Text (WKT), and Shape-file (SHP). Although translations between these file formats might be required, there are existing tools to enable such transformations. An example is the Feature Manipulation Engine (FME), which supports over 350 data formats transformations (Safe Software Incorporation, 2017). Due to these reasons, this type of heterogeneity is considered to have been resolved, and is not a focus in this thesis.

2.7 Structural and Semantic Heterogeneity

As different organisations create and store data independently, the same concept is represented differently. These different representations are known as semantic heterogeneity (Hakimpour & Geppert, 2005; Halevy, 2005; Hull, 1997). He (2010) gives an example of the word 'Ramp' used in the Canadian road network and USA TIGER/line datasets.

In the Canadian road network dataset, the word ‘Ramp’ is defined as:

> inter-connecting roadways providing for the controlled movement between two or more roadways and includes not only highways, but also other kinds of roads such as main roads. (p. 12)

In the USA TIGER/line dataset, a ‘ramp’ has the definition of:

> a road that allows controlled access from adjacent roads onto a limited access highway. (p. 12)

Although the same word ‘ramp’ is used in both examples, its definition is different. Goh (1997) identifies three causes of data heterogeneity:

1. Conflicts in the interpretation of data, where the data seem to be similar but in actual fact are different;
2. Usage of different measuring or scaling units. For example, different reference systems, or map scales; and
3. Different naming used among organisations, including naming conventions, synonyms, and homonyms.

On the other hand, structural heterogeneity refers to discrepancies in the structure of data models (Cruz & Xiao, 2005; Halevy, 2005). These discrepancies arise from different classification, class relationships, or naming conventions. Another interpretation of structural heterogeneity is when object classes are aggregated or inherited differently even though they represent the same real world entity (Bishr, 1998).

Mohammadi and Binns (2006) differentiate structural and semantic heterogeneity with the example of road datasets. They explain structural heterogeneity as one system storing the name and information of the side walk of a street, while another system stores the width and the centre line. Semantic heterogeneity, however, is explained as the concept of a road being a paved way used by motor vehicles including the side walks in one system, and as any path used by auto-mobiles in another system. Although these two terms have different definitions, they are often mentioned together as in Halevy (2005) and Pluempitiwiriyawej and Hammer (2000).

2.7.1 Language

Language is identified by Open Semantic Framework (2013) as being a cause of data heterogeneity. Language is the tool used by humans to communicate with one another. Although natural language has evolved over the years, there are still instances where a particular phrase is misunderstood. Without any context, the meaning of a sentence can be vastly different from its initial purpose. Such a problem is prominent when context cannot be practically or explicitly stated. For example, when representing a real-world entity in a computerised format. To accommodate for the lack of context, metadata are used. Metadata describe data with data outlining its context. In terms of spatial data, attributes such as the name of the data, date created, and measurement scale are examples of metadata used.

Vocabulary Adoption

The English language has evolved with influences from other languages. As a language evolves over time, it borrows words from other languages. For example, the English word 'garage' is borrowed from French. Some of those influences fit syntactically and semantically in the English language (e.g. garage), but other terms might be semantically understood, but syntactically incompatible. For example the phrase 'déjà-vu', deriving from the French language includes 'accents' that have no equivalences in English. This type of incompatibility forces the English language to change the word in an equivalent that fits in the English language, that is 'deja vu' without the 'accents'. This poses an issue when processing natural language. They are written differently but their semantics are the same and a search for either 'déjà-vu' or 'deja vu' should lead to the same results. In computer terms, this results in encoding issues, where different encoding is required for specialised characters in different languages.

Other difficulties also arise in languages not originating from Latin. The Japanese, and Arabic languages, for examples use their own characters to express themselves. Resolving such issues includes changing the characters to equivalent letters using the Latin alphabet. Research involved in language similarity and matching include Jiang and Conrath (1997); Morsy and Karypis (2016); Resnik (1999) and Damashek (1995).

Although language is acknowledged as a potential conflict when dealing with data, only the English language is required for the investigation in this thesis. Therefore, this type of conflict is not significant in this case and is not extended upon.

2.8 Spatial Data Heterogeneity

Heterogeneities have been explained generally in the previous sections. This section addresses heterogeneities occurring specifically in spatial data.

Syntactic heterogeneity is of minimal consequence in the spatial domain due to standardised data formats and standards used to describe the geometries in spatial data; Geography Markup Language (GML), Geo-JavaScript Object Notation (GeoJSON), Well-Known Text (WKT), and Shape files (SHP) are among the most used ones. Tools also exist to transform one data format to another. Although these data formats have mostly solved the issue of differing data formats (syntactic heterogeneity), other aspects of spatial data need to be considered such as spatial references and projections which are explained below.

The spatial reference and projection of data is dependent on the location of the data. For example, the main datum used in Australia is the Geocentric Datum of Australia (GDA94, or simply GDA). It is used as it was directly compatible with the datum used by Global Positioning Systems (GPS)—the WGS84 (Australian Government, 2004). More recently though, due to the shift in Australia's tectonic plate, a new national Datum was introduced. In early January 2017, the GDA2020 was launched (Wallace, 2017) requiring existing data to be changed to the new datum. However, converting data to the new datum is time consuming and some existing data still continue to use the old datum. Consequently, although the GDA is the current datum used in Australia, there are nonetheless datasets that have been surveyed with older datums (Australian Government, 2004).

Aside from the different datums, there are also a multitude of map projections that can be applied to them. In New Zealand, there are five official projections that can be used with the New Zealand Geodetic Datum 2000 (NZGD2000). To name them, they are the New Zealand Transverse Mercator 2000 (NZTM2000), the NZGD2000 meridional circuits, the New Zealand offshore island projections, the New Zealand Continental Shelf Lamber Conformal 2000 (NZCS2000), and the Ross Sea Region projections (Land Information New Zealand (LINZ), n.d.).

Some of the ones used in Australia are Australian Geodetic Datum (AGD), Australian Map Grid (AMG), Map Grid of Australia (MGA), and the Geocentric Datum of Australia (GDA) (Australian Government, 2004). Depending on the state or territory and organisation, they would each have a preference on the type of projections to be used, and hence the spatial projection is a factor to consider when combining spatial data.

2.9 Solving Data Heterogeneities

Resolving data heterogeneities requires a process called matching (Rahm & Bernstein, 2001; Shvaiko & Euzenat, 2005). Matching can be described as finding the mappings between semantically equivalent nodes from two graph-like structures (Giunchiglia & Shvaiko, 2003). Figure 2.2, obtained from Rahm and Bernstein (2001), demonstrates the different approaches and their classifications. For this section the 'individual matcher approaches' branch is focused on.

That branch is divided into schema-based and instance-based matching. Schema-based matching refers to the structure of a graph, while instance-based matching refers to the actual values of the structure—their instantiation. Shvaiko and Euzenat (2005) provide a similar diagram where they classify the approaches based on their granularity and their type instead. Their diagram is shown in figure 2.3.

From these two diagrams, schema matching can be summarised as either being at the structure level, or at the element level. For both levels though, the broad categories of syntactic, structural, and semantic approaches are used.

2.9.1 Syntactic Approaches

Syntactic matching attempts to resolve data heterogeneities by finding the mapping between two elements based on their syntactic features; although the semantics of the elements are not compared directly, an assumption is made where the syntax of an element is indicative of its meanings. Two syntactic approaches are

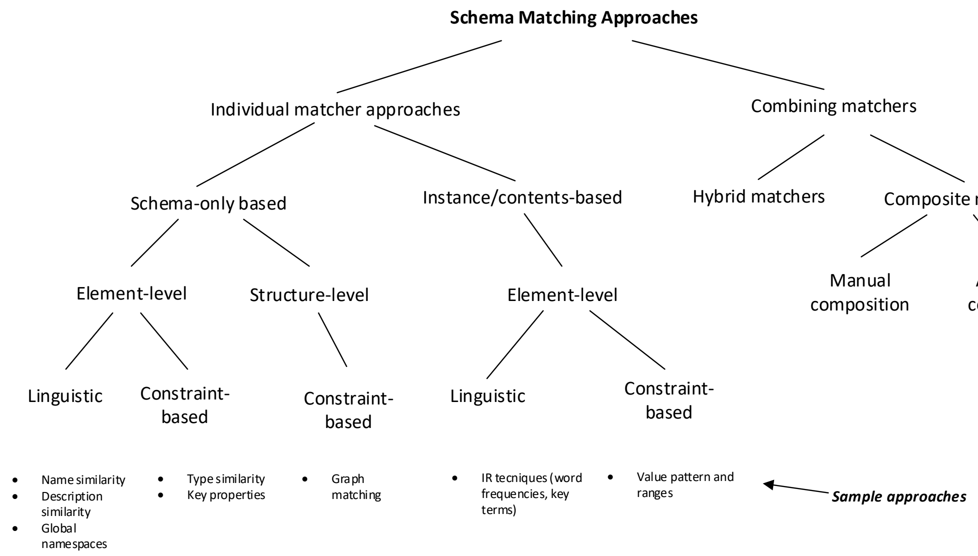


Figure 2.2: Classification of Schema Matching Approaches (Rahm & Bernstein, 2001)

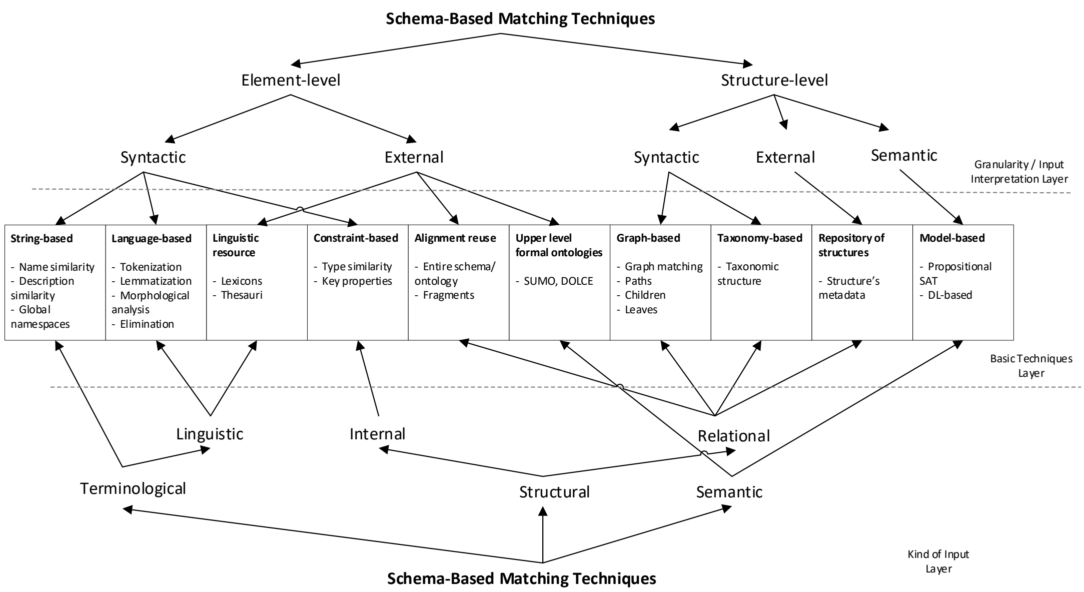


Figure 2.3: Retained Classification of Elementary Schema-based Matching Approaches (Shvaiko & Euzenat, 2005)

string-based, and language-based matching. Although Shvaiko and Euzenat (2005) classify constraint-based techniques as syntactic, they are treated as structural approaches in this thesis.

String-based Matching

A string matching process is when two strings are compared to generate an indicative measure index of their similarity (Shvaiko & Euzenat, 2005). This process is usually applied in the context of entity classification, categorisation, and to find out whether two strings are related or not. There has been much research on this subject (Bernstein, Madhavan, & Rahm, 2011; Christen, 2006; Cohen, Fienberg, Ravikumar, & Fienberg, 2003; Halevy, 2005; Navarro, 2001; Winkler, 1999), ranging from semi-automated methods carried out to largely unsupervised ones.

2.9.2 Structural Approaches

Structural approaches view data as graph-like structures with nodes and their leaves. If two data are similar in concept, then the assumption is that their structures will be similar as well—having nodes in the same or similar place within the structure. However, Halevy (2005) states that this is a brittle assumption and an initial match that drives the similarity must first be found.

2.9.3 Semantic Approaches

Semantic approaches use domain knowledge to match data. Li (2017); Srivastava et al. (2012); Zhao et al. (2008) state that data heterogeneities can be resolved by aligning the data's semantic differences. Currently, data on the Web are still lacking explicit semantics. Two possibilities to remedy this issue are topic modelling and Semantic Web technologies.

Topic Modelling

Topic modelling attempts to discover a document's semantics by modelling abstract topics over a document. Blei et al. (2003) define a document as a sequence of words. Given a topic, it is intuitive to think that some words will be used more often than others. For example, in regards to pollution, words such as ‘fumes’, ‘smoke’, ‘cars’, and ‘industry’ will occur more often than with the topic of library, which leans more towards the words ‘books’, ‘tables’, and ‘novel’. Hence, the word ‘topic’ used to describe topic modelling can be described as being clusters of similar words. Machines cannot extrapolate the topic ‘pollution’ from the words ‘fumes’, ‘smokes’ and ‘cars’, but can identify anonymous clusters of words.

If words appearing in a particular cluster also appear in another document with similar frequency, then there is a high chance that they belong to the same cluster; hence the same topic.

Semantic Web Techniques

Data heterogeneities can be resolved by consolidating their semantic differences (Srivastava et al., 2012; Zhao et al., 2008). However, a lot of data in the current Web do not contain semantics because a Web language that is both standardised and expressive was not used at their creation (Berners-Lee, Hendler, & Lassila, 2001). This is also true for the structure of spatial data (Zhao et al., 2008). Semantic Web techniques aim to resolve that issue *via* the use of ontologies (Berners-Lee, 2006).

2.10 Ontologies

The term ontology originates from philosophy, where it refers to the study of existence and the nature of things (Gruber, 1993; He, 2010). The term ontology is also widely known for its use in information technology (Chandrasekaran, Josephson, & Benjamins, 1999). The term used in this thesis refers to semantic technologies used in computer science, and is defined as the explicit specification of a knowledge domain and concept and their relationships (Gruber, 1993; Partyka et al., 2008; Pedro, 2009; Uschold et al., 1996). In simple terms, ontologies are graphs that allow concepts to be expressed.

For this goal, an interoperable language allowing for the representation of data, alongside their reasoning and rules is required (Berners-Lee et al., 2001). The Resource Description Framework (RDF) specified by the W3C provides the framework to write ontologies.

2.10.1 The Resource Description Framework

As the Resource Description Framework (RDF) is a W3C framework, this section is based on Schreiber and Raimond (2014). The RDF allows the expression of resources on the Web. Schreiber and Raimond (2014) define the term ‘resources’ as anything from real world entities to abstract concepts. It should be noted that interoperability is possible with the RDF, as it is a common framework, and can be used outside of its intended purpose by other applications.

The RDF uses a combination of three resources in the form of <subject, predicate, object>to express statements known as **triples**. The predicate allows the expression of relationships between the subject and object, and can be interlinked with other resources.

In order for these resources to be uniquely identifiable, the RDF uses International Resource Identifiers (IRIs), IRIs are a generalised form of Uniform Resource Locators (URLs). They can be explained as being URLs without the constraint of HTTP and ASCII characters.

A simple expression in the RDF is given by Schreiber and Raimond (2014): <Bob><is-a><Person>.

The resources ‘bob’ and ‘person’ have been expressed with a ‘is-a’ relationship.

The same example can be expressed with the use of IRIs:

```
<http://example.com/bob> <http://example.com/is-a> <http://
    example.com/person>
```

The RDF also allows the expression of literal values such as numbers and letters. Examples are 123, and ‘abc’. Triples that use literals need to associate them to their datatypes. The datatypes presented in the RDF include but are not limited to those in XML such as string, boolean, integer, decimal, and date among others.

As the RDF is simply a framework, it sets the foundation of the Semantic Web, but foundational terms are required to standardise the expression of resources.

2.10.2 RDF Vocabularies

In the Semantic Web, a vocabulary provides definitions of terms used to express resources. These terms are resources themselves, and hence are identified by their IRIs. While it is possible to use the entire IRI for every term, the cohesion would degrade rapidly. As such, prefixes are used instead. Prefixes allow the domain name of an IRI to be abbreviated for better readability.

For example, if the URL `http://www.example.com` is abbreviated to 'ex', any resource with that URI can be abbreviated with that prefix (e.g. `http://www.example.com/bob` to ex:bob).

W3C implemented two vocabularies located at `http://www.w3.org/1999/02/22-rdf-syntax-ns#`, and `http://www.w3.org/2000/01/rdf-schema#`. They are abbreviated as rdf and rdfs respectively. The rdfs prefix represents RDF schema (RDFs) which provides more expressivity to RDF by adding more terms such as class, property, domain, and range.

Construct terms in RDF are:

1. **Class**
   A class allows resources to be grouped together based on their common characteristics. For example Bob and Jane are persons, and as such person can be a class. The syntax is:

   ```
   <Resource>    rdf:type    rdfs:Class
   ```

   The following example demonstrates how the term 'Person' can be represented as a class.

   ```
   ex:Person    rdf:type    rdfs:Class
   ```

2. **Property**
   A property identifies a resource to be used as a predicate. That is, a property resource is used to link two other resources. For example the 'is-a' relationship is a property. The syntax is:

   ```
   <Resource>    rdf:type    rdfs:Property
   ```

   An example of the 'is-a' relationship being represented as a property is shown below.

```
ex:is-a    rdf:type    rdfs:Property
```

3. **type**

   This identifies a resource as an instance of a class. It permits ‘bob’ to be expressed as being part of the group ‘person’. The syntax is:

```
<Resource>    rdf:type    <Class>
```

   The syntax to denote bob as a person is given below.

```
ex:bob    rdf:type    ex:Person
```

4. **subClassOf**

   This allows a class to be a specialisation of another class, inheriting its predicates from other resources. An example is the class ‘boy’ being a subclass of the class ‘person’. The syntax is:

```
<Class>    rdfs:subClassOf    <Class>
```

   The example below shows how a boy class can be represented as a subclass of a person class.

```
ex:boy    rdf:subClassOf    ex:Person
```

5. **subPropertyOf**

   A sub property is treated as a specialisation of another property. For example, the property ‘has-arm’ can be a sub property of ‘has-limb’. The syntax is:

```
<Resource>    rdfs:subPropertyOf    <Property>
```

   This example demonstrates how the property ‘has-arm’ can be made a sub property of ‘has-limb’.

```
ex:has-arm    rdf:subPropertyOf    ex:has-limb
```

6. **domain**

   The domain of a property is always the subject of that property. In the case of <person, has-arm, left-arm>, the domain of ‘has-arm’ would be ‘person’. The syntax is:

```
<Property>    rdfs:domain    <Class>
```

   The domain of the predicate ‘has-arm’ is set to Person in the following example:

```
ex:has-arm    rdfs:domain    ex:Person
```

7. **range**

   The range of a property is always the object of that property. In the same example as above, the range of has-arm would be left-arm. The syntax is:

```
<Property>    rdfs:range    <Class>
```

   The range of the predicate 'has-arm' is set to 'left-arm' in the following example:

```
ex:has-arm    rdfs:range    ex:left-arm
```

Examples of other widely known RDF vocabularies include Friend of a Friend (FOAF) (Brickley & Miller, 2014), Dublin Core (Dublin Core Metadata Initiative (DCMI), 2017), and SKOS (W3C, 2012).

2.10.3 Web Ontology Language

The Web Ontology Language (OWL) is the next step towards semantic data. It allows the expression of **what** a resource is, and differs from the RDF which specifies **how** a resource is written. With OWL, an ontology can be reasoned over, allowing the entailment of information and how they relate to one another without the user explicitly expressing them.

The Semantic Web is still undergoing continuing development. Problems identified in OWL were fixed in OWL2 (OWL Working Group, 2012), and at the same time more expressive terms and features were introduced. Further, the Shapes Constraint Language (SHACL) became a W3C recommendation as of July 2017. It aims to describe the shape or structure of an ontology and allowing for its validation (Knublauch & Kontokostas, 2017).

Due to the apparent growth in Semantic Web technologies, for all intents and purposes where ontologies are mentioned or used, this thesis refers to RDF, RDFS, OWL and OWL2. While SHACL could benefit in validating an ontology, it is not explored as it was introduced during the writing up of this thesis, after much of the research had been concluded.

2.10.4 SPARQL Protocol and RDF Query Language (SPARQL)

Once ontologies are created, a way to query them is required. SPARQL (Prud'hommeaux & Seaborne, 2013) is a recursive acronym for SPARQL Protocol and RDF Query Language. It is a language designed for the querying of ontologies (RDF documents) by using queries similar to SQL. 'SPARQL is for ontologies what SQL is for databases' is a common saying. A simple SPARQL query contains a **SELECT**, and **WHERE** statements identifying the triples to look for with variables being identified by a question mark (?) or a dollar sign ($). Some examples are provided from Prud'hommeaux and Seaborne (2013):

Listing 2.1 is a simple query requesting all triples whose subject is ***ex:book1*** and whose predicate is ***dc:title***. Such a query results in all the titles of books with titles to be returned. Prefixes for the URIs are used in the example.

```
PREFIX ex: <http://example.org/book/book1>
PREFIX dc: <http://purl.org/dc/elements/1.1/title>
SELECT ?title
WHERE {
  ex:book1 dc:title ?title .
}
```

Listing 2.1. Simple SPARQL Query 1

The next example in listing 2.2 queries for three variables: ***?x***, ***?name***, and ***?mbox*** but only ***?name***, and ***?mbox*** will be returned as specified in the **SELECT** clause. This query returns the name and mailbox of any instance whose name and mailbox both exist. Attention should be given to the role of variable ***?x*** where it grounds both the ***?name*** and ***?mbox*** variables to the same subject.

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
SELECT ?name ?mbox
WHERE  {
  ?x foaf:name ?name .
  ?x foaf:mbox ?mbox .
}
```

Listing 2.2. Simple SPARQL Query 2

The next example, figure 2.3, shows the usage of filters using regular expressions (regex). On top of returning triples that have existent names and mailboxes, this query further filters the names to only return the ones matching a string literal. The sample query specifies that the variables ***?name*** should match the string literal 'Smith' by using the **FILTER** keyword.

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
SELECT ?name ?mbox
WHERE  {
  ?x foaf:name ?name .
  ?x foaf:mbox ?mbox .
  FILTER regex(?name, "Smith")
}
```

Listing 2.3. SPARQL Query using a Filter

2.10.5 Ontology Serialization Formats

To allow machines to parse and read ontologies, standardised data formats have been established. Some of them are Turtle (ttl) (Beckett, Berners-Lee, Prud'hommeaux, & Carothers, 2014), JSON-LD (JSON-LD, 2014), RDFa (RDFa, n.d.), and RDF/XML (Schreiber & Raimond, 2014).

JavaScript Object Notation for Linked Data (JSON-LD) is used to serialise ontologies in JSON format. RDFa serialises ontologies in HTML, and RDF/XML uses XML as its serialisation format. Different to these, Turtle is a format designed specifically for ontologies.

Terse RDF Triple Language (Turtle) has a syntax similar to SPARQL by grouping three URIs together to represent a triple. As an example, the triple '<bob> <is-a> <Person>' is represented in Turtle as:

```
@prefix ex: <http://www.example.com> .
ex:bob ex:is—a ex:Person .
```

Listing 2.4. Turtle Example 1

The prefix keyword is used to assign constants to domain names for easier readability which is similar in SPARQL. The dot symbol is used at the end of a statement or block of statements. To group multiple statements which have the same subject, square brackets can be used. For example, for the triples '<bob> <is-a> <Person>' and '<bob> <has-a> <left-arm>', the following syntax can be used:

```
@prefix ex: <http://www.example.com> .
ex:bob[
  ex:is—a ex:Person;
  ex:has—a ex:left—arm;
] .
```

Listing 2.5. Turtle Example 2

The Turtle syntax is used in this thesis because of its terse format. Once an ontology is created using RDF and serialized, it can be interpreted by machines and queried using SPARQL. This technology allows the expression of the meaning of data by linking them to pre-determined terms and definitions as defined in RDF vocabularies. As ontologies require expert domain knowledge to properly model a domain concept, this thesis also describes some methods to facilitate ontology creation where adequate.

2.11 Ontologies as a Model

Data models originate from databases where schemas are used to structure them. In a database paradigm, two approaches to integrate data sources to a global schema are Local as View (LaV) and Global as View (GaV) (Lenzerini, 2002). GaV requires a global schema to encompass all data sources in their terms. LaV, however, depends on an independent overarching schema to which the different data sources need to conform to.

LaV offers benefits regarding system flexibility and scalability as additional Web services only need to conform to the global schema. GaV, on the other hand, provides easier querying facilities as the global schema is intimately linked to each data source. Their disadvantages amount to the flexibility in defining the schemas. LaV requires all data sources to adhere to a global schema, making it prone to changes in data availability. GaV, on the other hand, requires all data from the data sources to be mapped irrespective of their usefulness.

Friedman, Levy, and Millstein (1999) proposed the GLaV approach which combines both LaV and GaV. Using this approach requires local schemas for each data source, alongside a global schema. It allows flexibility in defining schemas from both data sources and global schema point of view.

Ontologies can be utilised similarly to the approaches described above. In fact, Wache et al. (2001) describe three similar approaches for ontology networks: (1) single ontology approach, which is similar to LaV, (2) multiple ontologies approach, which is similar to GaV, and (3) hybrid approach, which is similar to GLaV.

2.11.1 Single Ontology Approach

The single ontology approach uses an ontology as an abstraction over all datasets. It defines the vocabulary required to express all related datasets. The data at the sources must be described in terms of the global ontology. Wache et al. (2001) state that the single ontology approach can be used where the sources provide nearly identical views over the same domain. However, the implementation of the single ontology approach can be challenging if the sources provide different levels of granularity in their views. This approach is also susceptible to changes in data from the data sources because the ontology has to reflect those changes without affecting any other sources. This approach depends on the Web services to structure their data in terms of the ontology and hence is the easiest method to integrate heterogeneous datasets as this responsibility is shifted to the data providers.

2.11.2 Multiple Ontologies Approach

This approach relies on each data source being described by their own local ontology. This results in multiple smaller ontologies, which do not necessarily interoperate. The mappings between the different ontologies can be challenging because this method does not guarantee that each ontology uses the same vocabulary. However, this method provides the best semantic reflection of the data as each ontology is customised for a specific data source.

2.11.3 Hybrid Approach

The hybrid approach combines the single ontology and multiple ontologies approach. While the data sources describe their data using a local ontology, they use a defined common shared vocabulary. This method takes advantage of the multiple ontologies approach while removing its disadvantages. The shared vocabulary can be described as another ontology (Stuckenschmidt, Wache, Vögele, & Visser, 2000).

2.12 Designing an Ontology

There are various methodologies that have been suggested and used for ontology design (Bermejo, 2007; Brusa, Caliusco, & Chiotti, 2006; López, 1999; Malik, Prakash, & Rizvi, 2010; Noy & McGuinness, 2001; Uschold et al., 1996; Yasunaga, Nakatsuka, & Kuwabara, 2010; Yuhana, 2007). Nonetheless, not one methodology has been agreed upon to be used as the *de facto* method for designing ontologies, and no formal methods have been widely adopted by the community. As such, the methodology employed in this thesis is a combination of common steps from various methodologies.

The first step is defining the scope and the purpose of the ontology (Brusa et al., 2006; Malik et al., 2010; Noy & McGuinness, 2001; Yasunaga et al., 2010). The scope limits the ontology and specifies what must be included and can be excluded. In this step, Noy and McGuinness (2001) specify four questions to be answered: (1) what is the domain to be covered by the ontology?, (2) What is the ontology being used for?, (3) What types of questions the ontology should provide answers to?, and (4) who will use and maintain the ontology? This step minimises the volume of data and concepts to be analysed and the scope of the ontology can be adjusted during successive verification iterations (Brusa et al., 2006).

The second step is to identify queries that the ontology is meant to answer. This step helps in finding the motivation behind the ontology creation, and can also be used as an initial evaluation of the ontology (Grüninger, Fox, & Gruninger, 1995). Additionally, this step can be used in conjunction with the first step to identify the scope (Noy & McGuinness, 2001).

The third step is finding ontologies that can be reused (Bermejo, 2007; Noy & McGuinness, 2001; Yasunaga et al., 2010). This step includes analysing existing ontologies within the same domain to (1) find reusable ontologies, and (2) getting knowledge of the domain. Analysing existing ontologies provides partial knowledge about the domain to be represented (Bermejo, 2007). Given that the purpose of the ontology is to enable the querying of multiple Web services, it is important that it uses well-known ontologies as the foundation.

The fourth step requires a brainstorm of the terms, and concepts to be used in the ontology. This step is identified as the 'ontology capture' stage (Uschold et al., 1996), but is also part of other methodologies proposed by Noy and McGuinness (2001) and Bermejo (2007). The terms should be directly related to the task and purpose of the ontology. At this stage the specific categories of the terms do not need to be determined. This step is carried out alongside the other ontologies from step three, where terms already defined in another ontology are not repeated but made aware of. In this step, the terms identified are expanded by adding synonyms, descriptions, types, and sources to document their purpose (Bermejo, 2007).

The fifth step differs based on the granularity of the engineering process. Noy and McGuinness (2001) combine the definition of classes and the ontology hierarchy as a single step, but separate the definition of the properties as a different step. In Bermejo (2007), the classes and properties of an ontology are identified in step four before the hierarchy and class relationships identification. Other methods include grouping class definitions and property definitions alongside cardinality restraints and semantic relationships in one big step (Brusa et al., 2006), but does not provide much granularity as to what they encompass. Both class identification and property identification can also be separated into two distinctive steps (Yasunaga et al., 2010) but this does not consider the general brainstorming phase (step four).

As there are differing methodologies for the next steps, the methodology used in this thesis is the most detailed one. The steps are separated into the identification of classes and properties first, then the organisation of the classes into a hierarchy.

After step four—the identification of key terms—the fifth step divides the terms into either classes or properties. Classes are terms that can act as single entities, usually nouns, while properties are terms that describe a class, usually verbs (Bermejo, 2007). The sixth step involves organising the classes into a hierarchy. A class hierarchy can be visualised as a tree structure, with the most abstract/general class on top of the tree, with each branch subdividing into more specific leaves. There are three ways of deriving a class hierarchy (Uschold et al., 1996):

- Top-down approach: where the developer starts with the most abstract or general class, and then derives the leaves of that class into more specific terms;

- Bottom-Up approach: where the starting classes are the most specific ones, and then more general terms are built as their parent node; and
- Middle-Level approach: a combination of the first and second approaches in this list. It means that a term that lies somewhere in between the tree structure is the starting node. Then both the leaves (more specific terms), and the parents (more abstract terms) are derived from it.

Although all of these methods can work (Uschold et al., 1996), Rosch (2013) found that a middle-level approach corresponds to the intuition of people characterising non-biological taxonomies.

The seventh step includes defining the attributes required in a class. Some classes can be changed into attributes, and if a specific term can only be represented with a primitive data type (string, integer, float), then it is an attribute (Bermejo, 2007). The term 'slot' is also used when talking about attributes, which are identified by Noy and McGuinness (2001) as intrinsic, extrinsic, a part of an object, or some relationships between instances of a class. With a reference to how ontologies are implemented though, class attributes are triples with either the predicate *owl:ObjectProperty* when linking classes, or *owl:DatatypeProperty* when linking classes to data types (Yasunaga et al., 2010). For the purpose of this thesis, an attribute/property is considered to be any entity that is linked with either of these two predicates.

The eighth step is to decide upon the cardinalities, restrictions, and rules placed upon each property and class—the logic of the ontology. Cardinalities refer to the number of associations a class can have with another. For example, a person can generally only have one gender, while having up to a maximum of four limbs. Cardinalities are a subset of restrictions, but restrictions also include the specification of the domain (the subject) and the range (the object) of the properties. They can define a set of values that is restrictive of a certain property, as well as limit the values used in datatypes. Rules are used to infer new information. An inherent rule in ontologies is that if class B is a subclass of class A, and class C is a subclass of class B, then class C is also a subclass of class A.

The last step involves implementing the ontology using any standardised semantic language of preference. The implementation language used in this thesis is the Web Ontology Language (OWL) (McGuinness & Van Harmelen, 2004). This step encompasses populating the ontology with instances, as well as pre-evaluating the ontology based on the queries identified in step two.

A summary of the nine steps is provided below:

1. Define the scope and the purpose of the ontology;
2. Identify queries to be answered for the motivation of the ontology and early evaluation;
3. Find reusable ontologies;
4. Brainstorm concepts and terms to be part of the ontology;
5. Identify key terms divided into either classes or properties;
6. Organise the classes into a hierarchy;
7. Define the attributes for the classes;
8. Decide upon the cardinalities, restrictions, and rules; and
9. Implement the ontology using an ontology language.

2.13 Works Related to Ontology-Based Infrastructures

This section reviews existing work related to using Semantic Web approaches in the spatial domain. Janowicz et al. (2010) proposed a Semantic Enablement Layer (SEL) for OGC services. The purpose of a SEL is to create semantic profiles for existing Web services to integrate in a spatial data infrastructure. Their proposed SEL has functionalities categorised as (1) storage of the ontologies, (2) lookup and retrieval of the data, (3) reasoning of the ontology, and (4) deployment of OGC services documents with semantic annotations. However, their work primarily aims to emphasise that a SEL is, not only possible, but also needed to bridge the gap between OGC Web services and the Semantic Web.

Homburg et al. (2016) explored the use of ontologies to provide a common unified semantic view over heterogeneous spatial datasets. They adapted the INSPIRE model for their common view, and investigated how spatial datasets can be transformed into ontologies. Bhattacharjee and Ghosh (2014) explored how concepts within non-semantic datasets can be matched semantically through the use of thesauri and knowledge graphs. While all these approaches help to solve the spatial data issue, this thesis differs by describing a more complete approach by providing a common unified semantic view over Web services, with the use of ontologies for their on-the-fly integration.

Hasani et al. (2015) investigated an ontology-based approach to homogeneously integrate and query spatial databases. Similarly, Zhao et al. (2008) proposed a method by which distributed WFSs are accessed through ontologies, however, their methods take into account only one dataset—a real world transportation application system. Different to them, this thesis looks at modelling spatial Web services instead of databases, alongside integrating the data at the feature type level instead of their instances. Multiple datasets from different WFSs are used and a solution to combine these differing datasets based on WFS filters is offered. Further, the ontology that Zhao et al. (2008) use is one which they created and does not reuse existing ontologies. In this thesis, existing ontologies are reused to provide a novel solution for the federation of spatial data by using high-level ontologies that can be customised for specific lower-level applications. The benefit of high-level ontologies is that they are already recommended and thus have wider applicability.

A different work about the use of a broker system in the spatial domain is by Li (2017). She proposed a novel solution to aid in accessing spatial data. She introduced PolarHub which is a 'large-scale geospatial data crawler and content analyzer' (Li, 2017, p. 2). PolarHub helps in finding spatial data on the Web and categorises them into themes. The author identifies five key facets to the data access problem: (1) cyber-location, (2) theme, (3) spatial extent, (4) temporal extent, and (5) quality. Cyber-location is concerned about where the data is located, theme is about the identification of the theme of the data, spatial extent relates to geographical aspect of the data, temporal extent is similar but encompass the data's time period, and quality refers to data acceptance in regards to uncertainty and reliability.

PolarHub automatically finds and categorises spatial data based on themes, spatial and temporal filters using these criteria. While it certainly aids in facilitating the search for spatial data, it differs from the work in this thesis, as the issue of federated query is not addressed in their work. The task of filtering through the numerous amount of spatial data found by PolarHub is made easier but the responsibility of finding the right data source is still reliant on the users. Although geographical data can be found more easily than with current methods, the challenge from querying different regions is still present. In addition, this thesis uses ontologies to semantically describe Web services to enable their unified querying. PolarHub, on the other hand, uses a taxonomy ontology to semantically match data. The manner in which Web services work and how requests can be made are encapsulated in the ontology described in this thesis. As such, the work in this thesis is complementary to the research of Li (2017) but different in purpose.

Another approach called Ontology Based Data Access (OBDA) is used to access disparate datasets. Its aim is to provide a query-able ontological view of the data sources to the users. A recent evaluation of the OBDA approach found that the approach can be 'orders of magnitude faster than standard triple stores' (Lanti, Rezk, Xiao, & Calvanese, 2015, p. 10), with proper optimisation techniques. However, OBDA can also perform poorly if proper techniques are not used. Even though this specific method is not used in this thesis, the idea is similar. While OBDA aims to access data through ontologies, this thesis aims to use ontologies to describe and query Web services instead of the databases directly. Some works using OBDA include the Optique System (Haase, Horrocks, & Hovland, 2013) and MASTRO (Calvanese et al., 2011).

A real-life application of OBDA using the MASTRO system was explored by Antonioli et al. (2013). From their case study, they found that mapping definitions in ontology to data had to be mostly done manually. They had to manually analyze the structure of the data sources to understand the data semantics. And although this only had to be done once for any new data source (Antonioli et al., 2013), as known from previous studies (Calvanese et al., 2011), this process can take several man-months.

While the MASTRO system requires customised manually-created ontologies for each application, this thesis reuses existing ontologies to investigate their fitness for use in accessing distributed end points and how they can be populated as automatically as possible. Another difference is that for disparate sources, the MASTRO system uses an external federation tool to present all the data sources as a single relational database and then OBDA is used on that federated database. In contrast, this thesis focuses on the federation aspect integrating disparate data sources to an ontology without requiring their federation before-hand.

2.14 Research Methodologies

This section identifies and explains the different types of research methodologies. First, a background of the different types of research is given, followed by the identification of the type of this research and the explanation of existing methodologies.

2.14.1 Types of Research

Selecting a research methodology depends on the nature of the research at hand. Kothari (2004) groups research into multiple categories:

1. **Descriptive vs Analytical Research**
   Descriptive research aims to explain what is happening, and thus is a typical methodology used in social science. For that type of research, the researcher only reports an event and has no influence over the present variables. Analytical research, on the other hand, makes use of available information and facts to evaluate the research material.

2. **Applied vs Fundamental Research**
   Applied research aims at solving and finding a conclusion to an immediate problem. Fundamental research targets more at generalisation and formulation of a theory, such as the domain of pure mathematics. The latter is concerned about the broad discovery of new knowledge, to add on top of existing knowledge.

3. **Quantitative vs Qualitative Research**
   Quantitative Research is mostly based on the analysis of data. It is used when a specific behaviour or pattern is to be discovered. Such use case could be investigating the correlation between drug usage and the age of the population. Quantitative research is thus more objective, based on measurements. On the other hand, qualitative research uses surveys, focus groups, and interviews with which it investigates opinions or feelings of people, answering questions that cannot be easily quantified. Hence qualitative research is more subjective.

4. **Conceptual vs Empirical Research**
   Conceptual research involved the exploration of abstract ideas or theories. It either gives rise to new concept or to challenge and reinterpret existing

ones. On the other side, empirical research deals solely with experiences and observations. That type of research is accompanied with a hypothesis, which then the researcher aims to prove. The experiments and variables are all under the control of the researcher and thus their experimental proofs need to be duplicable.

5. **Other Types of Research**
   All other types of research are based on the four mentioned above, and Kothari (2004) gives some examples of such research. There is one-time research which is done over a certain time frame, and there is longitudial research which is done over a certain length of time. Field-setting and laboratory research are other examples provided, where the experiments depend on their environments. Research where one builds hypotheses instead of proving them is known as exploratory research, while formalized research is one where the hypothesis is clearly defined before hand. Another type of research provided is historical research which is based on past documents and other historical artifacts.

This thesis can be identified as applied research, where the problem identified is how to better the integration of disparate spatial datasets.

2.14.2 Types of Research Approaches

Having identified the nature of the research in the previous section, two main categories of research approaches to be looked at are: (1) science and engineering approach, and (2) social science approach (McMeekin, 2010).

Science and Engineering Approach

The aim of this approach is to make theoretical predictions and to validate them (McMeekin, 2010). Galliers (1990) states that the aim in the engineering domain is to make things work, this requires three different levels or stages in research:

1. Conceptual level: at this level, new ideas are created by analysis;
2. Perceptual level: at this level, new methods and approaches are generated; and

3. Practical level: at this level, experiments are conducted, tested, and validated.

Social Science Approach

The social science approach can be defined as qualitative, quantitative, or a mixture of both approaches (Jick, 1979). Quantitative research is the more objective and it is based on measurements or data. On the other hand, qualitative research leans towards human interpretations and opinions, and is thus more subjective.

McMeekin (2010) describes the social science approach as an approach used to test and evaluate existing methodologies produced by the science and engineering approach.

Thus, in summary, the science and engineering approach involves the creation of new ideas, approaches, and or experiments, while the social science approach is concerned with the evaluation and testing of approaches created by the former approach.

2.15 Summary

With the advent of better technologies, the creation of spatial data has become easier among both expert and non-expert users. However, the inherent issue of distributed data which is heterogeneity remains. Although there exist systems, such as INSPIRE and EuroGEOSS, whose goal is to integrate heterogeneous spatial data, they are not suitable for countries such as Australia and New Zealand, and thus cannot be utilised. Australia's current solution for nation-wide data integration requires an improvement as issues such as maintainability and data duplication persist. This research therefore investigates ways to better Australia and New Zealand's data integration nation-wide *via* data federation.

To this end, this chapter reviewed relevant works to this thesis. Spatial Web services were explained alongside the technologies used. A review of existing spatial data supply chain patterns was conducted and it was identified that the brokered pattern is more suited for an immediate approach to federate Australia and New Zealand's spatial data. Afterwards, the types of, causes of, and solutions to data heterogeneity were discussed and the usage of ontologies was chosen to resolve semantic heterogeneity. The concept of ontologies was explained, and this chapter reviewed works in relation to ontologies and mentions how this thesis differs to them. The last section of this chapter provided a background of existing research types and this thesis was identified as being an applied research. The different types of approaches to tackle this type of research alongside the conclusion finalised chapter 2.

CHAPTER 3

THE GLOBAL ONTOLOGY FOR THE BROKER SYSTEM

3.1 Introduction

The broker proposed in this thesis requires a global model to enable the mapping of data and provide a unified view for querying heterogeneous datasets. For these purposes, this thesis presents the usage of an ontology as a global model. The global model described in this chapter reuses four existing ontologies and is unique in that it caters for the description of all types of Web service, alongside the semantic description of spatial features.

The main reason to use an ontology is to reach semantic interoperability by bridging the semantic gap between spatial data Web services (Janowicz et al., 2010). While comparing the datasets at a syntactical or structural level has been achieved, semantic interoperability is still an issue (Li, 2017; Zhao et al., 2008). Using an ontology provides the means to reconcile the semantic differences in heterogeneous datasets.

The proposed ontology serves as the foundation to describe Web Feature Services (WFS) at a semantic level. This chapter focuses on the description of the ontology, outlining the approach and methodologies used for its development. First, this chapter investigates the Foundation Spatial Data Framework (FSDF)[1] as a potential global ontology, followed by the description of the ontology—named Web Services Ontology (WSO).

[1]The FSDF is an initiative by the Australian and New Zealand Spatial Information Council for a common reference to spatial data in Australia and New Zealand (ANZLIC the Spatial Information Council, 2014).

3.2 Choice of Ontology Approach

For this research, the ontology approach of choice is the hybrid approach (section 2.11.3). The hybrid approach is a mixture of the single ontology approach and the multiple ontologies approach. The single ontology approach requires the Web services to be described in terms of a global ontology, which can be challenging as the datasets investigated vary in terms of their granularity (i.e. the amount of details recorded in the datasets). The multiple ontologies approach is not applicable as a unified view is required for a user query. Therefore, the hybrid approach is chosen for this research. The global ontology is used as the unified view for querying, and the local ontologies are used to describe the data sources.

For the global ontology, the first considered candidate ontology is the Foundational Spatial Data Framework (FSDF).

3.2.1 Foundation Spatial Data Framework

The FSDF is an initiative by the Australian and New Zealand Spatial Information Council (ANZLIC), to 'provide a common reference for the assembly and maintenance of Australian and New Zealand foundation level spatial data' (ANZLIC the Spatial Information Council, 2014, p. 4). The FSDF categorises spatial data under ten themes: administrative boundaries, elevation and depth, geocoded addressing, imagery, land cover and land use, land parcel and property, place names, positioning, transport, and water.

While the FSDF is a strong candidate for the role of global ontology, some issues were identified. As the FSDF is still under development, it is currently only available in UML format (ANZLIC: the Spatial Information Council, n.d.) through the proprietary software Enterprise Architect (Sparx Systems Pty Ltd, 2016). Inherently, UML models cannot be directly utilised by machines and must be converted to a machine readable data format. To this end, the UML of the FSDF was manually converted to an ontology.

Modelling the FSDF as an ontology offers multiple benefits. It enables the linkage of the FSDF classes to the data served by the data providers, allowing their reasoning. Ontology rules and axioms allow for the automated inference of new knowledge based on existing data while ensuring that the restrictions (e.g. class constraints) of the FSDF model are fulfilled.

Conversion of the FSDF UML model to an ontology was made manually with the help of Protégé (Stanford University, 2016)—an open source ontology editor. While manually adding datasets from Landgate (Landgate - Western Australian Land Information Authority, n.d.) to the ontology, some problems were noted:

1. The FSDF is a conceptual schema (Box et al., 2015), which is too abstract to link directly to the datasets, or to be an efficient query platform. For example, the FSDF contains a 'UnitDefinition' class under which most categories of datasets can be grouped, rendering lower-level queries impossible unless more details classes are added to the model;

2. The FSDF's goal is different to the goal of an ontology. A conceptual schema is application specific and depends on challenges pertaining to data representation and independence, while an ontology is based on understanding the needs of the community by reducing ambiguity in communication (Hakimpour & Geppert, 2005);

3. The relationships presented among the FSDF classes do not apply at the dataset level because relationships among datasets are not specified in WFS. Mapping the relationships requires manual integration of the datasets, which is not investigated in this research.

While the FSDF is an appropriate model for an abstract role of overarching schema, it does not match well with the investigated datasets due to its abstraction. A lower level of abstraction is required, which to our knowledge, was not available at the time of writing this thesis. To obtain the correct level of abstraction, the Web Service Ontology was engineered.

3.3 Web Service Ontology Overview

The Web Service Ontology (WSO) was developed to allow the semantic description of capabilities of Web feature services (WFSs), and to provide a unified view over the Web services to allow for federated querying. Even though this thesis focuses on WFS 1.0.0, other versions and non-OGC compliant Web services can be included in the ontology.

The core ontology reused in WSO is the Web Ontology Language for Services (OWL-S) (Martin et al., 2004). It is an ontology published by W3C for the general description of Web services. Although OWL-S is described as an ontology capable of describing any Web service, its *grounding*—the concrete realisation of message passing between server and client—depends on Web Services Description Language (WSDL) documents. WSDL is a definition language using XML syntax for describing the functionalities a Web service offers. However, OGC Web Services (e.g. WFS) do not require to be WSDL compliant and hence another approach was devised. Instead of the current grounding of OWL-S, the HTTP ontology (Koch et al., 2017a) is used for non-WSDL compliant Web services.

The HTTP ontology allows the description of message passing at a concrete level (i.e. when they are realised) which can be used instead of the current OWL-S grounding. Further, the HTTP ontology can be adapted to any HTTP request—which the Web is based on—allowing it to be used for any Web service.

Another ontology that is used is the GeoSPARQL ontology (OGC, 2012). GeoSPARQL is an OGC standard developed to allow the representation and querying of spatial objects on the Semantic Web (OGC, 2012). It extends SPARQL by representing spatial data and allowing their spatial querying. By using this ontology in conjunction with OWL-S, spatial objects can be described, reasoned over, and queried spatially. Given that the datasets used in this thesis are spatial, making use of such an ontology is important for their proper description.

Further to these, a last ontology that is reused is the vCard ontology (Iannella & McKinney, 2014). It is an RDF/OWL representation of the vCard specification. vCard was developed by the Internet Engineering Task Force (IETF) as a file format to describe individuals and entities (Perreault, 2011). It contains information such as addresses, emails, and contact information. The OWL-S specification mentions the vCard ontology as an example to be used, and hence is utilised in this thesis to describe data providers.

The next section describes how these ontologies integrate.

3.3.1 Ontology Components Linkages

This section describes a summary of the linkages between the various ontologies reused in WSO. To easily identify each ontology, their namespaces must be stated.

Namespaces are important as they are the reference point to any ontology's domain URI.

1. geo: refers to the GeoSPARQL ontology,
   URI: <`http://www.opengis.net/ont/geosparql#`>
2. vcd: refers to the vCard ontology,
   URI: <`http://www.w3.org/2006/vcard/ns#`>
3. http: refers to the HTTP ontology,
   URI: <`http://www.w3.org/2011/http#`>
4. cnt: refers to the Content ontology as part of GeoSPARQL,
   URI: <`http://www.w3.org/2011/content#`>
5. service: refers to the OWL-S Service ontology,
   URI: <`http://www.daml.org/services/owl-s/1.2/Service.owl#`>
6. profile: refers to the OWL-S Profile ontology,
   URI: <`http://www.daml.org/services/owl-s/1.2/Profile.owl#`>
7. process: refers to the OWL-S Process ontology,
   URI: <`http://www.daml.org/services/owl-s/1.2/Process.owl#`>
8. grounding: refers to the OWL-S Grounding ontology,
   URI: <`http://www.daml.org/services/owl-s/1.2/Grounding.owl#`>
9. wso: refers to the proposed ontology (WSO),
   URI: <`http://www.purl.org/net/wso#`>

Figure 3.1 demonstrates the different ontologies used with dashed lines separating them, each ontology is noted in bold. The diagram does not show the entirety of the ontologies. Only the core entities are shown to depict the main linkages among the ontologies.

The reused ontologies in WSO are the OWL-S ontology, the GeoSPARQL ontology, the HTTP ontology and the vCard ontology. The grey ellipses and arrows in figure 3.1 denote the classes and properties added to link the ontologies together. The classes are numbered as a reference.

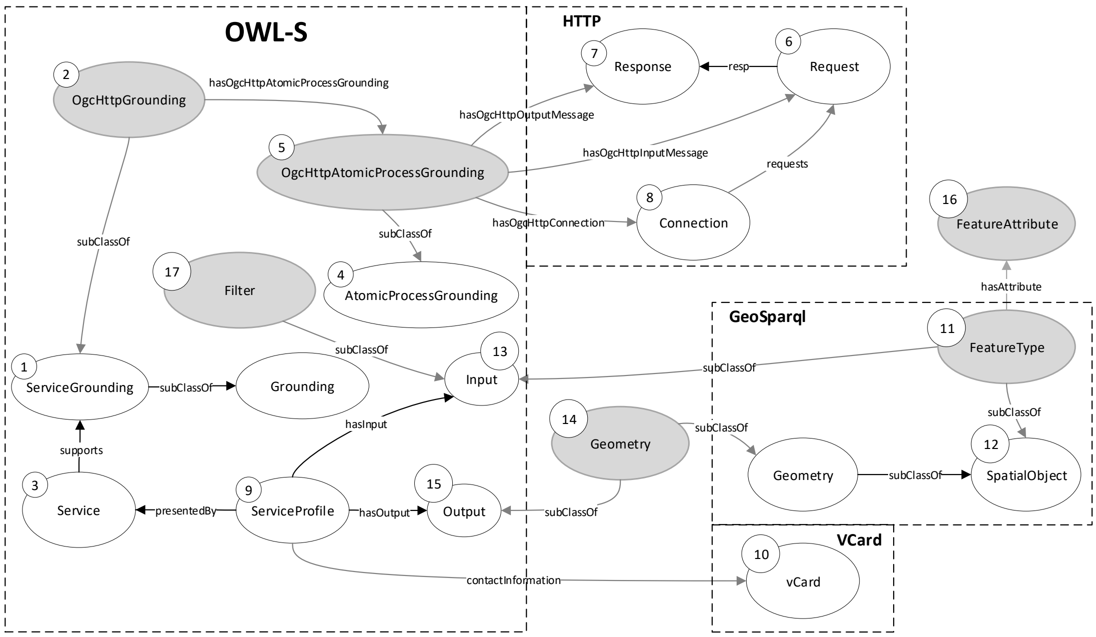


Figure 3.1: Core Components of the Broker's Ontology

Starting with the OWL-S ontology on the left: *service:ServiceGrounding* (1) links OWL-S to the HTTP ontology. *wso:OgcHttpGrounding* (2) is made a subclass of *service:ServiceGrounding* as it follows the same pattern as the OWL-S grounding specifications regarding WDSL—the WSDL grounding class is a subclass of *service:ServiceGrounding*. In this manner, any *service:Service* (3) instance follows the predicate *service:supports* towards a grounding. In the OWL-S ontology, the predicate *grounding:hasAtomicProcessGrounding* has a domain of *grounding:Grounding* and a range of *grounding:AtomicProcessGrounding*. *wso:OgcHttpGrounding* (2) is an indirect subclass of *grounding:Grounding* and *wso:OgcHttpAtomicProcessGrounding* (5) is a subclass of *grounding:AtomicProcessGrounding* (4), therefore *ogc:hasOgcHttpAtomicProcessGrounding*, which is a subclass of *grounding:hasAtomicProcessGrounding* can be used as a predicate between (2) and (5).

The OWL-S grounding links to the HTTP ontology *via* the predicates *wso:hasOgcHttpOutputMessage*, *wso:hasOgcHttpInputMessage*, and *wso:hasOgcHttpConnection*. *wso:hasOgcHttpInputMessage* is linked to the *http:Request* (6) class as a request is the input required to make a WFS call. The result of a request is considered to be the output which is why *wso:hasOgcHttpOutputMessage* is the link to *http:Response* (7). For each request, a connection must be made which is described by the *http:Connection* (8) class being connected by the *wso:hasOgcHttpConnection* predicate.

To link the OWL-S ontology to the vCard ontology, the *profile:contactInformation* predicate is used. It links the *service:Profile* (9) class to a vCard class (10). In the OWL-S specification, it mentions that the predicate *profile:contactInformation* can be linked to other ontologies giving vCard as an example, thus, that ontology is used.

The GeoSPARQL ontology is linked to OWL-S *via* a *wso:FeatureType* (11) class which is a subclass of both *geo:SpatialObject* (12) and *process:Input* (13). These subclass relationships are used to take advantage of the already defined class *geo:SpatialObject* without modifying its axioms. The *wso:FeatureType* can thus be considered both an input of the OWL-S ontology, and a spatial object of GeoSPARQL.

A similar idea is used on the *wso:Geometry* (14) class, which is a subclass of *geo:Geometry* and *process:Output* (15) to benefit from the advantages of both classes without modifying their axioms. Having such relationships allow the ontology to determine that an input from the OWL-S ontology has the same axioms as a spatial object from the GeoSPARQL ontology. The same idea applies for the output class and the Geometry class.

Further, the *wso:FeatureAttribute* (16) class is added to the *wso:FeatureType* (11) class to enable a feature type to link to its attributes which spatial features have. Another class that has been added is the *wso:Filter* (17) class which is a subclass of *process:Input* (13). The goal of this subclass relationship is to imply that a filter can be used as an input in a WFS call. This allows for the querying of particular WFS with specific filters.

To enable these linkages, some modifications in regards to each ontology had to be undergone. The section below provides an in-depth explanation of each ontology alongside with details regarding their modifications.

3.4 OWL-S

OWL-S is an ontology submitted by W3C. This ontology was chosen because of its comprehensive documentation. The purpose of OWL-S is to enable the discoverability, invocation, composition, and monitoring of Web services with a high degree of automation (Martin et al., 2004). The ontology has one major class *service:Service* subdivided into three other classes: *service:ServiceModel*, *service:ServiceProfile*, and *service:ServiceGrounding* as depicted in figure 3.2.

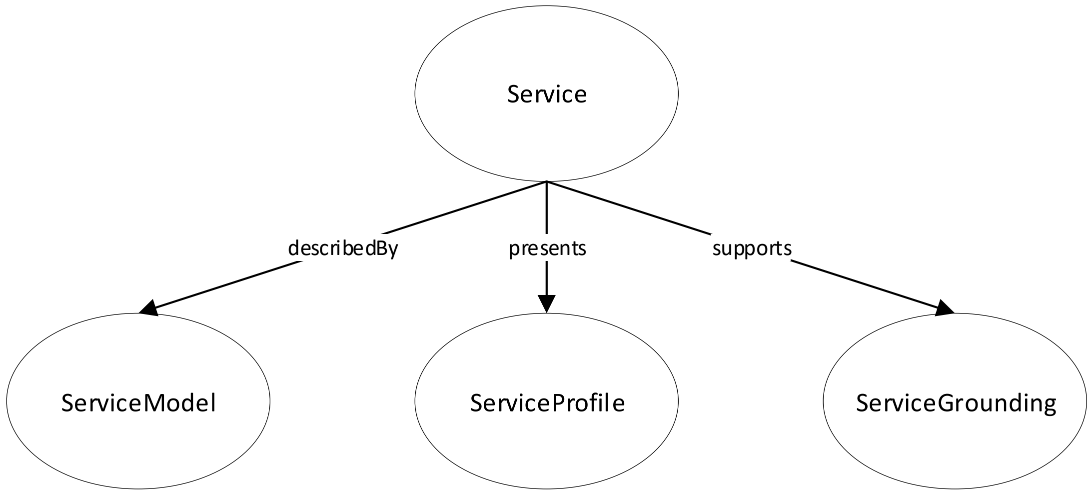


Figure 3.2: Core Components of OWL-S

1. *service:ServiceModel* dictates how the service works by providing a schema of the service's processes, and indicating at an abstract level how each process is performed;

2. *service:ServiceProfile* is tasked with advertising the service, indicating any basic information relating to the service;

3. *service:ServiceGrounding* is a concrete realisation of *service:ServiceModel*. It provides the explicit details regarding a service's processes, such as protocols, message formats, serialization, transport, and addressing. This part of the ontology has to be linked to a respective WSDL document.

Work related to OWL-S include Chen, Chen, Hu, and Di (2011). They proposed a methodology to find OGC Web services and describe them using ontologies but their methods do not consider the grounding component of OWL-S and only the service profile and model are used. Their implementation only considers the *GetCapabilities* document of a WFS, while in this research, the semantic description of WFS include the *DescribeFeatureType* document as well, and a grounding for OGC Web services is used.

Stock, Robertson, and Small (2011) on the other hand, created their own OGC grounding to cater for OGC Web services. They state that the grounding used is a simplified one reflecting the OWL-S grounding, and that a standard-compliant solution using an RDF mapping of WSDL by Kopeck (2006) was not achieved due to time constraints. The ontology described in this thesis describes a more complete grounding of OWL-S for OGC Web services alongside other ontologies to cater for spatial filtering as well.

3.4.1 Service Profile

Figure 3.3 shows the main classes related to the Profile class of OWL-S. The *service:ServiceProfile* class has the two predicates *service:presentedBy* and *service:presents* which links *service:ServiceProfile* and the general class *service:Service*. Details regarding the advertising of the service are accessed through its subclass *profile:Profile*.

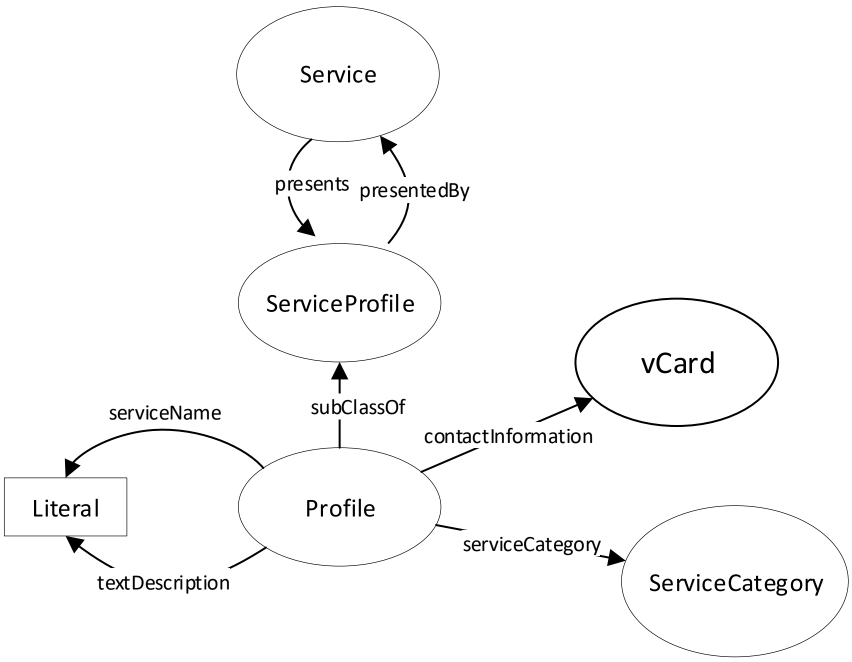


Figure 3.3: OWL-S Profile Entities

profile:Profile allows for the specification of basic details regarding a service functionalities such as its category, name, description, and contact information. These pieces of information are *profile:serviceCategory*, *profile:serviceName*, *profile:-textDescription*, and *profile:contactInformation* respectively.

profile:serviceCategory is linked to a *service:ServiceCategory* class which links to *value*, *category name*, *taxonomy* and *code* predicates with unspecified ranges (not shown in figure 3.3). The purpose of the service category is to allow the classification of Web services based on other classifications outside the scope of OWL-S (Martin et al., 2004). *profile:textDescription*, and *profile:contactInformation* are datatype properties and thus can only link to literal values, however, the *profile:contactInformation* is a predicate with an unspecified range. Hence, this predicate is used to link the OWL-S ontology to the vCard ontology (section 3.5) while still respecting the ontology's axioms.

Figure 3.4 demonstrates the *Input* and *Output* classes of the OWL-S ontology with the modifications in grey. To advertise the filtering abilities of a WFS, a *wso:Filter* class, which is a subclass of *process:Input*, is created. *process:Input* is a class which is linked to *profile:Profile* by the predicate *profile:hasInput*. By making *wso:Filter* a subclass of *process:Input*, filters serviced by a particular WFS can be queried as a *process:Input* class. This also implies that filters can be used as an input. Each filter available in a WFS has their own class created and made a subclass of *wso:Filter*.

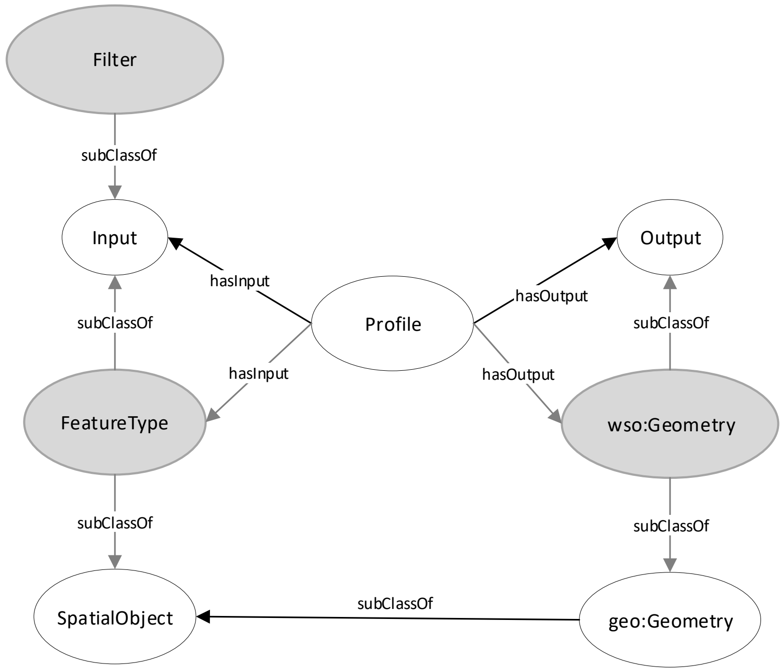


Figure 3.4: OWL-S Input and Output Entities

The profile has two predicates: *profile:hasInput* and *profile:hasOutput* that dictate which inputs and outputs a particular process has. In terms of a WFS, the inputs and outputs are feature types and geometries respectively. Hence, the GeoSPARQL ontology is used (section 3.6) to conceptualise feature layers alongside their geometries. The two ontologies are integrated by creating a *wso:FeatureType* class with a subclass relationship to both *geo:SpatialObject* and *process:Input*, and a *wso:Geometry* class which is a subclass of both *geo:Geometry* and *process:Output*.

Making subclasses of these classes allows the ontology to take advantage of the already defined classes *geo:SpatialObject* and *geo:Geometry*, without modifying their axioms. At the same time, these classes are inferred as *process:Input*, and *process:Output* allowing the OWL-S and the GeoSPARQL ontologies to be integrated together. The Turtle syntax of the created classes is provided in listing 3.1.

```
wso:Filter a owl:Class;
rdfs:subClassOf process:Input .

wso:Geometry a owl:Class;
rdfs:subClassOf process:Output, geo:Geometry .

wso:FeatureType a owl:Class;
rdfs:subClassOf process:Input, geo:SpatialObject .
```

Listing 3.1. OWL-S and GeoSPARQL Components Integration

The *wso:Geometry* class is changed into a subclass of *process:Output* as the output of a *GetFeature* call is a geometry. *wso:FeatureType* is included as a subclass of *process:Input* because a WFS call requires the user to specify which feature type they wish to query.

3.4.2 Service Model

The *service:ServiceModel* class provides an abstract description of the service's processes. For this thesis, only the *GetFeature* operation of a WFS is considered, as the information provided by both *GetCapabilities*, and *DescribeFeatureType* is stored in the ontology and therefore can be queried from the ontology itself. Figure 3.5 portrays the ontology classes relevant to this section with the grey ellipses denoting newly created classes and white denoting existing ones.

A *GetFeature* request is described as a *process:AtomicProcess* class in this thesis. *process:AtomicProcess* is a subclass of *process:Process* which is linked to the *process:Input* and *process:Output* classes. The atomic process can then dictate that an input of a *GetFeature* call is a *wso:FeatureType* class, and a *wso:Filter* class as explained in the previous section. This same idea is followed by the output of the atomic process which can state what the output of a *GetFeature* call is. For this component, no major modifications were made except the inputs and outputs classes as described earlier.

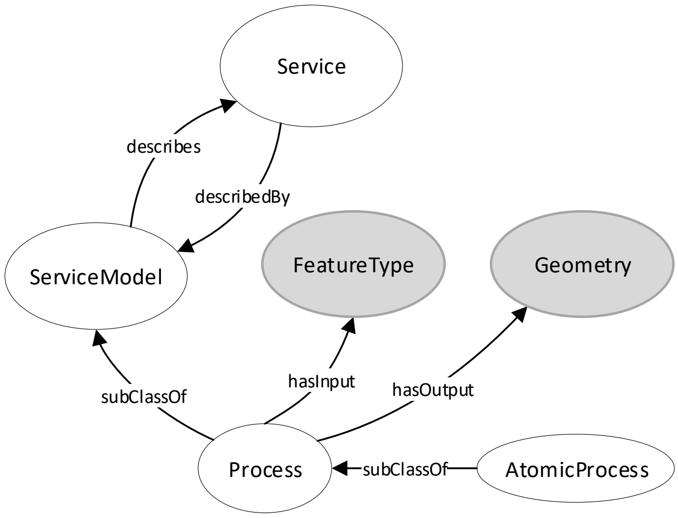


Figure 3.5: OWL-S Model Entities

3.4.3 Service Grounding

The *service:ServiceGrounding* class links the OWL-S ontology to a WSDL document, but as OGC Web services do not require to be WSDL compliant, a different approach is taken. Figure 3.6 shows the relevant classes pertaining to the service grounding class, the grey ellipses show classes that were created as part of WSO.

Instead of the *grounding:WsdlGrounding* class in OWL-S, a *wso:OgcHttpGrounding* class is created which is a subclass of *grounding:Grounding* and by association a subclass of *service:ServiceGrounding*. The *wso:OgcHttpGrounding* class is then linked to a *wso:OgcHttpAtomicProcessGrounding* class mirroring *grounding:WsdlAtomicProcessGrounding*, which then links to the HTTP ontology (section 3.7) through the predicates *wso:ogcHttpOutputMessage*, *wso:ogcHttpInputMessage*, and *wso:ogcHttpConnection*.

wso:OgcHttpGrounding uses the OWL-S predicate *grounding:hasAtomicProcessGrounding* to link to *wso:OgcHttpAtomicProcessGrounding*. This does not violate OWL-S axioms as both the subject and object of the triple are subclasses of the domain and range of the predicates. The *wso:OgcHttpAtomicProcessGrounding* can also be linked back to the OWL-S ontology via the predicate *grounding:owlsProcess* as specified in the OWL-S ontology. The description of these triples is provided in listing 3.2.

```
wso:OgcHttpGrounding
rdf:type owl:Class;
```

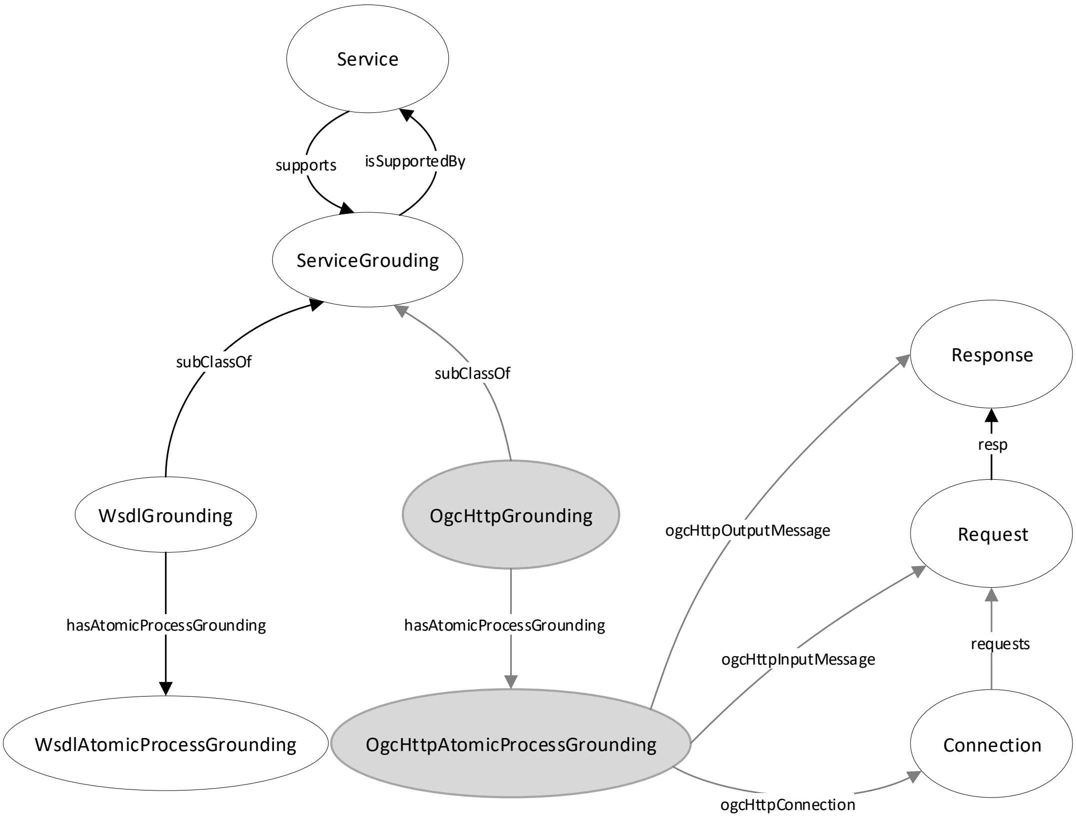


Figure 3.6: OWL-S Grounding Entities

```
rdfs:subClassOf grounding:Grounding,
[
  rdf:type owl:Restriction;
  owl:onProperty grounding:hasAtomicProcessGrounding;
  owl:allValuesFrom wso:OgcHttpAtomicProcessGrounding
] .

wso:OgcHttpAtomicProcessGrounding
rdf:type owl:Class;
rdfs:subClassOf grounding:AtomicProcessGrounding .

wso:ogcHttpOutputMessage
rdf:type owl:ObjectProperty;
rdfs:domain wso:OgcHttpAtomicProcessGrounding;
rdfs:range http:Response .

wso:ogcHttpInputMessage
rdf:type owl:ObjectProperty;
rdfs:domain wso:OgcHttpAtomicProcessGrounding;
```

```
rdfs:range http:Request .

wso:ogcHttpConnection
rdf:type owl:ObjectProperty;
rdfs:domain wso:OgcHttpAtomicProcessGrounding;
rdfs:range http:Connection .
```

Listing 3.2. OWL-S Grounding Modifications

3.5 vCard

The vCard ontology (Iannella & McKinney, 2014) is an RDF/OWL representation of the vCard specification which was developed by the Internet Engineering Task Force (IETF) (Perreault, 2011). Its purpose is to describe individuals and entities. It contains information such as addresses, emails, and contact information.

Figure 3.7 demonstrates how the vCard ontology integrates with OWL-S. The *service:ServiceProfile* from OWL-S is the linking point between the two ontologies. The OWL-S predicate *profile:contactInformation* has an unspecified range, and from its documentation, it states that it can be restricted to another ontology with vCard and Friend of a Friend (FOAF) ontologies given as examples.

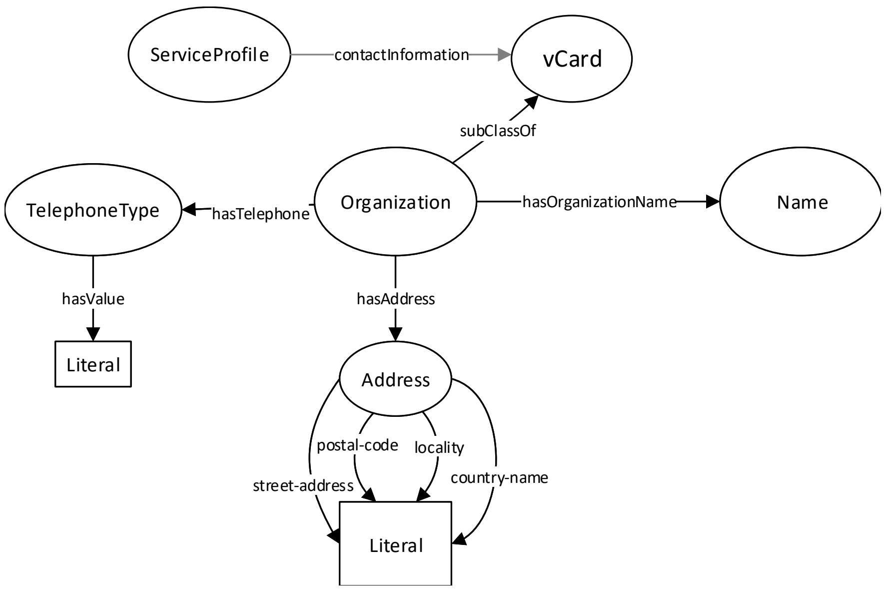


Figure 3.7: vCard Ontology

The vCard ontology is preferred over the FOAF ontology in this thesis because the vCard ontology is more focussed on an organisation. Contact information for organisations is not currently specified in the FOAF ontology as it caters more towards individuals than groups. Additionally, the vCard ontology is a representation of the vCard specification which is in XML, and can be directly transformed into an ontology and integrated into WSO. However, this transformation is not explored in this thesis but is mentioned here as a possibility.

No change was made to the vCard ontology. The only remark is that the class *service:ServiceProfile* from OWL-S, links to the vCard ontology through the *profile:contactInformation* predicate.

3.6 GeoSPARQL

GeoSPARQL is an OGC standard developed to allow the representation and querying of spatial objects on the Semantic Web (OGC, 2012). It extends SPARQL by enabling spatial functions over its ontology. Even though no full scalable implementation of GeoSPARQL has yet been achieved (Athanasiou, Hladky, Giannopoulos, Garcia Rojas, & Lehmann, 2014), the spatial characteristics specified in the GeoSPARQL ontology can still be used.

The GeoSPARQL ontology has predicates that allow for the representation of relationships between *geo:SpatialObject* classes. Three relation families are specified, namely the *Simple Feature*, *Egenhofer*, and *RCC8* relation family. Only the *Simple Feature* relation family predicates (Open Geospatial Consortium Inc., 2010) are shown in table 3.1 and only the *sfEquals* predicate is shown in figure 3.8 for brevity.

Relation Name	**Relation URI**	**Domain/Range**
equals	geo:sfEquals	geo:SpatialObject
disjoint	geo:sfDisjoint	geo:SpatialObject
intersects	geo:sfIntersects	geo:SpatialObject
touches	geo:sfTouches	geo:SpatialObject
within	geo:sfWithin	geo:SpatialObject
contains	geo:sfContains	geo:SpatialObject
overlaps	geo:sfOverlaps	geo:SpatialObject
crosses	geo:sfCrosses	geo:SpatialObject

Table 3.1: Simple Feature Predicates

SPARQL examples provided by the GeoSPARQL specification include finding: (1) features that contain a specific geometry, (2) features that are within a transient bounding box, (3) features that touch the union of two other features, (4) the closest features to a geometry, and (5) features that overlap.

It follows from these examples that the GeoSPARQL ontology can be beneficial to represent spatial objects within OWL-S, and to enable their semantic and spatial queries.

In conjunction with this ontology, another ontology that could be used is the NeoGeo ontology (NeoGeo Spatial Ontology, 2012). It is a vocabulary that focuses on the description of geometries, and thus can be used to extend the geometry class from GeoSPARQL. The NeoGeo ontology is not used in this thesis as the only additional information required from it is that of a bounding box, and the bounding box class used in NeoGeo does not contain sufficient detail for its efficient implementation..

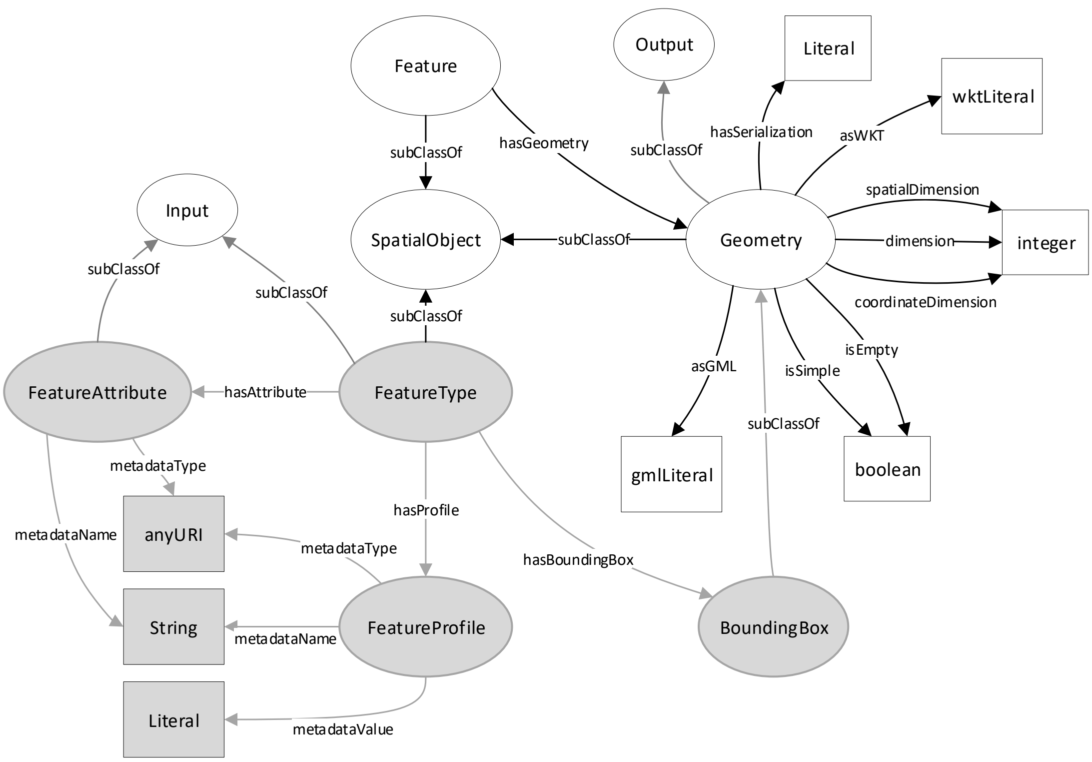


Figure 3.8: GeoSPARQL Ontology

Figure 3.8 shows the GeoSPARQL ontology and the modifications made in grey while listing 3.3 shows them in Turtle syntax. They first include the addition of a *wso:BoundingBox* class (line 1) which is a subclass of *geo:Geometry* (line 3). The bounding box literals can be represented in terms of GML or WKT as a *geo:Geometry* class is linked to *geo:asWKT* and *geo:asGML* predicates.

Secondly, the classes *wso:FeatureAttribute* (line 5) and *wso:FeatureProfile* (line 9) have been added to store the metadata of a feature found in its WFS *DescribeFeature* and *GetCapabilities* requests respectively. These classes can be used when a user wishes to find a feature with particular metadata. To allow for a query requesting both feature profiles and feature attributes, they were made a subclass of *wso:Metadata* (lines 7, 11). *wso:Metadata* (line 13) has datatype properties identifying its name (line 31), value (line 36), and type (line 41), and predicates *wso:hasAttribute* (line 52), and *wso:hasProfile* (line 58) are made sub-properties of *wso:hasMetadata* (line 64). This allows both predicates to be considered as a *wso:hasMetadata* predicate when reasoning over the ontology.

```
1  wso:BoundingBox
2  rdf:type owl:Class;
3  rdfs:subClassOf wso:FeatureProfile, geo:Geometry .
4
5  wso:FeatureAttribute
6  rdf:type owl:Class ;
7  rdfs:subClassOf wso:Metadata .
8
9  wso:FeatureProfile
10 rdf:type owl:Class;
11 rdfs:subClassOf wso:Metadata .
12
13 wso:Metadata rdf:type owl:Class;
14 rdfs:subClassOf process:Input,
15 [
16   rdf:type owl:Restriction;
17   owl:onProperty wso:metadataName;
18   owl:allValuesFrom xsd:string
19 ],
20 [
21   rdf:type owl:Restriction;
22   owl:onProperty wso:metadataType;
23   owl:allValuesFrom xsd:anyURI
24 ],
25 [
26   rdf:type owl:Restriction;
27   owl:onProperty wso:metadataValue;
```

```
  owl:allValuesFrom rdfs:Literal
] .

wso:metadataName
rdf:type owl:DatatypeProperty;
rdfs:domain wso:Metadata;
rdfs:range xsd:string .

wso:metadataValue
rdf:type owl:DatatypeProperty;
rdfs:domain wso:Metadata;
rdfs:range rdfs:Literal .

wso:metadataType
rdf:type owl:DatatypeProperty;
rdfs:domain wso:Metadata;
rdfs:range xsd:anyURI .

wso:hasBoundingBox
rdf:type owl:ObjectProperty;
rdfs:subPropertyOf wso:hasMetadata;
rdfs:domain wso:FeatureType;
rdfs:range wso:BoundingBox .

wso:hasAttribute
rdf:type owl:ObjectProperty;
rdfs:subPropertyOf wso:hasMetadata;
rdfs:domain wso:FeatureType;
rdfs:range wso:FeatureAttribute .

wso:hasProfile
rdf:type owl:ObjectProperty;
rdfs:subPropertyOf wso:hasMetadata;
rdfs:domain wso:FeatureType;
rdfs:range wso:FeatureProfile .

wso:hasMetadata
rdf:type owl:ObjectProperty;
rdfs:domain wso:FeatureType;
rdfs:range wso:Metadata .
```

Listing 3.3. GeoSPARQL Modifications

3.7 HTTP Ontology

The HTTP ontology (Koch et al., 2017a) intends to represent the messages sent and received from a client to a server. It describes the messages and the protocols used in the request and response from each party. As the WSDL grounding that OWL-S provides cannot be utilised with OGC Web services, the HTTP ontology is used instead by extending the *wso:OgcHttpAtomicProcessGrounding* class from WSO (see section 3.4.3).

The HTTP ontology allows the description of message passing at a concrete level which is required by OWL-S grounding. By using the HTTP ontology, the ontology can be adapted to any HTTP request. Further, its documentation states that it can be used to report test results and evaluation, hence providing a way to control Web service quality when used alongside quality assurance tools (Koch et al., 2017a). It also enables the identification of required conformance by a Web service—a precise constraint regarding the server request. The only limitations identified are privacy issues, but given that the solution proposed in this thesis uses publicly available Web services, this limitation is of no concern.

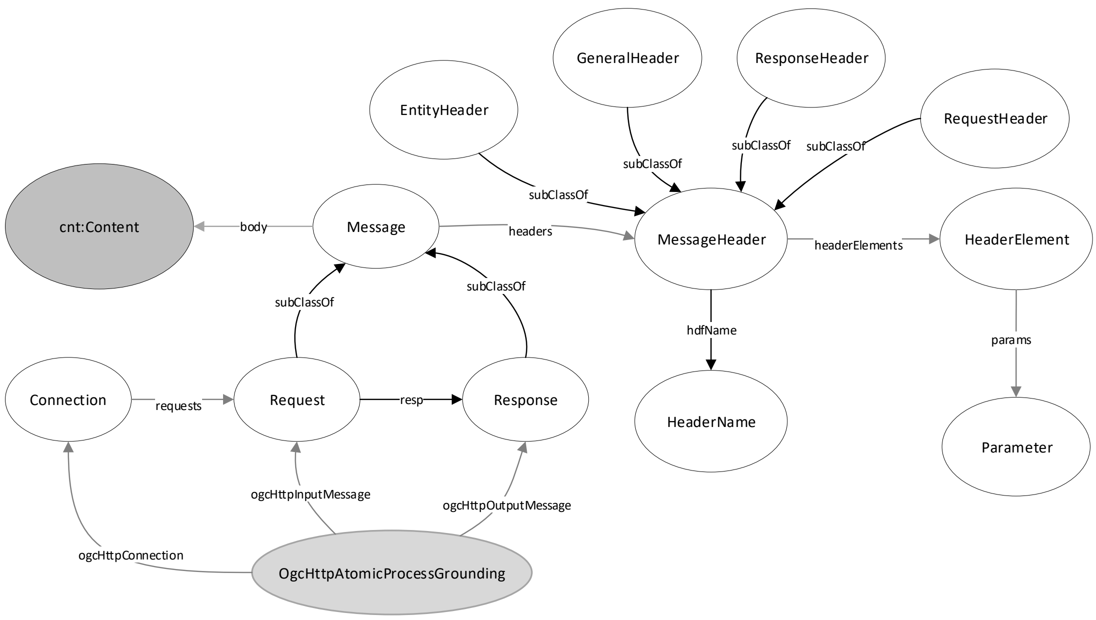


Figure 3.9: Modified HTTP Ontology

The main classes of the HTTP ontology are shown in figure 3.9 with the modifications shown in grey. The modifications include linkages between *wso:OgcHttp-AtomicProcessGrounding* to the *http:Request*, *http:Connection*, and *http:Response* classes of the ontology as explained in section 3.4.3.

The *cnt:Content* class is from the Content-in-RDF ontology (Koch, Velasco, & Ackermann, 2017b). Although in the specification of the HTTP ontology, *cnt:Content-AsBase64* is used as the range of the predicate *http:body*, the superclass *cnt:Content* was substituted instead; as it provides more flexibility, and given that geometries will be the retrieved results, it is appropriate to specify which *cnt:Content* class each of the response or request call have: *cnt:ContentAsBase64*, *cnt:ContentAsText*, or *cnt:ContentAsXML*.

The *cnt:ContentAsBase64* class is more appropriate for abstract utilisation of the HTTP ontology, but given the specifications of WSO, the request and response have different content types - *cnt:ContentAsText* and *cnt:ContentAsXML* respectively for JSON, GML, and XML. This change is shown in listing 3.4 where the predicate *wso:wfsRequestBody* is used to specify the range of *wso:WfsRequest* and *wso:WfsResponse*.

The content class can also be linked to *process:Input* and *process:Output* of the OWL-S ontology. Below are the classes that have not already been explained in previous sections in Turtle syntax.

```
wso:wfsRequestBody
rdf:type owl:ObjectProperty;
rdfs:subPropertyOf http:body;
rdfs:domain wso:WfsRequest;
rdfs:range cnt:ContentAsText .

wso:wfsResponseBody
rdf:type owl:ObjectProperty;
rdfs:subPropertyOf http:body;
rdfs:domain wso:WfsResponse;
rdfs:range cnt:ContentAsXML .
```

Listing 3.4. HTTP Ontology Modifications

3.8 Ontology Publishing

Although ontologies can be used locally, they need to be publicly available to allow other users to access and reuse them. Ontology publishing refers to making the ontology available on the Web. The usage of a persistent URI is preferable as it maintains the ontology's existence on the Web for both current and future applications.

Persistent Uniform Resource Locator (PURL), located at `https://archive.org/services/purl`, is used for this reason. PURL allows the redirection of a URL to its content. Even if the location of the ontology is changed, the redirection service that PURL offers can be changed to a new location, hence allowing the ontology to be stored in different places under the same URL.

The Web Service Ontology is available at `https://purl.org/net/wso`.

Another important aspect of ontology publishing is the use of content negotiation. Content negotiation allows the content of a website to be changed depending on the requestor. In terms of ontologies, human users will get the content in a human readable format, while machines will get it in a machine parseable format. Content negotiation has been implemented in the ontology publishing process for WSO.

3.9 Summary

A global ontology to use in the broker was developed and explained in this chapter. Its aim is to provide a unified querying platform over multiple Web services, and to enable the semantic mapping between feature types. To achieve this, the FSDF was investigated and it was deemed inappropriate for the level of abstraction required in the broker system. For this reason, an ontology engineering process was undertaken.

A hybrid approach was chosen as the type of ontology required because of its flexibility and scalability. Although the hybrid approach requires both a global ontology and local ontologies, this chapter only described the former; the latter is explained in chapter 4.

The methodology undergone in creating the ontology was explained, followed by the ontology's descriptions and characteristics. In the created ontology, four main ontologies are reused: OWL-S, HTTP, vCard, and GeoSPARQL. OWL-S enables the description of Web services, HTTP allows the modelling of message passing, vCard models business information, and GeoSPARQL describes spatial features. Using this combination of ontologies, the Web Service Ontology was developed. Despite using multiple ontologies, the Web Service Ontology (WSO) is used hereafter as an *umbrella* term to encapsulate all the ontologies explained in this chapter for succinctness.

The next step is to describe the creation of the local ontologies based on WFS, and to showcase the application of the ontology. These are explained in chapter 4 by demonstrating how WSO can be populated from existing live datasets automatically, as well as the testing of the ontology.

CHAPTER 4

AUTOMATED ONTOLOGY POPULATION

4.1 Introduction

In chapter 3, the global ontology (referred to as Web Service Ontology - WSO) used in the broker was described. Its purpose is to lay the ground-work for the querying of multiple Web services over a unified view, and to enable the reconciliation of semantic differences among datasets. This chapter follows through by describing the approaches undertaken to integrate existing Web services into WSO.

This chapter describes automatic approaches to transform the XML documents obtained from WFSs into Resource Description Framework (RDF) documents, allowing WFSs to directly interoperate with WSO. By doing so, the datasets can be linked together expressing their semantics, and can be queried using SPARQL.

First, the structure of WFSs is described and how the different components of a WFS can be described in WSO terms. Afterwards the automatic process to integrate the description of a WFS into WSO is explained, and the application of the ontology is demonstrated through the testing of WSO.

4.2 Web Feature Service

Among all operations available from a WFS, this thesis is scoped down to the three operations *GetCapabilities*, *DescribeFeatureType*, and *GetFeature*.

GetCapabilities provides an XML document which describes the operations and datasets that are served by the WFS. The feature types available and operations supported are outlined in the *GetCapabilities* XML document. *DescribeFeatureType* describes a specific feature type by stating its schema and structure. *GetFeature* returns the actual features of a feature type — its instantiations. This *GetFeature* operation allows the filtering of the features both spatially and non-spatially.

To enable the description of WFSs within WSO, the XML documents describing a WFS need to be transformed into an ontology, linked to the WSO, and stored in the broker. Although it is possible to convert all the features of a WFS to an ontology, it is not practical as all data will have to be duplicated and stored leading to scalability, duplication, and update issues. For this reason, the translation process used is only at the *GetCapabilities* and *DescribeFeatureType* level. This minimises the amount of copied data and required storage while allowing the mapping of feature types.

4.3 Mapping GetCapabilities Documents to WSO

The XML document returned from a *GetCapabilities* request is composed of the service description, capabilities, feature type list, and filter capabilities sections. Each section has their own sub-sections and metadata describing the WFS. This part of the chapter explains how the metadata from these sections and sub-sections are translated and integrated into WSO.

4.3.1 Service Description Section

The service description section of WFS contains metadata describing the service such as its name, title, abstract, keyword, URL, fees, and access constraints. The metadata that can be stored in WSO (using the OWL-S ontology) is the name and title of the service. As shown in figure 4.1, which is the OWL-S service profile and related classes from chapter 3, the name and title in the service section can be copied into the *serviceName* and *textDescription* datatype objects. As for the *ServiceCategory* class, the literal value of 'Web Feature Service' is used in this thesis because the definition of what constitutes a WFS is beyond scope.

4.3.2 Capabilities section

This section states the capabilities of a WFS. The methods available to request each operation in the WFS are described in the *Capabilities* section. It includes HTTP re-

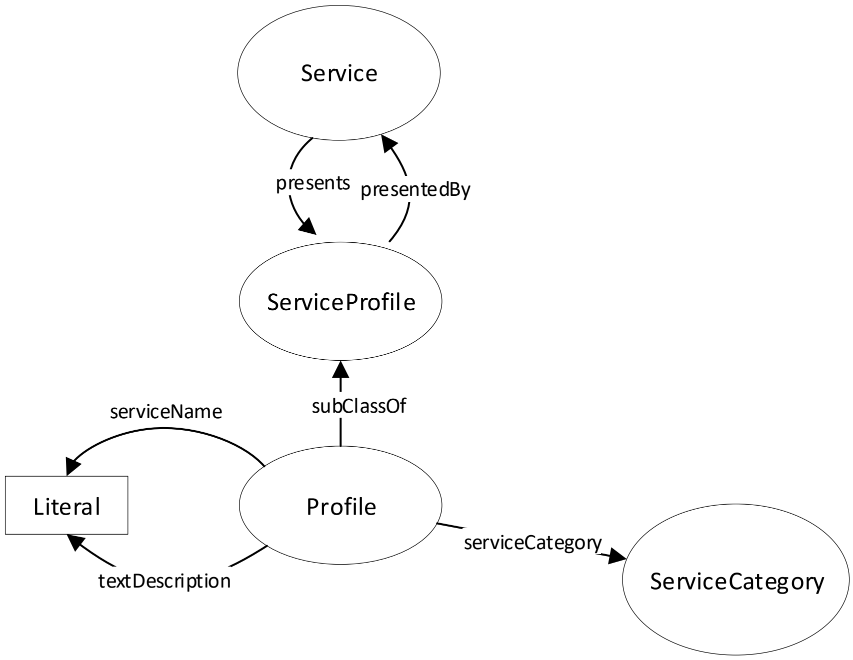


Figure 4.1: OWL-S Service Profile Entities

quest methods to call the *GetCapabilities*, *DescribeFeatureType*, and *GetFeature* operation, as well as, the formats that are available for the result of a *GetFeature* operation.

The only piece of data that is stored in WSO is the *ResultFormats*. The *ResultFormats* are the formats available when data at the feature level are returned after a *GetFeature* request; it is also known as the output format. Using this piece of information, the broker can then specify the output format for each request call, facilitating the parsing of the returned data (i.e. instead of trying to parse data whose format is yet to be determined, the broker can request an output format it supports). Further, the output format also specifies which version of GML can be used by the service. The terms used in GML2 and GML3 differ[1], and knowing in advance which version is served eliminates potential parsing errors.

Figure 4.2 demonstrates the *OutputFormat* class that was created and linked to the OWL-S ontology. For each output format served by a WFS, the *OutputFormat* class is instantiated in WSO, which allows its retrieval by the broker.

[1]The specifications for all versions of GML can be found at `http://www.opengeospatial.org/standards/gml`.

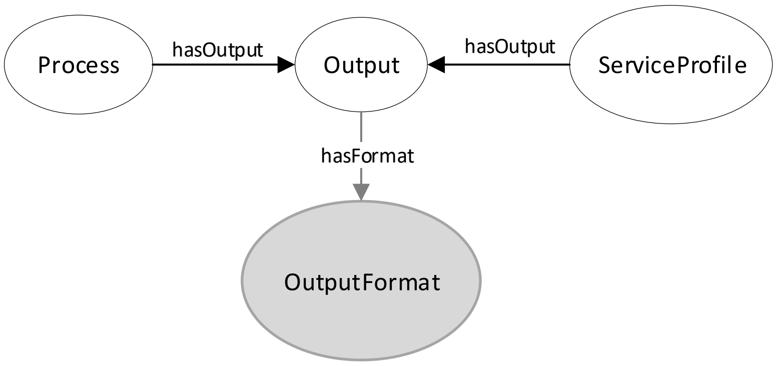


Figure 4.2: WSO Output Format Entities

4.3.3 FeatureTypeList section

The *FeatureTypeList* section in a WFS lists the feature types that the service offers. A feature type is described by, at least, its name, title, abstract, keyword, Spatial Reference System (SRS), and a bounding box. Figure 4.3 demonstrates the part of WSO that stores these values. Each feature type has a feature profile from which the metadata can be stored as literal values. Each metadata has a *metadataName*, *metadataType*, and *metadataVaue*. The bounding box class takes advantage of the *Geometry* class from the GeoSPARQL ontology, and can be stored in either WKT or GML formats.

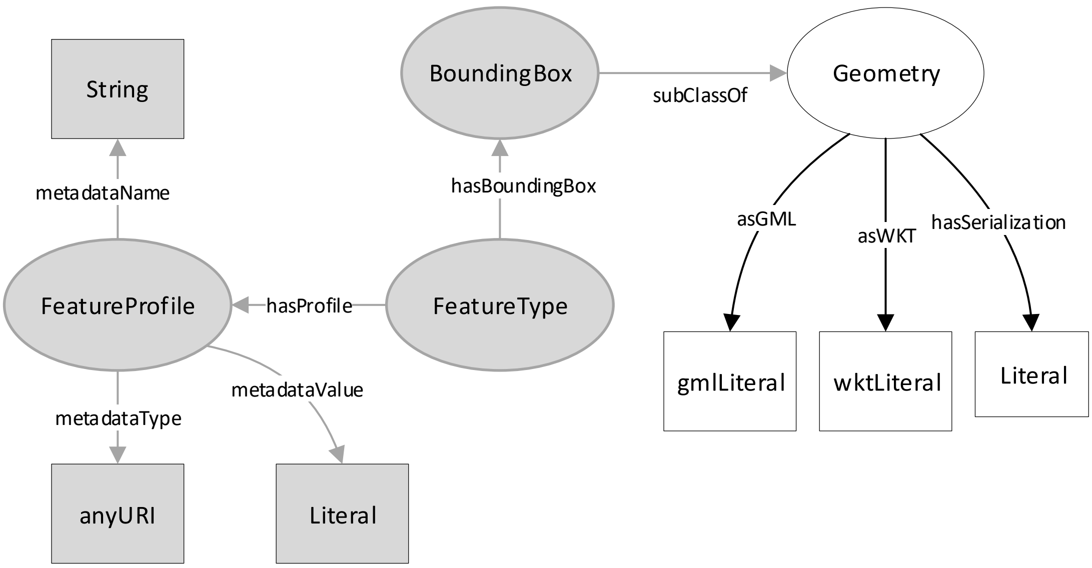


Figure 4.3: WSO Feature Profile Entities

4.3.4 Filter section

The filter capabilities section of a WFS is divided into spatial and scalar filters identifying the filter operations available in the service. Figure 4.4 shows the *Filter* class being a subclass of the *Input* class from OWL-S. The filter class is further subclassed into spatial and scalar filters. As the scalar filter can be refined further, more subclasses of the scalar class is made. The hierarchy shown mimics the one from WFS 1.0.0 (OGC, 2005).

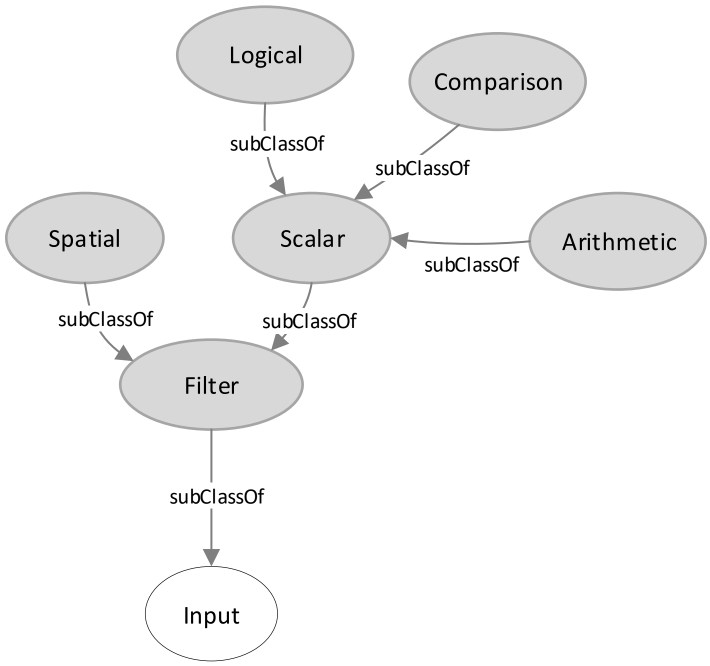


Figure 4.4: WSO Filter Entities

4.4 Mapping DescribeFeatureType Documents to WSO

The *DescribeFeatureType* operation provides the schema of a feature type. For each feature type, the XML document returned by the operation will differ. As such, to enable seamless representation of the different attributes for each different feature type, another ontology structure for *DescribeFeatureType* documents is required.

Figure 4.5 demonstrates the predicate *metadataName* and *metadataType*. The *metadataName* predicate relates to the name of the attribute, while the *metadataType* predicate relates to the type of the attribute. 'anyURI' is used as the range of the *metadataType* predicate because W3C uses existing URIs to define each XML data type. For example, for the data type 'integer', the URI referring to it is `http://`

www.w3.org/2001/XMLSchema#integer. Feature attribute is also a subclass of input, meaning that attributes can be an input in a request call.

It should be noted that the bounding box of the feature type is stored as a subclass of the geometry class from GeoSPARQL, and hence is indirectly included as part of the *FeatureAttribute* class.

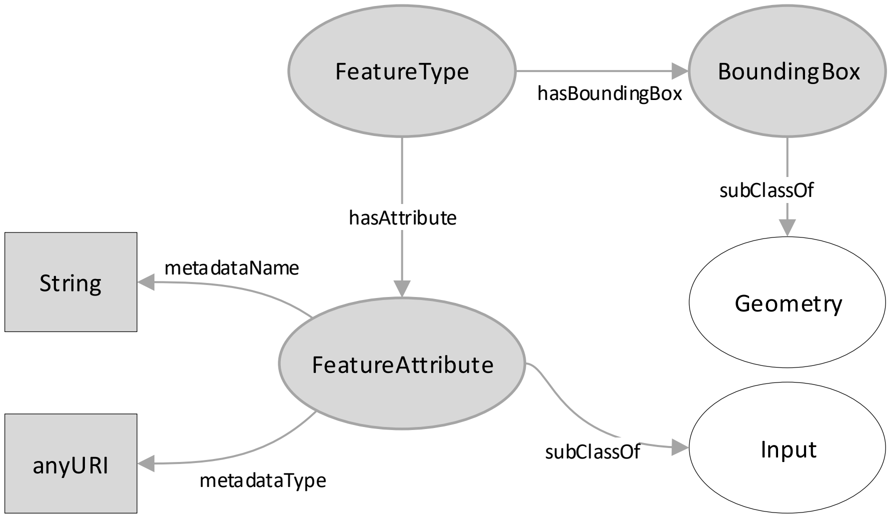


Figure 4.5: WSO Feature Attribute Entities

4.5 Automating the Transformation Process

The previous sections described how the content from the *GetCapabilities* and *DescribeFeatureType* documents maps into the ontology. This section discusses the conversion process of XML documents to RDF documents. Converting XML documents to RDF format automatically has been achieved in various disciplines (Brishniz, n.d.; García, n.d.; Incunabulum, n.d.). For this thesis, two methods were used; the first method was used with *GetCapabilities* documents, while the second method was used with *DescribeFeatureType* documents.

4.5.1 Automatic Mapping of GetCapabilities Documents to WSO

The first method to map XML documents to an ontology is an iterative process. It is used to parse through *GetCapabilities* documents and iteratively create links within WSO based on the attributes encountered. For WFS version 1.0.0, the steps in the iterative process are as follows:

1. Create an instance for the *Service* class;
2. Create a *ServiceProfile*, *ServiceGrounding*, and *ServiceModel* instances for the service class and link them to the *Service* instance;
3. Add the predicates between the *Service* instances, and the *Profile*, *Grounding*, and *Model* instances:
   (a) <Service> <presents> <Profile>;
   (b) <Service> <supports> <Grounding>;
   (c) <Service> <describedBy> <Model>;
4. Create an *OgcHttpGrounding* instance;
5. Create a vCard instance;
6. Create a category instance with *categoryName* as 'Web Feature Service' (This step can be modified to represent a more accurate representation of what a WFS is');
7. Create *OgcHttpAtomicProcessGrounding* instance, link the *OgcHttpGrounding* instance with the *hasAtomicProcessGrounding* predicate to *OgcHttpAtomicProcessGrounding* instances;
8. Iterate through the *GetCapabilities* document;
9. For each element with tag 'Service':
   (a) Find the tag 'Title', and assign its text to the corresponding *Profile*, *serviceName*, and *title* instances;
   (b) Find the tag 'Abstract', and assign its text to the corresponding *Profile*, *abstract*, and *textDescription* instances;
10. For each element with the tag 'Capability':
   (a) Find the *GetFeature* instance;
   (b) Add the *name* of the *Model* instance as the 'Capability' text;
   (c) Add an *owlsProcess* predicate from the corresponding *OgcHttpAtomicGrounding* instance to the corresponding *Model* instance;

It must be noted that the actual name of the instances does not matter, as SPARQL queries are based on the relationships between ontology entities instead of their names. The full Python code for the iterative *GetCapabilities* document mapping is provided in appendix C.1.

4.5.2 Automatic Mapping of DescribeFeatureType Documents to WSO

There are multiple ways to transform an XML document to another form, but the one used in this section is through the eXtensible Stylesheet Language Transformations (XSLT) language. XSLT is highly customisable and enables the transformation of an XML Schema to RDF without needing any human assistance; XML Schemas use a standardised vocabulary known as XML Schema Definitions (XSD).

The XSLT developed is utilised to automatically map the XML schema of a feature type (obtained with the *DescribeFeatureType* operation) to WSO. The XSLT steps to transform the *DescribeFeatureType* document into the WSO are:

1. For each XSD *targetNamespace*, convert them to RDF namespaces;
2. For each XSD *complexType*, convert them to an OWL Class;
3. For each XSD *extension* within an XSD complexType, convert the class to a subclass of the extension;
4. For each *sequence* within an XSD *complexType*, convert them to a subclass of owl:Restriction;
5. For each XSD *element* within an XSD *sequence*, convert them to an owl:onProperty class with the rdf:resource being the base URL of the element plus the element's name;
6. For each *minOccurs* within the xsd:element, convert them to owl:minCardinality;
7. For each *maxOccurs* within the xsd:element, convert them to owl:maxCardinality; and
8. For each *type* within the xsd:element, convert them to an owl:Datatype with the rdfs:range being the xsd:type and the rdfs:domain being the owl:Class;

Following these mapping guidelines, RDF files are automatically generated from the XML documents obtained from *DescribeFeatureType* documents. The RDF file for each feature type can then be linked into the broker's ontology. The full XSLT script can be found in appendix B.1.

4.6 Application of WSO

The ontology has been populated from live WFS from:

1. Landgate:
   `https://www2.landgate.wa.gov.au/ows/wfspublic_4283/wfs?SERV\-ICE=WFS&REQUEST=getcapabilities`;
2. DELWP:
   `http://services.land.vic.gov.au/catalogue/publicproxy/guest/dv_geoserver/wfs?request=getCapabilities`; and
3. LINZ:
   `https://data.linz.govt.nz/services;key=<your_api_key>/wfs/?request=getCapabilities`[2].

WSO was automatically populated from these three WFS using the two methods described above. To demonstrate the capabilities of the ontology developed, this section provides preliminary queries and the results obtained from the ontology.

4.6.1 Ontology Testing

There are multiple categories of ontology testing (Brank, Grobelnik, & Mladenić, 2005; Hlomani & Stacey, 2014):

1. The comparison to a 'golden standard', which involves comparing the ontology to a 'gold standard' which can be another ontology;

[2] <your_api_key> refers to the API key required to access the WFS from LINZ. More information can be obtained at `https://www.linz.govt.nz/data/linz-data-service/guides-and-documentation/creating-an-api-key` (Retrieved February 20,2018).

2. Application- or task-based testing, which tests the efficiency of an ontology in relation to a task or use case;

3. User-based testing, which makes use of user experience to test the ontology; and

4. Data-driven testing, which compares the ontology to existing data in the same domain as the ontology.

For this thesis, application-based evaluation is utilised. The 'golden standard' comparison is not needed as W3C recommended ontologies have been reused, which have already undergone community driven evaluations and acceptance. User-based testing was not achieved due to resource limitations to properly deploy a system that can be freely tested by users. Data-driven testing was not explored as the large amount of data dealt with are outside of our control and hence controlled data-based evaluation would be a challenge.

Further, the developed ontology is not a solution of its own but rather part of a broker solution. As such, it is reasonable to evaluate the ontology as part of an application. However, Brank et al. (2005) mentions that it is more practical to evaluate an ontology at different levels separately rather than evaluating it as a whole. These different levels are: hierarchy or taxonomy, other semantic relations, context or application level, syntactic level, and structure level. Most of these levels are unnecessary due to the heavy reuse of existing ontologies, but a preliminary testing is executed.

Grüninger et al. (1995) mentions that preliminary queries can be used during the development of an ontology as an initial evaluation for its purpose. To observe whether these queries can be answered by the ontology, we executed sample queries against the ontology and recorded the results. This preliminary testing is not meant to be exhaustive but rather to observe whether the ontology can answer basic but necessary queries for the proper functioning of the broker.

For a whole application-based evaluation of the ontology alongside the broker system, see chapter 8 .

For this section, a SPARQL query for each query is provided alongside the results obtained after populating the ontology with the three Web services mentioned earlier. The ontology was loaded in and queried from Stardog (Stardog

Union, 2018), a knowledge graph platform. Stardog was used due to its fast querying time, and its limited but functional implementation of GeoSPARQL. While Jena (The Apache Software Foundation, 2017) could be used as well, Stardog was found to be easier to setup and use.

Listing 4.1 provides the prefixes and URIs for the ontologies used in testing WSO.

```
wso: <http://www.purl.org/net/wso#>
service: <http://www.daml.org/services/owl-s/1.2/Service.owl#>
profile: <http://www.daml.org/services/owl-s/1.2/Profile.owl#>
process: <http://www.daml.org/services/owl-s/1.2/Process.owl#>
grounding: <http://www.daml.org/services/owl-s/1.2/Grounding.
    owl#>
vcd: <http://www.w3.org/2006/vcard/ns#>
http: <http://www.w3.org/2011/http#>
geo: <http://www.opengis.net/ont/geosparql#>
cnt: <http://www.w3.org/2011/content#>
```

Listing 4.1. Prefixes used in WSO

With the prefixes identified, the following section outlines the query and the results obtained.

What available WFSs are there?

This query allows the user to find the WFSs that are linked within the ontology. The WFSs can be discovered automatically using a Web crawler (Li, Yang, & Yang, 2010; Patil, Bhattacharjee, & Ghosh, 2014) and then added to the ontology. By using this query, the user can discover existing Web services that can be queried. A SPARQL query to achieve this is:

```
SELECT DISTINCT ?service_name
WHERE {
  ?wfs_service service:presents ?wfs_profile .
  ?wfs_profile profile:serviceCategory ?service_cat .
  ?service_cat profile:categoryName ?cat_name .
  ?wfs_profile profile:serviceName ?service_name .
  FILTER(?cat_name = "Web Feature Service")
}
```

This query finds all the feature services whose *category* predicate from their *ServiceProfile* equates to the string 'Web Feature Service'. If it matches that filter, then the service node and its name are returned.

This particular filter can be modified based on the user's specific needs. A simple string matching method is used here to identify a WFS. The results of the query are shown in table 4.1 (SLIP is the name of the platform that Landgate uses).

service_name
DELWP Web Feature Service
LINZ Data Service
SLIP Public Web Feature Service - EPSG 4283

Table 4.1: Get WFS Results

What feature types does a particular WFS offer?

This question is aimed at finding the feature types that are available for a specific WFS. The SPARQL query is:

```
SELECT DISTINCT ?service_name ?input_value
WHERE {
  ?wfs_service service:presents ?wfs_profile .
  ?wfs_profile profile:serviceCategory ?service_cat .
  ?service_cat profile:categoryName ?cat_name .
  ?wfs_profile profile:serviceName ?service_name .
  ?wfs_profile profile:hasInput ?input .
  ?input a wso:FeatureType .
  ?input wso:hasProfile ?profile .
  ?profile wso:metadataName ?input_name .
  ?profile wso:metadataValue ?input_value .
  FILTER(
    ?input_name = "Name"
    && ?cat_name = "Web Feature Service"
    && regex(str(?service_name), "DELWP ")
  )
}
```

This query retrieves a service whose category is a WFS, and the service name containing the string 'DELWP'. It then retrieves all nodes linked by the *hasInput* predicate, and checks if they are from the type *wso:FeatureType*. A summary of the results are shown in table 4.2. For the full results, see appendix D.1.

service_name	**input_value**
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_1_2
DELWP Web Feature Service	datavic:MINERALS_RRREGO100_POLYGON
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EXTENT

Table 4.2: Get Feature from DELWP Results

The query is general, and more filters can be applied depending on the attributes for different feature types by using the *metadataName* or *metadataValue* of the feature type. An example of a more complex query is shown next.

What feature types have a similar string in their attribute names?

This query allows for the filtering of feature types specific to their attributes. It allows a federated search over all the WFSs in the ontology, and returns only feature types that match that particular filter. Below shows the SPARQL query:

```
SELECT ?service_name ?input_value
WHERE {
    ?wfs_service service:presents ?wfs_profile .
    ?wfs_profile profile:serviceCategory ?service_cat .
    ?service_cat profile:categoryName ?cat_name .
    ?wfs_profile profile:serviceName ?service_name .
    ?wfs_profile profile:hasInput ?input .
    ?input a wso:FeatureType .
    ?input wso:hasProfile ?profile .
    ?profile wso:metadataName ?input_name .
    ?profile wso:metadataValue ?input_value .
    FILTER regex(str(?input_value), '^.water.$', 'i')
}
```

The query retrieves feature types whose attribute 'name' has the substring 'water' in them. It uses a filter on a regular expression (regex), and thus can be modified for more complex and specific strings. A summary of the results of the query is given in table 4.3. For the full results, see appendix D.2.

service_name	input_value
DELWP Web Feature Service	ANZVI0803004341, **WATER** surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:**WATER**_BFI_UNREG_RIVERS_1889_2012
DELWP Web Feature Service	ANZVI0803004904, GEOSCIENCES Hydrogeology, **WATER** Surface, **WATER** Rivers
SLIP Public Web Feature Service - EPSG 4283	**Water** Meter (WCORP-006)
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - **Water** Repellence (DAFWA-015)
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - **Water** Erosion (DAFWA-014)
LINZ Data Service	**Water** turbulence polygons (Hydro, 1:4k - 1:22k))
LINZ Data Service	Under**water**/awash rock points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Tokelau Break**water** Centrelines (Topo, 1:25k)

Table 4.3: Results of SPARQL Regex Filter

What filters does a particular WFS offer?

The aim of this question is to find out the different filters that a specific WFS offers. A reason for such a query is if a user requires a specific filter to be present in a WFS. This query can be combined with the above query to process both features and filters at the same time (i.e. retrieving a WFS which offers a specific feature and a specific filter), and more specific filters can be added to the SPARQL query to retrieve more specific WFSs. The SPARQL query is:

```
SELECT DISTINCT ?service_name ?filter_label
WHERE {
    ?wfs_profile a profile:Profile .
    ?wfs_profile profile:serviceName ?service_name .
    ?wfs_profile profile:hasInput ?filter .
    ?filter a wso:Filter .
    ?filter rdfs:label ?filter_label .
    FILTER (regex(str(?service_name), "LINZ "))
}
```

This query retrieves a service name that includes the string ‘LINZ’. It then retrieves all nodes linked by the *hasInput* predicate, and checks if they are of the type *wso:Filter*.

Table 4.4 shows the results of the query.

service_name	filter_label
LINZ Data Service	Between
LINZ Data Service	Beyond
LINZ Data Service	Contains
LINZ Data Service	Crosses
LINZ Data Service	DWithin
LINZ Data Service	Disjoint
LINZ Data Service	Equals
LINZ Data Service	Intersect
LINZ Data Service	Like
LINZ Data Service	NullCheck
LINZ Data Service	Overlaps
LINZ Data Service	Simple_Comparisons
LINZ Data Service	Touches
LINZ Data Service	Within

Table 4.4: Get Filters from LINZ Results

Which WFS allow a specific filter?

This query is the reverse of the previous query, it allows the user to discover which WFS offer a particular filter. Below, the filter 'Within' is used as an example.

```
SELECT DISTINCT ?service_name ?filter_label
WHERE {
  ?wfs_profile a profile:Profile .
  ?wfs_profile profile:serviceName ?service_name .
  ?wfs_profile profile:hasInput ?filter .
  ?filter a wso:Filter .
  ?filter rdfs:label ?filter_label .
  FILTER (?filter_label = 'Within')
}
```

It queries for the service name of a filter class that has the label 'Within'. The results for such a query are shown in table 4.5.

service_name	filter_label
LINZ Data Service	Within
DELWP Web Feature Service	Within
SLIP Public Web Feature Service - EPSG 4283	Within

Table 4.5: WFS with 'Within' Filter

How to make a request call to the services?

This query is important for a more varied usage of the ontology. Even though this thesis ony covers WFS, it can be used for other OGC Web Services such as WMS, and WCS. This query enables a user to find out which methods can be used to request a Web service. The SPARQL is:

```
SELECT ?service_name ?method_resource ?uri
WHERE {
  ?profile service:presentedBy ?wfs_service .
  ?profile profile:serviceName ?service_name .
  ?wfs_service service:supports ?grounding.
  ?grounding grounding:hasAtomicProcessGrounding ?
     atomic_process .
  ?atomic_process wso:ogcHttpInputMessage ?request .
  ?request http:requestURI ?uri .
  ?request http:mthd ?method .
  ?method rdf:resource ?method_resource
}
```

The query asks for the *grounding* of all services present in the ontology. It fetches the URI of the service end-point as well as the methods available to query them, which is another ontology. The results are displayed in table 4.6.

service_name	method_resource	uri
LINZ Data Service	http://www.w3.org/2011/http-methods#GET	https://data.linz.govt.nz/services/wfs?request=GetFeature
DELWP Web Feature Service	http://www.w3.org/2011/http-methods#GET	http://services.land.vic.gov.au/catalogue/publicproxy/guest/dv_geoserver/datavic/wfs?request=GetFeature
SLIP Public Web Feature Service - EPSG 4283	http://www.w3.org/2011/http-methods#GET	http://www2.landgate.wa.gov.au/ows/wfspublic_4283/wfs?request=GetFeature
LINZ Data Service	http://www.w3.org/2011/http-methods#POST	https://data.linz.govt.nz/services/wfs
DELWP Web Feature Service	http://www.w3.org/2011/http-methods#POST	http://services.land.vic.gov.au/catalogue/publicproxy/guest/dv_geoserver/datavic/wfs
SLIP Public Web Feature Service - EPSG 4283	http://www.w3.org/2011/http-methods#POST	http://www2.landgate.wa.gov.au/ows/wfspublic_4283/wfs?

Table 4.6: Get Request Call Results

What are the metadata describing a specific feature type?

This query allows a user to find specific metadata related to each feature type from multiple WFS. The filter can be more detailed and specific to the user's needs, returning only feature types with metadata that the user wants. The SPARQL query is shown below:

```
SELECT DISTINCT ?service_name ?name_value ?metadata_name
WHERE {
    ?wfs_profile profile:serviceName ?service_name .
    ?wfs_profile profile:hasInput ?feature_type .
    ?feature_type a wso:FeatureType .
    ?feature_type wso:hasProfile ?profile .
    ?profile wso:metadataName ?name.
    ?profile wso:metadataValue ?name_value .
    ?feature_type wso:hasAttribute ?attribute .
    ?attribute wso:metadataName ?metadata_name .
    FILTER (?name = 'Title' && regex(str(?input_value), '^.
       water.$', 'i'))
}
```

The SPARQL query looks for a *wso:FeatureType* associated with a profile and attributes. It then looks for its attributes, and returns them to the user. Each of these metadata can be further processed and filtered based on the user's needs. In the example, the feature type queried has to contain the word 'water' in its title. Three results from each WFS are shown in table 4.7. See appendix D.3 for the whole result set.

service_name	name_value	metadata_name
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	nobjnm
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Irrigation Districts (HARWA-002)	shape_area
SLIP Public Web Feature Service - EPSG 4283	Water Meter (WCORP-006)	gid
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	enabled

Table 4.7: Results of Feature Type Attributes

Which feature types are located within a certain bounding box?

This query demonstrates a spatial operation applied on the ontology. Only feature types that match the spatial filter will be returned to the user. The query will thus show all feature types from multiple WFSs that match a particular spatial filter — in this instance a 'within' filter. This operation only covers the bounding boxes of the feature types because the features themselves are not stored in the ontology. Filtering of the geometry instances is achieved during the WFS request in chapter 8. The SPARQL for this query is:

```
SELECT DISTINCT ?service_name ?name_value
WHERE {
  ?wfs_profile profile:serviceName ?service_name .
  ?wfs_profile profile:hasInput ?feature_type .
  ?feature_type a wso:FeatureType .
  ?feature_type wso:hasProfile ?profile .
  ?profile wso:metadataName ?name.
  ?profile wso:metadataValue ?name_value .
  ?feature_type wso:hasBoundingBox ?bbox .
  FILTER (
  ?name = 'Title'
  && geof:within(?bbox, "POLYGON((135.050165 -53.808896,
      135.456819 -27.608735 , 179.610019 -30.049612,
      179.858945 -50.031488, 135.050165 -53.808896))"^^
      geo:wktLiteral)
  )
}
```

The query looks for subclasses of *wso:FeatureType* and finds their bounding box. It then uses the GeoSPARQL filter to find the bounding boxes that fall within the specified polygon. Three results from each WFS are shown in table 4.8 while the full result set can be found in appendix D.4. For this query, the bounding box is big enough to encompass both DELWP and LINZ, and as such feature types from Landgate are not returned from the query.

4.7 Summary

This chapter has described two methods for the automatic population of WSO which was developed in chapter 3. It was explained that *GetFeature* documents are not

service_name	name_value
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA
DELWP Web Feature Service	Permian Geological Basement, Goulburn-Murray Area
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Antipodes Island Descriptive Texts (Topo, 1:25k)
LINZ Data Service	NZ Cemetery Polygons (Topo, 1:50k)

Table 4.8: Get Feature Type in Bounding Box Results

used because feature instances are not stored in the broker. However, *GetCapabilities* and *DescribeFeatureType* documents are processed and transformed into RDF using an iterative parsing method and an XSLT script respectively.

This chapter explained how the different components of WFS documents are integrated into WSO. Afterwards, a preliminary testing of the ontology was undertaken. The testing involved querying WSO for critical pieces of information that are required for its proper functioning in the broker system. This was necessary to make sure that the developed ontology could be used as a unified querying view over the different WFSs.

CHAPTER 5

THE MATCHING OF SIMILAR FEATURE LAYERS

5.1 Introduction

This chapter investigates some methods to determine which feature types are semantically similar. This process is required to facilitate the matching of heterogeneous feature types within the broker; it enables the removal of redundant feature types (those that have no match) while making sure that needed ones are properly matched. The contribution of this chapter includes the comparison of different feature types using a variety of non-spatial techniques including a topic modelling technique called Latent Dirichlet Allocation (LDA). As far as we are aware of, LDA has never been used with spatial data, and hence this chapter presents the first findings of analysing spatial data with LDA.

Chapters 3 and 4 described the Web Service Ontology (WSO) used in the broker, which serves as a unified querying platform and a model to semantically describe WFS at the *GetCapabilities* and *DescribeFeatureType* levels. After the feature types from WFS are added to WSO, WSO can be semantic enriched. This process is generally best achieved manually but it is time consuming and resource intensive. Hence, the methods investigated in this chapter are to facilitate this manual process.

This chapter begins by analysing the WFS architecture to identify components that can depict the relatedness of feature layers. Then, this chapter explains and justifies the methods to be investigated. Afterwards, the methods are applied, evaluated, and the results are compared.

5.2 Feature Layer Representation in a WFS Architecture

To compare feature layers, the components of their description need to be investigated. In a WFS, information about a feature layer can be retrieved with the *GetCapabilities*, and *DescribeFeatureType* operations. The *GetCapabilities* operation returns generic details such as a layer's title, keywords, abstract, Spatial Reference System (SRS), and bounding box, while the *DescribeFeatureType* operation returns details regarding a feature layer's attributes specific to that layer such as the height of an elevation point or the address of a house.

5.2.1 Metadata in a GetCapabilities Document

For this thesis, from the metadata of a *GetCapabilities* document, only the title of feature types is used for their comparison. SRSs do not need to be compared because different SRSs can be transformed to a common one. As for the bounding box, it does not indicate whether two feature types are similar because feature types can often be geographically disparate, and similar feature types can have different bounding boxes (e.g. the feature type 'contour lines' will inherently have different bounding boxes).

From the other metadata available—name, title, abstract, and keyword—title was found to be more descriptive of the feature layer. However, this is based on the datasets used in this thesis and it is acknowledged that the description of the metadata can differ depending on the Web service. Nonetheless, in this chapter, title is used because the name, abstract, and keywords do not provide much information about a feature layer, while the metadata title provides a more understandable description of the layer's purpose. This can be observed in listings 5.1, 5.2, and 5.3.

In all three listings, the name refers to the feature layer as used by the data provider which is not useful outside the scope of the Web service. The abstract of the feature types differs, with Landgate providing information on how the WFS was generated, LINZ providing a proper definition of the feature type, while DELWP does not provide any abstract. For the keywords metadata, Landgate gives the same information as in the name, but LINZ and DELWP provides information related to the feature type showing inconsistency. The SRS and bounding box metadata give the expected information in all three data providers which, as discussed previously, is not indicative of how similar two feature types are.

```
<FeatureType>
  <Name>slip:DER-007</Name>
  <Title>2003-2005 ASS Site Evaluation (DER-007)</Title>
  <Abstract>Generated from postgis database</Abstract>
  <Keywords>der_007 DER</Keywords>
  <SRS>EPSG:4283</SRS>
  <LatLongBoundingBox minx="114.68" miny="-35.36" maxx="118.7" maxy="-31.7"/>
</FeatureType>
```

Listing 5.1. GetCapabilities Snippet from Landgate

```
<FeatureType>
  <Name>data.linz.govt.nz:layer-50845</Name>
  <Title>12 Mile Territorial Sea Limit Basepoints</Title>
  <Abstract>
    New Zealand Territorial Seas The territorial sea is the belt of sea adjacent to the coast out to a distance of 12 nautical miles from prescribed baselines over which New Zealand, as the coastal state, has the same rights of sovereignty that it exercises over its land territory subject to the right of innocent passage (and transit passage through any straits used for international navigation) of ships of other states. 'Innocent passage' excludes fishing activities. Maritime Boundary Definitions: http://www.linz.govt.nz/hydro/nautical-info/maritime-boundaries/definitions#zones Further References: http://www.linz.govt.nz/hydro/nautical-info/maritime-boundaries License: Creative Commons Attribution 3.0 New Zealand - http://data.linz.govt.nz/license/attribution-3-0-new-zealand/ More Information: http://data.linz.govt.nz/layer/50845-12-mile-territorial-sea-limit-basepoints/
  </Abstract>
  <Keywords>
    New Zealand, Hydrographic & Maritime, Maritime Boundaries
  </Keywords>
  <SRS>EPSG:4326</SRS>
  <LatLongBoundingBox minx="165.868611111" miny="-52.621666667" maxx="184.181666667" maxy="-29.230838889"/>
</FeatureType>
```

Listing 5.2. GetCapabilities Snippet from LINZ

```
<FeatureType>
  <Name>datavic:WATER_ISC2010_BANKFULL_WIDTH_R</Name>
```

```
  <Title>
    2010 Index of Stream Condition - Bank Full Width Reach polygon
        features
  </Title>
  <Abstract/>
  <Keywords>
    ANZVI0803005112, WATER Rivers, ISC, LiDAR, PHYSICAL FORM,
        RIPARIAN, ELEVATION
  </Keywords>
  <SRS>EPSG:4283</SRS>
  <LatLongBoundingBox minx="140.888196123417" miny="
      -39.032198371076845" maxx="149.796963189816" maxy="
      -33.97378749712523"/>
</FeatureType>
```

Listing 5.3. GetCapabilities Snippet from DELWP

Among these examples, the most consistent and indicative attribute is the title, which provides definite details about the nature of the feature types. Although the naming convention for generating the title differs, the title can be tokenised and its parts analysed for similarity. This chapter explores this possibility. However, a more direct and useful comparison of feature types could be achieved if the metadata provided were more consistent and standardised. A simple way to achieve a standardised description of feature types is to describe them based on a word dictionary.

5.2.2 Metadata in a DescribeFeatureType Document

The information from a *DescribeFeatureType* document vary depending on the feature type chosen and it represents a list of XML elements that are attributed to the chosen feature type. These elements have a name, a type and other specifications such as their cardinalities and whether they can have a null value.

Listing 5.4, 5.5, 5.6 show snippets of the *DescribeFeatureType* documents of arbitrary layers from Landgate, DELWP, and LINZ respectively. In listings 5.5 and 5.6, DELWP and LINZ, have simple data types for all their attributes. Landgate, on the other hand, added a restriction on the data type for ‘postcode’ and ‘name’ (lines 14-21 in listing 5.4).

This type of variation does not provide any insight in regards to the relatedness of the attributes as they are simply restrictions added onto a basic data type. These variations can also be omitted as in DELWP and LINZ without affecting the significance of the attributes. As such, this chapter does not consider the structure of an XML schema from a *DescribeFeatureType* document to be significant in finding the relatedness between feature types.

```
<xs:schema xmlns:slip="http://www.openplans.org/slip" xmlns:gml="http://www.opengis.net/gml" xmlns:xs="http://www.w3.org/2001/XMLSchema" targetNamespace="http://www.openplans.org/slip" elementFormDefault="qualified" attributeFormDefault="unqualified" version="1.0">
  <xs:import namespace="http://www.opengis.net/gml" schemaLocation="http://www2.landgate.wa.gov.au/ows/wfspublic_4283/schemas/gml/2.1.2.1/feature.xsd"/>
  <xs:complexType xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns="http://www.w3.org/2001/XMLSchema" name="LGATE-069_Type">
  <xs:complexContent>
    <xs:extension base="gml:AbstractFeatureType">
      <xs:sequence>
        <xs:element name="ogc_fid" minOccurs="0" nillable="true" type="xs:int"/>
        <xs:element name="land_id_number" minOccurs="0" nillable="true" type="xs:int"/>
        <xs:element name="usage_code" minOccurs="0" nillable="true" type="xs:int"/>
        <xs:element name="postcode" minOccurs="0" nillable="true">
        <xs:simpleType>
        <xs:restriction base="xs:string">
        <xs:maxLength value="2147483647"/>
        </xs:restriction>
        </xs:simpleType>
        </xs:element>
          <xs:element name="name" minOccurs="0" nillable="true">
          <xs:simpleType>
            <xs:restriction base="xs:string">
              <xs:maxLength value="2147483647"/>
            </xs:restriction>
          </xs:simpleType>
        </xs:element>
        <xs:element name="row_id" minOccurs="0" nillable="true" type="xs:int"/>
        <xs:element name="the_geom" minOccurs="0" nillable="true" type="gml:MultiPolygonPropertyType"/>
      </xs:sequence>
    </xs:extension>
```

```
    </xs:complexContent>
    </xs:complexType>
    <xs:element name="LGATE-069" type="slip:LGATE-069_Type" substitutionGroup="gml:_Feature"/>
</xs:schema>
```

Listing 5.4. DescribeFeatureType Snippet from Landgate

```
<xsd:schema xmlns:datavic="http://land.vic.gov.au/datavic" xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:wfs="http://www.opengis.net/wfs/2.0" xmlns:xsd="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified" targetNamespace="http://land.vic.gov.au/datavic">
  <xsd:import namespace="http://www.opengis.net/gml/3.2" schemaLocation="http://services.land.vic.gov.au/catalogue/publicproxy/guest/dv_geoserver/schemas/gml/3.2.1/gml.xsd"/>
  <xsd:complexType name="VMADMIN_DELWP_REGIONType">
    <xsd:complexContent>
      <xsd:extension base="gml:AbstractFeatureType">
        <xsd:sequence>
          <xsd:element maxOccurs="1" minOccurs="0" name="DELWP_REGION_CODE" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="DELWP_REGION" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="UFI_CREATED" nillable="true" type="xsd:date"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="OBJECTID" nillable="true" type="xsd:decimal"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="SHAPE" nillable="true" type="gml:MultiSurfacePropertyType"/>
        </xsd:sequence>
      </xsd:extension>
    </xsd:complexContent>
  </xsd:complexType>
  <xsd:element name="VMADMIN_DELWP_REGION" substitutionGroup="gml:AbstractFeature" type="datavic:VMADMIN_DELWP_REGIONType"/>
</xsd:schema>
```

Listing 5.5. DescribeFeatureType Snippet from DELWP

```
<xsd:schema xmlns:data.linz.govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:wfs="http://www.opengis.net/wfs/2.0" xmlns:xsd="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified" targetNamespace="http://data.linz.govt.nz">
```

```
2   <xsd:import namespace="http://www.opengis.net/gml/3.2"
        schemaLocation="https://data.linz.govt.nz/services;key=41
        b3c3b90c0247b587f512e1a4741498/schemas/gml/3.2.1/gml.xsd"/>
3   <xsd:complexType name="layer-52273Type">
4   <xsd:complexContent>
5     <xsd:extension base="gml:AbstractFeatureType">
6       <xsd:sequence>
7         <xsd:element maxOccurs="1" minOccurs="0" name="UFID"
              nillable="true" type="xsd:double"/>
8         <xsd:element maxOccurs="1" minOccurs="0" name="name_ascii"
              nillable="true" type="xsd:string"/>
9         <xsd:element maxOccurs="1" minOccurs="0" name="macronated"
              nillable="true" type="xsd:string"/>
10        <xsd:element maxOccurs="1" minOccurs="0" name="name"
              nillable="true" type="xsd:string"/>
11        <xsd:element maxOccurs="1" minOccurs="0" name="GEOMETRY"
              nillable="true" type="gml:SurfacePropertyType"/>
12      </xsd:sequence>
13    </xsd:extension>
14  </xsd:complexContent>
15  </xsd:complexType>
16  <xsd:element name="layer-52273" substitutionGroup="gml:
        AbstractFeature" type="data.linz.govt.nz:layer-52273Type"/>
17 </xsd:schema>
```

Listing 5.6. DescribeFeatureType Snippet from LINZ

Other notable differences are the naming conventions used. Landgate uses the 'under_score' naming convention (listing 5.4), while DELWP combines it with 'ALL_CAPS' (listing 5.5), and LINZ (listing 5.6) uses a mixture of them with 'UFID' being all caps (line 7), and 'name_ascii' (line 8) using an underscore.

Although strings using the underscore convention can be tokenised with the underscore as a separator, it is a much harder task for naming conventions without any explicit separator such as all caps. An example is in listing 5.5 where 'OBJECTID' (line 10) does not have any distinct separator. For these types of naming conventions, techniques such as n-grams (Damashek, 1995), which divide the strings into n tokens and compare them to one another, can be used but are computationally expensive.

Apart from the element's name, the other data available are the data types with 'int', 'date', 'decimal' and 'string' being the most common ones. Although it seems simple to compare one data type to another, the nature of a data type is complex. Take for instance a phone number. A phone number can be computationally represented as a number (e.g. 0498 219 084), but can also be a string (e.g. '0498 219 084'). Computationally these two terms are different; one is a number that can be algorithmically processed, and the other is a string similar to letters. Reasons for using strings instead of numbers in this instance is the usage of international phone numbers. As the '+' sign required for international calls cannot be represented in number format, it follows the data type string needs to be used. Data types can become more complex when using dates and decimal numbers. Dates can be represented as strings (e.g. '03 March 2017'), as numbers (e.g. 03032017), and as a date format (e.g. 'UFI_CREATED' in listing 5.5).

Differences for decimal numbers can be observed in listings 5.5, and 5.6 where 'OBJECTID' has the data type 'xsd:decimal', but 'UFID' has the data type 'xsd:double'. Due to this fluid nature of data types, this thesis does not consider them when attempting to find the relatedness of feature types. Instead, the data types associated with each metadata are stored in the broker's ontology using the URI of the data type as explained in section 4.4.

As neither the name nor the data type of an attribute are considered, a different approach is investigated—data dictionaries. Data dictionaries are human-readable documents that describe the purpose of XML elements in natural language. Using a data dictionary, the attributes can be compared from their description and a feature layer can then be described by the sum of its attributes' description.

Feature layers can then be compared to one another from their descriptions based on their data dictionary. The one drawback is that data dictionaries are often kept in Portable Document Format (PDF), which is not easily parsed by machines. To remedy this and allow the automated comparison of the description of feature layers, the data dictionaries were manually converted to a structured format in this chapter. However, this manual conversion is not practical in any system because human intervention is relied on; to make full use of data dictionaries, it is proposed that they should be made available in a machine-readable format such as JSON or XML.

Thus far, the two metadata considered to find similar feature types are their titles and their data dictionary-based descriptions.

5.3 Comparing the Titles

Titles of a feature type are words that express its purpose. To compare the titles and find their similarity, a similar approach as used by Giunchiglia and Yatskevich (2004) is employed. They find the similarity between nodes of a graph by using a series of matchers that are executed in the order of their approximation level. The matchers used are categorised as string-based, sense-based, and gloss-based. In this section, the titles of feature types are compared using sense-based matching techniques first, followed by string-based matching techniques. Gloss-based techniques are utilised afterwards when comparing the data dictionaries of the feature layers' metadata.

The sense-based matching techniques (also referred to as semantic matching techniques in this thesis) are attempted first as they provide the better approximation level according to Giunchiglia and Yatskevich (2004). To use a sense-based matching technique, a synset-based corpus (a corpus composed of sets of synonyms) is required. For this thesis, a Wordnet (Princeton University, 2018) library available in Python is used. It allows the utilisation of four similarity measures: WUP, LCH, JCN, and LIN.

WUP is the Wu-Palmer similarity (Wu & Palmer, 1994) which is based on the depth of the taxonomy used and the Least Common Subsumer (LCS) of the words being compared. The Leacock and Chodorow (LCH) measure (Leacock & Chodorow, 1998) uses the distance between 'is-a' relationships between two words, and is scaled by the depth of the taxonomy used. The similarity index is obtained by taking the negative log of the scaled value. The LIN measure (Lin, 1998) calculates the similarity between two concepts by the ratio of common information between them. The Jiang and Corinth (JCN) measure (Jiang & Conrath, 1997) is similar to LIN except that JCN finds the difference between the common information instead of their ratio.

In this thesis, the Leacock and Chodorow (LCH) method is used. Using the Wordnet library, a Python script was written that utilises a LCH function to find the semantic similarity of two words. As LCH depends on the size of the taxonomy, the similarity value obtained is normalised by the depth of the taxonomy to provide a similarity measure between 0 and 1.

Semantic matching techniques depend on an external knowledge taxonomy.

As such, an issue arises when a word to be compared is either misspelled, spelled differently, or not included in the taxonomy. In such cases, the algorithm calculates a similarity index of 0 as the link between the words cannot be found. Obviously, this is an error that is not indicative of the actual relatedness of the words but is an issue of human errors or taxonomy limitations. Due to this, when semantic techniques do not work, the string matching technique Damerau-Levenshtein (Damerau, 1964) is used.

The Damerau-Levenshtein algorithm finds the distance between two words based on how many operations are required to change one word to another. Although the Levenshstein (Levenshtein, 1966) distance algorithm works similarly, the Damerau-Levenshtein algorithm improves it by adding the ‘substitute’ operation alongside the ‘addition’, and ‘subtraction’ of characters.

Comparing the titles using a knowledge taxonomy and edit-distances work for simple nouns. However, feature layer titles are often compound by nature. They are made up of more than one noun, which leads to some challenges that are addressed in the section.

5.3.1 Compound Nouns

Comparing compound nouns offers its own challenges as taxonomies or dictionaries cannot practically contain all possible compound nouns. An approach to find the similarity index of compound nouns is to analyse each word forming the compound noun individually and then combine the similarity indexes together. Using this method allows the use of simple nouns comparison such as the LCH method. Another possibility is to string match the whole compound noun, but this method does not take semantic equivalences into consideration.

The method used is the former. Each word is compared individually using the Leacock and Chodorow approach (Leacock & Chodorow, 1998), and if this fails, the Damerau-Levenshtein (Damerau, 1964) algorithm is used. To combine the similarity indexes together, the weighted summation method is used. Each index is given a weight, and then summed up together. Equal weights have been used for each similarity indexes as S. N. Kim and Baldwin (2005) and J. Kim, Vasardani, and Winter (2017) demonstrate that it yields better results than assigning uneven weights.

Another issue to be addressed is comparing compound nouns of different lengths. As little work has been done in this area, the method used is to assume that any extra constituent noun acts as an adjective of the head noun. That is, they provide more details about the head noun (e.g. an 'administrative boundary' is a 'boundary'). Based on this assumption, two compound nouns with different lengths a and b, are treated the same as their lengths are reduced to $min(|a|,|b|)$. As such, any extra constituents that cannot be paired up can be ignored so that it does not affect the similarity index negatively.

5.4 Comparing the Documents

Data dictionaries are also used to compare the metadata of feature types. A data dictionary describes the attributes of a feature layer in natural language, using strings. The concatenation of those strings can be used to describe a feature layer without needing to know the title or the data type of its attributes. A document can be described as a sequence of words (Blei et al., 2003), as such, it can also be described as the concatenation of strings. A document representing a feature type can therefore be produced by concatenating the descriptions of the attributes.

Another approach to generate a feature type's document is by using its definition. For each feature layer, the title can be dissected into unary-words (words consisting of only one component) and the concatenated definitions of those words used as a document.

To compare these documents though, methods such as string matching become inefficient as they fail to capture any latent semantics in the document. Instead, topic modelling is explored.

5.4.1 Topic Modelling

Topic modelling works by identifying topics within documents. The topics can then be compared to one another and a similarity index between two documents can be calculated. A model for such task is Latent Dirichlet Allocation (LDA) (Blei et al., 2003).

Latent Dirichlet Allocation

Blei et al. (2003) describe LDA as a simple and popular topic modelling method used in data mining (Duckworth, Alomari, Charles, Hogg, & Cohn, 2017; Espinoza-Molina, Bahmanyar, Datcu, Díaz-Delgado, & Bustamante, 2017; Guo, Barnes, & Jia, 2017). LDA is a generative probabilistic model of a corpus; documents are represented randomly over latent topics that are characterised by word distribution (Blei et al., 2003). LDA generalises probabilistic Latent Semantic Indexing (pLSI) (Hofmann, 1999), which is equivalent to LDA under a uniform Dirichlet prior distribution (Girolami & Kabán, 2003). Topics are discovered using a bag of words assumption, where the sequence of words is assumed to be negligible. Stop words and punctuations are also removed, allowing LDA to form topics based solely on key words. Further to its wide adoption, this thesis also uses LDA because of its ease of use using the gensim API (Řehůřek, 2017).

5.5 Simple Geometry Comparison

While the metadata of feature types vary depending on the feature type, all features require a geometry. This attribute is required in spatial data and dictates what types of geometry is used to describe the features spatially. Therefore, it is important to explore the efficacy of geometry types in discriminating feature layers. In the case of geometry comparison, a simple filtering approach is taken. Two layers that do not have matching geometry types have their similarity indexes reduced to 0. Thus, in the geometry comparison approach used in this chapter, only layers of the same geometry type are considered similar.

5.6 Data Preparation

This section outlines the methods used to prepare the data for evaluation. The datasets were obtained from two data providers from Australia, and one from New Zealand. They were selected based on their geographic and jurisdictional differences, and the availability of their data dictionaries. The chosen data providers are Landgate, LPI, and LINZ. DELWP was not chosen as their data dictionaries could not be found and was substituted with LPI instead.

Title Preparation

In order to prepare the titles for comparison, it must be processed by tokenising, filtering, lemmatising, and standardising them. For this process, a Python script was used. Listing 5.7 shows the code used to tokenise the titles. It first removes brackets and the content inside the brackets (lines 7-8), then removes the punctuation marks replacing them with blank spaces (lines 11-12). Afterwards, it removes any numbers (lines 15-16), and tokenises the string by both capital letters and blank spaces, then reduces each word to their singular form, and transforms them to lower case (line 19).

```
1  def tokenise_title(in_title):
2      """
3      Tokenise the title by delimiters and stop words
4      """
5  
6      # Remove brackets and content of brackets
7      regex = re.compile("[\(\[].?[\)\]]")
8      in_title = regex.sub("", in_title)
9  
10     # Remove punctuations
11     regex = re.compile("[%s]" % re.escape(string.punctuation))
12     in_title = regex.sub(" ", in_title)
13 
14     # Remove numbers
15     regex = re.compile("\d+")
16     in_title = regex.sub("", in_title)
17 
18     # Split words by capital letters and blank spaces
19     in_title = [singularize(c.lower()) for c in re.split(r'([A
           -Z][a-z]+)|[\s]+', in_title) if c]
20 
21     return in_title
```

Listing 5.7. Script to Tokenise Titles of Feature Types

Document Preparation

The source for each data dictionary of each data provider is shown in table 5.1; where the URL links to a geoportal website, the data dictionary for each feature type had to be found manually. To enable machine parsing, the data dictionaries were manually converted to JSON format from their original PDF format. The definition of the layers' attributes forming the documents were collated verbatim and no errors such as misspellings, or punctuations were fixed. The titles for each layer were also duplicated verbatim keeping misspellings and naming conventions in the JSON file.

Data Providers	**URLs (Retrieved 02 March, 2018)**
Landgate	`https://catalogue.data.wa.gov.au/group` (manually searched)
LINZ	`https://data.linz.govt.nz/` (manually searched)
LPI	`http://spatialservices.finance.nsw.gov.au/__data/assets/pdf_file/0003/60933/NSW_Cadastral_Data_Dictionary.pdf`
	`http://spatialservices.finance.nsw.gov.au/__data/assets/pdf_file/0019/60931/NSW_Topographic_Data_Dictionaryv8.pdf`

Table 5.1: Source of Data Dictionaries

Similar to the titles, documents need to be tokenised. As LDA uses a bag of words approach, the order of words is not important, but punctuation marks, and stop words need to be removed. The tokenised strings are then transformed into vectors based on their count number. The corpus is then the set of vectors of the documents.

Once another document is matched against the corpus, LDA calculates the similarity between the document and the corpus, and each document in the corpus is given a similarity index based on the cosine similarity of their vectors. In order to use LDA, Gensim is used in this thesis.

Word Dictionary Preparation

To find the definition of feature type's titles, the Online Plain Text English Dictionary (OPTED) was used. OPTED is based on project Gutenberg and the 1913 US Webster's Unabridged Dictionary (OPTED, n.d.). The titles were tokenised with the same algorithm from listing 5.7, and for each word their definitions were gathered from OPTED and concatenated. This resulted in each feature layer having a document based on the definition of their title.

Afterwards, LDA is used on the new documents. The aim of this approach is to determine whether layers described based on the definition of their titles offer more discriminatory power than layers described by non-standardised data dictionaries.

5.7 Evaluation Methods

This section explains the methods employed in evaluating the different approaches to find similar feature types. Figure 5.1 shows the order of operation, with the ground truths being established first, followed by getting the optimal variables for the algorithms, running the algorithms and obtaining the ratios of the results.

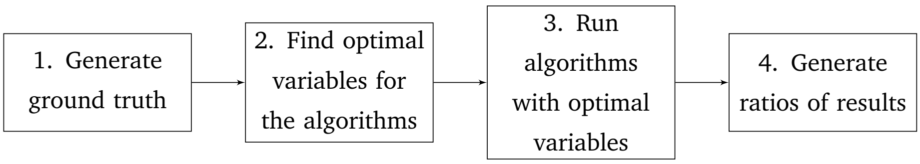


Figure 5.1: Order of Evaluation Methods

5.7.1 Ground Truth

A ground truth is a set of results that are known to be correct. The experiments are evaluated by comparing them to the ground truth. The ground truth used is based on existing feature layers from the three data providers used. Equivalent feature layers were manually determined, taking into consideration the title, description, and attributes of the layers. For two feature layers to be equivalent, they need to be referring to the same type of object including hypernym-hyponym pairs and synonyms.

For each dataset, 41 feature layers were selected: 10 of which were found to be common in all three datasets, 16 feature layers were found to be similar between Landgate and LINZ, 22 between Landgate and LPI, and 17 between LINZ and LPI. These overlaps are portrayed in figure 5.2.

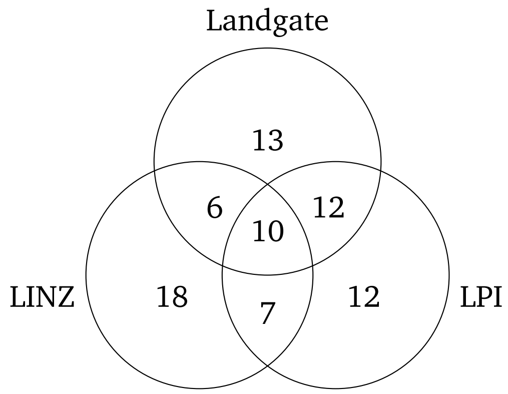


Figure 5.2: Distribution of Test Layers

Only 41 feature layers with data dictionaries were found for LPI, and hence the datasets from LINZ, and Landgate were reduced to that number. The reduction of layers is required to prevent skewing the results due to an unequal amount of noise feature layers. The 41 layers were randomly chosen by a Python script, which included the ground truth datasets.

Snippets of the roads' dataset for each data provider are provided in table 5.2, 5.3, and 5.4. Attributes that align can be observed, as well as those that do not match.

For example, 'OGC_FID' from table 5.2 can be matched to 'road_id' from figure 5.3 and 'RoadNameOID' from figure 5.4. Similarly for 'THE_GEOM', 'geometry_class', and 'GeometryType'. Other matching attributes are 'MSD_CLASS', 'road_name_class', and 'RoadNameType'.

5.7.2 Finding the Variables

LDA requires two starting variables: (1) starting seed, and (2) number of topics (Blei et al., 2003). Multiple tests were run to find the optimal seed and number of topics based only on document comparison. 100 seeds were randomly generated, each iterating through the number of topics ranging from 5 to 100 in intervals of 5. The similarity threshold for this case had a fixed value of 0.5. As iterating the similarity threshold at a 0.1 increment would lead to a 10 times increase in sample

Ref	*Field Name*	*Field Type*	*Description*	*Associated Attribute Values Y/N*
1.	OGC_FID	Integer	Feature Identifier Number	N
2.	THE_GEOM	Geometry	A system-generated ID created upon loading the SDE layer into PostGIS.	N
3.	GEONOMA_ID	Integer	Index field	Y
4.	MSD_CLASS	Variable Character	Road classification e.g. CL=Closed Road CN=Connector, HF=Highway/Freeway, MI=Minor Roads, MN=Main Roads, NA=Not Applicable, NH=National Highway, TR=Tracks, SU=Surveyed Un-constructed, UU=Unsurveyed Un-constructed. (dependant on Feature Code)	Y
5.	SPECIAL_PU(SPECIAL PURPOSE)	Variable Character	Other than traffic purpose eg. AR=Access Road, BA=Bus Access, CL=Closed Road, CN=Connector, LA=Laneway, ML=Mail Access, NA=Not Applicable, OR=On/Off Ramp, RO=Roundabout, SU=Surveyed Un-constructed, UU=Unsurveyed	Y

Table 5.2: Landgate Roads Dataset Snippet

Column Name	*Data Type*	*Length*	*Example*	*Description*
road_id	integer		1056423	Unique Identifier for a road or route.
geometry_class	character	40	Road	The geometry class (whether for addressing purposes or to represent the physical road). Includes: Addressing Road, Addressing Waterway, Physical Road. Physical Road not in use at initial dataset release.
road_type	character	40	Accessway	The type of road. Includes Unknown, Roadway, Accessway, Service Lane.
road_name_class	character	40	Road	The class of road name. Includes: Local Route, Road, Road Designation, Tourist Route or Water Route
full_road_name	character	250	Upper Smith Road East	All road name components concatenated.
road_name_label	character	250	Upr Smith Rd E	All road name components concatenated with prefixes, types and suffixes abbreviated.

Table 5.3: LINZ Roads Dataset Snippet

***GeometryType:*esriGeometryPolyline**		*HasM:*False	*HasZ:*True
Attribute Name	***Data Type***	***Allow Nulls***	***Constraints***
AttributeReliabilityData	Date/Time		
CaptureMethodCode	SmallInteger	T	DmT_CaptureMethod
CaptureSourceCode	SmallInteger	T	DmT_CaptureSource
ClassSubtype	Integer	T	Subtype values for this class
CreateDate	Date/Time		
FeatureModDate	Date/Time	T	
FeatureReliabilityDate	Date/Time		
FunctionHierarchy	SmallInteger	F	DmT_RoadFunctionHierarchy
LaneCount	SmallInteger	F	DmT_RoadLanesClassification
ObjectModDate	Date/Time	T	
OperationalStatus	SmallInteger	F	DmT_BuiltOperationalStatus
PlanimetricAccuracy	Single(6,2)	T	
Relevance	SmallInteger	F	DmT_RelativeSignificanceRange
RoadNameBase	Char(50)	T	
RoadNameExtentOID	Integer	T	
RoadNameOID	Integer	T	
RoadNameSuffix	Char(10)	T	
RoadNameType	Char(20)	T	
RoadOnType	SmallInteger	F	DmT_RoadOnType
Surface	SmallInteger	F	DmT_RoadSurface
TopoID	Integer	T	DmT_TopoID_Range
VerticalAccuracy	Single(6,2)	T	<null>

Table 5.4: LPI Roads Dataset Snippet

size, this value was not changed.

The best seed and number of topics were based on the mean of the ratio of correctly matched feature layers and the ratio of feature layers returned. The best mean obtained was 0.321619 with the seed being 1775641100 and number of topics being 75. All further experiments were based on these two values.

Using the optimal seed and number of topics obtained, each method is iterated over using a varying similarity threshold from 0 to 1 with increments of 0.2. The ratios of correctly matched feature layers over ratio of feature layers returned is then plotted.

5.7.3 Evaluation Methods

To evaluate the explained methods, a semi-automated rank-based matching process is assumed. Given a feature layer f, the matching algorithm returns a number of feature layers back to the user based on a similarity threshold (i.e. only feature layers with similarity higher than the similarity threshold are returned). The returned feature layers are ranked in descending order based on their similarity scores, and it is assumed that the user manually selects which feature layer is similar to f. Following this assumption, the ratio of matched feature layers over the ratio of returned documents graphs is generated.

Formally, take two sets of feature layers $X = \{x_1, x_2, ..., x_m\}$ and $Y = \{y_1, y_2, ..., y_n\}$ where $m, n \in \{1, 2, ...\}$. M_{x_i,y_j} are feature layers that are matched pairs, sim_{x_i,y_j} is the similarity index between layers x_i and y_j where $0 < i \leq m$ and $0 < j \leq n$. t is a threshold value. The ratios for each dataset is calculated as follows:

$$ratio_{matched} = \sum_{i=1}^{i=m} \sum_{j=1}^{j=n} \frac{M_{x_i,s_j} \wedge sim_{x_i,x_j} > t}{M_{x_i,x_j}} \tag{5.1}$$

$$ratio_{returned} = \sum_{i=1}^{x=m} \sum_{j=1}^{y=n} \frac{(\neg M_{x_i,y_j} + M_{x_i,y_j}) \wedge sim_{x_i,x_j} > t}{\neg M_{x_i,y_j} + M_{x_i,y_j}} \tag{5.2}$$

where $ratio_{matched}$ is the number of matched pairs which have a similarity score above the similarity threshold divided by the total number of matched pairs. $ratio_{returned}$ is the number of all pairs with a similarity score above the threshold divided by the number of all pairs.

Methods that are being evaluated include the topic modelling and the string matching of the feature layers' description and their titles. Further, the impact of the geometry type is investigated. For the topic modelling method, the data dictionaries of the feature layers as described by the data providers are compared to an approach utilising a word dictionary to describe the feature layers based on their title.

In all of the experiments involving the matching of documents, the cosine similarity is measured between the vectors of the topics obtained by LDA. The similarity indexes from the layer's title and documents are combined using an equal weighted summation approach as described earlier.

5.8 Evaluation Results

Figure 5.3 shows the ratio curve of using data dictionaries against using a word dictionary. The data dictionary approach creates smaller clusters of similar feature layers leading to more evenly spread matching over returned ratios. Contrastingly, as the word dictionary based approach derives the definition of the layers from their titles, it follows that feature layers titled similarly would be clustered together offering bigger similarity clusters. The results suggest that using a consistent definition of words (in this case a word dictionary) to describe feature layers might not necessarily mean an overall better approach. This is explained by the ratio matched suddenly jumping from 0.46 up to 1.00 with no data points in between. More than half of the matchable feature layers could only be matched when all layers were returned (at a similarity threshold of 0). Hence, the usage of data dictionaries can be observed to be more efficient overall.

Figure 5.4 compares the approach of using only the title of layers against using only documents with data dictionary and word dictionary. Although the word dictionary based approach derives the document from the layers' titles, the clustering when comparing titles is not the same. This can be explained by semantic differences. Titles can use the same words that describe different things (homonyms), as the word dictionary approach used was a naïve one where the first definition of each word was taken, and the different meanings of the layer titles were not captured. Therefore, in this case, using the plain titles of the layers is more beneficial,

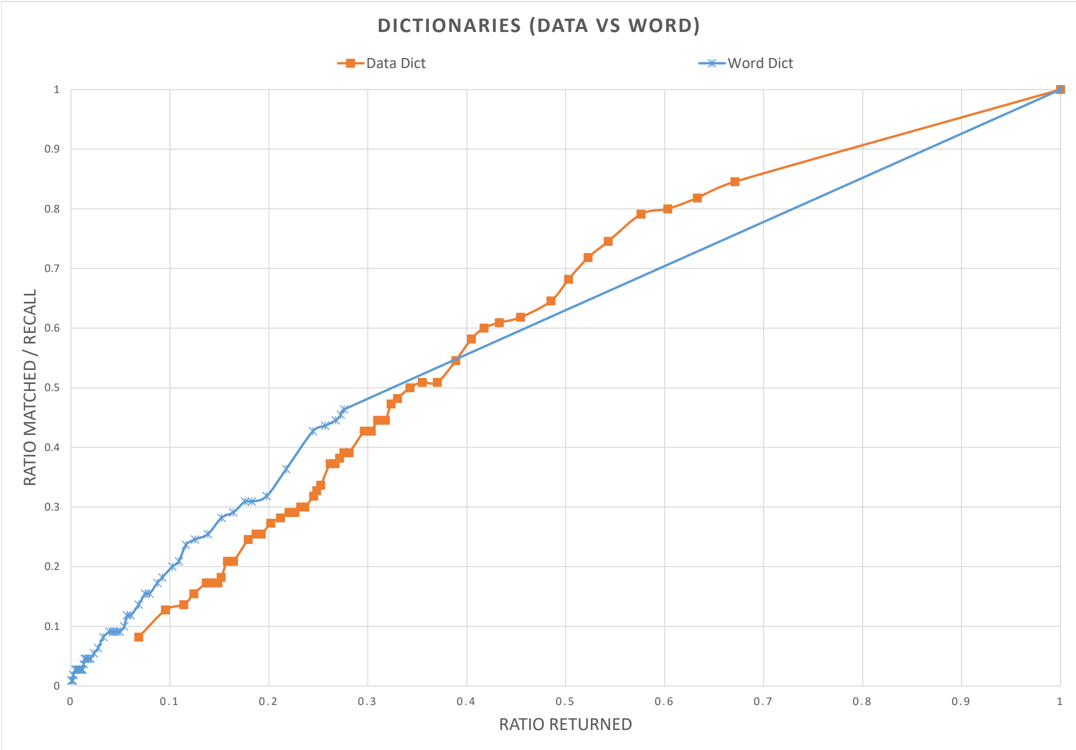


Figure 5.3: Dictionary Based Methods

as it uses Wordnet as a knowledge base. It is interesting to note that the data dictionary approach seems to plateau at a higher ratio returned than the title based approach. It also follows a smoother curve, due to its smaller clustering. The title based approach, however, has a steep curve at the start and seems to lose momentum soon after. In this case, the title based approach would be more efficient for smaller number of returned documents, but the data dictionary is better for larger documents returned.

As the results for comparing the titles of the layers and the data dictionaries showed different ranges of efficiency, they were combined together. Figure 5.5 demonstrates the curve when title and data dictionaries are combined. The efficiency of the new approach beats the title based approach at around 0.32 ratio returned, as opposed to the method comparing only the data dictionaries which was at around 0.53. This can be deemed an improvement of around 20%. The combined approach loses some efficiency at around the ratio of 0.35 for returned documents identified by the diminished gradient at that point.

Despite finding a better overall approach by combining the data dictionary and the title comparison approaches, there is still an aspect from spatial data that

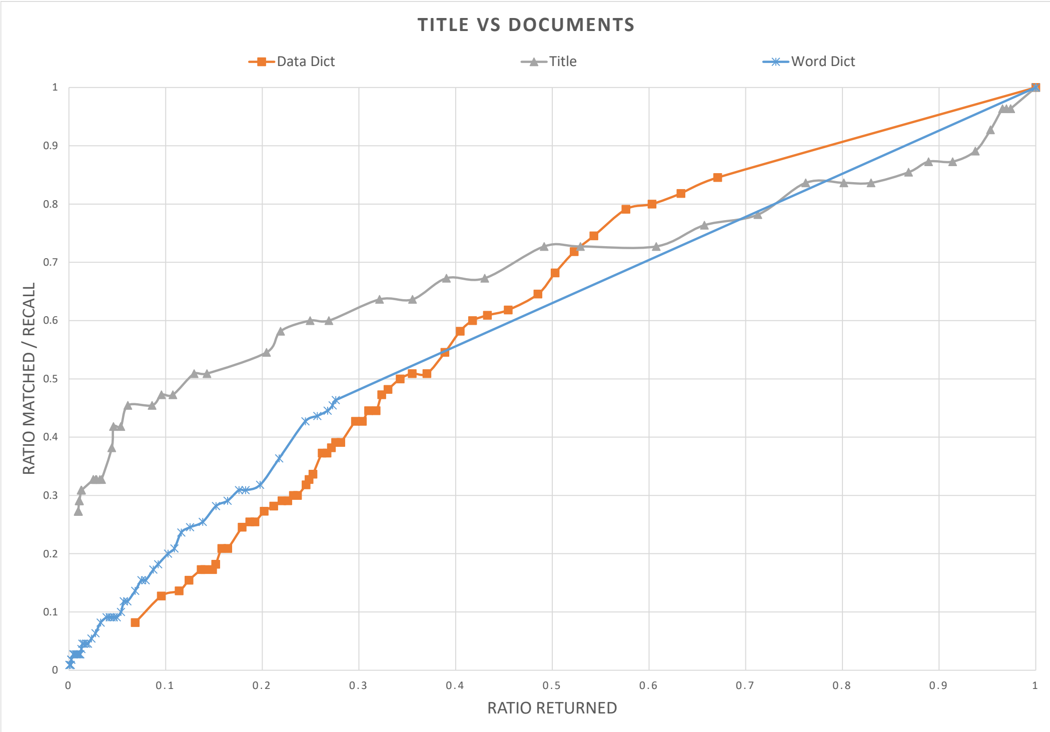


Figure 5.4: Document Based Approaches and Title Based Method

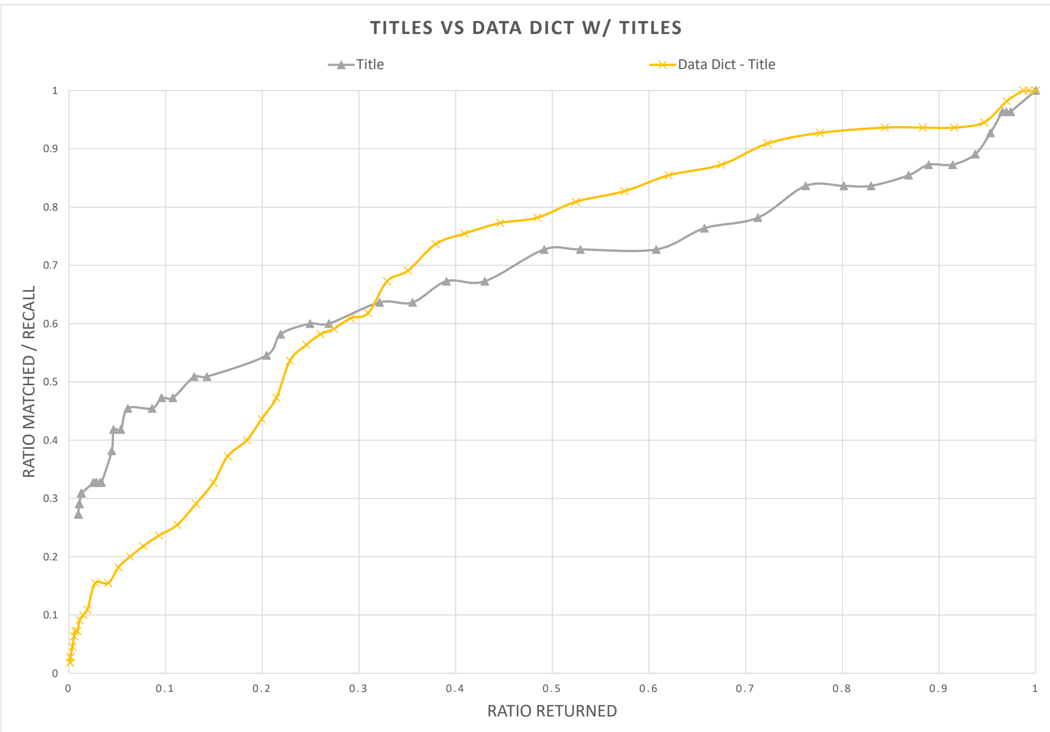


Figure 5.5: Title Only and Document with Titles Based Method

was not looked at. Specifically it is the geometries of the layers. In figure 5.6, a simple geometry filter is added to the combined approach, where for a layer to be matched, its geometries must be the same. This addition significantly boosts the efficiency of matching layers. All layers could be matched by returning less than 35% of all layers available. The steep curve also demonstrates its efficiency: with 10% documents returned, 60% of matchable layers could be found. It demonstrates that even a simple geometric comparison is significant in matching feature layers.

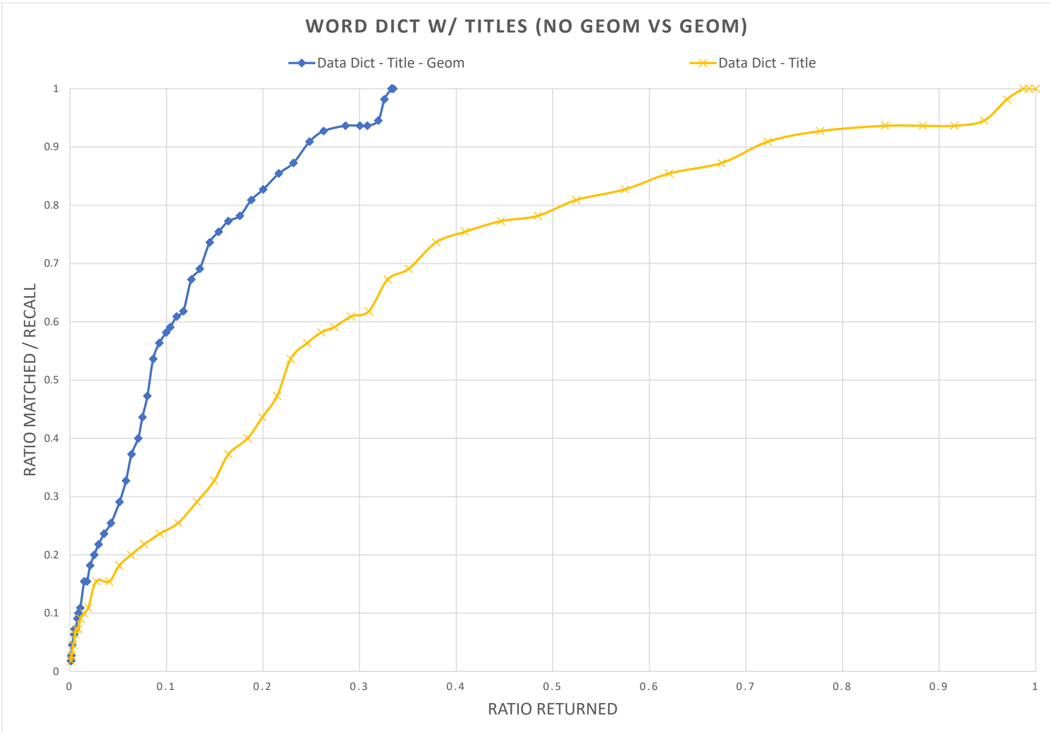


Figure 5.6: Geometry Based Method

5.9 Combined Results

Figure 5.7 contains results for all methods evaluated. As observed in the graph, the title of the layers is initially a better indication of whether layers are similar or not by allowing approximately 25% of matched layers to be found with fewer layers returned. Its efficiency though quickly diminishes and can be outperformed by a comparison of data dictionaries of the layers. However, comparing the titles of layers requires analysing their naming conventions and standards. In the experiments used, various naming conventions were noted, and hence a filter for each had to be utilised. The titles themselves among the data providers were not always consistent. It is also important to cater for the semantic aspects of the titles which can be

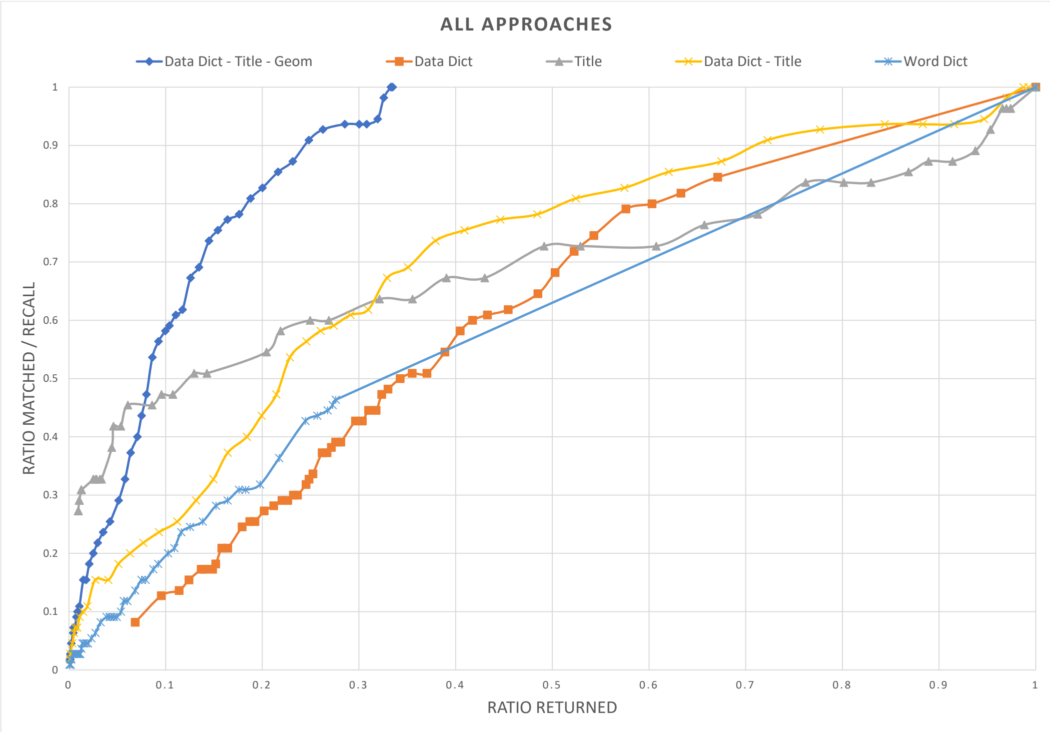


Figure 5.7: All Methods

observed between the curves of the word dictionary approach, which derived the definitions naïvely, and the titles comparison approach.

The word dictionary approach does not cater for homonyms. An example would be the word ‘crane’ which can be both a type of bird or machinery. Finding the proper definitions for homonyms depends heavily on the context in which they are being used, and the area of natural language processing is required. This is outside the scope of this thesis and it is not investigated.

Dealing with synonyms would prove to be efficient as they would have similar definitions in a word dictionary. Further, in dealing with compound nouns, the word dictionary approach only works if the compound nouns are the sum of its constituent parts in isolation. As an example, with the layer ‘landing ground’, the definition for ‘landing’ and the definition for ‘ground’ do not necessarily have the same definition as a ‘landing ground’. Due to these issues, the data dictionary approach performed more consistently than the word dictionary approach. The gap of data points from 0.3 to 1.00 in figure 5.7 for the word dictionary approach demonstrates this aspect.

As the data dictionary approach is more efficient and plateaus later than the title based approach, a combination of both was used. This combination offered an efficiency increase of around 20% demonstrating that more meta-data provides more discrepancy power for comparing layers. However it must be stated that the title based approach still outperforms the combined approach for smaller numbers of documents.

Lastly, the geometry aspect of the layers was used as another dimension of metadata. Although a basic filter was used, there was a significant improvement, enabling matchable layers to be found with less than 35% of documents returned. This significant improvement reinforces the idea that more metadata provides better discrepancy power, with the geometric aspect of feature layers being a major contributor to the similarity of feature types.

5.10 Summary

This chapter investigated different approaches to finding similar feature layers. The evaluation of these approaches was based on a semi-automatic approach where an expert would pick the best matching layer from a ranked list. The experiments undergone used actual data from Landgate, LPI, and LINZ. The human errors were not corrected to represent a real world scenario.

The approaches included comparing the titles of feature layers, their descriptions based on their data dictionaries and on a word dictionary, and their geometries. It was found that more metadata makes finding similar layers better, with their geometries being a key contributor.

To this effect, further investigation regarding the geometry attributes is pursued in the next chapter.

CHAPTER 6

COMPARING THE GEOMETRY DISTRIBUTION OF FEATURE TYPES

6.1 Introduction

This chapter investigates the use of geometries in discriminating feature types. The previous chapter established that the XML description of feature types provides an insight in matching them. However, using the metadata alone is not sufficient and further characteristics are required to disambiguate them. A possibility explored in this chapter is the comparison of their geometries.

Among the XML descriptors used in the previous chapter, the geometry type was the most discriminant one. However, the geometry type attribute only provides information regarding the type of the geometry (point, linestring, or polygon) and hence can only be used for a direct string comparison of the geometry type. To further the matching of feature types, their geometry instances can be utilised to determine whether feature types across jurisdictions are similar in their general shape. While there exists a whole discipline of shape analysis, this chapter is intended to be exploratory. Its primary aim is to determine whether information can be extracted from the geometries of feature instances and whether this information can be abstracted as a distribution for comparing features types from different data providers.

For each geometry type, latent information (referred to as predictors) is extracted from the features and analysed. The predictors are expected to discriminate a feature type from another but need to be abstracted from the instance level to the feature type level. For this, by combining the geometric characteristics of all feature instances of a feature type, the general characteristic of the feature type can be determined in terms of a distribution. The distribution of predictors from one feature type is then compared to the distribution of another and their similarity is determined.

This chapter, thus, aims to analyse the geometry distribution of multiple feature types at the instance level. Latent information regarding these geometries is extracted, and their distributions compared to one another. Information is extracted based on three basic geometry types (point, linestring, polygon) and the implications of these pieces of information are discussed. The distributions are compared using the Earth Mover's Distance (EMD) (Rubner, Tomasi, & Guibas, 2000) algorithm; EMD was not found to have been used with spatial geometries before, and hence this chapter will be the first to explore this area. It is expected that the geometry distribution between feature types will enable their differentiation and, in response, facilitate the matching of similar ones.

6.2 Feature Type Selection

To compare the geometric distribution of feature types, feature types of similar semantics first need to be selected to provide a ground truth. For each geometry type, five feature types were manually selected. The selection of the feature types is based on their availability in Web feature services (WFS). For this chapter, WFS used are those from Landgate, DELWP, and LINZ. As Landgate uses the Shared Location Information Platform (SLIP), it is referred to as such.

In contrast to chapter 5, LPI is not included because the availability of the required data is sparse and the variety of their data format limited. Instead, it is substituted with DELWP. Table 6.1 shows the selected feature layers for each geometry type and table 6.2 shows how they are titled by each WFS.

Multipoints, multilinestrings, multipolygons are not considered because they can be decomposed into their non-multi form (e.g. Multipoints to points) for analysis.

Point Feature	Linestring Feature	Polygon Feature
Rail Station	Road	Water Tank
Height Point	Contour	Building
Geographic Name	Railway	District
Street Address	Pipeline	Mine
Mine Point	River	Lake

Table 6.1: Selected Features for each Geometry Type

6.3 Information Extraction

To compare feature types, the distributions of the features' geometries are required. For this task, information that best discriminates the feature types needs to be extracted from their geometries; each feature type has different geometries. This section discusses the extraction of predictors from the three geometry types: points, linestrings, and polygons.

6.3.1 Points

> A Point is a 0-dimensional geometric object and represents a single location in coordinate space. A Point has an x-coordinate value, a y-coordinate value. (OGC, 2010, p. 20)

Examples of feature types represented as points are rail stations and height points. Provided that a point can be plotted in relation to another with a relative distance and an azimuth bearing, it is intuitive to use these two components as predictors to identify the distribution of point geometries.

Figure 6.1 shows an example with points P_0, P_1, and P_2. P_1 can be described relative to P_0 by the bearing α and distance a. Similarly P_2 can be described with bearing β and distance b relative to P_0.

By having the distribution of the bearings and distances from every point to all the other points, a spread of the points is modelled. Comparing these spreads can provide clues to the relatedness of the feature types described by the points. For instance, it is expected that rail stations have a sparser spread than height points, and this information can be reflected in the distribution of the distances and bearings

Feature Type	SLIP Title	LINZ Title	DELWP Title
Point Feature Types			
Height Point	LGATE-144	LAYER-50165	VMELEV_EL_GRND_SURFACE_POINT
Geographic Name	LGATE-013	LAYER-50280	VMFEAT_GNR
Rail Station	LGATE-038	LAYER-50318	VMLITE_TR_RAIL_STATION
Mine point	LGATE-114	LAYER-50300	MINERALS_MINSITE
Street Address	LGATE-150	LAYER-53353	VMADD_ADDRESS
Linestring Feature Types			
Road	LGATE-012	LAYER-53378	VMTRANS_TR_ROAD_LOCAL
Contour	LGATE-015	LAYER-50768	VMELEV_EL_CONTOUR
Railway	LGATE-036	LAYER-50319	VMLITE_TR_RAIL
Pipeline	LGATE-111	LAYER-50309	MINERALS_PIPELINE
River	LGATE-018	LAYER-50327	VMHYDRO_WATERCOURSE_RIVER
Polygon Feature Types			
Building	LGATE-139	LAYER-50246	VMFEAT_BUILDING_POLYGON
Water Tank	WCORP-007	LAYER-50361	VMHYDRO_HY_WATER_STRUCT_AREA_TANK
District	LGATE-009	LAYER-50785	VMADMIN_DELWP_REGION
Mine	LGATE-113	LAYER-50301	MINERALS_MINERAL
Lake	LGATE-016	LAYER-50293	VMHYDRO_WATER_AREA_LAKES_DAMS

Table 6.2: WFS Selected Features

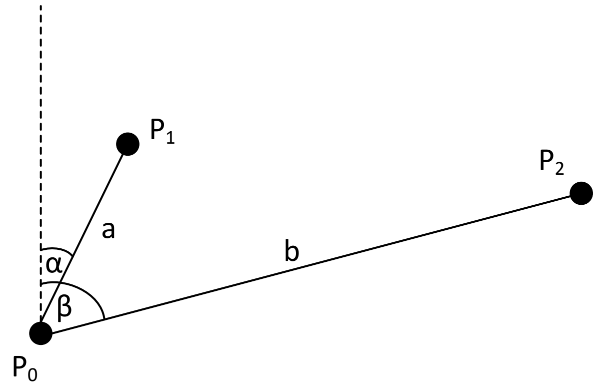


Figure 6.1: Point Predictors

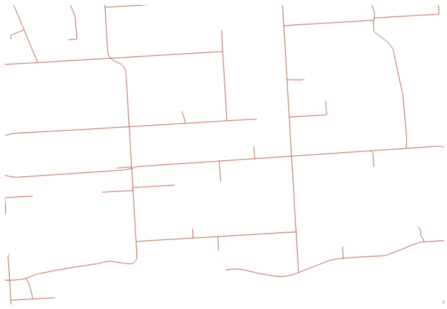
among the points.

6.3.2 Linestrings

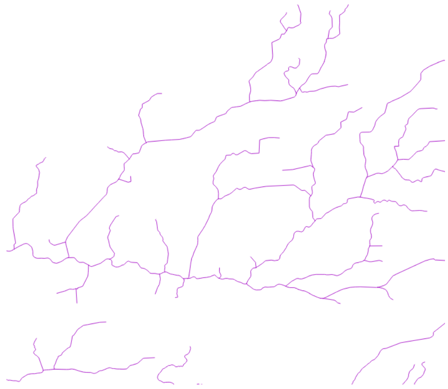
> A LineString is a Curve [1-dimensional geometric object usually stored as a sequence of Points] with linear interpolation between Points. Each consecutive pair of Points defines a Line segment. (OGC, 2010, p. 22)

Linestrings are used to denote features that span over certain distances such as rivers and roads. Due to this characteristic, the length of a linestring is considered a strong predictor. Another characteristic of linestrings is the angle between their line segments. From figure 6.2a, it can be observed that a road linestring tends to be straight, which means that its line segments will tend to have a 180^o angle between them. Contrastingly, figure 6.2b shows that rivers have more acute angles between their line segments. For this reason, another predictor identified is the average of the interior angles between line segments in a linestring.

Another characteristic that can be extracted is the area of the convex hull of the linestrings. A convex hull is the 'smallest convex set containing a given geometric object' (ISO, 2005, p. 6), and a convex set is defined as a 'geometric set in which any direct position on the straight-line segment joining any two direct positions in the geometric set is also contained in the geometric set' (ISO, 2005, p. 6). Rivers and contour lines are examples where the area of their convex hulls can prove to be a strong predictor to differentiate them, with contour lines having a bigger area than rivers on average. The area of the convex hulls of linestrings is another predictor used in this chapter.



(a) LINZ Roads



(b) LINZ Rivers

Figure 6.2: Linestring Features

6.3.3 Polygons

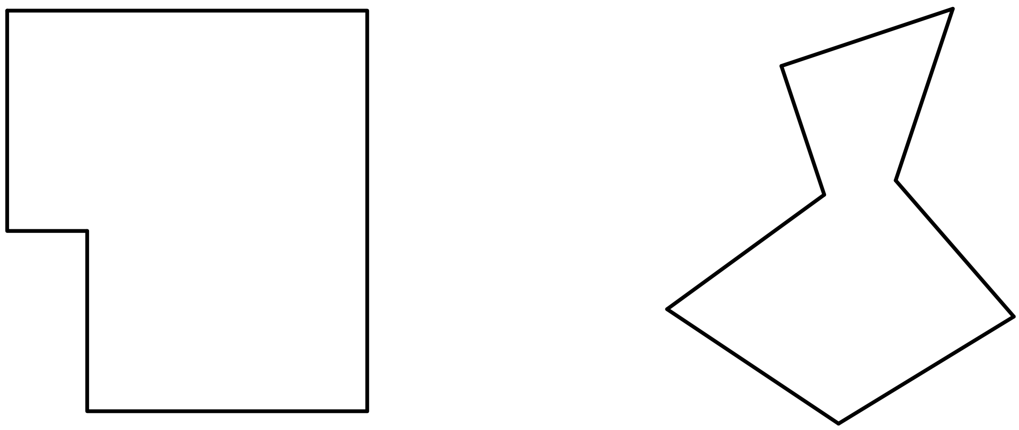
> A Polygon is a planar Surface defined by 1 exterior boundary and 0 or more interior boundaries. Each interior boundary defines a hole in the Polygon. (OGC, 2010, p. 26)

OGC (2010, p. 8) describes a boundary as a ‘set that represents the limit of an entity....where the set is a collection of points or a collection of objects that represent those points’.

Polygons can be considered composed of linestrings; similar to linestrings, the average interior angles of polygons are considered as predictors, together with the average length of its boundary, and its area. These three components are enough to describe the shape of a polygon.

Additionally, the $\frac{bounding box}{area}$ ratio of a polygon is calculated to factor in the regularity of the shape. A more regular object will have a smaller $\frac{bounding box}{area}$ ratio than an irregular shape. The other characteristic processed is the average distance between the polygons. Similar to points, this characteristic notes the location distribution of the polygons in reference to one another.

Figure 6.3 demonstrates two polygons of different regularity with figure 6.3a being more regular than figure 6.3b. The differences between the two shapes are the predictors identified: the interior angles, average lengths of their linestrings, areas, and $\frac{bounding box}{area}$ ratios. The lengths of the sides is taken as an average instead of a sum because a line can be broken down into smaller segments, thus the same total length can be achieved with different shapes. Finding the mean length of the sides helps in finding out whether the shape is made up of longer or shorter line segments on average.



(a) More Regular Polygon (b) More Irregular Polygon

Figure 6.3: Polygon Features

6.4 Selecting the Best Predictors

Once the predictors are extracted, the ones that best differentiate the feature types need to be chosen. To find the best combination of predictors, a method is to compare the variance in the data. The more variant the data is, the higher its discriminatory power. The variance can then be used to find out which predictors are more important in discerning the differences among feature types.

Another method is to use decision tree learning. Decision tree learning uses information to create a tree structure. The tree structure finds pattern in the predictors to reach an outcome. By using decision tree learning, and finding the patterns in the predictors, their importance can be gauged.

6.4.1 Decision Tree Learning

A decision tree is a structure made up of nodes and edges that partitions the predictor space to reach the most correct outcomes. At each node, a boolean test is made to decide how the tree is split based on the attributes of the data. These tests are iteratively or recursively processed until a leaf node is reached and no further tests are required. The leaf node is the predicted outcome.

Two main types of decision trees are classification trees and regression trees. The predicted outcomes from a classification tree are discrete values predicting the class of the data while a regression tree predicts real values such as the price of a house.

This chapter uses classification trees because the outcomes to be derived from the datasets are their discrete classifications. An example of a classification problem is the Iris dataset by Fisher (1936). The datasets are composed of measurements of sepal length, sepal width, petal length, and petal width and they need to be classified into three iris species. The measurements in the Iris datasets are the predictors because they help in predicting the classification of the data.

In decision tree learning, a decision tree is formed by automatically splitting the training datasets based on predictors and their intended outcomes. The algorithm recursively splits the datasets using each predictor until all datasets have been classified (Loh, 2011). To produce an efficient decision tree, the choice of predictors is important as these will dictate how well the tree is split into branches.

A way to calculate a predictor's efficiency is by using the branches' entropy or their Gini index (Breiman, Friedman, Stone, & Olshen, 1984).

Entropy

Entropy is a measure of disorder or uncertainty. In other words, entropy gauges the amount of information contained in a dataset as more information can be gained from a more disordered dataset. A higher entropy means more information and is defined as (Quinlan, 1986):

$$entropy(p_1, p_2, ..., p_n) = -\sum_{i=1}^{n} p_i log_2 p_i,$$

where p_i is the proportion of datasets in class i. By finding the difference between the entropy before and after a split, the amount of information gained using a particular predictor can be calculated. The better the predictor used, the higher the information gain. In other words, information gain is equivalent to the difference between the disorder of a node and its children nodes.

Gini Impurity Index

The Gini index is similar to entropy but instead of calculating the information contained within a node, it calculates the node's impurity. A node's impurity can be described as the probability that a random dataset element is classified correctly based on the distribution of a branch in a tree structure. The Gini index is calculated as (Breiman et al., 1984):

$$gini(p_1, p_2, ..., p_n) = \sum_{i=1}^{n} p_i \sum_{j \neq i} p_j,$$

where p_i is the probability of the dataset element being correctly classified as class i, and $p_j, j \neq i$ is the probability of the dataset element being misclassified as a class other than i. Gini gain is similar to information gain, where the differences between the purity of the nodes are calculated instead. In this case, a better predictor used would yield an overall higher Gini gain - the probability that a random element is classified correctly. An average of the Gini gains over all branches using a predictor can then dictate how well that predictor performs - that importance score is known as the Gini importance (Breiman et al., 1984).

6.5 Distribution Comparison - Earth Mover's Distance

To compare the geometry distributions, the Earth Mover's Distance (EMD) (Rubner et al., 2000) is used. EMD is based on a solution to the transportation problem by Hitchcock (1941), in which suppliers with limited capacity need to supply several consumers. The problem is to find the least expensive flow of goods from suppliers to consumers (Rubner et al., 2000).

A similar concept can be applied to the comparison of two distributions, where instead of having suppliers and consumers, a distribution is seen as a mass of land properly spread in a space, and another distribution as a collection of holes in the same space (Rubner et al., 2000). The distance in this case is the minimum amount of work done required to fill the holes.

Rubner et al. (2000) formally describes EMD as:

$$EMD(P,Q) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} d_{ij} f_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} f_{ij}},$$

where d_{ij} is the ground distance between two distributions, and f_{ij} is the flow between them. The EMD is thus the minimum resulting work of transforming a distribution to another, normalised by the total flow.

Rubner et al. (2000) mentions the benefits of EMD. EMD allows the partial matching of distributions, where the sizes of both distributions do not need to be equal. EMD is also a true metric if the ground distance used is a true metric and the weights of the distributions are equal.

Further to these, the ground distance used in EMD can be customised to better fit the dataset—a common ground distance is the Euclidean distance. EMD can also be used in any dimension spaces allowing the comparison of distributions with any number of variables, in this case, any number of predictors.

6.6 Methods for Comparing the Predictors

For each dataset from SLIP, LINZ, and DELWP, the features were downloaded as a GML file.

The GML files were then stored in a PostgreSQL/PostGIS database. PostgreSQL is an OGC-compliant extension of PostGIS, which natively enables data to be queried spatially (`https://www.postgresql.org`). While entering the data in the database, a few considerations were taken. The coordinates of the datasets were changed to an arbitrary common spatial reference system (EPSG:4326), and any multi geometries were converted into their non-multi equivalent to facilitate processing. That is, points were extracted from multi points, linestrings from multi multistrings, and polygons from multi polygons.

The layer LGATE-038 from SLIP is a transport layer containing transport facilities other than rails stations. To this effect, only rail stations from the layer were extracted and inserted into the database.

Afterwards the predictors for each datasets are calculated, and processed by the Classification And Regression Tree (CART) algorithm (Breiman et al., 1984).

CART uses the Gini index to find the best splits in a decision tree, and based on the Gini index, it is possible to find the Gini importance for each predictor. The Python library *scikit-learn* (Scikit-Learn Developers, 2017) is used to generate a decision tree based on CART and the Gini importance for each predictor.

For each feature type, the best predictors were selected until their sum reaches at least 50%. If the best predictor has a Gini importance of 45%, the next best predictor is chosen until the sum of Gini importance is above 50%. Once the predictors for each geometry type are selected, the distribution of the predictors for each feature types are compared to one another using EMD and the results are then recorded.

The EMD algorithm used is Pyemd (Doran, 2017) which implements the transportation algorithm described in Jensen and Barnes (1980, Chapter 5).

6.7 Results

This section articulates the EMD scores obtained for each feature type. A lower EMD score indicates less disparity between distributions. As such, for a perfect table representation of the similarity of feature types, the lowest EMD scores would be in the diagonal cells from the top left corner down to the bottom right corner.

The cells representing correct similar pairs are in blue. However, the similarity can be asymmetric. While a feature type f_{LINZ} can be found to be similar to a feature type f_{SLIP}, f_{SLIP} could be more similar to a different feature g_{LINZ}. For example, 'height points' from SLIP in table 6.4 is similar to 'height points' from LINZ, but 'height points' from LINZ is more similar to the 'rail stations' from SLIP. For such cells, they are coloured in orange showing a correct similarity that is true for one data provider only.

6.7.1 Point Feature Types

The point feature types selected are rail stations, height points, geographic names, street addresses, and mine points. The predictors identified are the average distance and the average azimuth of one point to all the other points.

Table 6.3 demonstrates the Gini importance of each predictor and their variances. The average distance predictor has a 71% involvement in the separation of the selected feature types, and the average azimuth predictor 29%. Similarly, their variances indicate that the average distance predictor is more varied than the average azimuth predictor.

Given that the average distance by itself is above 50%, only the distributions of this predictor are compared.

Feature Name	**Importance**	**Variance**
Average Distance	0.71064585	6.45071089
Average Azimuth	0.28935415	1.00893463

Table 6.3: Point Geometry Features

Table 6.4 shows the EMD scores between SLIP and LINZ. None of the feature types were properly matched based on their EMD scores. Although the feature types 'height pt' and 'mine pt' are correctly matched, it is only true for one data provider. Height points for LINZ are more similar to rail stations from SLIP, while mine points from SLIP are more similar to New Zealand's street addresses.

		SLIP				
		Rail Stn	**Height Pt**	**Geo Name**	**Street Add**	**Mine Pt**
LINZ	**Rail Stn**	1.380914	3.149399	4.452414	2.108857	1.332614
	Height Pt	0.318240	1.522419	6.079394	1.063926	2.953062
	Geo Name	0.699800	2.386680	5.215133	1.555239	2.088801
	Street Add	1.580227	3.302180	4.299633	2.383034	1.173301
	Mine Pt	1.503646	3.252631	4.349182	2.238666	1.276646

Table 6.4: Point Geometry Similarity - LINZ vs SLIP

In table 6.5 which shows the EMD scores between the datasets from LINZ and DELWP, the only scores reflecting the similarity of the feature types are 'height pt', and 'geographic names'. These though, are not symmetric; height points from LINZ and geographic names from DELWP resemble each other more.

The disagreements regarding the similarity of the feature types can be explained by the geographic differences between Western Australia for SLIP, Victoria for DELWP, and New Zealand for LINZ. It is apparent from the geographic names that the dissimilarity is greater when comparing LINZ and SLIP. Geographically SLIP has a greater area coverage than either LINZ or DELWP. According to Com-

		DELWP				
		Rail Stn	**Height Pt**	**Geo Name**	**Street Add**	**Mine Pt**
LINZ	**Rail Stn**	2.144560	2.181624	1.219791	3.449258	3.060643
	Height Pt	0.539320	0.644246	0.430543	1.822278	1.433663
	Geo Name	1.381841	1.418905	0.460774	2.686539	2.297924
	Street Add	2.297341	2.334405	1.372573	3.602040	3.213424
	Mine Pt	2.247792	2.284856	1.323023	3.552490	3.163875

Table 6.5: Point Geometry Similarity - SLIP vs DELWP

monwealth of Australia (n.d.), Western Australia has an area of 2.646 million km^2, Victoria 237 629 km^2, and New Zealand Government (n.d.) mentions New Zealand has an area of 268 021 km^2, .

It is expected that the EMD score for the geographic names of LINZ and DELWP is more similar than comparing them to the ones from SLIP. In fact, this expectancy is reflected in the result tables. When comparing LINZ and DELWP (table 6.5), the EMD score of their geographic names is 0.46 while the ones from LINZ against SLIP is 5.21 and SLIP against DELWP is 5.67. The similar numbers of 5.21 and 5.67 further affirms that the geographical region of LINZ and DELWP are similar, and that SLIP has a different geography.

Apart from the geographic names, other features that can be affected by the coverage area of the data provides include height points, and mine points. While the 'height pt' feature type follows the expected pattern of being lower when comparing LINZ - DELWP against LINZ - SLIP, the 'mine point' feature type does not. This would suggest that for natural deposits such as mine points, the area is not necessarily the only variable.

Point clustering also affects man-made feature types such as rail stations, and street addresses. With the methods used to calculate the predictors, the distribution of these two feature types is affected by the distance between main clusters - in this case main cities. As LINZ has two islands, it creates two cluster points where features such as rail stations and street addresses are effectively duplicated in structure. This clustering effect skews the distribution because the distance of the features in one cluster to the features of another cluster are deemed to be further apart on average.

This clustering effect can be observed in table 6.6 which shows the EMD scores between DELWP and SLIP. Both rail station and street address feature types have smaller EMD scores in table 6.4, and 6.5. From the data it can be concluded that clustering of points is another factor that affect the general shape of point geometries.

		DELWP				
		Rail Stn	**Height Pt**	**Geo Name**	**Street Add**	**Mine Pt**
SLIP	**Rail Stn**	0.796941	0.834005	0.455763	2.101640	1.713024
	Height Pt	1.00483	0.967774	1.929607	0.301892	0.352772
	Geo Name	6.596975	6.634039	5.672206	7.901673	7.513050
	Street Add	0.608650	0.533514	1.328735	1.644269	1.255650
	Mine Pt	3.470642	3.507706	2.545874	4.775341	4.386725

Table 6.6: Point Geometry Similarity - SLIP vs DELWP

6.7.2 Linestring Feature Types

The linestring feature types selected are roads, contours, railways, pipelines, and rivers. The predictors identified are the average angle between the line segments, the length of the linestrings, and the area after closing the linestring. Table 6.7 demonstrates the Gini importance of each predictor and their variances. The average angle predictor has an importance of 43% in classifying the feature types, followed by the length of the linestring with 41%. The areas only scored 16% importance. The same pattern is seen with the variances, with the average angle and length having the bigger variances.

In order to have a sum total of importance above 50%, both the average angle and length predictors were used to compare the feature types.

Feature Name	**Importance**	**Variance**
Average Angle	0.43435986	4240
Length	0.40611012	0.0178
Area	0.15953001	0.000165

Table 6.7: Linestring Geometry Features

Table 6.8 shows the results when comparing linestring feature types from LINZ and SLIP. The feature type ‘contour’ has the lowest EMD score for both data providers and hence is correctly considered more similar than the other feature types. Contrastingly, roads from SLIP are more similar to roads from LINZ but roads from LINZ are more similar to pipelines from SLIP.

		SLIP				
		Road	**Contour**	**Railway**	**Pipeline**	**River**
LINZ	**Road**	14.051691	54.5153121	30.2277842	9.76637047	28.1339788
	Contour	65.4908798	4.2625831	45.3654720	46.6056840	30.7009202
	Railway	43.6572403	40.0651282	8.53849929	33.3478552	16.0795157
	Pipeline	24.8373403	50.7860016	30.9865547	8.44722413	29.1165476
	River	64.6312938	21.053413	33.6169830	50.1548813	27.8868199

Table 6.8: Linestring Geometry Similarity - LINZ vs SLIP

In tables 6.9 and 6.10, the results are not as optimistic with only pipelines showing higher similarity between LINZ and DELWP, and only rivers for SLIP and DELWP.

		DELWP				
		Road	**Contour**	**Railway**	**Pipeline**	**River**
LINZ	**Road**	30.9705608	51.0203167	52.9730255	23.9957570	41.8397549
	Contour	76.4274536	15.5674558	19.7541715	60.76070	26.4967621
	Railway	67.5413736	29.4314486	27.4085018	61.8694255	16.0496941
	Pipeline	30.6261845	52.7326925	54.9660168	23.4260972	44.168645
	River	83.3784253	7.13245361	2.63158630	74.4556226	10.9026413

Table 6.9: Linestring Geometry Similarity - LINZ vs DELWP

		DELWP				
		Road	**Contour**	**Railway**	**Pipeline**	**River**
SLIP	**Road**	24.2591254	64.4868973	65.7620197	18.6011345	53.7386588
	Contour	80.345719	14.6086470	18.7802881	64.9458133	25.8555759
	Railway	59.8841686	36.5060392	35.3293785	54.2186033	23.5989376
	Pipeline	34.4307763	48.6622362	50.6835030	28.7672560	39.469943
	River	58.3404147	25.1594347	26.8005483	47.2557075	19.112077

Table 6.10: Linestring Geometry Similarity - SLIP vs DELWP

In all cases, some emerging patterns are observed. For one, roads and pipelines constantly show a similarity between them. In all three tables when comparing roads and pipelines, both are either the first or second best similar feature types.

This pattern suggests that the length and angles of pipelines and roads are usually similar, which is to be expected given that pipes are usually laid down in the same pattern as roads. In order to differentiate between the two, a density predictor would have to be used. In the same area, the number of pipelines and roads could be used to differentiate them from one another.

A similar argument can be made for the other feature types. Contour lines will generally be the more consistently dense feature type, followed by roads and rivers, with pipelines and railways last. This poses an issue in terms of computing power. To make sense of the density of string lines, a large amount of the data has to be processed. Due to a lack of memory space, only 1000 features for each feature type were used. For larger amount of features, a different method is needed.

In addition to that, to get the density of the feature types, a region needs to be specified. The region can be specified as the whole area covered by the data provider but this would mean processing the entire dataset which is impractical for anyone besides the data providers themselves. As such, while density can prove to be useful to differentiate the varying linestring feature types, the computation overheads are to be considered.

(a) LINZ Rivers at 1:500K

(b) LINZ Rivers at 1:50K Overlayed

Figure 6.4: LINZ Rivers at Different Scales

Another issue that would affect the length and average interior angles of a linestring is the scale at which it was taken. For varying scales, the details recorded for the linestrings can vary greatly. Figure 6.4 shows a snippet of the river dataset from LINZ. Figure 6.4a is the river dataset taken at 1:500K scale while figure 6.4b shows the river dataset at 1:50K overlayed onto the 1:500K scale. The differences in accuracy is evident. The 50K scale dataset have details that are not present in the 500K dataset, and it can be observed that the length of the line segments are different based on which scale is chosen.

6.7.3 Polygon Feature Types

The selected polygon feature types are water tanks, buildings, districts, mines, and lakes. The predictors identified are the average interior angles of the polygon, the average distance between polygons, the average length of the polygon's sides, the $\frac{bounding box}{area}$ ratio, and the area of the polygon. Table 6.11 demonstrates the Gini importance of each predictor and their variances. It was found that the average of the interior angles of the polygon has an importance of 50%. As this predictor is at the borderline of the 50% cut-off percentage, the next predictor of average distance is used as well. Together they sum up to 73% importance which is above the 50% threshold used. They are the average of the interior angles and the average distance between polygons.

Feature Name	Importance	Variance
Average Angle	0.5092611	1190
Average Distance	0.22331595	702
Average Length	0.10581218	1.02
Bbox/Area	0.08160678	0.0325
Area	0.08000398	0.193

Table 6.11: Polygon Geometry Features

Tables 6.12, 6.13, and 6.14 contain the EMD score when comparing the polygon feature types using the two most important predictors for each WFS.

		SLIP				
		Water Tank	**Building**	**District**	**Mine**	**Lake**
LINZ	**Water Tank**	13.5332428	80.247763	17.6143150	28.4957713	17.4217335
	Building	69.3731640	4.62669290	64.6368630	52.1471869	62.7598932
	District	16.8122342	79.7653904	18.6664579	28.0678326	17.0119796
	Mine	26.3216589	58.8564132	17.0608393	10.9085160	7.5138345
	Lake	27.9148364	46.5053470	18.5909240	7.07798432	16.7114700

Table 6.12: Polygon Geometry Similarity - LINZ vs SLIP

In all three tables, the buildings are correctly identified as being more similar. It suggests that buildings from all data providers are similar in interior angles and

		DELWP				
		Water Tank	Building	District	Mine	Lake
LINZ	Water Tank	9.35801181	81.0075342	20.1591755	4.1411517	33.6917413
	Building	70.808486	3.32602764	60.6459536	78.8475531	46.4034240
	District	8.85699421	80.5254651	19.2155649	2.35414886	33.2075447
	Mine	14.9478861	59.6291673	3.70154554	20.2438710	12.3743613
	Lake	24.8206502	47.6447634	15.1670851	32.8701576	3.93263651

Table 6.13: Polygon Geometry Similarity - LINZ vs DELWP

		DELWP				
		Water Tank	Building	District	Mine	Lake
SLIP	Water Tank	15.516741	70.4282818	26.0605104	17.1575934	26.1237900
	Building	71.0190371	2.97177179	60.7750542	79.0436915	46.5890405
	District	14.5258143	65.8652176	17.7250483	19.3729497	19.3022726
	Mine	20.087588	53.401020	13.1286751	27.8855778	8.12927693
	Lake	9.59200701	63.8142164	8.62020700	16.7524024	16.8107214

Table 6.14: Polygon Geometry Similarity - SLIP vs DELWP

average distances between them. This is of significance because as opposed to point feature types, buildings do not seem to be affected by the clustering effect as much as point feature types. This might be due to the difference in importance between the distance predictor for points and polygons: the average distance predictor for points has an importance of 71% while the same predictor for polygons has an importance of 22%.

It is surprising to note that among the predictors, the area was the weakest of them. This predictor would help in separating water tanks from districts, and lakes. Generally speaking though, it would seem that the area of polygons has overall less importance than the shape of the polygon itself described by the interior angles. As such, despite the significant contribution that the area of polygons can provide, it is only true for a few selected feature types while most benefit more from the interior angle and distance predictors. Separating districts from the other feature type, is only a fifth of the feature types tested.

For lakes, a significant variable would be with the region type. From the tables, lakes have higher similarity between LINZ and DELWP suggesting that these two regions are similar. The same idea is portrayed when comparing the geographic name point features in section 6.7.1.

Similarly for facilities that require a good spread such as water tanks, a smaller EMD score is observed when comparing LINZ and DELWP. This difference can be accounted for by the difference in area coverage of the region. As the distance predictor accounts for less discriminatory power than the interior angles of the polygons, the small difference is justified.

6.8 Results and Discussion

While the overall result of this experiment is inconclusive, various aspects have been discussed that can explain the differences between the calculated EMD scores and the ground truth. One of the most important factors is the region coverage where the data was collected. Region based features such as geographic names, height points, s and lakes are more similar when comparing similar region coverage such as LINZ and DELWP.

The reason for such difference can be summarised because of the longer distances between features for points, and of the length of features for linestrings. These predictors can be said to be proportional to the coverage area as a larger coverage area encourages longer distances between points and longer linestrings for rivers.

Another major issue identified is the geographical clustering of features. Different to Western Australia and Victoria, New Zealand has two islands. This difference accounts for the discrepancies in man-made features such as rail stations, and street addresses. Each island creates a central hub where residents dwell, and hence the distances between the clusters need to be accounted for in the distribution of the features.

Separate to regions, there is also a problem regarding the scale of the datasets. It was observed that the same datasets of different scales vary greatly in accuracy and details even if coming from the same data source. This is of more concern with linestring and polygon geometries than with points. This would not be an issue if all data providers had datasets of the same scale, but this is not the case. SLIP has datasets with different scales depending on the regions, while DELWP uses different scales to LINZ.

It was also found that some predictors might be useful for specific features such as the area of polygons, but because they are not important for most feature types, they have a low Gini importance and were not used in the experiments. Overall, this experiment shows that to successfully discriminate geographic features, a lot of variables need to be considered.

6.9 Summary

This exploratory chapter looked at comparing the latent information (predictors) in the geometries of features to determine whether they can be used to facilitate the matching of feature types. In an ideal world, finding similar datasets could be achieved only by analysing the metadata of each dataset. However, because of the lack of suitable metadata, the approaches discussed in this chapter are needed.

This chapter explained the predictors used for each geometry type, as well as the methods used for their extraction. The CART algorithm and Gini importance was used to determine the most significant predictors, and their distribution was compared using EMD.

The results obtained were inconclusive but a discussion was made about the variables that were overlooked, and how they can affect the EMD scores. The variables discussed are mainly about the origin of the data: the scale at which the data were recorded, and the surveyed coverage area. This information cannot be obtained from the datasets alone, and further investigations would have to be done. Such a task is not covered in this thesis but can be subject for further research.

To conclude, it was found that there are several variables to consider when dealing with features of different regions. While some issues pertaining to this investigation have been discussed, more experiments are needed to confirm their associations and correlations to the task described. These experiments have complexities that are too large for the scope of this thesis and are left for future work.

CHAPTER 7

BROKER COMPOSITION AND IMPLEMENTATION

7.1 Chapter Overview

This chapter explains the architecture of the broker system. Previous chapters justified the usage of a broker system and introduced the technologies developed and used in this thesis. Here, an overview of the broker's components, their implementations and issues are addressed.

The structure of this chapter is as follows. First, an overview of the functions of the broker is provided. Afterwards, an explanation of the broker's processes, potential error handling, and its evaluation are discussed, to follow with the chapter's summary.

7.2 Broker Overview

A broker is a mediator which facilitates the transactions between users and data end-points. In this thesis, a user means any user interface or interactive tool that facilitates the interaction between consumers and the broker (e.g. an Application Programming Interface (API) or a Web Service).

A data end-point can be described as a Web service with capabilities to provide data over the Web. The end-point can be any Web service as long as the data are made available to its users. However, for simplicity in this thesis, the end-points are narrowed down to Web Feature Services (WFSs).

To aid the users in querying the end-points, a broker can be specified as the following steps (Widom, 1995):

1. Accepting a query;
2. Interpreting the query to determine appropriate information sources that can answer the query;
3. Decomposing and re-writing the query for each information source;
4. Querying the information sources and obtaining the results of the sub-queries;
5. Processing the obtained results by appropriately transforming, filtering, and merging them; and
6. Returning the final responses to the requestor.

Steps 1 and 6 are implementation issues that are dependent on the stakeholders, and as such are not focal to this thesis. Instead, the focus is on processes 2 to 5. The information required in these processes can be summarised as the answers to the following questions: (1) which data sources can answer the query and (2) which information is needed to query the data sources. These pieces of information are captured with ontologies using Semantic Web techniques.

The list of steps by Widom (1995) assumes that the broker transforms and filters the data locally. This, however, adds computational overheads to the broker system leading to performance degradation. Instead, in this thesis, the filtering of datasets is done through the filter capabilities of WFSs. This on-the-fly data querying alleviates the burden on the broker and utilises existing Web services to only obtain datasets specific to a query.

As such, a better representation of the processes used in this thesis is:

1. Accepting a query;
2. Interpreting the query to determine which information to gather;
3. Gathering the information needed for rewriting the query;
4. Decomposing and re-writing the query for each information source;
5. Querying the information sources and merging the response; and

6. Returning the final merged response to the requestor.

Following these modifications, our broker is divided into three main components: the *query interpreter*, the *ontology query processor*, and the *WFS query processor*; a fourth process is the compilation of the retrieved results into one comprehensive result list: the *query assembler*.

7.3 Broker Components

The components of the broker is shown in figure 7.1. A user query (1) passes through the *query interpreter* (2) which separates the query into components to be answered by either the *ontology query processor* (3) or the *WFS query processor* (5). The *ontology query processor* retrieves information from the Web Service Ontology (WSO) (4) described in chapter 3, and the *WFS query processor* makes request calls to the WFS servicing the required datasets. The results are then passed to the *query assembler* (6) to combine and return them to the user as a federated result (7). The main components are discussed in more details in the next section.

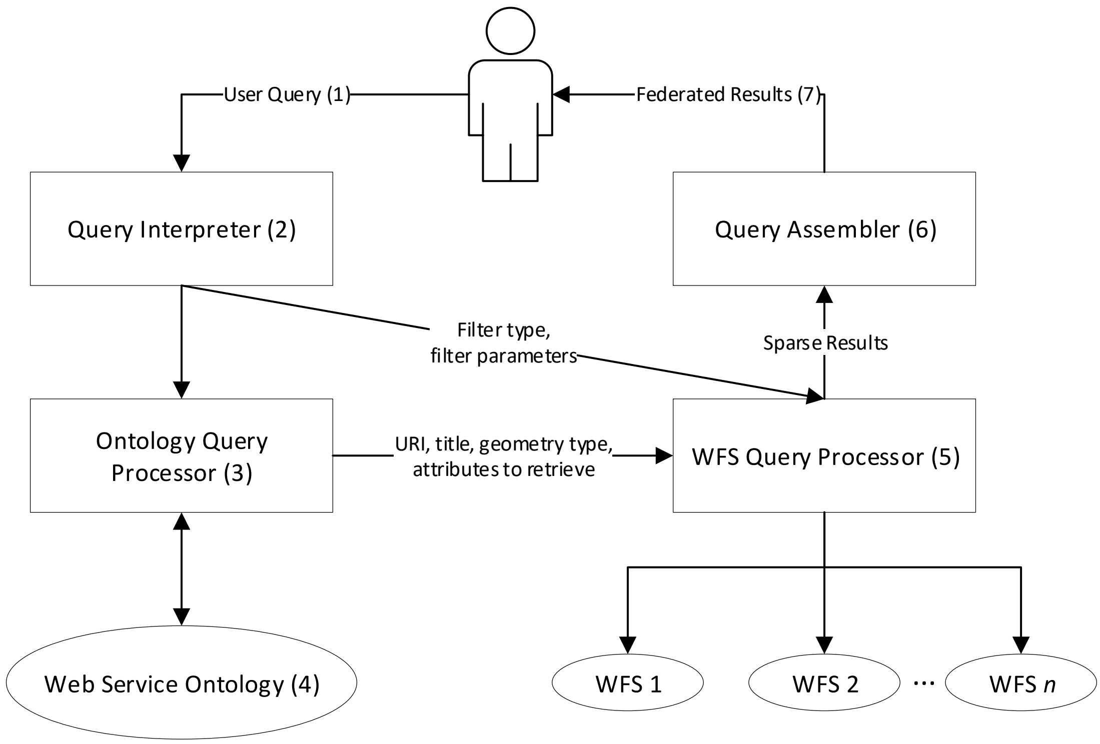


Figure 7.1: Summary of Broker Components

7.3.1 Query Interpreter

The *query interpreter* receives a query from a user and decomposes it into sub-queries to be answered by WSO and sub-queries to be answered by the Web services. This separation is needed because the filtering of the datasets is executed by the WFSs, which are outside of the broker's system. As such, the queries to be answered by WSO include:

1. Which Web services can answer the query requested by the user;
2. What are the URI of the relevant Web services;
3. What is the name of each requested feature type in terms of each Web service; and
4. What is the name for each requested attribute of each feature type in terms of each Web service.

The queries to be answered by the WFSs include:

1. Which filters are to be applied in the request call; and
2. What are the parameters of the filters;

User queries are separated into **select**, **where**, and **filter** clauses. The **select** clause identifies the attributes that the user wishes to retrieve. The **where** clause states the combination of triples to query from WSO, and the **filter** clause states how the datasets need to be filtered. The **select** and **where** clauses can be considered normal SPARQL queries over WSO without the filtering, while the **filter** clause needs to be specified according to the OGC standard for filters which can be found at `http://www.opengeospatial.org/standards/filter`.

Select and where clauses

The **select** and **where** clauses are queries over WSO. Their structure depends on: (1) which feature types are to be queried, and (2) which attributes need to be retrieved.

To query for a specific feature, the query takes the following form:

```
SELECT ?feature
WHERE {
  ?feature a x.
}
```

where x is the feature type to be queried in terms of WSO. The variable *?feature* has an arbitrary name denoting that a subject is to be retrieved having the specified triple. As such, only x needs to be specified. For example, to query the feature type *Building*, the following query can be used:

```
SELECT ?feature
WHERE {
?feature a wso:Building .
}
```

Such a query will return all ontology entities which are buildings in WSO.

To specify which attributes of the feature type are to be retrieved, two main object properties are used: (1) *wso:hasAttribute* and (2) *wso:metadataName*. *wso:hasAttribute* is a predicate that links to an attribute based on the *DescribeFeatureType* document of the feature type. To extract the name of the attribute, *wso:metadataName* can be used. The right attribute to retrieve can be specified using the 'a' predicate which ensures that the type of the attribute matches.

In general form: given that a user needs to retrieve n attributes, let $x_1, x_2, ..., x_n$ be the types of attributes and v be the feature type to be queried. The query structure can thus be represented as:

```
SELECT ?attr_1 ?attr_2 ... ?attr_n
WHERE {
  ?feature a v .

  ?feature wso:hasAttribute ?indiv_1 .
  ?indiv_1 a x1 .
  ?indiv_1 wso:metadataName ?attr_1 .

  ?feature wso:hasAttribute ?indiv_2 .
  ?indiv_2 a x2 .
  ?indiv_2 wso:metadataName ?attr_2 .
```

```
  ...

  ?feature wso:hasAttribute ?indiv_n .
  ?indiv_n a xn .
  ?indiv_n wso:metadataName ?attr_n .
}
```

The variables in red are the only information the user is required to provide. They are the feature type v, and the attributes $x_1, x_2, ..., x_n$ pertaining to this feature type. The same structure can be used if multiple feature types need to be queried. These variables are vocabularies used by WSO. The translation from these variables to WFS is executed when querying WSO (section 7.3.2).

Filter clause

For this thesis, three types of filters available in WFS 1.0.0 are looked at. They are comparison filters, spatial filters, and logical filters.

- **Comparison filters** are filters used to match an attribute to literal values. They are PropertyIsLessThan, PropertyIsGreaterThan, PropertyIsLessThanOrEqualTo, PropertyIsGreaterThanOrEqualTo, PropertyIsEqualTo, PropertyIsNotEqualTo, PropertyIsLike, PropertyIsBetween, PropertyIsNull, and PropertyIsNil filters.
- **Spatial filters** are filters that compare two features to one another based on their spatial relationship (geometries and/or distance). They are Disjoint, Equals, DWithin, Beyond, Intersects, Touches, Crosses, Within, Contains, Overlaps, and BBOX filters.
- **Logical filters** are filters allowing the combination of filters using the logical operators AND and OR.

Comparison Filters

To specify comparison filters, the user needs to specify the comparison attribute and the literal values required for comparison. All of the comparison filters only require one literal value except of PropertyIsBetween which requires a lower bound and an upper bound values.

Examples for specifying the PropertyIsLike and PropertyIsBetween filter in the broker system are:

```
FILTER:
attr_1 PropertyIsLike 'Lane'

FILTER:
attr_1 PropertyIsBetween 120 140
```

Spatial Filters

For spatial filters, geometries from two features are required to be compared to one another. The user, thus, has to specify the two feature types. The geometry attribute does not need to be specified as it can be inferred that they are required because spatial filters are defined in the query. An exception is for the filters *DWithin* and *Beyond*. Both of them require the specification of a distance threshold and its unit alongside a point geometry. Examples of spatial filters are:

```
FILTER:
feature_1 Intersects feature_2

FILTER:
feature_1 Beyond feature_2 500 meters
```

Logical Filters

Logical filters allow the combination of comparison and spatial filters, and the user needs to specify which parts of the filters are to be segmented into OR or AND blocks. Special symbols can be used to separate logical operators from the query blocks. Examples where the && symbol represents the AND operator, and the || symbol represents the OR operator are:

```
FILTER:
feature_1 Beyond feature_2 700 meters && attr_1 PropertyIsLike
    Lane

FILTER:
```

```
feature_1 Beyond feature_2 700 meters || feature_1 DWithin
    feature_2 100 meters
```

The specifics of the user interface to achieve these queries are left open as they can vary greatly and depends on the target audience and developers. For this thesis, the queries are encoded directly into dictionaries and arrays.

7.3.2 Ontology Query Processor

The ontology query processor retrieves information from WSO, the broker's ontology. To achieve this goal, sub-queries decomposed from the user query are transformed into SPARQL. Information that is retrieved from the ontology include the Web sources that can answer the query, their URLs, and the feature types and attributes related to the user's query.

To allow federated queries over multiple WFS, similar feature types need to be matched to a common vocabulary in WSO. As an example, to retrieve the names of the feature type roads, this process gives back the URLs of the WFS alongside the road feature types as described by each WFS. LINZ titles their road feature type as LAYER-50329, while DELWP titles theirs as VMTRANS_TR_ROAD_LOCAL. Each WFS refers to the attributes of the feature type differently, but this information is represented in the ontology and makes the querying of multiple WFS from a single unified view seamless.

To obtain all this information, the ontology processor augments the user query to include the retrieval of the URLs, the title of the feature types, and the geometry name in each Web service. Listing 7.1 demonstrates the template for an augmented query.

```
SELECT ?uri ?title ?geom_name ?attr_1 ?attr_2 ... ?attr_n
WHERE {

  # Get the name of the service and set up their OWL-S
      instances
  ?wfs_profile profile:serviceName ?service_name .
  ?wfs_profile service:presentedBy ?wfs_service .

  # Finds the uri of the method of choice (POST in this case)
```

```
?wfs_service service:supports ?grounding.
?grounding grounding:hasAtomicProcessGrounding ?atomic_process .
?atomic_process wso:ogcHttpInputMessage ?request .
?request http:requestURI ?uri .
?request http:mthd ?method .
?method rdf:resource ?method_resource .
?wfs_profile profile:hasInput ?feature .

# This is the user query
?feature a v .

?feature wso:hasAttribute ?indiv_1 .
?indiv_1 a x_1 .
?indiv_1 wso:metadataName ?attr_1 .

?feature wso:hasAttribute ?indiv_2 .
?indiv_2 a x_2 .
?indiv_2 wso:metadataName ?attr_2 .

...

?feature wso:hasAttribute ?indiv_n .
?indiv_n a x_n .
?indiv_n wso:metadataName ?attr_n .

# Get the name of the geometry attribute of the feature type being queried
?feature geo:hasGeometry ?geom .
?geom wso:metadataName ?geom_name .

# Get the feature type title as used by the different WFS
?feature wso:hasProfile ?feature_profile .
?feature_profile wso:metadataName ?prof_name .
?feature_profile wso:metadataValue ?title .
FILTER (?prof_name = "Name" && ?method_resource = "http://www.w3.org/2011/http-methods#POST")
}
```

Listing 7.1. WSO Augmented Query

In the **select** clause on line 1, the attributes in the 'select', and 'filter' components of the user's query are added in. In addition to the requested data from the user, the URI, title, and geometry name are queried as well. Lines 4-15 queries for the profiles of the Web services available and their URI relevant to a POST query as defined by the filter (line 44-45). Lines 18-34 are the SPARQL query from the user *verbatim*, and lines 37-38 queries for the name of the geometry attribute of the feature types queried. Lines 41-43 retrieve the titles of the feature types as used by each WFS.

The only information that is required from the user is the type of feature (variable v), and the attributes pertaining to that feature type (variables $x_1, x_2, ..., x_n$). In the case of spatial filters and logical filters, where multiple feature types need to be queried, the same structure can be used for each feature type. The filter from the user query is not used because they do not apply to the ontology but rather are used when querying the WFS (section 7.3.3).

To summarise, with this querying format, the ontology manages to capture the URIs of the WFS, the title of the feature types to be queried as named in each WFS, the attributes to be queried, and the geometry name of the feature types. This information is passed on to the WFS query processor alongside the **filter** component of user's query to construct the request call required for each WFS.

7.3.3 WFS Query Processor

Once the required information from the ontology has been gathered, the *WFS query processor* constructs request calls for each WFS. Multiple queries, and filters can be used in the Web service call.The different WFS calls are thus described in the ontologies in the broker: the way to call the WFS, which filters are available, and the available data formats of the responses. From these, possible queries, filters, and processes served by the Web service are automatically identified.

The only additional process required in this step is to transform the **filter** component of the user query into WFS compliant ones, and to combine them with the information from the ontology to form a complete WFS request. This section outlines the XML structure for each filter type used. They are: comparison operators, spatial operators, and logical operators as specified for WFS 1.0.0 (OGC, 2005).

```
<ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
  <ogc:α wildCard=" " singleChar="#" escape="!">
    <ogc:PropertyName>β</ogc:PropertyName>
    <ogc:Literal>θ</ogc:Literal>
  </ogc:α>
</ogc:Filter>
```

Listing 7.2. XML Structure for Comparing One Literal Value

Comparison Operators

Comparison operators compare literal values and fall under the scalar capabilities of a WFS. Table 7.1 shows the requirements of the different comparison operators. It can be observed that the first seven operators require the same variables, but the last three have different requirements. While PropertyIsNull (9) and PropertyIsNil (10) have different requirements to the other operators, they can be said to have a literal value of 'null' or 'nil' respectively. As such, they are seen as being similar to number 1-7.

#	Operator	Required Variables		
1	PropertyIsLessThan	property name	literal value	
2	PropertyIsGreaterThan	property name	literal value	
3	PropertyIsLessThanOrEqualTo	property name	literal value	
4	PropertyIsGreaterThanOrEqualTo	property name	literal value	
5	PropertyIsEqualTo	property name	literal value	
6	PropertyIsNotEqualTo	property name	literal value	
7	PropertyIsLike	property name	literal value	
8	PropertyIsBetween	property name	literal value	literal value
9	PropertyIsNull	property name		
10	PropertyIsNil	property name		

Table 7.1: Point Geometry Features

For the group of queries requiring one literal value, the XML structure is shown in listing 7.2. α is the type of filter (e.g. PropertyIsLike, PropertyIsEqual), β is the name of the property to compare, and θ is the literal value to compare. For each of the WFS, β will be different depending on the data source itself.

Listing 7.3 shows the XML structure for the PropertyIsBetween operator, where

```
<ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
  <ogc:PropertyIsBetween>
    <ogc:PropertyName>β</ogc:PropertyName>

    <ogc:LowerBoundary>
      <ogc:Literal>θ</ogc:Literal>
    </ogc:LowerBoundary>

    <ogc:UpperBoundary>
      <ogc:Literal>μ</ogc:Literal>
    </ogc:UpperBoundary>
  </ogc:PropertyIsBetween>
<\ogc:Filter>
```

Listing 7.3. XML Structure for Comparing Two Literal Values

β is the name of the property to compare, and θ is the literal value denoting the lower boundary, while μ is the literal value denoting the upper boundary. β differs depending on the data source.

Spatial Operators

Spatial operators deal with the comparison of geometries. They include the Disjoint, Equals, DWithin, Beyond, Intersects, Touches, Crosses, Within, Contains, Overlaps, and Bounding Box (BBOX) operators. All of these operators compare geometries in GML format.

The operators Disjoint, Equals, Intersects, Touches, Crosses, Within, Contains, Overlaps, and BBOX require the comparison of two geometries, while DWithin and Beyond need another variable, the threshold distance. DWithin calculates whether a feature is within a certain perimeter identified by a point and its radius. Similarly, the Beyond operator finds features outside of the perimeter defined.

For filters requiring the comparison of two geometries, the XML filter is shown in listing 7.4.

```
<ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
  <ogc:α>
    <ogc:PropertyName>β</ogc:PropertyName>
```

```
    <ogc:θ>
      ω
    </ogc:θ>
  </ogc:α>
</ogc:Filter>
```

Listing 7.4. XML Structure for Comparing Two Features Spatially

where α is the spatial operator to use (e.g. Within, Intersects), β is the name of the geometry attribute to compare, θ is the type of geometry to compare to, and ω is the geometry in GML. Using this filter, any features whose geometries matches the spatial operator will be returned.

Contrastingly, XML filters requiring a point and threshold distance (DWithin, Beyond) take the XML structure as shown in listing 7.5.

```
<ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
  <ogc:α>
    <ogc:PropertyName>β</ogc:PropertyName>
    <ogc:θ>
      ω
    </ogc:θ>
    <Distance units=ϕ>μ</Distance>
  </ogc:α>
</ogc:Filter>
```

Listing 7.5. XML Structure for Comparing a Feature with a Threshold Distance

where α is the spatial operator to use (e.g. DWithin, Beyond), β is the name of the geometry attribute to compare, θ is the type of geometry to compare to, and ω is the geometry in GML. The distance threshold is defined as μ with the unit of measurements being ϕ.

Logical Operators

Logical operators are operators that allow the combination of the previous filters discussed. Two logical operators are 'And' and 'Or'. 'And' is true if and only if all the filters within an 'And' block are true, while the 'Or' operator is satisfied when at least one filter in the block is true. Listing 7.6 demonstrates the XML structure for logical operators.

```
<ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
  <ogc:α>
    <ogc:θ> ... </ogc:θ>

    <ogc:ω> ... </ogc:ω>
  </ogc:α>
</ogc:Filter>
```

Listing 7.6. XML Structure for Logical Operators

where α is either 'And' or 'Or', θ is the first filter, and ω is the second filter. Multiple logical operators can be combined for more complex queries.

7.3.4 Query Assembler

After each WFS has been queried based on the requests formed in the previous component, their results are combined by the *query assembler*. The *query assembler* combines the datasets obtained from the different data sources, and returns the combined results to the user. While this component can be used for harmonisation purposes, in this thesis, its function is scoped down to returning all datasets in a uniform format because its implementation is subjective to the real world requirements of the broker. In this thesis, the results from the *query assembler* include the URLs from where the data come from, the requested attributes, and the total number of results obtained. Examples of the combined results can be seen in appendix F.

7.4 Error Handling

In this section, a potential error handling mechanism is discussed to cope with schema changes at the data endpoints. Error handling is required to be dynamic in regards to the broker. There are two types of errors that can happen during data retrieval. First one is an error message on the server's side, the other is an error message on the broker's side.

7.4.1 Identifying the Error Type

To distinguish between the two types of error, the error message needs to be parsed. An error on the server side contains an HTTP error code (e.g. Error 404 for 'file not found'). By parsing the error code, the root cause of the error is found and proper reporting of events is carried out.

The second type of error which is from the broker's side, is reported in a pre-determined format by the Web service. This format is stored in the ontology to facilitate the parsing of the error. For example, a WFS returns a JSON error message that can be parsed by the broker. If the error is not known, the broker can report the error and human intervention ensues. Otherwise, for a known error message the broker can automatically resolve it by searching the ontology for the proper processes to undertake. For example, given a schema mismatch, any discrepancies in the broker's ontology can be resolved by parsing the end-point's schema and editing the ontology based on any changes required.

Handling of errors are not expanded further in this thesis. Due to using existing, real-world WFS, the control over the endpoints is limited and hence error handling evaluation cannot be consistently achieved. For this reason, the broker's error handling method is simply stated as a possibility.

7.4.2 Server Side Error Handling

The server-side error cannot be solved by any external program including the broker. The root cause of this error is from the server's side, whose control is independent and outside of our own control. Examples of such an error are a change in URL, the maintenance of the server, or the deletion of the endpoint. In such a situation, the only action is to report the error to the user—either the consumer or the creator of the user interface.

7.4.3 Broker Side Error Handling

The broker-side error relates to a query that the broker did not form properly. Such an error can happen due to multiple reasons. One example being when the server's administrators decide to change their schema, and another example would be a change in the way the Web services are exposed. An example of the latter is to supersede an output format with a new one. This can be resolved by changing the ontology to reflect the changes for that particular URL only. This method can be achieved automatically by parsing through the capabilities of the WFS, which is explained in chapter 4. Once the parsing process is completed, the rest of the ontology is realigned to the Web service. This method fixes any ambiguities by rewriting that part of the ontology based on the modified WFS.

Possible extensions of this error handling mechanism include: keeping track of the different versions, thus having the broker allow the viewer to track changes of the schemas, and re-aligning the old schemas with the most recent ones, through an ontology relationship to indicate the similarities between schema versions.

7.5 Summary

In this chapter, we proposed an implementation of the broker. The broker's aim is to facilitate the querying of disparate and heterogeneous datasets. The various components of the broker were explained: the *query interpreter*, *ontology query processor*, *WFS query processor*, and the *query assembler*.

The query interpreter decomposes a query based on the **select**, **where**, and **filter** components of a SPARQL query and the sub-queries are sent to the *ontology query processor* or *WFS query processor* depending on which information needs to be retrieved. It was also shown how a SPARQL query can be augmented to get all the information required from the broker's ontology without needing extra input from the user. As for the *WFS query processor*, the different types of filters and their XML structures that can be queried were explained. Additionally, a potential error handling mechanism for the broker was discussed, more specifically, how the broker system could handle errors both from the broker and server side.

CHAPTER 8

EVALUATION OF THE BROKER SYSTEM

8.1 Introduction

This chapter demonstrates and evaluates the capabilities of the broker system presented in this thesis. The broker system facilitates the querying of disparate data sources for users through the abstraction of Web services using ontologies. In this chapter, Web Feature Service version 1.0.0 is used to evaluate the broker system; however, the approach underlined in this thesis can be adapted for any existing WFS versions, and other non OGC-compliant Web services.

To evaluate the system, sample queries over the WFSs are manually performed *via* standard WFS requests; this establishes the ground truth for subsequent comparison to the results obtained using the broker system. The datasets used are live and stored at existing remote locations, as such, there is no control over them. For this reason, a coverage evaluate approach is utilised in which different predefined queries from different categories are used. These queries cover all possible categories of requests that can be served by WFSs. The ground truth is then gathered manually, and is compared to the results obtained by using the broker. A query evaluation succeeds if the result obtained from the broker is the combined results from the different WFSs.

8.1.1 Scope of the Evaluation

In this thesis, stress evaluation is not implemented due to limited resources, and only functional evaluations are accomplished. In addition, the semi-automated process to find similar feature types from chapter 5 is assumed to have been conducted, and superclasses have been generated for similar feature types.

As an example, for buildings, the feature types LAYER-50246 and VM_BUILDI-NG_POLYGON are identified as being similar feature types representing buildings. To allow their querying, a superclass (wso:Building) is created where both feature types are subclasses. Each feature type also has a feature id or feature name linked to their related attributes (depending on which information is available). This idea is presented in figure 8.1 where both features are made types of buildings and having 't50_fid' and 'OBJECTID' as feature ids as used by the Web services.

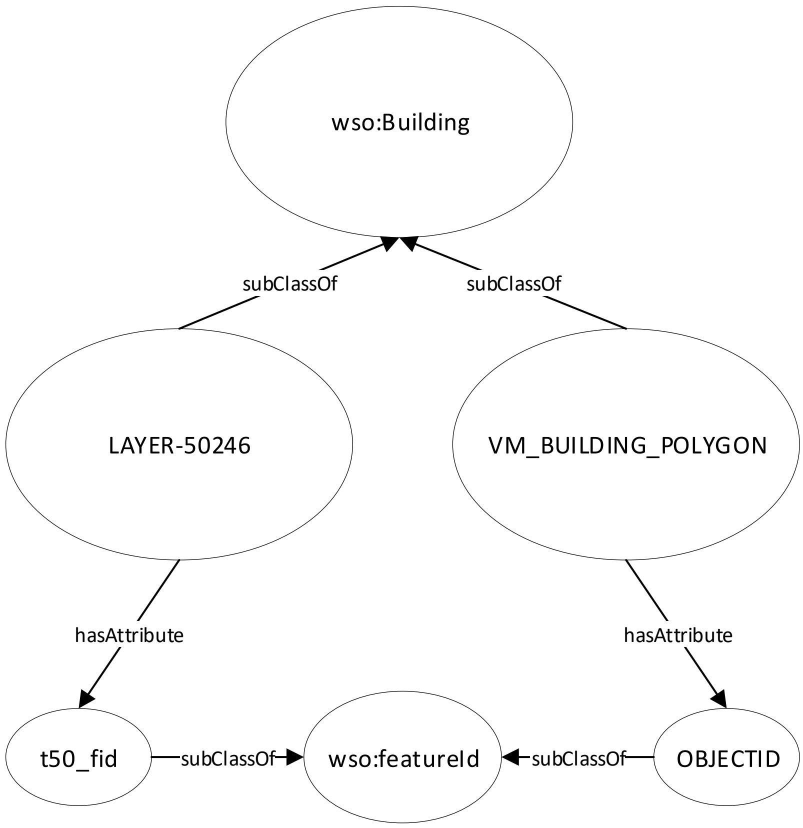


Figure 8.1: Summary of Broker Components

The WFS used are the ones from LINZ and DELWP. SLIP is not used because it lacks filtering support and while their datasets can be filtered directly through the broker (using code scripts), this scenario is not ideal due to computation overheads and hence is not explored. The seven feature types used in this chapter are shown in table 8.1, alongside their title as registered by each data provider.

Additionally, because live WFSs are used (and hence big data is involved), the spatial extent of the datasets are restricted in this evaluation. Two spatial extents for LINZ and DELWP are used; the spatial extents for LINZ are the Karori region

Feature Type	LINZ	DELWP
Addresses	LAYER-53353	VMADD_ADDRESS
Building	LAYER-50246	VMFEAT_BUILDING_POLYGON
Lake	LAYER-50293	VMHYDRO_WATER_AREA_LAKES_DAMS
Mine	LAYER-50301	MINERALS_MINERAL
Height Point	LAYER-50284	VMELEV_EL_GRND_SURFACE_POINT_1TO5M
Road	LAYER-50329	VMTRANS_TR_ROAD_LOCAL
Water Tank	LAYER-50361	VMHYDRO_HY_WATER_STRUCT_AREA_TANK

Table 8.1: Identified Similar Feature Types

(figure 8.2a) and the Lower Buller region (figure 8.2b), while the spatial extents for DELWP are the Marrondah region (figure 8.2c) and the Thowgla Valley region (figure 8.2d).

The coordinates of the spatial extents for each region is shown in table 8.2 using the EPSG::4326 coordinate system. The same spatial extents are used in both the ground truth and the broker system by using the *Within* OGC filter operation upon a WFS request. In the broker system the spatial extents are hard-coded for each WFS query. Rectangles have been used as the polygon of choice because they are the simplest 2D geometry.

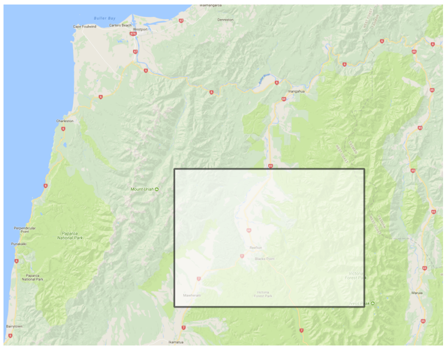
Region	Lower Corner	Upper Corner
Karori	-41.2991,174.7426	-41.3453,174.8262
Lower Buller	-41.9849,171.6812	-42.2121,172.1028
Marrondah	-37.7884,145.2605	-37.8727,145.3746
Thowgla Valley	-36.0553,147.8224	-36.2111,147.9756

Table 8.2: Region Used for each Query and their Results

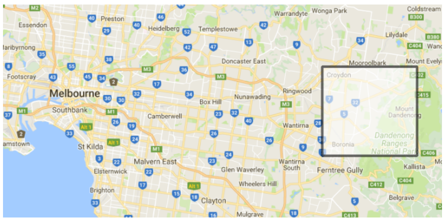
8.2 Methods for Evaluating the Broker System

To evaluate the results of the proposed broker, a ground truth is first established. Six sample queries (2 for each WFS filter type) are defined and queried for each WFS separately, with their respective results recorded. In this section, the specific queries used for the evaluation are introduced alongside their ground truth.

(a) Karori Dataset Spatial Extent



(b) Lower Buller Dataset Spatial Extent



(c) Marrondah Dataset Spatial Extent

(d) Thowgla Valley Dataset Spatial Extent

Figure 8.2: Dataset Spatial Extent

8.2.1 Comparison Queries

The requirements for the comparison queries can be generalised as comparing an attribute to either one literal value or to two literal values. Two queries evaluated are:

Query 1: *Retrieve Roads that are lanes*; and

Query 2: *Retrieve height points that have an elevation between 120 and 140*.

The first query requires the comparison of the road type to one literal 'Lane', hence PropertyIsLike is used. The second query uses the PropertyIsBetween operator. The PropertyIsLike filter compares an attribute to one literal, while PropertyIsBetween compares an attribute to two literals. Using these two queries, both categories of comparison queries are catered for.

8.2.2 Spatial Queries

Two categories of spatial queries are: (1) comparing two geometries spatially, and (2) comparing a feature to a threshold distance. Two queries that cover both categories are:

Query 3: *Retrieve mines that are underneath a lake*; and

Query 4: *Retrieve buildings within 500m of a water tank*.

To find mines that are underneath lakes, the Intersects operator is used, evaluating the queries that compare two geometries. The second query evaluates the queries making use of a point and distance threshold, in this case, the operator Beyond is used. These two queries encompass the two different types of spatial queries available in WFS 1.0.0.

8.2.3 Logical Queries

The logical queries available in WFS 1.0.0 are the AND and OR operators. The two queries used to test the logical operators are:

Query 5: *Retrieve addresses that are within 500m from a water tank AND whose road is a lane*; and

Query 6: *Retrieve roads that are either of type lane OR street*.

Both AND and OR operators are tested with these queries to combine previous queries evaluated and hence ensure that all available types of logical operators are tested.

8.3 The Ground Truth

This section contains the ground truth for each query specified in the last section. It shows a map of the features obtained for each query. The complete results in XML format can be found in appendix E.

8.3.1 Query 1: Retrieve roads that are lanes

A *PropertyIsLike* operator is used to identify whether a particular road has the string 'Lane' in its name. For LINZ, the layer used is LAYER-50329, for DELWP it is VM-TRANS_TR_ROAD_LOCAL.

LINZ Query

The spatial extent used for LINZ is the region of Karori in New Zealand. Although LAYER-50239 does not inherently have a road type attribute, this information can be extrapolated from the name of the road. Hence, to identify whether the road is a lane or not, its 'name' attribute is filtered. Below is the query used on the WFS serviced by LINZ.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.
    opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50329">
    <ogc:Filter>
      <ogc:PropertyIsLike wildCard=" " singleChar="." escape="
          !">
        <ogc:PropertyName>name</ogc:PropertyName>
        <ogc:Literal> LANE </ogc:Literal>
      </ogc:PropertyIsLike>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

LINZ Results

The total number of roads in the spatial extent is 677. With the specified filter, three features were identified as being lanes. This is demonstrated in figure 8.3.

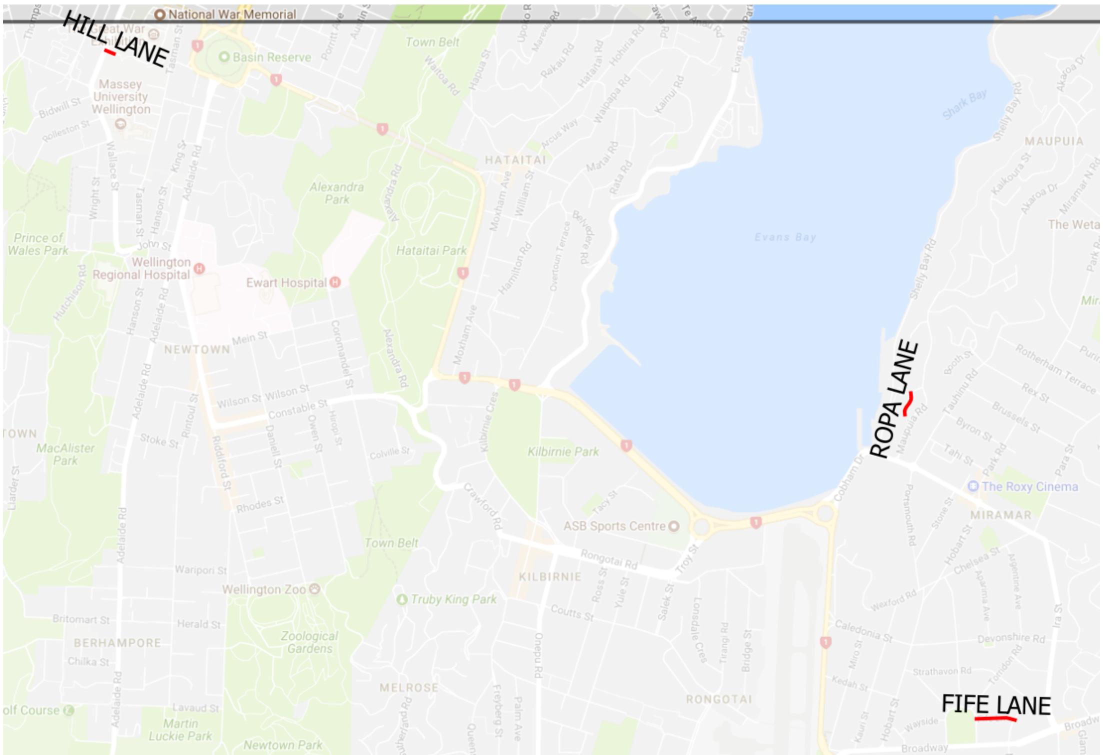


Figure 8.3: Query 1 Results from LINZ

DELWP Query

The query for DELWP is limited to the Maroondah region in Victoria. The name of the feature type used for roads is VMTRANS_TR_ROAD_LOCAL, with the attribute for the road type being ROAD_TYPE. The query is shown below.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs"  xmlns:
    ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.
    opengis.net/gml"  service="WFS" version="1.0.0">
  <wfs:Query typeName="datavic:VMTRANS_TR_ROAD_LOCAL">
    <ogc:Filter>
      <ogc:PropertyIsLike wildCard=" " singleChar="." escape="
          !">
        <ogc:PropertyName>ROAD_TYPE</ogc:PropertyName>
        <ogc:Literal> LANE </ogc:Literal>
      </ogc:PropertyIsLike>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

DELWP Results

Within the region queried, there are a total of 3526 features from the VMTRANS_TR_ROAD_LOCAL layer. Of them, 58 were filtered to be of type lane. Figure 8.4 shows the results.

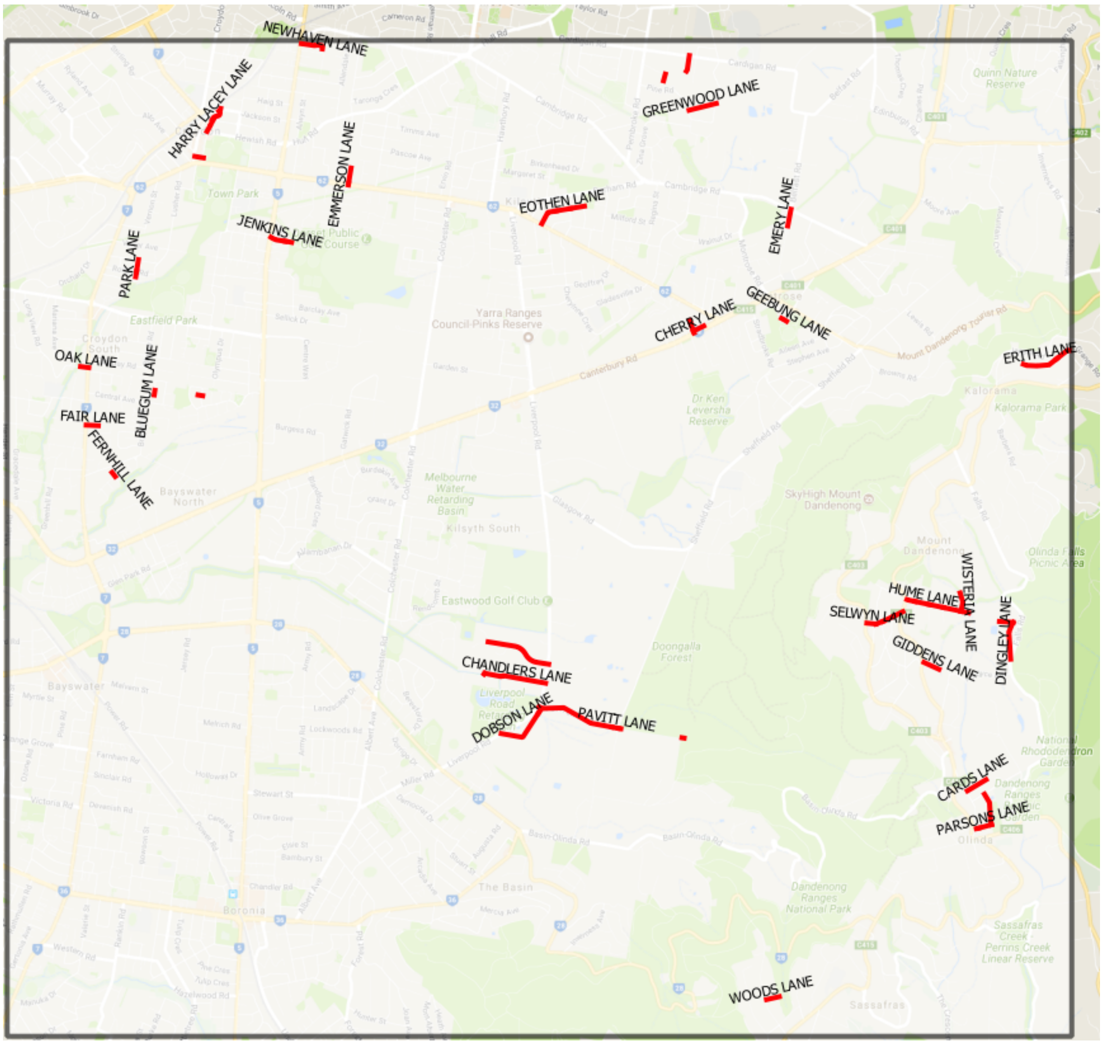


Figure 8.4: Query 1 Results from DELWP

8.3.2 Query 2: Retrieve height points that have an elevation between 120 and 140

This query uses the *PropertyIsBetween* operator. It requires the input of a property name and two literals - a lower bound and an upper bound. In this instance, the literals 120 and 140 are used alongside the height point layers. For LINZ it is equivalent to LAYER-50165, and for DELWP it is VMELEV_EL_GRND_SURFACE_POINT.

LINZ Query

The spatial extent for this query in LINZ is the same as query 1, the Karori region in New Zealand. The elevation attribute for LAYER-50165 has the name ‘elevation’. This attribute is filtered to be between 120 and 140. The WFS query used is as follows:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50284">
    <ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
      <ogc:PropertyIsBetween>
        <ogc:PropertyName>elevation</ogc:PropertyName>

        <ogc:LowerBoundary>
          <ogc:Literal>120</ogc:Literal>
        </ogc:LowerBoundary>

        <ogc:UpperBoundary>
          <ogc:Literal>140</ogc:Literal>
        </ogc:UpperBoundary>
      </ogc:PropertyIsBetween>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

LINZ Results

Out of the 10 height points contained within the spatial extent, four results were filtered from the query which have an elevation between 120 and 140 as shown in figure 8.5, with the elevation number shown.

DELWP Query

For DELWP, the feature type used is VMELEV_EL_GRND_SURFACE_POINT_1TO5M. The spatial extent is within the region of Maroondah. For this feature type, the

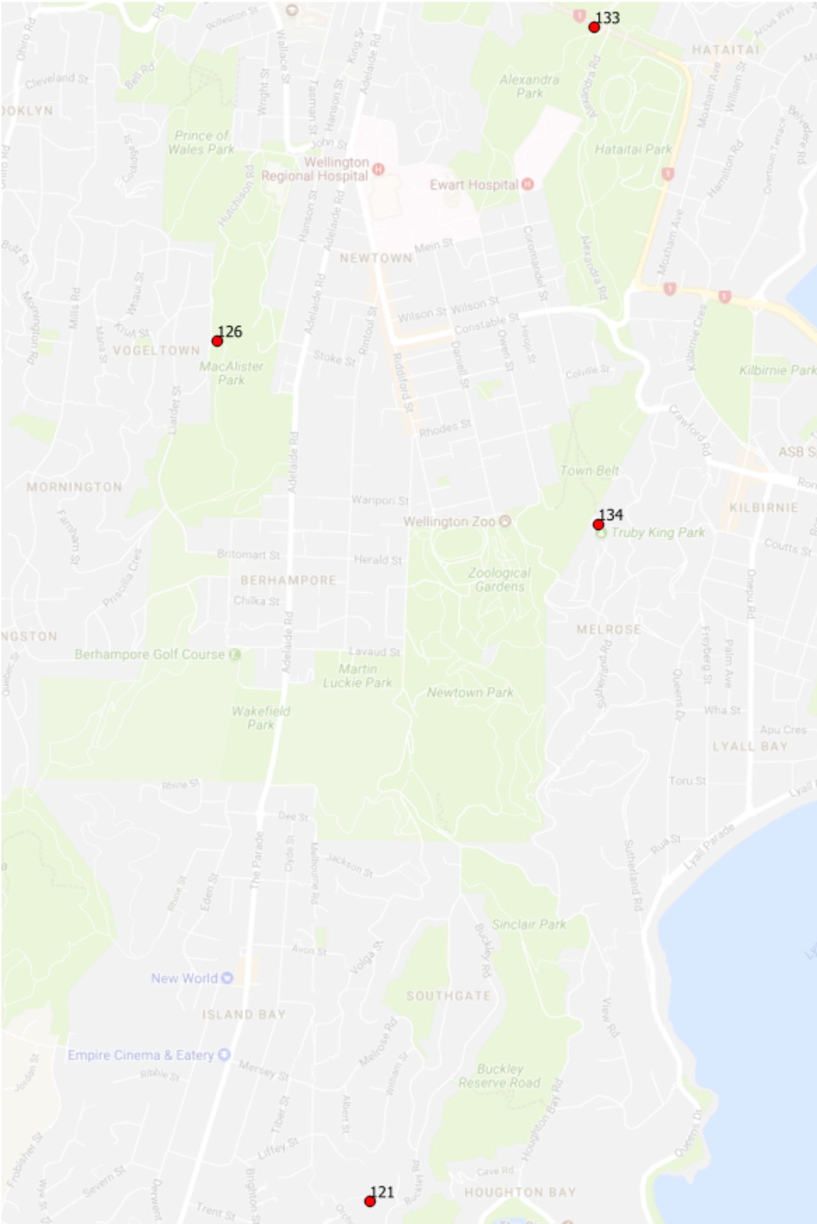


Figure 8.5: Query 2 Results from LINZ

elevation attribute is named 'ALTITUDE', and this is reflected in the request used:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="VMELEV_EL_GRND_SURFACE_POINT_1TO5M">
    <ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
      <ogc:PropertyIsBetween>
        <ogc:PropertyName>ALTITUDE</ogc:PropertyName>

        <ogc:LowerBoundary>
          <ogc:Literal>120</ogc:Literal>
        </ogc:LowerBoundary>

        <ogc:UpperBoundary>
          <ogc:Literal>140</ogc:Literal>
        </ogc:UpperBoundary>
      </ogc:PropertyIsBetween>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

DELWP Results

In this region, the number of height points totals 523. The results obtained demonstrate that 66 of them have an elevation between 120 and 140, which is shown in figure 8.6 with the elevation number labels.

8.3.3 Query 3: Retrieve mines that are underneath a lake

This query uses the *Intersects* operator to compare two geometries together; *Intersects* is used over *Within* to capture mine sites that are bigger than lakes as well as those that are engulfed by lakes. The feature type for mines is LAYER-50301 for LINZ, and MINERALS_MINERAL for DELWP. As for the lake feature types, they are LAYER-50293 and VMHYDRO_WATER_AREA_LAKES_DAMS respectively.

For this query, given that the two polygons of different feature types need to intersect, two WFS requests are needed. The first one obtains the geometries from

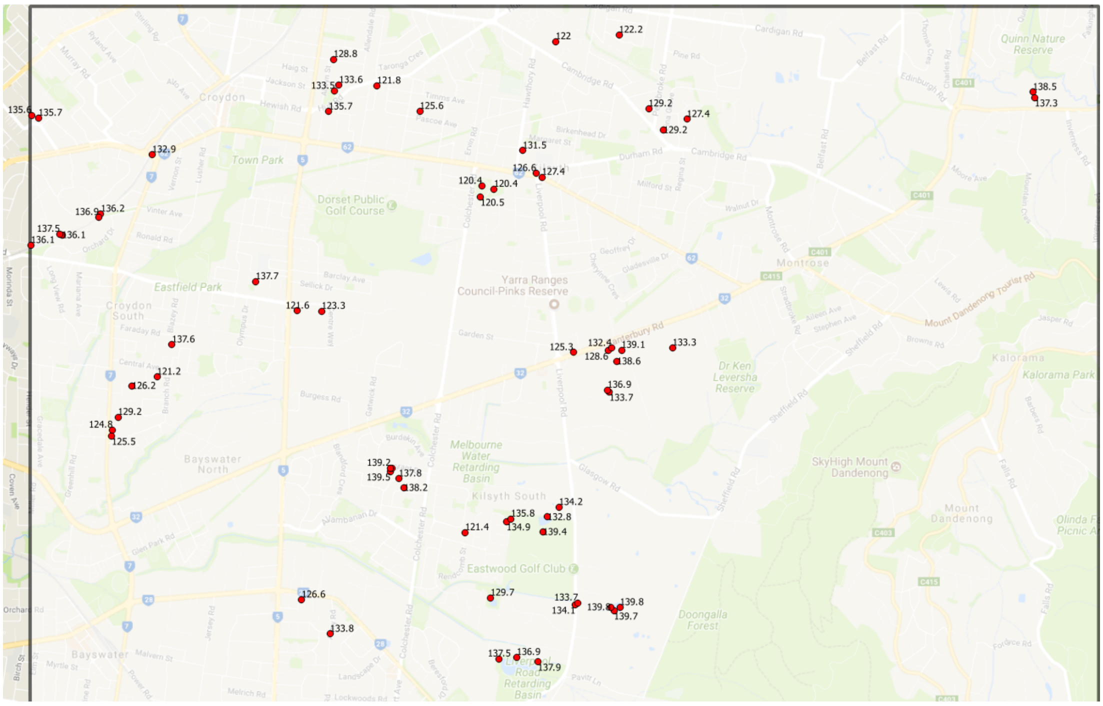


Figure 8.6: Query 2 Results from DELWP

all mines. Afterwards, the mine geometries are used as filter parameters when requesting the lake feature type. The features that intersect one another are returned.

LINZ Queries

The mine region chosen for LINZ is the Lower Buller, NZ region. First, LAYER-50301 which represents mines is queried for all of its features as shown:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50301">
  </wfs:Query>
</wfs:GetFeature>
```

For the second query, an intersect operator is used in the request call. As the feature to be compared can be disparate and hence a WFS might not have knowledge of them all, the geometries of the feature need to be extracted and queried as part of a WFS filter.

In this case, the geometries to intersect are the geometries of the mines. There are multiple geometries to filter and any of them can be intersected, a brute force solution is to query multiple times to check the intersection of the feature type against each geometry. Below is a query that looks for geometries that intersect with a specified one. LAYER-50293 is the feature type for lakes.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50293">
  <ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
      <ogc:Intersects>
        <wfs:PropertyName>GEOMETRY</wfs:PropertyName>
        <gml:Polygon srsName="EPSG:2193">
          <gml:outerBoundaryIs>
            <gml:LinearRing>
              <gml:coordinates decimal="." cs="," ts=" "> ...
                </gml:coordinates>
            </gml:LinearRing>
          </gml:outerBoundaryIs>
        </gml:Polygon>
      </ogc:Intersects>
  </ogc:Filter>
</wfs:Query>
```

This query would have to be made for each of the nine geometries. Alternatively, multiple geometries can be specified in one request by using the logical operator OR. This operator can be used to denote that features intersecting any of the provided geometries are to be returned.

For example, given the three geometries of mines obtained with the previous query. A query requesting lakes that intersect any of them is shown below. Any number of geometries can be specified. Although too many geometries can cause a time-out response from the server, it was found, by trial and error, that 17 geometries can be successfully specified in any one request.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50293">
```

```
      <ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
        <ogc:Or>
          <ogc:Intersects>
            <wfs:PropertyName>GEOMETRY</wfs:PropertyName>
            <gml:Polygon srsName="EPSG:2193"> ... </gml:Polygon>
          </ogc:Intersects>

          ...

          <ogc:Intersects>
            <wfs:PropertyName>GEOMETRY</wfs:PropertyName>
            <gml:Polygon srsName="EPSG:2193"> ... </gml:Polygon>
          </ogc:Intersects>
        </ogc:Or>
      </ogc:Filter>
    </wfs:Query>
</wfs:GetFeature>
```

This query requests for features from LAYER-50293 that are in a bounding box **and** that intersects **any** of the polygons specified.

LINZ Results

The results for the mine query returns 16 mines from the bounding box, which is the total number of mines in that region. The mines are shown in figure 8.7.

For the query requesting lakes, 8 lakes out of the total of 72 were found to match the specified filter. Figure 8.8 demonstrates the lakes retrieved.

DELWP Queries

The region chosen for DELWP is near the Thowgla Valley region, Victoria. MINERALS_MINERAL represents the mines in Victoria and all of them present in the bounding box are queried for:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.
    opengis.net/gml" service="WFS" version="1.0.0">
```

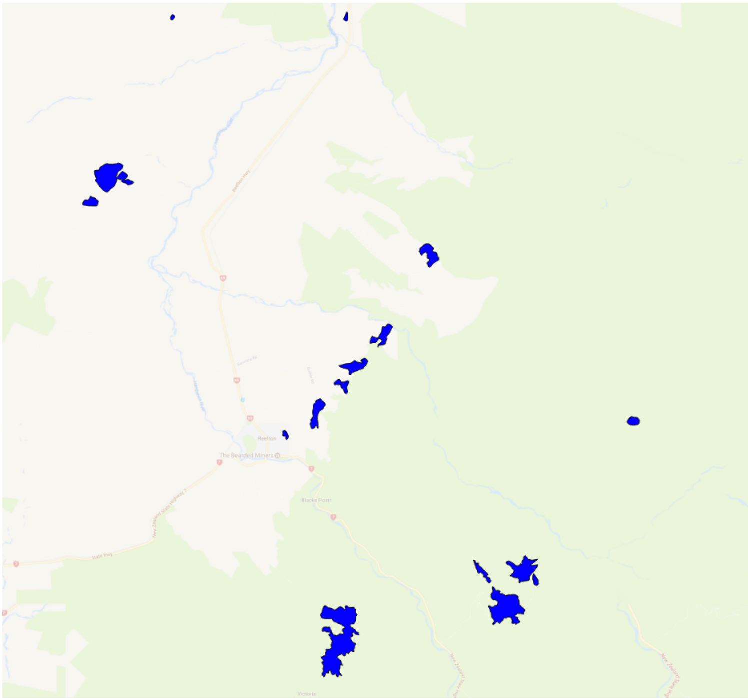


Figure 8.7: Query 3 Mine Results from LINZ

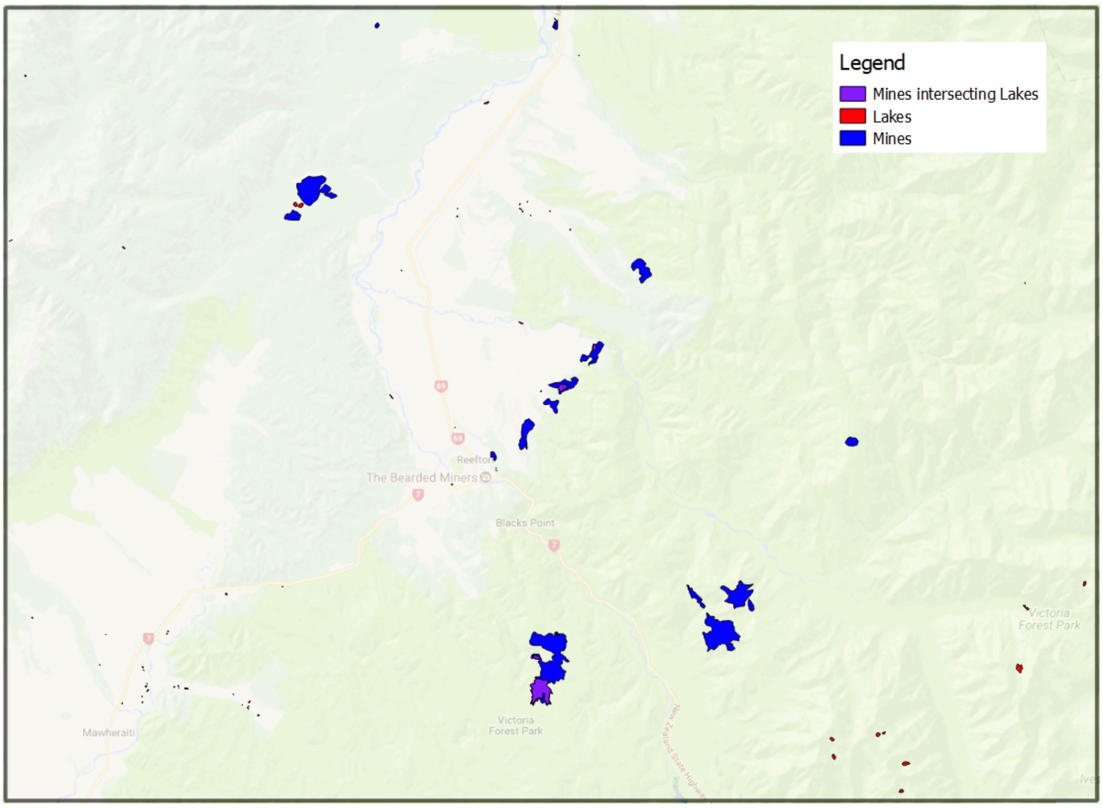


Figure 8.8: Query 3 Lake Results from LINZ

```
  <wfs:Query typeName="MINERALS_MINERAL">
  </wfs:Query>
</wfs:GetFeature>
```

Afterwards, the lakes - represented by the feature type VMHYDRO_WATER_AREA_LAKES_DAMS - are queried using the OR operator to denote that lakes intersecting any specific geometries are to be returned. The geometries used are the ones from the mines obtained with the previous query.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.
    opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="VMHYDRO_WATER_AREA_LAKES_DAMS">
    <ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
      <ogc:Or>
        <ogc:Intersects>
          <wfs:PropertyName>SHAPE</wfs:PropertyName>
          <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
        </ogc:Intersects>

        ...

        <ogc:Intersects>
          <wfs:PropertyName>SHAPE</wfs:PropertyName>
          <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
        </ogc:Intersects>
      </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

DELWP Results

Within the specified bounding box, two mines are retrieved, shown in figure 8.9.

For the query requesting the lakes intersecting the mine polygons, 77 out of 279 lakes were found to match the specified criteria. The results are shown in figure 8.10.

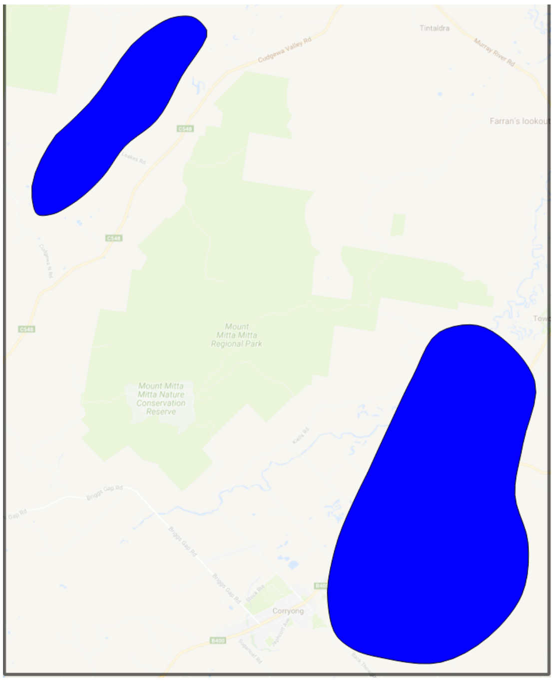


Figure 8.9: Query 3 Mine Results from DELWP

8.3.4 Query 4: Retrieve buildings within 500m of a water tank

Similar to query 3, this query requires the filter of one feature type based on the attributes of another. In this case, the *DWithin* operator is used to retrieve buildings that are within 500m of a water tank. *DWithin* requires the specification of a geometry and a distance threshold. To this end, the WFS are queried for all water tanks first. Then, the geometries of the water tanks alongside the literal 500 are used to filter the building feature types. The *DWithin* operator also allows the specification of the unit of measurements used, in this case meters.

LINZ Query

The first query requests for all water tanks within the bounding box in the Karori region in New Zealand. The water tanks are represented by the feature type LAYER-50361.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50361">
    <ogc:Filter xmlns:ogc="http://www.opengis.net/ogc">
```

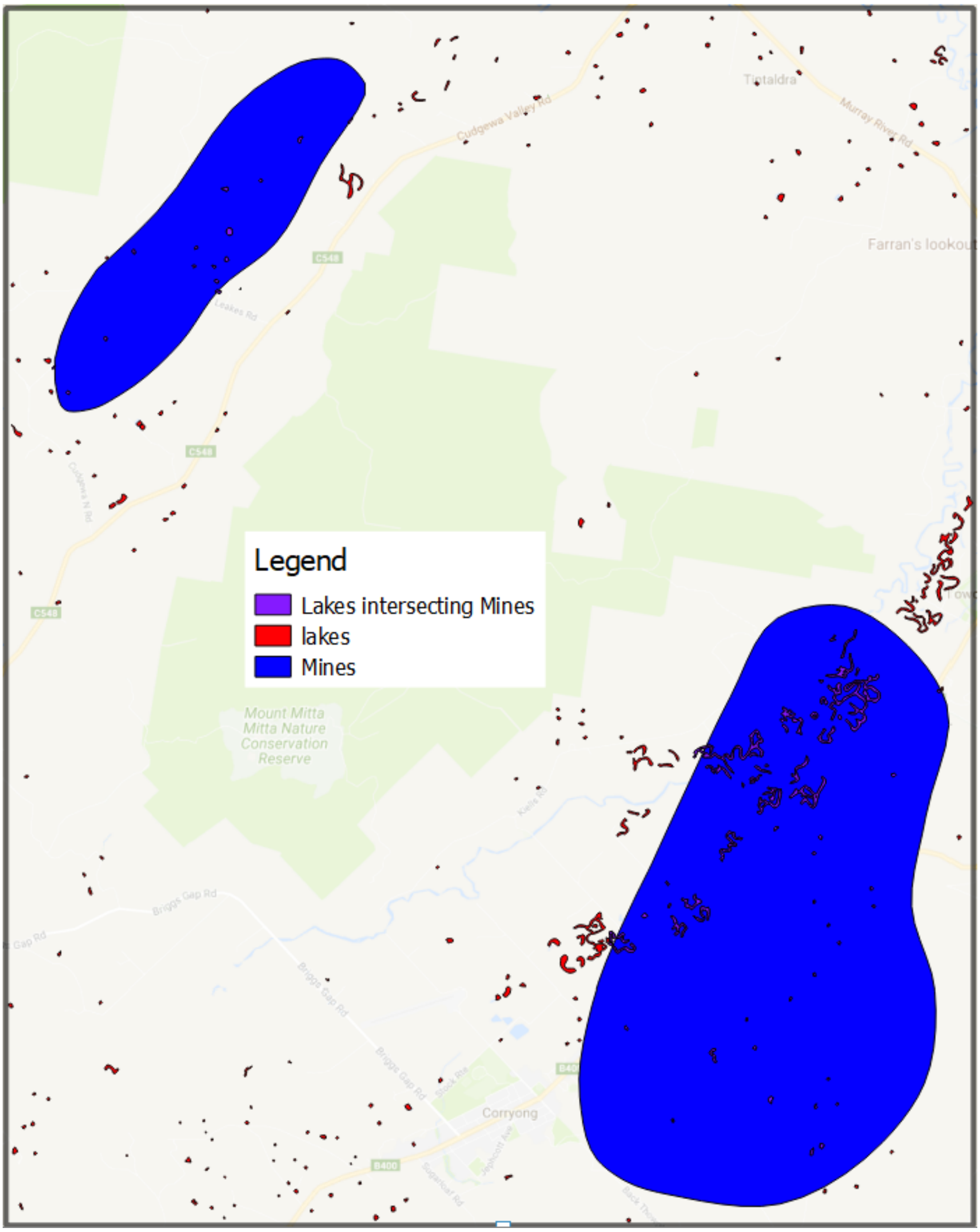


Figure 8.10: Query 3 Lake Results from DELWP

```
      <ogc:BBOX>
        <ogc:PropertyName>GEOMETRY</ogc:PropertyName>
        <gml:Box srsName="urn:ogc:def:crs:EPSG::4326">
          <gml:coordinates>-41.2991,174.7426 -41.3453,174.8262
              </gml:coordinates>
        </gml:Box>
      </ogc:BBOX>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

Afterwards, for each of the water tanks, their geometry is used as part of the filter. The logical operator OR is utilised to denote that a building (LAYER-50246) can be within 500 meters of **any** water tank point.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    gml="http://www.opengis.net/gml" xmlns:ogc="http://www.
    opengis.net/ogc" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50246">
    <ogc:Filter>
      <ogc:Or>
        <ogc:DWithin>
          <wfs:PropertyName>GEOMETRY</wfs:PropertyName>
          <gml:Polygon srsName="EPSG:2193"> ... </gml:Polygon>
          <ogc:Distance units="meter">500</ogc:Distance>
        </ogc:DWithin>

          ...

        <ogc:DWithin>
          <wfs:PropertyName>GEOMETRY</wfs:PropertyName>
          <gml:Polygon srsName="EPSG:2193"> ... </gml:Polygon>
          <ogc:Distance units="meter">500</ogc:Distance>
        </ogc:DWithin>
      </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

LINZ Results

For the Karori region, five water tanks were retrieved. For the second query, out of the 185 buildings available in the bounding box, 24 were found to be within 500 meters of a water tank. The retrieved feature are shown in figure 8.11.

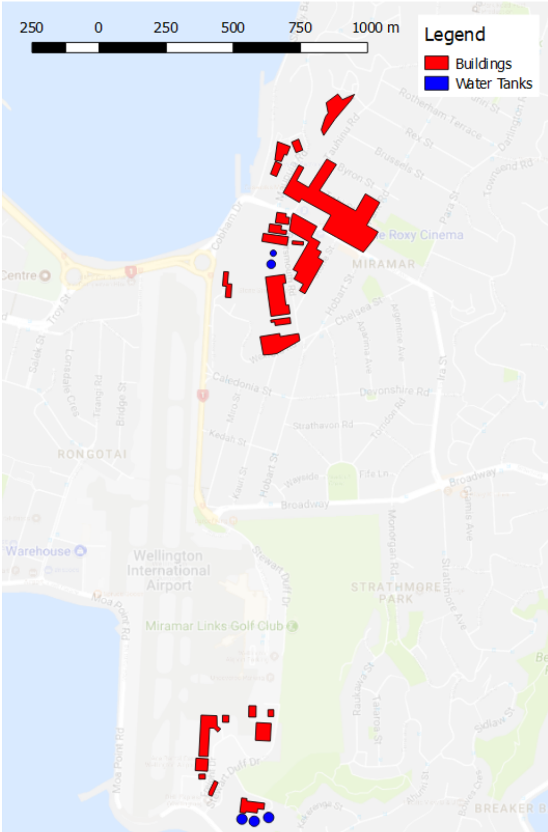


Figure 8.11: Query 4 Results from LINZ

DELWP Query

Similarly for DELWP, all water tanks within the bounding box are retrieved. The water tank feature type is represented by the VMHYDRO_HY_WATER_STRUCT_AREA_TANK layer. The region used is the Maroondah region in Victoria. The query used is:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs"  xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml"  service="WFS" version="1.0.0">
  <wfs:Query typeName="datavic:VMHYDRO_HY_WATER_STRUCT_AREA_TANK"
  </wfs:Query>
```

```
</wfs:GetFeature>
```

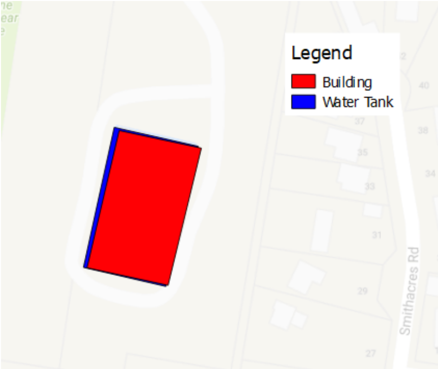
For the buildings, the feature type VMFEAT_BUILDING_POLYGON is used alongside the location of the water tanks obtained with the previous request. The request used is shown below.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:gml="http://www.opengis.net/gml" xmlns:ogc="http://www.opengis.net/ogc" service="WFS" version="1.0.0">
  <wfs:Query typeName="datavic:VMFEAT_BUILDING_POLYGON">
    <ogc:Filter>
      <ogc:Or>
      <ogc:DWithin>
        <wfs:PropertyName>SHAPE</wfs:PropertyName>
        <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
        <ogc:Distance units="meter">500</ogc:Distance>
      </ogc:DWithin>

      <ogc:DWithin>
        <wfs:PropertyName>SHAPE</wfs:PropertyName>
        <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
        <ogc:Distance units="meter">500</ogc:Distance>
      </ogc:DWithin>

      <ogc:DWithin>
        <wfs:PropertyName>SHAPE</wfs:PropertyName>
        <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
        <ogc:Distance units="meter">500</ogc:Distance>
      </ogc:DWithin>
      </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

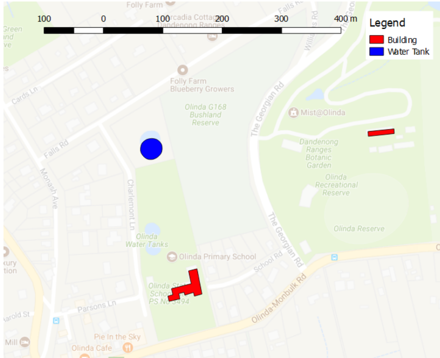
DELWP Results

In the Maroondah region, three water tanks were returned. However, only two of the water tanks had buildings within a 500m radius. There are 666 VMFEAT_BUILD-

ING_POLYGON features available within the Maroondah region. Of them, three were found to satisfy the filter specified, they are shown in figures 8.12a and 8.12b.



(a) Query 4 First Results from DELWP



(b) Query 4 Second Results from DELWP

Figure 8.12: Query 5 Results Close-up from DELWP

8.3.5 Query 5: Retrieve addresses that are within 500m from a water tank AND whose road is a lane

This query evaluates the AND logical operator. Although it was used in previous queries in regards to bounding boxes, this section demonstrates how two previous queries can be used together with the logical operator. In this instance, the two queries are: (1) retrieve addresses within 500m of a water tank, (2) retrieve addresses whose roads are lanes.

To achieve this, two queries are required. The first requests the water tanks within the bounding box, and the second finds the addresses within 500m of them while filtering their road type.

LINZ Query

Similar to query 4, all water tanks are queried first as shown below:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.
    opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50361">
  </wfs:Query>
</wfs:GetFeature>
```

The addresses are queried next. The address feature type for LINZ is LAYER-53353. For each of the water tanks obtained from the previous query, their geometries are used within the logical operator OR to find any address within 500m of any water tank.

Different to query 4 though, an additional filter is used. The filter PropertyIsLike is used to filter the roads of the addresses to that of a lane. As the addresses do not have an explicit road type attribute, the full name of the road is used instead. The name of this attribute is 'full_road_name'.

Below is the query used.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    gml="http://www.opengis.net/gml" xmlns:ogc="http://www.
    opengis.net/ogc" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-53353">
    <ogc:Filter>
      <ogc:And>
        <ogc:PropertyIsLike wildCard=" " singleChar="." escape
            ="!">
          <ogc:PropertyName>full_road_name</ogc:PropertyName>
          <ogc:Literal> Lane </ogc:Literal>
        </ogc:PropertyIsLike>

        <ogc:Or>
          <ogc:DWithin>
            <wfs:PropertyName>shape</wfs:PropertyName>
            <gml:Polygon srsName="EPSG:2193">
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates decimal="." cs="," ts=" ">
                      ... </gml:coordinates>
                </gml:LinearRing>
              </gml:outerBoundaryIs>
            </gml:Polygon>
            <ogc:Distance units="meter">500</ogc:Distance>
          </ogc:DWithin>

          ...

```

```
            <ogc:DWithin>
              <wfs:PropertyName>shape</wfs:PropertyName>
              <gml:Polygon srsName="EPSG:2193">
                <gml:outerBoundaryIs>
                  <gml:LinearRing>
                    <gml:coordinates decimal="." cs="," ts=" ">
                        ... </gml:coordinates>
                  </gml:LinearRing>
                </gml:outerBoundaryIs>
              </gml:Polygon>
              <ogc:Distance units="meter">500</ogc:Distance>
            </ogc:DWithin>
          </ogc:Or>
        </ogc:And>
      </ogc:Filter>
    </wfs:Query>
  </wfs:GetFeature>
```

LINZ Results

The number of water tanks obtained is five as in the previous query. There are a total of 25 589 addresses within the Karori region. 13 of them are within 500 meters of a water tank, and have roads that are lanes. Figure 8.13 shows all water tanks and addresses with lanes, only two water tanks have addresses with lanes within 500m. Figure 8.14 provides a close-up of the results of the query (i.e. Addresses within 500m of a water tank and whose road type is a lane).

DELWP Query

Similar to the previous query, the following requests all water tanks within the Maroondah region.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:
    ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.
    opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="datavic:
      VMHYDRO_HY_WATER_STRUCT_AREA_TANK">
  </wfs:Query>
```

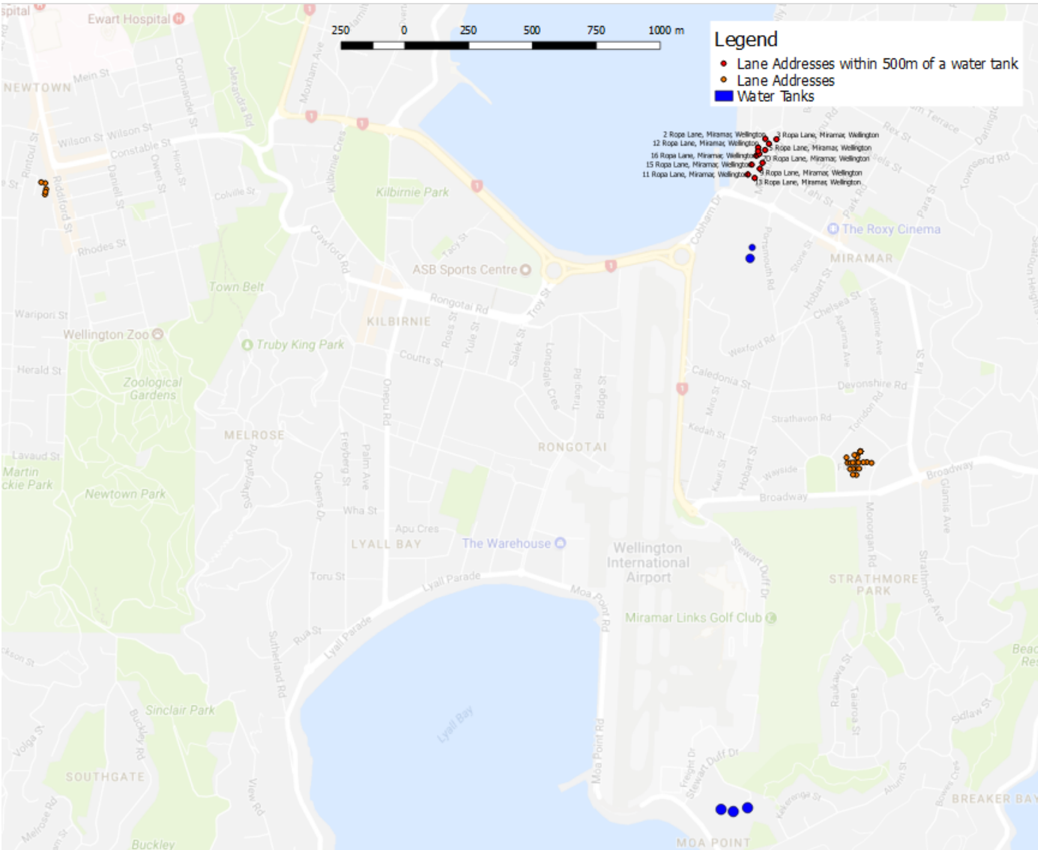


Figure 8.13: Query 5 Results from LINZ

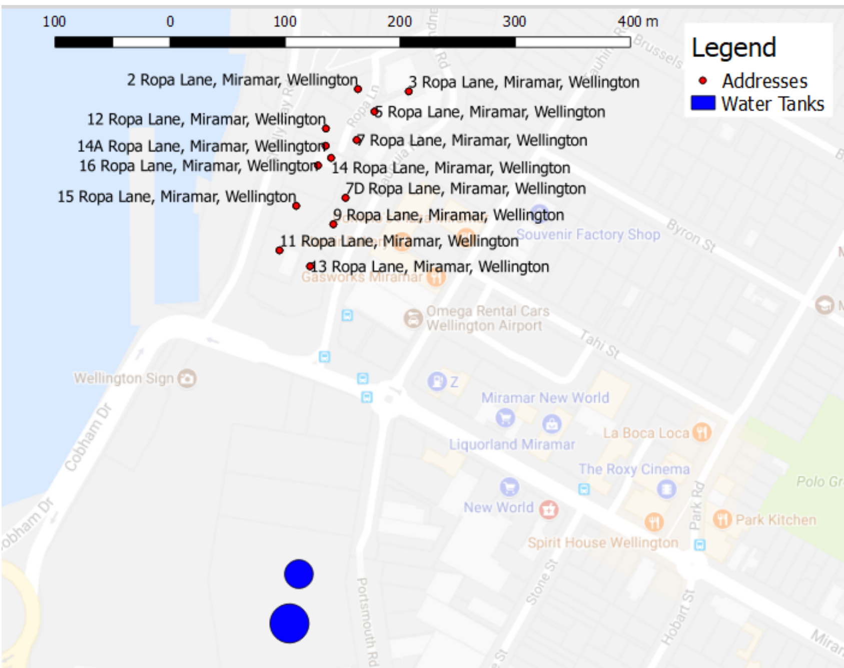


Figure 8.14: Query 5 Results Close-up from LINZ

```
</wfs:GetFeature>
```

Addresses in DELWP are stored as the feature type VMADD_ADDRESS, and different to LINZ they have attributes denoting the type of road they are on. This attribute is 'ROAD_TYPE'. This difference is reflected in the request used as shown below.

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:gml="http://www.opengis.net/gml" xmlns:ogc="http://www.opengis.net/ogc" service="WFS" version="1.0.0">
  <wfs:Query typeName="datavic:VMADD_ADDRESS">
    <ogc:Filter>
      <PropertyIsLike wildCard=" " singleChar="#" escape="!">
        <PropertyName>ROAD_TYPE</PropertyName>
        <Literal> LANE </Literal>
      </PropertyIsLike>

      <ogc:Or>
        <ogc:DWithin>
          <wfs:PropertyName>SHAPE</wfs:PropertyName>
          <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
          <ogc:Distance units="meter">500</ogc:Distance>
        </ogc:DWithin>

        ...

        <ogc:DWithin>
          <wfs:PropertyName>SHAPE</wfs:PropertyName>
          <gml:Polygon srsName="EPSG:4283"> ... </gml:Polygon>
          <ogc:Distance units="meter">500</ogc:Distance>
        </ogc:DWithin>
      </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

DELWP Results

Three water tanks were found in the Maroondah region for DELWP. However, out of the three, only two water tanks were near a ‘lane’ and as such, only addresses close to two water tanks were retrieved. As such, for addresses within 500m of a water tank and whose roads are lanes, it was found that there are 40 of them in the Maroondah region. The total number for unfiltered addresses is 57 581.

Figure 8.15 shows all water tanks and lane addresses, while figure 8.16a and 8.16b show addresse that are within 500m from a water tank.

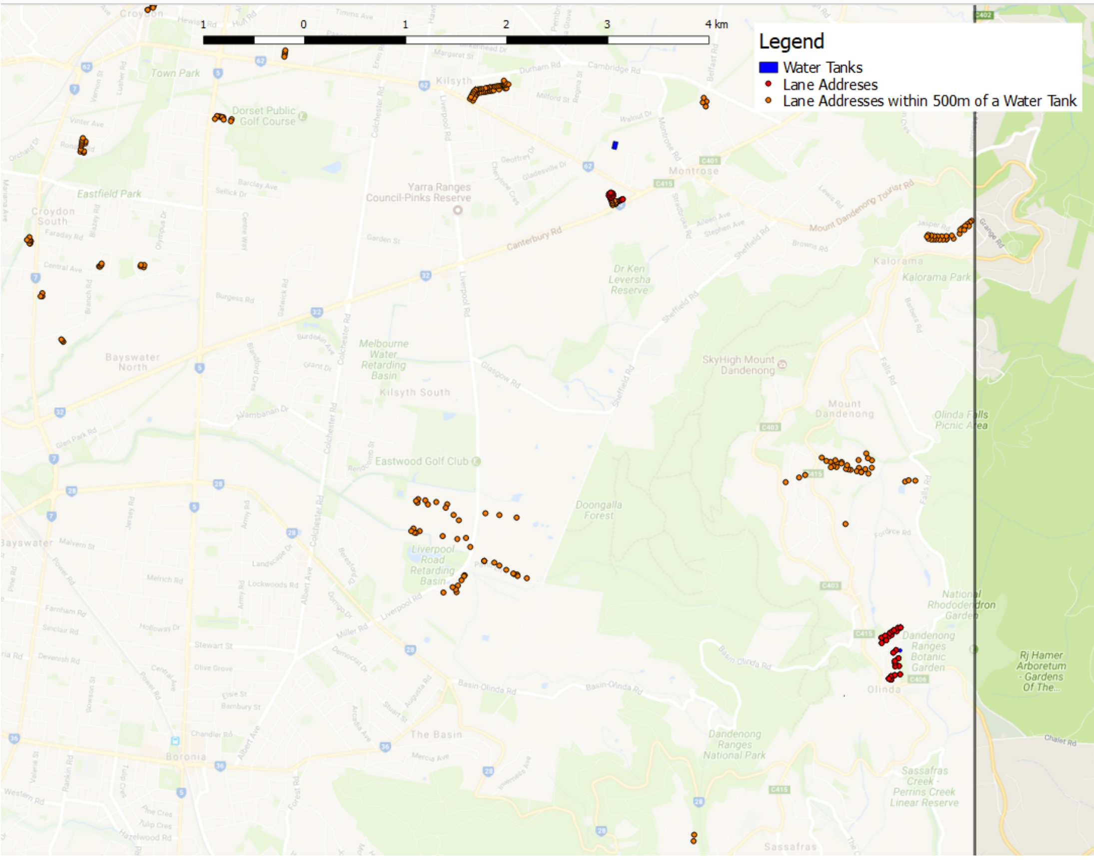
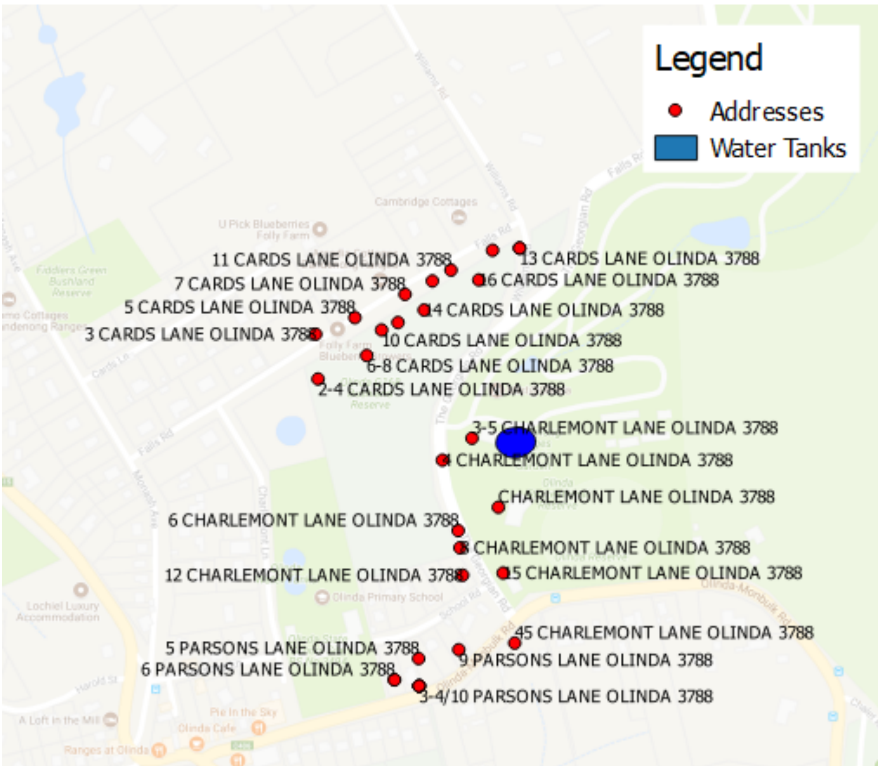


Figure 8.15: Query 5 Results from DELWP

8.3.6 Query 6: Retrieve Roads that are either lane OR street

Although the OR operator has been demonstrated in previous queries, this section is described for completeness purposes. It aims at demonstrating the filtering of properties which requires any condition to be matched. In this case, the retrieved datasets are roads that are either lanes or streets.

(a) Query 5 First Results Close-up from DELWP



(b) Query 5 Second Results Close-up from DELWP

Figure 8.16: Query 5 Results Close-up from DELWP

LINZ Query

The region used is the Karori in New Zealand. LINZ uses LAYER-50329 to denote road feature types, and because they do not have an explicit road type attribute, the full name of the road (‘name’) is filtered instead. The query is:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="data.linz.govt.nz:layer-50329">
    <ogc:Filter>
      <ogc:Or>
        <ogc:PropertyIsLike wildCard=" " singleChar="." escape="!">
        <ogc:PropertyName>name</ogc:PropertyName>
        <ogc:Literal> LANE </ogc:Literal>
        </ogc:PropertyIsLike>

        <ogc:PropertyIsLike wildCard=" " singleChar="." escape="!">
        <ogc:PropertyName>name</ogc:PropertyName>
        <ogc:Literal> STREET </ogc:Literal>
        </ogc:PropertyIsLike>
      </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

LINZ Results

Out of the 677 roads within the region specified, 289 roads were found to be either lanes or streets. These are shown in figure 8.17.

DELWP Query

The region used for this query in DELWP is the Maroondah region in Victoria. The feature type for roads is named VMTRANS_TR_ROAD_LOCAL and different

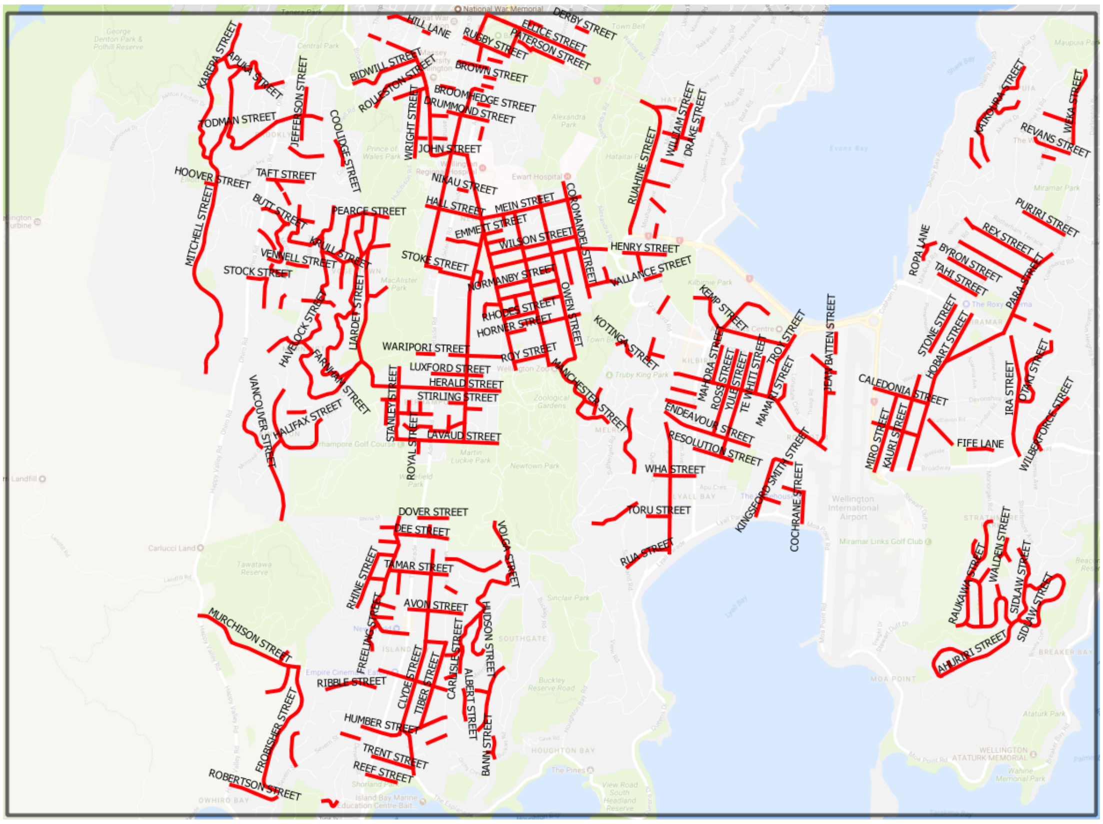


Figure 8.17: Query 6 Results from LINZ

to LINZ, DELWP has an explicit road type attribute. It is ‘ROAD_TYPE’. The query used to request DELWP WFS is:

```
<wfs:GetFeature xmlns:wfs="http://www.opengis.net/wfs" xmlns:ogc="http://www.opengis.net/ogc" xmlns:gml="http://www.opengis.net/gml" service="WFS" version="1.0.0">
  <wfs:Query typeName="datavic:VMTRANS_TR_ROAD_LOCAL">
    <ogc:Filter>
      <ogc:Or>
        <ogc:PropertyIsLike wildCard=" " singleChar="." escape="!">
          <ogc:PropertyName>ROAD_TYPE</ogc:PropertyName>
          <ogc:Literal> LANE </ogc:Literal>
        </ogc:PropertyIsLike>

        <ogc:PropertyIsLike wildCard=" " singleChar="." escape="!">
          <ogc:PropertyName>ROAD_TYPE</ogc:PropertyName>
          <ogc:Literal> STREET </ogc:Literal>
        </ogc:PropertyIsLike>
```

```
      </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

DELWP Results

In the region specified, 472 roads out of 3 526 were found to be either lanes or streets. Figure 8.18 shows the results.

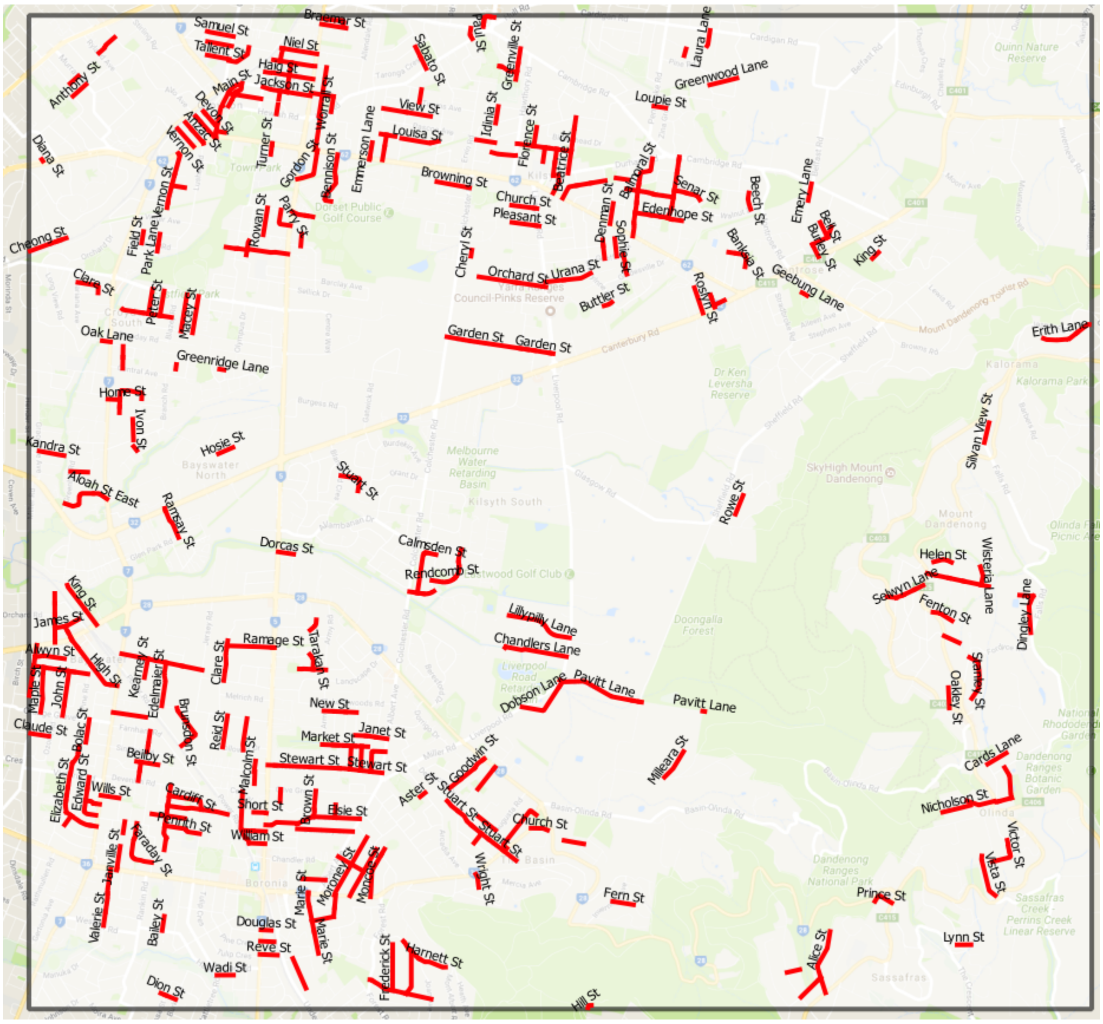


Figure 8.18: Query 6 Results from DELWP

8.4 Ground Truth Summary

Six queries were evaluated with each of them corresponding to a different type of filter operator. The queries were:

1. *Retrieve Roads that are lanes*;
2. *Retrieve height points that have an elevation between 120 and 140m*;
3. *Retrieve mines that are underneath a lake*;
4. *Retrieve buildings within 500m of a water tank*;
5. *Retrieve addresses that are within 500m from a water tank AND whose road is a lane*; and
6. *Retrieve Roads that are either lane OR street*.

The spatial extent of each query was limited based on the Karori, Lower Buller regions from New Zealand, and the Maroondah and Thowgla Valley regions in Victoria. The regions, alongside the number of features returned for each query, are shown in table 8.3 as a summary.

	Region		**Num. of Retrieved Features**	
	LINZ	DELWP	LINZ	DELWP
Query 1	Karori	Maroondah	3	58
Query 2	Karori	Maroondah	4	66
Query 3	Lower Buller	Near Thowgla Valley	7	77
Query 4	Karori	Maroondah	24	3
Query 5	Karori	Maroondah	13	40
Query 6	Karori	Maroondah	289	472

Table 8.3: Region Used for each Query and their Results

8.5 Results from Querying the Broker System

This section demonstrates how a user would query the broker system for each of the sample queries specified previously. Further, these queries are requested from a broker system prototype and the results obtained are recorded. For each result, only three features are shown as a snippet. A summary of the results is also provided at the end and the full results can be found in appendix F.

The geometries from each result snippet are removed for brevity purposes. The geometry contains the GML of the features which consists of multiple points for linestrings and polygons and hence can be large depending on the amount of coordinates used to describe a particular geometry. As an example, listing 8.1 shows the GML of a polygon which can be much larger for more complex geometries.

```
<Polygon srsName="EPSG:2193">
<outerBoundaryIs>
    <LinearRing>
      <coordinates cs="," decimal="." ts=" ">
      1751840.7748227464,5424563.342728305
         1751840.1588273942,5424562.259041253
         1751766.5929323826,5424607.993264217
         1751776.959873001,5424665.056207
         1751782.138263001,5424676.283921001
         1751874.3413495542,5424622.394489708
         1751851.044001381,5424581.408734659
         1751885.1834063763,5424561.008358503
         1751870.1752133826,5424534.493884214
         1751889.1855911743,5424523.9881491205
         1751875.678217481,5424500.975586531
         1751896.7165521784,5424488.157262071
         1751822.2084060702,5424362.069208937
         1751800.6372525143,5424374.906765386
         1751816.1986599648,5424399.238595169
         1751780.0190810002,5424420.186049
         1751795.4698477406,5424446.926286769
         1751776.944301445,5424456.591789182
         1751841.1593735944,5424563.009450902
         1751840.7748227464,5424563.342728305
      </coordinates>
    </LinearRing>
  </outerBoundaryIs>
</Polygon>
```

Listing 8.1. Polygon GML example

For all queries, the three pieces of information required are the feature types, attributes, and filters. They differ slightly based on the queries as demonstrated in this section. Results are shown in JSON format as it is the format used in the broker for easier machine parsing but any other format can be used.

8.5.1 Query 1

Query 1 involves retrieving roads that are lanes. As seen in table 8.4, the feature type, attributes, and filter are *wso:Road*, *wso:FeatureName*, *wso:RoadType*, and *wso:RoadType PropertyIsLike *LANE**. The symbol * is used to specify wild cards (strings that can be used in *lieu* of other strings), this symbol is hardcoded in the WFS request, but can be made to change depending on the user requirements.

Feature Type	**Attributes**	**Filter**
wso:Road	wso:FeatureName wso:RoadType	wso:RoadType PropertyIsLike *LANE*

Table 8.4: Information Entered by User for Query 1

For this query, the feature types retrieved were LAYER-50329 for LINZ, and VMTRANS_TR_ROAD_LOCAL for DELWP. The attributes pertaining to feature name and road type for LINZ were both 'name' as LINZ does not have an explicit road type attribute. However, DELWP does, which leads to the attributes 'ROAD_NAME' and 'ROAD_TYPE'.

Below is a snippet of the results obtained.

```
{
  "https://data.linz.govt.nz/services/wfs": [
    {
      "geom": "...",
      "name": "FIFE LANE"
    },
    {
      "geom": "...",
      "name": "HILL LANE"
    },
    {
      "geom": "...",
      "name": "ROPA LANE"
    }
  ],

  "http://services.land.vic.gov.au/catalogue/publicproxy/guest
      /dv_geoserver/datavic/wfs": [
```

```
        {
            "ROAD_TYPE": "LANE",
            "ROAD_NAME": "BRIENS",
            "geom": "..."
        },
        {
            "ROAD_TYPE": "LANE",
            "ROAD_NAME": "HARRY LACEY",
            "geom": "..."
        },
        {
            "ROAD_TYPE": "LANE",
            "ROAD_NAME": "PARK",
            "geom": "..."
        }
    ]
}
```

8.5.2 Query 2

Query 2 is about retrieving height points that have an elevation between 120 and 140. As seen in table 8.5, the information required from the user is the feature type, attributes, and filter. As the filter needed is PropertyIsBetween, two literals are needed instead of one.

The *wso:HeightPoint* feature type extracted from the ontology are LAYER-50284 and VMELEV_EL_GRND_SURFACE_POINT_1TO5M for LINZ and DELWP respectively. For the attributes, they are ‘elevation’ and ‘ALTITUDE’.

Feature Type	**Attributes**	**Filter**
wso:HeightPoint	wso:elevation	wso:elevation PropertyIsBetween 120 140

Table 8.5: Information Entered by the User for Query 2

Three results for each WFS are shown below:

```
{
    "https://data.linz.govt.nz/services/wfs":
    [
        {
```

```
            "elevation": "121",
            "geom": "..."
        },
        {
            "elevation": "126",
            "geom": "..."
        },
        {
            "elevation": "134",
            "geom": "..."
        }
    ],

    "http://services.land.vic.gov.au/catalogue/publicproxy/guest/dv_geoserver/datavic/wfs": [
        {
            "ALTITUDE": "135.7",
            "geom": "..."
        },
        {
            "ALTITUDE": "135.6",
            "geom": "..."
        },
        {
            "ALTITUDE": "133.5",
            "geom": "..."
        }
    ]
}
```

8.5.3 Query 3

Query 3 required the retrieval of mines that are underneath a lake. For this query, the *Intersects* operation is used alongside two feature types as shown in table 8.6. For this query, the ontology had to be queried twice for each feature, and the results from *wso:Mine* had to be used as a filter requirement for *wso:Lake* on the fly. This difference in processing is required for spatial filters, but nonetheless the information required is still the feature type, attributes, and filter.

The feature type for mines retrieved were LAYER-50301 and MINERALS_MINERAL for LINZ and DELWP. As for lakes, they were LAYER-50293 and VMHYDRO_WATER_AREA_LAKES_DAMS. The attributes required were 't50_fid' and 'PFI' respectively.

Feature Type	**Attributes**	**Filter**
wso:Mine	wso:featureId	wso:Mine Intersects wso:Lake
wso:Lake	wso:featureId	

Table 8.6: Information Entered by the User for Query 3

Snippets of the results are shown below:


```
{
  "https://data.linz.govt.nz/services/wfs": [
  {
    "geom": "...",
    "t50_fid": "5004686"
  },
  {
    "geom": "...",
    "t50_fid": "5007575"
  },
  {
    "geom": "...",
    "t50_fid": "5026561"
  }
  ],
  "http://services.land.vic.gov.au/catalogue/publicproxy/guest
     /dv_geoserver/datavic/wfs": [
  {
    "geom": "...",
    "PFI": "16459523"
  },
  {
    "geom": "...",
    "PFI": "16459600"
  },
  {
    "geom": "...",
    "PFI"": "8125577"
```

```
    }
  ]
}
```


8.5.4 Query 4

Query 4 involves retrieving buildings within 500m of a water tank. Similar to query 3, this query requires two features: *wso:WaterTank* and *wso:Building*. As for the filter, two additional pieces of information are needed for this type of query. The distance threshold and the unit of the distance. In this case, they are simply specified as part of the filter string.

The feature types obtained for water tanks were LAYER-50361 for LINZ and VMHYDRO_HY_WATER_STRUCT_AREA_TANK for DELWP. The buildings were LAYER-50246 and VMFEAT_BUILDING_POLYGON. The attributes to be recovered are the feature id for each feature type. They correspond to 't50_fid' and 'OBJECTID' respectively.

Feature Type	Attributes	Filter
wso:WaterTank	wso:featureName	wso:Building DWithin wso:WaterTank 500 meter
wso:Building	wso:featureName	

Table 8.7: Information Entered by the User for Query 4

Below is a snippet of the results obtained for each WFS.


```
{
  "https://data.linz.govt.nz/services/wfs": [
    {
      "t50_fid": "4916917",
      "geom": "..."
    },
    {
      "t50_fid": "4926285",
      "geom": "..."
    },
    {
      "t50_fid": "4926362",
      "geom": "..."
```

```
        }
    ],
    "http://services.land.vic.gov.au/catalogue/publicproxy/
        guest/dv_geoserver/datavic/wfs": [
        {
            "geom": "...",
            "OBJECTID": "273253"
        },
        {
            "geom": "...",
            "OBJECTID": "261421"
        },
        {
            "geom": "...",
            "OBJECTID": "277714"
        }
    ]
}
```

8.5.5 Query 5

Query 5 retrieves addresses that are within 500m from a water tank AND whose road is a lane. This combines query 1 and query 4. The && symbol is used to denote the AND operator. In this case, the only additional process involved is to combine the filters from query 1 with those from query 4.

The feature type for *wso:Address* is LAYER-53353 and VMADD_ADDRESS for LINZ and DELWP. The attributes required correspond to 'full_road_name' and 'address_id' for LINZ, and 'ROAD_TYPE' and 'OBJECTID' for DELWP.

Feature Type	**Attributes**	**Filter**
wso:WaterTank	wso:featureName	wso:Address DWithin wso:WaterTank 500 meter && wso:roadType PropertyIsLike *Lane*
wso:Address	wso:featureName wso:roadType	

Table 8.8: Information Entered by the User for Query 5

Below is a snippet of the results.

```
{
  "https://data.linz.govt.nz/services/wfs": [
    {
    "full_road_name": "Ropa Lane",
    "address_id": "1522190",
    "geom": "..."
    },
    {
    "full_road_name": "Ropa Lane",
    "address_id": "382834",
    "geom": "..."
    },
    {
    "full_road_name": "Ropa Lane",
    "address_id": "382811",
    "geom": "..."
    }
  ],
  "http://services.land.vic.gov.au/catalogue/publicproxy/guest
      /dv_geoserver/datavic/wfs": [
    {
      "ROAD_TYPE": "LANE",
      "geom": "...",
      "OBJECTID": "3460884"
    },
    {
      "ROAD_TYPE": "LANE",
      "geom": "...",
      "OBJECTID": "3460885"
    },
    {
      "ROAD_TYPE": "LANE",
      "geom": "...",
      "OBJECTID": "1247628"
    }
  ]
}
```

8.5.6 Query 6

Query 6 retrieves roads that are either lane OR street. For this query, the only modification is the || symbol used to denote the OR operator. Changes in processes involves the addition of <ogc:Or> within the XML filter, but otherwise is similar to query 1.

Feature types for *wso:Road* are LAYER-50329 and VMTRANS_TR_ROAD_LOCAL for LINZ and DELWP. While DELWP has an explicit 'ROAD_TYPE' attribute, LINZ does not, and instead the full name of the road was used to filter through its type. This differences is modelled in the ontology and does not affect the processing of the broker.

Feature Type	Attributes	Filter
wso:Road	wso:featureName, wso:roadType	wso:roadType PropertyIsLike *LANE* || *STREET*

Table 8.9: Information Entered by the User for Query 6

A snippet of the results is:

```
{
  "https://data.linz.govt.nz/services/wfs": [
    {
      "geom": "...",
      "name": "BRIDGE STREET"
    },
    {
      "geom": "...",
      "name": "CALEDONIA STREET"
    },
    {
      "geom": "...",
      "name": "ROPA LANE"
    }
  ],
    "http://services.land.vic.gov.au/catalogue/publicproxy/
        guest/dv_geoserver/datavic/wfs": [
    {
      "ROAD_TYPE": "STREET",
```

```
            "ROAD_NAME": "KING",
            "geom": "..."
        },
        {
            "ROAD_TYPE": "STREET",
            "ROAD_NAME": "ALWYN",
            "geom": "..."
        },
        {
            "ROAD_TYPE": "LANE",
            "ROAD_NAME": "EMMERSON",
            "geom": "..."
        }
    ]
}
```

8.5.7 Result Evaluation

An evaluator (the script can be found in appendix C.2) was developed to evaluate the broker's results against the ground truth. Each query was input into the broker and the results recorded. To verify that the same datasets were obtained, the evaluator compared the geometry of each feature, their attributes and the total number of features from the results to the ground truth. Table 8.10 summarises the output of the evaluation.

	Expected (LINZ + DELWP)	Actual	Incorrect	Missing
Query 1	3 + 58	61	0	0
Query 2	4 + 66	70	0	0
Query 3	7 + 77	84	0	0
Query 4	24 + 3	27	0	0
Query 5	13 + 40	53	0	0
Query 6	289 + 472	761	0	0

Table 8.10: Region Used for each Query and their Results

The expected number of results is the sum of the results obtained from all WFS (LINZ and DELWP in this case). This number is compared to the number of features obtained from using the broker. Further, each attribute that does not match is considered an incorrect feature, while any feature missing an attribute is counted as a missing feature.

From table 8.10, it can be seen that the results obtained are as expected and no incorrect or missing features were found.

8.6 Summary

This chapter demonstrated the methods used to evaluate the broker system. It was established that the filters from WFS 1.0.0 can be categorically evaluated based on six queries. The ground truth for these six queries was achieved by manually constructing and querying the differing WFS.

Afterwards, this chapter detailed the parameters that were required from the user to input into the broker. The developed evaluator compared the results obtained by the broker against the ground truth and no missing or incorrect features were found.

However, to successfully accommodate spatial comparison queries, a limitation was observed. To remove the chance of a server time-out occurring, the maximum number of geometries to filter per request was limited to 17. This limitation cannot be fully remedied from the broker's side and as such it becomes apparent that data fetching will be limited depending on the Web service used.

A partial solution to this issue could be the spatial caching of the features. For example, spatially indexing a requested feature would enable the broker to identify only the polygons that are nearest to the spatial extent of the queried feature type, hence limiting the number of polygons that must be included in the WFS request. This solution, however, only limits the number of geometries that must be compared and does not remove the limitation of 17 geometries per query request. A complete solution can only be achieved if the target WFS allocate more resources to its processes, increasing the limitation of 17 geometries to a higher number.

CHAPTER 9

CONCLUSIONS AND FUTURE WORK

9.1 Introduction

Spatial data is distributed and heterogeneous by nature. As spatial data has grown, it has become more challenging to discover, query, and combine the data because of their isolated exposure. This is especially true for users not familiar with spatial data and tools to access and query these data; these users are hence left with the task of learning GIS-specific skills to query spatial end-points. Although spatial data portals have been used as a medium to combine multiple spatial Web services, they merely act as search repositories.They do not help the user in the query or integration process of data, but simply offer limited filtering search capabilities over manually selected spatial endpoints.

At a lower level, current methods of integrating disparate spatial datasets either depend on the usage of a global schema, or of a data warehouse approach where a third party consolidates them. The former requires all data providers to agree to the schema and change their existing ones, which is resource intensive. The latter introduces data duplication and scalability issues. From both ends, the integration process requires human intervention either for changing the original schemas or for designing the transformation rules.

In Australia, because the States and Territories have ownership of their data, the adoption of a global schema is unlikely without a change in legislation or strong incentives. Instead, data warehousing is currently in use. In this thesis, the limitations of the data warehouse model were investigated and components to improve or solve them were researched, more specifically, the issues of scalability, data duplication, and manual data integration. As a possible solution, a broker approach was investigated. This investigation focused on the usage of Semantic Web technologies and spatial data similarity comparisons.

In this chapter, the findings of the research are summarised. The work achieved in each chapter alongside their relevance and significance is summarised, and the limitations of the proposed solution discussed. This chapter then concludes with future work to be done in relation to this research.

9.2 Thesis Objectives and their Fulfilment

The objectives of the research and how they were addressed are articulated in this section.

Objective 1: *Review the usage of Semantic Web techniques in data integration and its application in a broker.*

This objective is addressed in chapter 2. Chapter 2 introduced key concepts used in this thesis including Semantic Web technologies and how they are used. Further, chapter 2 reviewed some work related to ontology based spatial data infrastructures, which provided an insight in how Semantic Web techniques can be applied to the broker system.

Objective 2: *Implement Semantic Web technologies to use in the broker.*

Objective 2 was fulfilled by developing a novel ontology reusing various other ontologies—the Web Service Ontology (WSO) which is used in the broker system. Chapters 3 and 4 described WSO, and how it can be automatically populated based on existing Web feature services. The usage of WSO was shown in chapter 4 by testing it using key questions that the ontology needed to answer. Further, the usage of WSO as part of the broker system was explained in chapter 7.

Objective 3: *Explore methods to facilitate the integration of heterogeneous spatial data.*

Chapters 5 and 6 discussed how to compare the similarity of features types using both their non-spatial and spatial metadata. Chapter 5 used the metadata as served by Web feature services and LDA, while chapter 6 introduced the method to compare feature types spatially by making used of the distributions of the geometry instances and the EMD distance. Both LDA and EMD were not found to have been used with spatial data. These two chapters hence explored novel methods to compare and facilitate the integration of spatial data by identifying the efficacy of modern comparative methods.

Objective 4: *Implement methods for on-the-fly data retrieval.*

On-the-fly data retrieval was shown in chapters 7 and 8. Chapter 7 described the framework of the broker system and how the data is retrieved using information gathered from the user and WSO. Additionally, chapter 8 evaluated the broker system which showed that the on-the-fly retrieval process was successful in fetching the requested data.

Objective 5: *Implement a broker prototype over which multiple datasets can be queried from and evaluate the prototype.*

Chapters 7 and 8 described how the broker system works and how it was evaluated. From using two Web feature services (LINZ and DELWP), it was found that the broker system fetched the expected data compared to a ground truth. As such, the broker prototype was successfully demonstrated to be able to fetch multiple disparate datasets from both Australia and New Zealand.

9.3 Limitations

In this thesis, some limitations, and areas for improvement were identified. These are discussed below.

- The ontology developed in chapters 4 and 5 acts (1) as a mediator to consolidate the disparate feature types, and (2) as a querying platform. To this end, specifics of the ontologies and the SPARQL language need to be known for the querying to be possible. To help with this, further research is required to identify how to make the querying of the ontology easier without needing the technical knowledge in the area of Semantic Web technologies. Natural language processing is one such area where the user could specify a request in natural language, which would then be translated for the broker to understand. While this thesis mentioned the usage of an API or Web service, their implementation was not achieved due to time constraints.

- SHACL is a new Semantic Web technology that is a W3C recommendation. Given much of the research was finished and this thesis was written in the same year SHACL was released, it was not investigated but briefly discussed in chapter 2. SHACL can provide the means to check for the validity of an ontology, and hence could be used to validate Web services for conformance to the ontology developed in this thesis.

- Chapter 6 compared some methods pertaining to finding similar feature types. The comparison mentions a few different types of comparisons but is not exhaustive. A larger comparison of algorithms can provide a better observation of the best ways to compare feature types.

- Similarly, chapter 7 was exploratory and hence only more modern comparative techniques were used. More research is needed to observe the effects of the different variables discussed in that chapter.

- More Web service can be added into the broker system. Currently, only two Web services were evaluated because they had the filter capabilities required for proper evaluation. More datasets can also be used for better evaluation alongside stress testing.

- The error handling mechanism discussed in chapter 7 was not implemented because of the usage of real world end-points. This means that an error could not be purposefully made to test the error handling mechanism and hence was not implemented. This can be added into the broker system and tested to provide an overall more robust solution.

- The querying for the ontology requires a common vocabulary for each data themes. The method used in this thesis is a naïve one because developing a proper vocabulary for each data theme would require a longitudial research that identifies the needs and existing business models of different data providers and users; this was out of scope for this research. Therefore future work should include the development of a uniform querying schema over all spatial data themes.

9.4 Future Work

The next step for the broker approach described in this thesis is to integrate more Web services into the system. As a first step, a Web crawler could be set-up to automatically gather existing Web feature services and automatically integrate the new Web services into the broker system. PolarHub Li (2017) is a system that uses this approach.

Another step is to include other OGC-compliant Web services such as WMS in the broker system, and other non-OGC compliant ones afterwards. Once this is achieved, natural language processing could be investigated for a better user utilisation of the broker system. A user request in natural language should be able to be translated to a broker request. To this end, ontologies focussed on language could be explored.

To have a more functional broker system, the topics of data fusion and data conflation need to be considered. Data fusion is the combination of data to produce data. Once the data is federated, new data could be produced, and as such this work is deemed as a future research project. A flood-risk use-case was undergone with LINZ where the task was to identify places that are at risk of flood. However, because flood data was not available, they had to be extrapolated from disparate data from different Web services. This flood-risk scenario is data fusion work. Such a scenario though requires data federation to be resolved first, and hence data fusion is a next logical step for a more functional broker.

Alongside data fusion comes data conflation, which aims to identify which data are correct based on conflicting information. If two Web services serve the same data but those data conflict, data conflation is required to identify the correct data, or to compromise the data to create a new ‘more correct’ version. In the risk-flood scenario, two conflicting Web services could present the water level in the same area differently. As such, data conflation would be required to determine which is the more accurate one. This could be based on time stamp, or whether the source is authoritative for example.

This scenario leads to data governance. In a distributed environment, where the data can come from authoritative or being crowd-sourced, it is important to understand the origins of the data and whether they are fit-for-purpose. For the flood-risk scenario, it is important to research how the quality of spatial data can be determined based on their lineage and governance.

In summary, future research work in relation to this thesis include:

1. Integrate more Web services automatically using Web crawlers;
2. Integrate other OGC-compliant and non-OGC compliant Web services in the broker system;
3. Research and Implement natural language processing to query the broker system;
4. Research how data fusion and data conflation can be integrated in the broker system; and
5. Research spatial data governance, and how to determine if a spatial dataset is fit-for-purpose.

9.5 Summary

This thesis has covered the topic of disparate and heterogeneous datasets in Australia and New Zealand. A broker system was investigated and developed to allow the unified querying of Web services from a single platform. It allows for filtering of the feature types as well as the manual correction of semantic differences.

Specific investigations include facilitating the matching of similar feature types and the usage of ontologies. While the investigated solution was evaluated to be effective, some limitations were noted and future works pertaining to this research were provided.

This thesis advances the state of the art in the spatial domain by having investigated a potential solution to the current disparate and heterogeneous spatial datasets in Australia and New Zealand. By utilising Semantic Web techniques, it propels the framework onto which the semantic differences of disparate spatial data can be aligned. This thesis also provides further insight into the comparison of spatial data for a more automated approach to integrate them using modern techniques such as LDA and EMD.

This research has shown that Semantic Web techniques can be used with current spatial Web services to provide a uniform platform to query from and filter spatial feature types. While there are some limitations to be addressed, it is hoped that this work can be expanded to enable nation-wide spatial data integration for better access to and easier consumption of spatial data.

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APPENDIX A ONTOLOGIES

A.1 Web Service Ontology

This section presents the Web Service Ontology (WSO) developed in this thesis.

```
@prefix : <http://www.purl.org/net/wso#> .
@prefix geo: <http://www.opengis.net/ont/geosparql#> .
@prefix gml: <http://www.opengis.net/ont/gml#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22−rdf−syntax−ns#> .
@prefix vcd: <http://www.w3.org/2006/vcard/ns#> .
@prefix wso: <http://www.semanticweb.org/jez/ontologies/2017/2/ws−ontology>
    .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix http: <http://www.w3.org/2011/http#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf−schema#> .
@prefix content: <http://www.w3.org/2011/content#> .
@prefix process: <http://www.daml.org/services/owl−s/1.2/Process.owl#> .
@prefix profile: <http://www.daml.org/services/owl−s/1.2/Profile.owl#> .
@prefix service: <http://www.daml.org/services/owl−s/1.2/Service.owl#> .
@prefix grounding: <http://www.daml.org/services/owl−s/1.2/Grounding.owl#> .

<http://www.purl.org/net/wso#> a owl:Ontology ;
  owl:versionIRI <http://www.purl.org/net/wso#/1.0.0> ;
  owl:imports <http://www.w3.org/2011/http> , <http://www.opengis.net/ont/
      geosparql> , <http://www.daml.org/services/owl−s/1.2/Grounding.owl> , <
      http://www.w3.org/2006/vcard/ns> , <http://www.daml.org/services/owl−s
      /1.2/Profile.owl> .


# ################################################
# #
# # Object Properties
# #
# ################################################


# http://www.purl.org/net/wso#body

:body a owl:ObjectProperty ;
```

```
  rdfs:domain http:Message ;
  rdfs:range content:Content .
#
# http://www.purl.org/net/wso#hasAttribute

:hasAttribute a owl:ObjectProperty ;
  rdfs:subPropertyOf :hasMetadata ;
  rdfs:range :FeatureAttribute .
#
# http://www.purl.org/net/wso#hasBoundingBox

:hasBoundingBox a owl:ObjectProperty ;
  rdfs:subPropertyOf :hasMetadata ;
  rdfs:domain geo:SpatialObject ;
  rdfs:range :BoundingBox .
#
# http://www.purl.org/net/wso#hasMetadata

:hasMetadata a owl:ObjectProperty .
#
# http://www.purl.org/net/wso#hasProfile

:hasProfile a owl:ObjectProperty ;
  rdfs:subPropertyOf :hasMetadata ;
  rdfs:range :FeatureProfile .
#
# http://www.purl.org/net/wso#ogcHttpConnection

:ogcHttpConnection a owl:ObjectProperty .
#
# http://www.purl.org/net/wso#ogcHttpInputMessage

:ogcHttpInputMessage a owl:ObjectProperty .
#
# http://www.purl.org/net/wso#ogcHttpOutputMessage

:ogcHttpOutputMessage a owl:ObjectProperty .


# ################################################
```

```
# #
# # Data properties
# #
# #################################################


# http://www.purl.org/net/wso#hasMetadata

:hasMetadata a owl:DatatypeProperty .
#
# http://www.purl.org/net/wso#metadataName

:metadataName a owl:DatatypeProperty ;
  rdfs:domain :Metadata ;
  rdfs:range xsd:string .
#
# http://www.purl.org/net/wso#metadataType

:metadataType a owl:DatatypeProperty ;
  rdfs:domain :Metadata ;
  rdfs:range xsd:anyURI .
#
# http://www.purl.org/net/wso#metadataValue

:metadataValue a owl:DatatypeProperty ;
  rdfs:domain :Metadata ;
  rdfs:range rdfs:Literal .


# #################################################
# #
# # Classes
# #
# #################################################


# http://www.purl.org/net/wso#Address

:Address a owl:Class ;
  rdfs:subClassOf :FeatureType .
```

```
#
# http://www.purl.org/net/wso#Arithmetic

:Arithmetic a owl:Class ;
  rdfs:subClassOf :Scalar .
#
# http://www.purl.org/net/wso#Beyond

:Beyond a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#BoundingBox

:BoundingBox a owl:Class ;
  rdfs:subClassOf gml:Rectangle .
#
# http://www.purl.org/net/wso#Building

:Building a owl:Class ;
  rdfs:subClassOf :FeatureType .
#
# http://www.purl.org/net/wso#Comparison

:Comparison a owl:Class ;
  rdfs:subClassOf :Scalar .

:Between a owl:Class ;
  rdfs:subClassOf :Comparison .

:Like a owl:Class ;
  rdfs:subClassOf :Comparison .

:NullCheck a owl:Class ;
  rdfs:subClassOf :Comparison .

:SimpleComparisons a owl:Class ;
  rdfs:subClassOf :Comparison .

#
# http://www.purl.org/net/wso#Contains
```

```
:Contains a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#Crosses

:Crosses a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#DWithin

:DWithin a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#Disjoint

:Disjoint a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#Equals

:Equals a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#FeatureAttribute

:FeatureAttribute a owl:Class ;
  rdfs:subClassOf :Metadata .
#
# http://www.purl.org/net/wso#FeatureProfile

:FeatureProfile a owl:Class ;
  rdfs:subClassOf :Metadata .
#
# http://www.purl.org/net/wso#FeatureType

:FeatureType a owl:Class ;
  rdfs:subClassOf process:Input , geo:SpatialObject , _:genid1 .

_:genid1 a owl:Restriction ;
```

```
  owl:onProperty :hasAttribute ;
  owl:someValuesFrom :FeatureAttribute .

:FeatureType rdfs:subClassOf _:genid2 .

_:genid2 a owl:Restriction ;
  owl:onProperty :hasProfile ;
  owl:someValuesFrom :FeatureProfile .

:FeatureType rdfs:subClassOf _:genid3 .

_:genid3 a owl:Restriction ;
  owl:onProperty :hasBoundingBox ;
  owl:allValuesFrom :BoundingBox .
#
# http://www.purl.org/net/wso#Filter

:Filter a owl:Class ;
  rdfs:subClassOf process:Input .
#
# http://www.purl.org/net/wso#HeightPoint

:HeightPoint a owl:Class ;
  rdfs:subClassOf :FeatureType .
#
# http://www.purl.org/net/wso#Intersect

:Intersect a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#Lake

:Lake a owl:Class ;
  rdfs:subClassOf :FeatureType .
#
# http://www.purl.org/net/wso#Logical

:Logical a owl:Class ;
  rdfs:subClassOf :Scalar .
#
```

```
# http://www.purl.org/net/wso#Metadata

:Metadata a owl:Class ;
  rdfs:subClassOf process:Input .
#
# http://www.purl.org/net/wso#Mine

:Mine a owl:Class ;
  rdfs:subClassOf :FeatureType .
#
# http://www.purl.org/net/wso#OgcHttpAtomicProcessGrounding

:OgcHttpAtomicProcessGrounding a owl:Class ;
  rdfs:subClassOf grounding:AtomicProcessGrounding .
#
# http://www.purl.org/net/wso#OgcHttpGrounding

:OgcHttpGrounding a owl:Class ;
  rdfs:subClassOf grounding:Grounding .
#
# http://www.purl.org/net/wso#Overlaps

:Overlaps a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#Road

:Road a owl:Class ;
  rdfs:subClassOf :FeatureType .
#
# http://www.purl.org/net/wso#Scalar

:Scalar a owl:Class ;
  rdfs:subClassOf :Filter .
#
# http://www.purl.org/net/wso#Spatial

:Spatial a owl:Class ;
  rdfs:subClassOf :Filter .
#
```

```
# http://www.purl.org/net/wso#Touches

:Touches a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#WaterTank

:WaterTank a owl:Class ;
  rdfs:subClassOf :FeatureType .
#
# http://www.purl.org/net/wso#Within

:Within a owl:Class ;
  rdfs:subClassOf :Spatial .
#
# http://www.purl.org/net/wso#elevation

:elevation a owl:Class ;
  rdfs:subClassOf :FeatureAttribute .
#
# http://www.purl.org/net/wso#featureId

:featureId a owl:Class ;
  rdfs:subClassOf :FeatureAttribute .
#
# http://www.purl.org/net/wso#featureName

:featureName a owl:Class ;
  rdfs:subClassOf :FeatureAttribute .
#
# http://www.purl.org/net/wso#roadType

:roadType a owl:Class ;
  rdfs:subClassOf :FeatureAttribute .
#
# Generated by the OWL API (version 4.2.6.20160910—2108) https://github.com/
    owlcs/owlapi
```

WSO Ontology in Turtle Syntax

APPENDIX B XSLT SCRIPT

B.1 XSLT Script

This section presents the XSLT script used to convert a DescribeFeatureType document from WFS to an RDF equivalent.

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE fn:root [
  <!ENTITY xsd 'http://www.w3.org/2001/XMLSchema#'>
]>
<xsl:stylesheet version="1.0"
        xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
                xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                xmlns:owl="http://www.w3.org/2002/07/owl#"
                xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
   syntax-ns#"
                xmlns:rdfs="http://www.w3.org/2000/01/rdf-
   schema#"
                xmlns:cu="http://www.geosemantics01.curtin.edu
   .au#"
                xmlns:fo="http://www.w3.org/1999/XSL/Format"
                xmlns:xalan="http://xml.apache.org/xalan"
                xmlns:fn="http://www.w3.org/2005/xpath-
   functions">

  <xsl:output media-type="text/xml" version="1.0" encoding="
    UTF-8" indent="yes"/>
  <xsl:strip-space elements=" "/>

    <!-- SET UP TARGET NAMEPSACE VARIABLE -->
  <xsl:variable name="targetNamespace">
    <xsl:for-each select="xsd:schema/@ ">
      <xsl:if test="name(.)='targetNamespace'">
        <xsl:value-of select="."/><xsl:text>#</xsl:text>
      </xsl:if>
    </xsl:for-each>
  </xsl:variable>

  <!-- SET UP TARGET CLASS VARIABLE -->
  <xsl:variable name="targetClass">
```

```
  <!-- This won't work for multiple classes in the same file
      ! -->
  <xsl:value-of select="xsd:schema/xsd:element/@name"/>
</xsl:variable>


<!-- ////////////////////////////////////////////////////////
          MAIN TEMPLATE
     //////////////////////////////////////////////////////// -->

<xsl:template match="xsd:schema">

<!-- BASIC DOCTYPES -->
<!--  Generate entity definitions for each namespace  -->

  <rdf:RDF>

  <!-- START OF ONTOLOGY -->

  <!--  Import geosparql only for now  -->
  <xsl:text disable-output-escaping="yes">
    &#60;owl:Ontology rdf:about=""&#62;
  </xsl:text>
  <xsl:text disable-output-escaping="yes">
    &#60;owl:imports rdf:resource="http://www.opengis.net/
        ont/geosparql"/&#62;
  </xsl:text>
  <xsl:text disable-output-escaping="yes">
    &#60;/owl:Ontology&#62;
  </xsl:text>

  <xsl:for-each select="./node()">
    <xsl:variable name="postfix1" select="substring-after(
        name(.) ,':')"/>
    <xsl:variable name="temp" select="substring-before(name
        (.) ,':')"/>
    <xsl:variable name="ns-node" select="//namespace::[
        local-name()=$temp]"/>
```

```
  <xsl:if test="$ns-node = 'http://www.w3.org/2001/
      XMLSchema'">
    <xsl:choose>

      <!-- Ontology Class -->
      <xsl:when test="$postfix1 = 'complexType'">
        <xsl:call-template name="complex"/>
      </xsl:when>
    </xsl:choose>
  </xsl:if>
</xsl:for-each>

<!-- Define the Object and Datatype properties -->

<xsl:for-each select="//node()">
  <xsl:variable name="postfix2" select="substring-after(
      name(.) ,':')"/>
  <xsl:variable name="prefix1" select="substring-before(
      name(.) ,':')"/>
  <xsl:variable name="ns-node" select="//namespace::[
      local-name()=$prefix1]"/>

  <xsl:if test="$ns-node = 'http://www.w3.org/2001/
      XMLSchema'">
    <xsl:if test="$postfix2 = 'element'">
      <xsl:if test="not(./@substitutionGroup)">
        <xsl:call-template name="element"/>
      </xsl:if>
    </xsl:if>
  </xsl:if>
</xsl:for-each>

</rdf:RDF>
</xsl:template>

<!-- ////////////////////////////////////////////////
         HELPER TEMPLATES
      /////////////////////////////////////////////// -->
```

```
<xsl:template name="complex" match="xsd:complexType">
 <xsl:text disable-output-escaping="yes">&#xa;&#60;owl:
     Class rdf:about="</xsl:text>
 <xsl:value-of select="$targetNamespace"/><xsl:value-of
     select="$targetClass" />
 <xsl:text disable-output-escaping="yes">"&#62;&#xa;</xsl:
     text>

 <xsl:call-template name="extension">
   <!-- Can be xsd:complexContent or xsd:simpleComtent,
       hence the    -->
   <xsl:with-param name="node" select=".//xsd:extension"/>
 </xsl:call-template>

 <xsl:call-template name="sequence">
   <!-- Can be xsd:complexContent or xsd:simpleComtent,
       hence the    -->
   <xsl:with-param name="node" select=".///xsd:sequence"/
       >
 </xsl:call-template>

   <xsl:text disable-output-escaping="yes">&#xa;&#60;/owl:
       Class&#62;</xsl:text>
</xsl:template>

<xsl:template name="extension">
 <xsl:param name="node"/>
   <xsl:variable name="temp" select="substring-before($node
       /@base,':')"/>
   <xsl:variable name="ns-node" select="//namespace::[
       local-name()=$temp]"/>

   <xsl:text disable-output-escaping="yes">&#60;rdfs:
       subClassOf rdf:resource="</xsl:text>
   <xsl:value-of select="$ns-node"/><xsl:text>#</xsl:text><
       xsl:value-of select="substring-after($node/@base
       ,':')"/>
   <xsl:text disable-output-escaping="yes">"/&#62;&#xa;</
       xsl:text>
</xsl:template>
```

```
<xsl:template name="sequence">
 <xsl:param name="node"/>
   <xsl:for-each select="$node/xsd:element">
     <xsl:text disable-output-escaping="yes">
       &#60;rdfs:subClassOf&#62;
       &#60;owl:Restriction&#62;
     </xsl:text>

     <xsl:for-each select="@ ">
       <xsl:choose>
         <xsl:when test="name(.)='minOccurs'">
           <xsl:text disable-output-escaping="yes">
           &#60;owl:minCardinality rdf:datatype="&xsd;
               nonNegativeInteger"&#62;</xsl:text><xsl:
               value-of select="."/><xsl:text disable-
               output-escaping="yes">&#60;/owl:
               minCardinality&#62;
           </xsl:text>
         </xsl:when>

         <xsl:when test="name(.)='maxOccurs'">
           <xsl:text disable-output-escaping="yes">
           &#60;owl:maxCardinality rdf:datatype="&xsd;
               nonNegativeInteger"&#62;</xsl:text><xsl:
               value-of select="."/><xsl:text disable-
               output-escaping="yes">&#60;/owl:
               maxCardinality&#62;
           </xsl:text>
         </xsl:when>

         <xsl:when test="name(.)='nillable'">
         </xsl:when>

         <xsl:when test="name(.)='type'">
         </xsl:when>

         <xsl:when test="name(.)='name'">
           <xsl:text disable-output-escaping="yes">&#60;owl
               :onProperty rdf:resource="</xsl:text><xsl:
```

```
                value-of select="$targetNamespace"/><xsl:
                value-of select="." /><xsl:text disable-
                output-escaping="yes">"/&#62;</xsl:text>
            </xsl:when>

            <xsl:otherwise>
            </xsl:otherwise>
          </xsl:choose>
        </xsl:for-each>

        <xsl:text disable-output-escaping="yes">
          &#60;/owl:Restriction&#62;
          &#60;/rdfs:subClassOf&#62;
        </xsl:text>
      </xsl:for-each>
  </xsl:template>

<xsl:template name="element" match="xsd:element">

  <xsl:choose>
    <xsl:when test="@type">
    <xsl:variable name="temp" select="substring-before(@type
        ,':')"/>
    <xsl:variable name="ns-node" select="//namespace::[
        local-name()=$temp]"/>

      <xsl:choose>
        <xsl:when test="$ns-node = 'http://www.w3.org/2001/
            XMLSchema'">
          <xsl:text disable-output-escaping="yes">&#xa;&#60;
              owl:DatatypeProperty rdf:about="</xsl:text>
          <xsl:value-of select="$targetNamespace"/><xsl:
              value-of select="./@name"/>
          <xsl:text disable-output-escaping="yes">"&#62;&#xa
              ;</xsl:text>

          <xsl:text disable-output-escaping="yes">&#60;rdfs:
              range rdf:resource="</xsl:text>
          <xsl:value-of select="$ns-node"/><xsl:text>#</xsl:
              text><xsl:value-of select="substring-after(./
```

```
            @type, ':')"/>
        <xsl:text disable-output-escaping="yes">"/&#62;&#
            xa;</xsl:text>

        <xsl:text disable-output-escaping="yes">&#60;rdfs:
            domain rdf:resource="</xsl:text>
        <xsl:value-of select="$targetNamespace"/><xsl:text
            ></xsl:text><xsl:value-of select="$targetClass
            "/>
        <xsl:text disable-output-escaping="yes">"/&#62;&#
            xa;</xsl:text>

        <xsl:text disable-output-escaping="yes">&#60;/owl:
            DatatypeProperty&#62;&#xa;</xsl:text>
    </xsl:when>

    <xsl:otherwise>
        <xsl:text disable-output-escaping="yes">&#xa;&#60;
            owl:ObjectProperty rdf:about="</xsl:text>
        <xsl:value-of select="$targetNamespace"/><xsl:
            value-of select="./@name"/>
        <xsl:text disable-output-escaping="yes">"&#62;&#xa
            ;</xsl:text>

        <xsl:text disable-output-escaping="yes">&#60;rdfs:
            range rdf:resource="</xsl:text>
        <xsl:value-of select="$ns-node"/><xsl:text>#</xsl:
            text><xsl:value-of select="substring-after(./
            @type, ':')"/>
        <xsl:text disable-output-escaping="yes">"/&#62;&#
            xa;</xsl:text>

        <xsl:text disable-output-escaping="yes">&#60;rdfs:
            domain rdf:resource="</xsl:text>
        <xsl:value-of select="$targetNamespace"/><xsl:text
            ></xsl:text><xsl:value-of select="$targetClass
            "/>
        <xsl:text disable-output-escaping="yes">"/&#62;&#
            xa;</xsl:text>
```

```
            <xsl:text disable-output-escaping="yes">&#60;/owl:
                ObjectProperty&#62;&#xa;</xsl:text>
          </xsl:otherwise>
        </xsl:choose>
      </xsl:when>

      <xsl:otherwise>
        <xsl:text disable-output-escaping="yes">&#xa;&#60;owl:
            DatatypeProperty rdf:about="</xsl:text>
        <xsl:value-of select="$targetNamespace"/><xsl:value-of
             select="./@name"/>
        <xsl:text disable-output-escaping="yes">"&#62;&#xa;</
            xsl:text>

        <xsl:text disable-output-escaping="yes">&#60;rdfs:
            domain rdf:resource="</xsl:text>
        <xsl:value-of select="$targetNamespace"/><xsl:text></
            xsl:text><xsl:value-of select="$targetClass"/>
        <xsl:text disable-output-escaping="yes">"/&#62;&#xa;</
            xsl:text>

        <xsl:text disable-output-escaping="yes">&#60;rdfs:
            range rdf:resource="</xsl:text>
        <xsl:call-template name="simpleType">
          <xsl:with-param name="node" select="./xsd:simpleType
              "/>
        </xsl:call-template>
      </xsl:otherwise>
    </xsl:choose>
  </xsl:template>

  <xsl:template name="simpleType" match="xsd:simpleType">
    <xsl:param name="node"/>
    <xsl:variable name="postfix3" select="substring-after(
        $node/xsd:restriction/@base, ':')"/>
    <xsl:variable name="prefix2" select="substring-before(
        $node/xsd:restriction/@base, ':')"/>
    <xsl:value-of select="$targetClass"/><xsl:value-of select=
        "$postfix3"/>
```

```
<xsl:text disable-output-escaping="yes">"/&#62;&#xa;</xsl:
    text>
<xsl:text disable-output-escaping="yes">&#60;/owl:
    DatatypeProperty&#62;&#xa;</xsl:text>

  <!-- Redefine local type -->
  <xsl:text disable-output-escaping="yes">&#xa;&#60;rdfs:
     Datatype rdf:about="</xsl:text>
  <xsl:value-of select="$targetNamespace"/><xsl:value-of
     select="$postfix3"/>
  <xsl:text disable-output-escaping="yes">"&#62;&#xa;</xsl
     :text>

  <xsl:text disable-output-escaping="yes">&#60;rdfs:
     subClassOf rdf:resource="http://www.w3.org/2000/01/
     rdf-schema#Resource"/&#62;&#xa;</xsl:text>
  <xsl:text disable-output-escaping="yes">&#60;owl:
     equivalentClass&#62;&#xa;</xsl:text>
  <xsl:text disable-output-escaping="yes">&#60;rdfs:
     Datatype&#62;&#xa;</xsl:text>

    <xsl:text disable-output-escaping="yes">&#60;owl:
       onDataType rdf:resource="</xsl:text>
    <xsl:value-of select="$targetNamespace"/><xsl:value-of
        select="$postfix3"/>
    <xsl:text disable-output-escaping="yes">"/&#62;&#xa;</
       xsl:text>
    <xsl:text disable-output-escaping="yes">&#60;owl:
       withRestrictions rdf:parseType="Collection"&#62;&#
       xa;</xsl:text>
    <xsl:text disable-output-escaping="yes">&#60;rdfs:
       Description&#62;&#xa;</xsl:text>

    <xsl:for-each select="$node/xsd:restriction/ ">
      <xsl:variable name="postfix4" select="substring-
         after(name(.),':')"/>
      <xsl:variable name="prefix3" select="substring-
         before(name(.),':')"/>
      <xsl:variable name="ns-node" select="//namespace::[
         local-name()=$prefix3]"/>
```

```
<xsl:text disable-output-escaping="yes">&#60;</xsl:
    text>

            <xsl:call-template name="localPrefix">
                <xsl:with-param name="prefix" select="
                    $ns-node"/>
            </xsl:call-template>

            <xsl:text disable-output-escaping="yes">:<
                /xsl:text><xsl:value-of select="
                $postfix4"/><xsl:text disable-output-
                escaping="yes">&#62;&#xa;</xsl:text>
<xsl:value-of select="./@value"/>
<xsl:text disable-output-escaping="yes">&#60;/</xsl:
    text>

            <xsl:call-template name="localPrefix">
                <xsl:with-param name="prefix" select="
                    $ns-node"/>
            </xsl:call-template>

            <xsl:text disable-output-escaping="yes">:<
                /xsl:text><xsl:value-of select="
                $postfix4"/><xsl:text disable-output-
                escaping="yes">&#62;&#xa;</xsl:text>
</xsl:for-each>

    <xsl:text disable-output-escaping="yes">&#60;/rdfs
        :Description&#62;&#xa;</xsl:text>
  <xsl:text disable-output-escaping="yes">&#60;/owl:
      withRestrictions&#62;&#xa;</xsl:text>
<xsl:text disable-output-escaping="yes">&#60;/rdfs:
    Datatype&#62;&#xa;</xsl:text>
<xsl:text disable-output-escaping="yes">&#60;/owl:
    equivalentClass&#62;&#xa;</xsl:text>
<xsl:text disable-output-escaping="yes">&#60;/rdfs:
    Datatype&#62;&#xa;</xsl:text>

</xsl:template>
```

```
    <!-- Change when more prefixes necessary - as needed -->
    <xsl:template name="localPrefix">
        <xsl:param name="prefix"/>
        <xsl:choose>
            <xsl:when test="$prefix = 'http://www.w3.org/2001/
                XMLSchema'">
                 <xsl:text>xsd</xsl:text>
            </xsl:when>
        </xsl:choose>
    </xsl:template>

</xsl:stylesheet>
```

XSLT Script

APPENDIX C PYTHON SCRIPTS

C.1 Parsing a GetCapabilities Document into Ontology

This section presents the Python script used to convert a GetCapabilities document from a WFS to an RDF equivalent.

```
GROUNDING = Namespace('http://www.daml.org/services/owl-s/1.2/Grounding.owl#')
PROFILE = Namespace('http://www.daml.org/services/owl-s/1.2/Profile.owl#')
PROCESS = Namespace('http://www.daml.org/services/owl-s/1.2/Process.owl#')
SERVICE = Namespace('http://www.daml.org/services/owl-s/1.2/Service.owl#')
VCD = Namespace('https://www.w3.org/2006/vcard/ns#')
HTTP = Namespace('http://www.w3.org/2011/http#') #https://www.w3.org/TR/HTTP-in-RDF10/
CNT = Namespace('http://www.w3.org/2011/content#')
GEO = Namespace('http://www.opengis.net/ont/geosparql#') # Namespace('http://schemas.opengis.net/geosparql/1.0/geosparql_vocab_all.rdf#')
GEOM = Namespace('http://www.opengis.net/ont/sf#')
WSO = Namespace('http://www.purl.org/net/wso#')

WFS_NAMESPACE = ""

def process_ontologies():
  graph = rdflib.Graph()
  graph.parse("wso.ttl", format="n3")

  for url in urls:
    root = load_url(url + 'SERVICE=WFS&REQUEST=getcapabilities&version=1.0.0')

    service_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((service_node, RDF.type, OWL.NamedIndividual))
    graph.add((service_node, RDF.type, SERVICE.Service))

    profile_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((profile_node, RDF.type, OWL.NamedIndividual))
    graph.add((profile_node, RDF.type, PROFILE.Profile))
```

```
graph.add((service_node, SERVICE.presents, profile_node))
graph.add((profile_node, SERVICE.presentedBy, service_node
    ))

grounding_node = URIRef(WSO + str(uuid.uuid4()))
graph.add((grounding_node, RDF.type, OWL.NamedIndividual))
graph.add((grounding_node, RDF.type, URIRef(WSO + "
    OgcHttpGrounding")))
graph.add((service_node, SERVICE.supports, grounding_node)
    )
graph.add((grounding_node, SERVICE.supportedBy,
    service_node))

model_node = URIRef(WSO + str(uuid.uuid4()))
graph.add((model_node, RDF.type, OWL.NamedIndividual))
graph.add((model_node, RDF.type, PROCESS.AtomicProcess))
graph.add((service_node, SERVICE.describedBy, model_node))
graph.add((model_node, SERVICE.describes, service_node))

wfs_namespace = {}
wfs_namespace['ns'] = root.tag.split('}')[0].replace('{',
    '')
wfs_namespace['xml'] = 'http://www.w3.org/2001/XMLSchema'
wfs_namespace['gml'] = 'http://www.opengis.net/gml'

global WFS_NAMESPACE
WFS_NAMESPACE = wfs_namespace

for element in root:
  if element.tag.split('}')[1] == 'Service':
    parse_profile(graph, element, profile_node)

  elif element.tag.split('}')[1] == 'Capability':
    parse_capability(graph, element, model_node,
        grounding_node, profile_node)

  elif element.tag.split('}')[1] == 'FeatureTypeList':
    parse_feature_type_list(graph, element, profile_node,
        url)
```

```
            elif element.tag.split('}')[1] == 'Filter_Capabilities':
                parse_filter_capabilities(graph, element, profile_node
                    )
    graph.serialize(destination="ontology_eval_parsed.ttl",
        format="turtle")


def parse_profile(graph, element, profile_node):

    # Create a vCard
    vcard_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((vcard_node, RDF.type, OWL.NamedIndividual))
    graph.add((vcard_node, RDF.type, VCD.Organization))
    graph.add((profile_node, PROFILE.contactInformation,
        vcard_node))


    # Create category
    cat_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((cat_node, RDF.type, OWL.NamedIndividual))
    graph.add((cat_node, RDF.type, PROFILE.ServiceCategory))
    graph.add((cat_node, PROFILE.categoryName, Literal("Web
        Feature Service")))
    graph.add((profile_node, PROFILE.serviceCategory, cat_node))

    for tag in element:
        if tag.tag.split('}')[1] == 'Title':
            graph.add((profile_node, PROFILE.serviceName, Literal(
                tag.text, datatype=XSD.string)))

        elif tag.tag.split('}')[1] == 'Abstract':
            graph.add((profile_node, PROFILE.textDescription,
                Literal(tag.text, datatype=XSD.string)))


def parse_capability(graph, element, model_node,
    grounding_node, profile_node):
    atomic_grounding = URIRef(WSO + str(uuid.uuid4()))
    graph.add((atomic_grounding, RDF.type, OWL.NamedIndividual))
```

```
graph.add((atomic_grounding, RDF.type, WSO.
    OgcHttpAtomicProcessGrounding))
graph.add((grounding_node, GROUNDING.
    hasAtomicProcessGrounding, atomic_grounding))

for tag in element:
  if tag.tag.split('}')[1] == 'Request':

    for capability in tag:
      request_type = capability.tag.split('}')[1]

      # As OWL-S service can only be described by at most 1
          model (from the specs)
      # The GetFeature request call has been deemed to be
          more important than the others
      if request_type == 'GetFeature':
        graph.add((model_node, PROCESS.name, Literal(
            request_type, datatype=XSD.string)))
        graph.add((atomic_grounding, GROUNDING.owlsProcess,
            model_node))

        for c in capability.findall('.//ns:Get', namespaces=
            WFS_NAMESPACE):

          # Ontology for HTTP requests
          # https://www.w3.org/TR/HTTP-in-RDF10/
          # The Request
          get_request = URIRef(WSO + str(uuid.uuid4()))
          graph.add((get_request, RDF.type, OWL.
              NamedIndividual))
          graph.add((get_request, RDF.type, HTTP.Request))
          graph.add((get_request, HTTP.methodName, Literal(
              request_type, datatype=XSD.string)))
          graph.add((get_request, HTTP.requestURI, Literal(c
              .attrib['onlineResource'], datatype=XSD.string
              )))

          method_node = URIRef(WSO + str(uuid.uuid4()))
          graph.add((get_request, HTTP.mthd, method_node))
```

```
    graph.add((method_node, RDF.type, OWL.
        NamedIndividual))
    graph.add((method_node, RDF.type, HTTP.Method))
    graph.add((method_node, RDF.resource, Literal("
        http://www.w3.org/2011/http-methods#GET")))

    # The Response
    get_response = URIRef(WSO + str(uuid.uuid4()))
    graph.add((get_response, RDF.type, OWL.
        NamedIndividual))
    graph.add((get_response, RDF.type, HTTP.Response))
    graph.add((get_request, HTTP.resp, get_response))
    graph.add((atomic_grounding, WSO.
        ogcHttpInputMessage, get_request))
    graph.add((atomic_grounding, WSO.
        ogcHttpOutputMessage, get_response))


for c in capability.findall('.//ns:Post', namespaces
    =WFS_NAMESPACE):
    # Ontology for HTTP requests
    # https://www.w3.org/TR/HTTP-in-RDF10/
    # The Request
    post_request = URIRef(WSO + str(uuid.uuid4()))
    graph.add((post_request, RDF.type, OWL.
        NamedIndividual))
    graph.add((post_request, RDF.type, HTTP.Request))
    graph.add((post_request, HTTP.methodName, Literal(
        request_type, datatype=XSD.string)))
    graph.add((post_request, HTTP.requestURI, Literal(
        c.attrib['onlineResource'], datatype=XSD.
        string)))

    method_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((post_request, HTTP.mthd, method_node))
    graph.add((method_node, RDF.type, OWL.
        NamedIndividual))
    graph.add((method_node, RDF.type, HTTP.Method))
    graph.add((method_node, RDF.resource, Literal("
        http://www.w3.org/2011/http-methods#POST")))
```

```
  # The Response
  post_response = URIRef(WSO + str(uuid.uuid4()))
  graph.add((post_response, RDF.type, OWL.
     NamedIndividual))
  graph.add((post_response, RDF.type, HTTP.Response)
     )
  graph.add((post_request, HTTP.resp, post_response)
     )
  graph.add((atomic_grounding, WSO.
     ogcHttpInputMessage, post_request))
  graph.add((atomic_grounding, WSO.
     ogcHttpOutputMessage, post_response))

result_format = capability.find('.//ns:ResultFormat'
    , namespaces=WFS_NAMESPACE)
if result_format is not None:
  output_node = URIRef(WSO + str(uuid.uuid4()))
  graph.add((output_node, RDF.type, OWL.
     NamedIndividual))
  graph.add((output_node, RDF.type, PROCESS.Output))
  graph.add((model_node, PROCESS.hasOutput,
     output_node))
  for tag in result_format:
    result_format = tag.tag.split('}')[1]
    format_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((format_node, RDF.type, OWL.
       NamedIndividual))
    graph.add((format_node, RDF.type, WSO.
       OutputFormat))
    graph.add((output_node, WSO.hasFormat,
       format_node))

    if 'GML' in result_format:
      graph.add((format_node, RDF.type, WSO.GML))

    elif 'SHAPE' in result_format:
      graph.add((format_node, RDF.type, WSO.SHAPE))

    elif 'GEOJSON' in result_format:
```

```
                graph.add((format_node, RDF.type, WSO.GEOJSON)
                    )

            elif 'XML' in result_format:
                graph.add((format_node, RDF.type, WSO.XML))


            result_node = URIRef(WSO + str(uuid.uuid4()))
            graph.add((result_node, RDF.type, OWL.
                NamedIndividual))
            graph.add((result_node, RDF.type, PROCESS.Output))
            graph.add((result_node, RDFS.label, Literal(
                result_format, datatype=XSD.string)))



def parse_feature_type_list(graph, element, profile_node, url)
    :
  for tag in element:
    if tag.tag.split('}')[1] == 'FeatureType':
      feature_name = tag.find('.//ns:Name', namespaces=
          WFS_NAMESPACE).text

      feature_node = URIRef(WSO + str(uuid.uuid4()))
      graph.add((feature_node, RDF.type, OWL.NamedIndividual))
      graph.add((feature_node, RDF.type, WSO.FeatureType))
      graph.add((profile_node, PROFILE.hasInput, feature_node)
          )

      for feature in tag:
        if feature.tag.split('}')[1] == 'LatLongBoundingBox':
          bbox_node = URIRef(WSO + str(uuid.uuid4()))
          graph.add((bbox_node, RDF.type, OWL.NamedIndividual)
              )
          graph.add((bbox_node, RDF.type, WSO.BoundingBox))
          graph.add((feature_node, WSO.hasBoundingBox,
              bbox_node))

          wkt = "POLYGON((%s %s, %s %s, %s %s, %s %s, %s %s))"
              % (feature.attrib['minx'], feature.attrib['miny
```

```
        '], feature.attrib['minx'], feature.attrib['maxy
        '], feature.attrib['maxx'], feature.attrib['maxy
        '], feature.attrib['maxx'], feature.attrib['miny
        '], feature.attrib['minx'], feature.attrib['miny
        '])

    graph.add((bbox_node, GEO.asWKT, Literal(wkt,
        datatype=GEO.wktLiteral)))

else:
    prof_node = URIRef(WSO + str(uuid.uuid4()))
    graph.add((prof_node, RDF.type, OWL.NamedIndividual)
        )
    graph.add((prof_node, RDF.type, WSO.FeatureProfile))
    graph.add((prof_node, WSO.metadataValue, Literal(
        feature.text, datatype=XSD.string)))
    graph.add((prof_node, WSO.metadataName, Literal(
        feature.tag.split('}')[1], datatype=XSD.string))
        )
    graph.add((prof_node, WSO.medataType, XSD.string))
    graph.add((feature_node, WSO.hasProfile, prof_node))

    if feature.tag.split('}')[1] == 'Name':
        # Parse DescribeFeatureType FeatureAttribute
        d_url = ('%sSERVICE=WFS&REQUEST=
            DescribeFeatureType&typeName=%s&version=1.0.0'
            ) % (url, feature.text)
        feature_root = load_url(d_url)

        element = feature_root.findall('.//xml:sequence/
            xml:element', WFS_NAMESPACE)

        for e in element:
            name = e.attrib['name']
            attrib_node = URIRef(WSO + str(uuid.uuid4()))

            try:
                type = e.attrib['type']

                if type.split(':')[0] == 'gml':
```

```
gml = type.split(':')[1]
gml_node = URIRef(WSO + str(uuid.uuid4()))
graph.add((gml_node, RDF.type, OWL.
    NamedIndividual))

if 'MultiPolygon' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      MultiPolygon))

elif 'MultiLineString' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      MultiLineString))

elif 'MultiPoint' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      MultiPoint))

elif 'Polygon' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      Polygon))

elif 'LineString' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      LineString))

elif 'Point' in gml:
  graph.add((gml_node, RDF.type, GEOM.Point)
      )

elif 'GeometryAssociationType' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      Geometry))

elif 'GeometryPropertyType' in gml:
  graph.add((gml_node, RDF.type, GEOM.
      Geometry))

else:
  raise Exception('GML not specified %s: at
      %s' % (gml, feature.text))
```

```
                graph.add((feature_node, GEO.hasGeometry,
                    gml_node))
                graph.add((gml_node, WSO.metadataName,
                    Literal(name, datatype=XSD.string)))

            else:
                graph.add((attrib_node, RDF.type, OWL.
                    NamedIndividual))
                graph.add((attrib_node, RDF.type, WSO.
                    FeatureAttribute))
                graph.add((attrib_node, WSO.metadataName,
                    Literal(name, datatype=XSD.string)))
                graph.add((feature_node, WSO.hasAttribute,
                    attrib_node))
                type = type.split(':')[1]
                graph.add((attrib_node, WSO.metadataType,
                    Literal("http://www.w3.org/2001/
                    XMLSchema#" + type, datatype=XSD.anyURI)
                    ))


        except KeyError:
            restriction = e.find('.//xml:restriction',
                WFS_NAMESPACE)
            restriction = restriction.attrib['base'].split
                (':')[1]
            graph.add((attrib_node, WSO.metadataType,
                Literal("http://www.w3.org/2001/XMLSchema#
                " + restriction, datatype=XSD.anyURI)))



def parse_filter_capabilities(graph, element, profile_node):
  for tag in element:
    if tag.tag.split('}')[1] == 'Spatial_Capabilities':
      for capability in tag:
        if capability.tag.split('}')[1] == 'Spatial_Operators'
            :
          for op in capability:
```

```
op_tag = op.tag.split('}')[1]
spatial_op = URIRef(WSO + str(uuid.uuid4()))
graph.add((spatial_op, RDF.type, OWL.
    NamedIndividual))
graph.add((spatial_op, RDFS.label, Literal(op_tag,
     datatype=XSD.string)))
graph.add((profile_node, PROFILE.hasInput,
    spatial_op))

if op_tag == 'BBOX':
  graph.add((spatial_op, RDF.type, WSO.BBox))

elif op_tag == 'Beyond':
  graph.add((spatial_op, RDF.type, WSO.Beyond))

elif op_tag == 'Contains':
  graph.add((spatial_op, RDF.type, WSO.Contains))

elif op_tag == 'Crosses':
  graph.add((spatial_op, RDF.type, WSO.Crosses))

elif op_tag == 'Disjoint':
  graph.add((spatial_op, RDF.type, WSO.Disjoint))

elif op_tag == 'Equals':
  graph.add((spatial_op, RDF.type, WSO.Equals))

elif op_tag == 'Intersect':
  graph.add((spatial_op, RDF.type, WSO.Intersect))

elif op_tag == 'Overlaps':
  graph.add((spatial_op, RDF.type, WSO.Overlaps))

elif op_tag == 'Touches':
  graph.add((spatial_op, RDF.type, WSO.Touches))

elif op_tag == 'Within':
  graph.add((spatial_op, RDF.type, WSO.Within))

elif op_tag == 'DWithin':
```

```
          graph.add((spatial_op, RDF.type, WSO.DWithin))

elif tag.tag.split('}')[1] == 'Scalar_Capabilities':
  for capability in tag:
    if capability.tag.split('}')[1] == '
        Comparison_Operators':
      for op in capability:
        op_tag = op.tag.split('}')[1]
        spatial_op = URIRef(WSO + str(uuid.uuid4()))
        graph.add((spatial_op, RDF.type, OWL.
            NamedIndividual))
        graph.add((spatial_op, RDFS.label, Literal(op_tag,
             datatype=XSD.string)))
        graph.add((profile_node, PROFILE.hasInput,
            spatial_op))

        if op_tag == 'Simple_Comparisons':
          graph.add((spatial_op, RDF.type, WSO.
              SimpleComparisons))

        elif op_tag == 'Between':
          graph.add((spatial_op, RDF.type, WSO.Between))

        elif op_tag == 'Like':
          graph.add((spatial_op, RDF.type, WSO.Like))

        elif op_tag == 'NullCheck':
          graph.add((spatial_op, RDF.type, WSO.NullCheck))
```

Iterative parsing of GetCapabilities document to ontology

C.2 Evaluator Script

This section contains the script used to evaluate the broker system. It compares two files (the ground truth and the results of the broker system), and outputs whether any attributes are invalid or missing.

```
# MAIN of evaluator
# Requires: name of result JSON file, name of ground truth XML
    file
def main():
    evaluate(store_attrib("test.xml", ['OBJECT_ID']), "result.
        json")

# Has a list of all attribute
# Result file is a JSON file
def evaluate(all_attrib, result_file):
    result_json = json.load(open(result_file))

    invalid_count = 0
    total_count = 0

    # URL represents the data providers
    for url in result_json:
        count = 0
        local_count = 0
        local_invalid = 0
        j = 0

        for feature in result_json[url]:
            total_count += 1

            # LOOP through all attributes, if found then it is
                valid
            # If not It is invalid entry
            valid = False
            for attrib in feature.keys():
                local_count = len(all_attrib)

                for l_attrib in all_attrib:
```

```
                    if feature[attrib] in l_attrib:
                        valid = True

                if valid:
                    count += 1

                if not valid:
                    invalid_count += 1
                    local_invalid += 1
                j += 1

            print "For %s: %i/%i invalid; %i / %i count" % (url,
                local_invalid, len(result_json[url]), count,
                local_count)

        print "Invalids for query %s: %i" % (str(i), invalid_count
            )
        print "Missed %i" % (total_count - (linz_count +
            delwp_count))


# Extracts attributes from file
# And stores them in a list
# Attrib is a list of attribute the user requested to be
    retrieved
def store_attrib(file_name, attrib):
    with open(file_name, 'r') as xml_file:
        et = ET.iterparse(xml_file)
        for _, el in et:
            if '}' in el.tag:
                el.tag = el.tag.split('}', 1)[1]  # strip all
                    namespaces
        et = et.root

    all_attrib = []
    for feature in et:
        l_attrib = []

        # Based on the datasets used it'll be one of those
            three
```

```
        geom = feature.find('.//GEOMETRY')

        if geom is None:
            geom = feature.find('.//shape')

        if geom is None:
            geom = feature.find('.//SHAPE')

        if geom is not None:
            l_attrib.append(tostring(geom[0], method="xml").
                replace('\n', '').replace('\t', ''))

            for a in attrib:
                a = feature.find('.//%s' % (a))

                if a is not None:
                    l_attrib.append(a.text)

        if len(l_attrib) != 0:
            all_attrib.append(l_attrib)

    return all_attrib
```

Broker Evaluator Script

APPENDIX D PRELIMINARY ONTOLOGY RESULTS

This section presents the results from the preliminary evaluation of the Web Service Ontology (WSO) developed in this thesis.

D.1 What feature types do a particular WFS service?

DELWP Web Feature Service	datavic:WATER_STORAGE_
DELWP Web Feature Service	datavic:MINERALS_PETROL
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_MARINE_PARKRES_SU5
DELWP Web Feature Service	datavic:VMTRANS_AIRPORT_AREA_POLYGON
DELWP Web Feature Service	datavic:MINERALS_SIGFEAT
DELWP Web Feature Service	datavic:WATER_URBAN_WATER_CORP
DELWP Web Feature Service	datavic:PTV_TRAIN_STATION_BIKE_STORAGE
DELWP Web Feature Service	datavic:WATER_MODIFIED_RIVERS
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_5Y_ARI
DELWP Web Feature Service	datavic:VMADMIN_SHIRE500_1994
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_CHANNEL_REGULATOR
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_COMM_USE_AREA
DELWP Web Feature Service	datavic:VMTRANS_RAIL_STATION_DISUSED
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_WHARF
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_COASTAL_W_SU3
DELWP Web Feature Service	datavic:VMCLTENURE_RESERVE_MANAGEMENT
DELWP Web Feature Service	datavic:WATER_GMA_SUBZONE
DELWP Web Feature Service	datavic:WATER_GEOL_STRUCT_OVENS_VALLEY
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_FLOOD_REGUULATOR
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_STATE_PARK
DELWP Web Feature Service	datavic:VMVEG_TREE_DENSITY_DENSE
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_AREA_POLYGON
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_NATURE_CONSERV
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_7_2
DELWP Web Feature Service	datavic:MINERALS_CHERTH100_POLYGON
DELWP Web Feature Service	datavic:MINERALS_EWAHST
DELWP Web Feature Service	datavic:WATER_SDL_BASEFLOWS
DELWP Web Feature Service	datavic:MINERALS_MINERALP
DELWP Web Feature Service	datavic:WATER_DAM
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_UG_PIPE
DELWP Web Feature Service	datavic:WATER_GDE_TERR_CORCMA
DELWP Web Feature Service	datavic:WATER_GEOL_BSE_PERMIAN
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_16_1

DELWP Web Feature Service	datavic:WATER_GEOL_STRUCT_GOULBURN_MURRAY
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OVERLAYS_WZ
DELWP Web Feature Service	datavic:VMINDEX_FR_FRAMEWORK_AREA_POLYGON
DELWP Web Feature Service	datavic:VMADMIN_LOCALITY_POLYGON
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_1_1
DELWP Web Feature Service	datavic:MINERALS_GCHEM
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_WEIR
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_CHANNEL_OUTFALL
DELWP Web Feature Service	datavic:MINERALS_GPSTRLINE250
DELWP Web Feature Service	datavic:COASTS_SLR20CM_ST_2040
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_15_1
DELWP Web Feature Service	datavic:MINERALS_PL
DELWP Web Feature Service	datavic:PTV_BUS_ROUTE_SCHOOL
DELWP Web Feature Service	datavic:UDP_MRS2009
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_DISUSED
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_MARINE_SANC
DELWP Web Feature Service	datavic:WATER_GDE_TERR_GHCMA
DELWP Web Feature Service	datavic:VMPROP_PARCEL_VIEW
DELWP Web Feature Service	datavic:WATER_FLOWS_RIVER_REACHES
DELWP Web Feature Service	datavic:WATER_BU_LTER
DELWP Web Feature Service	datavic:MINERALS_GEOL1M_POLYGON
DELWP Web Feature Service	datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M
DELWP Web Feature Service	datavic:FLORAFAUNA1_WETLAND500
DELWP Web Feature Service	datavic:VMINDEX_FR_FRAMEWORK_AREA_LINE
DELWP Web Feature Service	datavic:WATER_LINEAMENTS_GRAVITY
DELWP Web Feature Service	datavic:UDP_MRS2008
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_14_1
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_WATER_PROD
DELWP Web Feature Service	datavic:VMPROP_PARCEL_MP
DELWP Web Feature Service	datavic:CATCHMENTS_SOIL_TYPE
DELWP Web Feature Service	datavic:VMVEG_TREE_DENSITY_MEDIUM
DELWP Web Feature Service	datavic:VMFEAT_LOCALITY_POINT
DELWP Web Feature Service	datavic:VMADMIN_AD_VICGOV_REGION
DELWP Web Feature Service	datavic:UDP_BH2009
DELWP Web Feature Service	datavic:MINERALS_SHALWK100_POLYGON
DELWP Web Feature Service	datavic:WATER_ISC2010_CHANNEL_TRANSECTS
DELWP Web Feature Service	datavic:MINERALS_GEOL100_ARC

DELWP Web Feature Service	datavic:MINERALS_GEXCURS
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_RETARDING_BASIN
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_18_1
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_5_1
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_NAT_CATCH
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_5_3
DELWP Web Feature Service	datavic:WATER_MELBOURNE_WATER_CORP
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_9_1
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_6_2
DELWP Web Feature Service	datavic:VMLITE_GEO_POINT_LABEL
DELWP Web Feature Service	datavic:WATER_IRRIGATION_DISTRICT
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_10_1
DELWP Web Feature Service	datavic:VMCLTENURE_GENERAL
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_2_2
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OTHER
DELWP Web Feature Service	datavic:VMPLAN_PLAN_ZONE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_13_1
DELWP Web Feature Service	datavic:WATER_BORES_VOLC_FA
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_STATE_PARK
DELWP Web Feature Service	datavic:WATER_GC
DELWP Web Feature Service	datavic:FORESTS_FCOV1000_1869_PRESENT
DELWP Web Feature Service	datavic:VMPROP_EASEMENT
DELWP Web Feature Service	datavic:VMADMIN_CFA_REGION
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_OTHER_SU5
DELWP Web Feature Service	datavic:FLORAFUANA1_SWOOPING_BIRD
DELWP Web Feature Service	datavic:WATER_GDE_TERR_WCMA
DELWP Web Feature Service	datavic:UDP_IND2009
DELWP Web Feature Service	datavic:WATER_CORP
DELWP Web Feature Service	datavic:UDP_IND2008_PROPOSED_AREAS
DELWP Web Feature Service	datavic:MINERALS_FLTROCK100_POLYGON
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SALT_LAKE
DELWP Web Feature Service	datavic:FLOOD_EXTENT_1000Y_ARI
DELWP Web Feature Service	datavic:VMPROP_ANNOTATION_TEXT
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_PROP_NPA
DELWP Web Feature Service	datavic:MINERALS_FACIES100_POLYGON
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_DRAIN_REGULATOR

DELWP Web Feature Service	datavic:VMLITE_FOREST_SU5
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_25D
DELWP Web Feature Service	datavic:WATER_ISC2010_BANKFULL_WIDTH_R
DELWP Web Feature Service	datavic:VMTRANS_AIR_INFRA_AREA_POLYGON
DELWP Web Feature Service	datavic:CATCHMENTS_GMU250
DELWP Web Feature Service	datavic:VMTRANS_AIRPORT_INFRASTRUCTURE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_8_1
DELWP Web Feature Service	datavic:MINERALS_OILGAS
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_PROPOSED
DELWP Web Feature Service	datavic:MINERALS_GEOL1M_ARC
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_2_1
DELWP Web Feature Service	datavic:MINERALS_DEEPLD100_ARC
DELWP Web Feature Service	datavic:MINERALS_RL
DELWP Web Feature Service	datavic:MINERALS_BASINS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_17_1
DELWP Web Feature Service	datavic:VMPROP_CAD_AREA_BDY_L
DELWP Web Feature Service	datavic:WATER_GW_SW_INTERACTION
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_50D
DELWP Web Feature Service	datavic:MINERALS_PETPHYS
DELWP Web Feature Service	datavic:MINERALS_GPMISCL250
DELWP Web Feature Service	datavic:VMPLAN_PLAN_UGA
DELWP Web Feature Service	datavic:MINERALS_STRLINE1M
DELWP Web Feature Service	datavic:VMADMIN_LGA_POLYGON
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_2_2
DELWP Web Feature Service	datavic:UDP_IND2008_NODES
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_INFRASTRUCTURE
DELWP Web Feature Service	datavic:VMPLAN_PLAN_UGB
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN
DELWP Web Feature Service	datavic:UDP_MRS2011
DELWP Web Feature Service	datavic:VMADMIN_TOWNSHIP_POLYGON
DELWP Web Feature Service	datavic:VMFEAT_FOI_INDEX_CENTROID
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_13_4
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_REGIONAL_P
DELWP Web Feature Service	datavic:MINERALS_ROCKS
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_DAM_WALL_ROAD
DELWP Web Feature Service	datavic:MINERALS_GMLHST
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_POINT

DELWP Web Feature Service	datavic:FORESTS_FCOV500_72_ABSENT
DELWP Web Feature Service	datavic:WATER_SPRING_LOCATIONS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_3_1
DELWP Web Feature Service	datavic:PLANNING_HERITAGE_REGISTER
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_16_3
DELWP Web Feature Service	datavic:VMPROP_ROAD_CASEMENT_POLYGON
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_7_1
DELWP Web Feature Service	datavic:WATER_GDE_TERR_WGCMA
DELWP Web Feature Service	datavic:FLOOD_EXTENT_10Y_ARI
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_50Y_ARI
DELWP Web Feature Service	datavic:MINERALS_GRAT10KM
DELWP Web Feature Service	datavic:VMADMIN_AD_LGA_AREA_POLYGON
DELWP Web Feature Service	datavic:VMFEAT_FOI_LINE
DELWP Web Feature Service	datavic:VMFEAT_BUILDING_POLYGON
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_200Y_ARI
DELWP Web Feature Service	datavic:CATCHMENTS_LSYS100
DELWP Web Feature Service	datavic:MINERALS_SHALLD100_ARC
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_17_3
DELWP Web Feature Service	datavic:WATER_PWSC100
DELWP Web Feature Service	datavic:VMFEAT_PL_PLACE_AREA_POLYGON
DELWP Web Feature Service	datavic:MINERALS_DEEPLD100_POLYGON
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_SOFTWOOD_SU5
DELWP Web Feature Service	datavic:WATER_GDE_TERR_PPCMA
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_13_2
DELWP Web Feature Service	datavic:VMFEAT_GEOMARK_SPORT_FACILITY_POLY
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_8_2
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_SIDING
DELWP Web Feature Service	datavic:VMCLTENURE_GOV_ROAD_POLY
DELWP Web Feature Service	datavic:WATER_ISC2010_VEGETATION_OVERHANG
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_UNCAT_PUBLIC
DELWP Web Feature Service	datavic:FLORAFAUNA1_VBIOREG100
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_500Y_ARI
DELWP Web Feature Service	datavic:FORESTS_RECWEB_TRACK
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_18_2
DELWP Web Feature Service	datavic:CATCHMENTS_FLAGSHIP500
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_PROP_NPA
DELWP Web Feature Service	datavic:PTV_BUS_ROUTE_REGIONAL

DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_19_1
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_WATER_PROD
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_WILDERNESS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_14_2
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_50S
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EXTENT
DELWP Web Feature Service	datavic:FLOOD_EXTENT_500Y_ARI
DELWP Web Feature Service	datavic:VMTRANS_GATE
DELWP Web Feature Service	datavic:VMLITE_TR_ROAD
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_LC
DELWP Web Feature Service	datavic:PTV_TRAIN_CARPARK
DELWP Web Feature Service	datavic:MAPSHARE3_DFW_CENT_STG_EDIT
DELWP Web Feature Service	datavic:VMCLTENURE_V_CL_TENURE_POLY
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_ROAD_EMBANKMENT
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_NPA_SHED_4
DELWP Web Feature Service	datavic:OWOF_WATER_CORPORATION
DELWP Web Feature Service	datavic:VMLITE_HY_WATER_AREA
DELWP Web Feature Service	datavic:FLOOD_EXTENT_100Y_ARI
DELWP Web Feature Service	datavic:VMADMIN_AD_LOCALITY_AREA_POLYGON
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_RAMP
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_20_1
DELWP Web Feature Service	datavic:UDP_BH2016
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_TUNNEL
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OVERLAYS_RA
DELWP Web Feature Service	datavic:VMADMIN_STATE_COUNCIL_2013
DELWP Web Feature Service	datavic:FLOOD_EXTENT_30Y_ARI
DELWP Web Feature Service	datavic:VMLITE_FOREST_SU2
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_11_2
DELWP Web Feature Service	datavic:MINERALS_GRAT1KM
DELWP Web Feature Service	datavic:FORESTS_RECWEB_SITE
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_COASTAL_RES
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_PRIVATE
DELWP Web Feature Service	datavic:VMFEAT_BUILDING_POINT
DELWP Web Feature Service	datavic:VMADMIN_PARISH_POLYGON
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_CONNECTOR
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_STRUCT_POINT
DELWP Web Feature Service	datavic:CATCHMENTS_BIOLINK500

DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_TANK
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_LAKES_DAMS
DELWP Web Feature Service	datavic:MINERALS_DLL
DELWP Web Feature Service	datavic:PTV_TRAM_TRACK_CENTRELINE
DELWP Web Feature Service	datavic:VMTRANS_ALPS_WALKING_TRACK
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_10_1
DELWP Web Feature Service	datavic:MINERALS_GEOL250_POLYGON
DELWP Web Feature Service	datavic:MINERALS_MP
DELWP Web Feature Service	datavic:WATER_EST_FLUV
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_OTHER
DELWP Web Feature Service	datavic:CROWNLAND_APIARY
DELWP Web Feature Service	datavic:MINERALS_MIN
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_STATE_FOREST
DELWP Web Feature Service	datavic:VMADMIN_DSE_REGION
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_D
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_CAUSEWAY
DELWP Web Feature Service	datavic:WATER_AQUIFER_SAL_BED
DELWP Web Feature Service	datavic:MINERALS_COAL_RES
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_13_4
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_STREAM
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_STATE_FOREST
DELWP Web Feature Service	datavic:CULTURE_SENSITIVITY_PUBLIC
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_H_A_C_FEAT_RES
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_CMNWTH_LAND
DELWP Web Feature Service	datavic:VMADD_ADDRESS
DELWP Web Feature Service	datavic:MINERALS_MINTEN
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_30DA3
DELWP Web Feature Service	datavic:MINERALS_MISCL250
DELWP Web Feature Service	datavic:WATER_GW_SITES
DELWP Web Feature Service	datavic:VMADMIN_STATE_ASSEMBLY_2013
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_8_2
DELWP Web Feature Service	datavic:WATER_BU_WTABLE
DELWP Web Feature Service	datavic:WATER_WSPA
DELWP Web Feature Service	datavic:PTV_TRAIN_TRACK_CENTRELINE
DELWP Web Feature Service	datavic:PTV_TRAIN_STATION_PLATFORM
DELWP Web Feature Service	datavic:VMFEAT_GEOMARK_INDEX_CENTROID
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_WATER_BODY

DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_BRIDGE
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_COMM_USE_AREA
DELWP Web Feature Service	datavic:MINERALS_OUTCROP
DELWP Web Feature Service	datavic:VMLITE_POSTCODE_POLYGON
DELWP Web Feature Service	datavic:VMCLTENURE_APIARY
DELWP Web Feature Service	datavic:VMADMIN_WARD_2008
DELWP Web Feature Service	datavic:VMADMIN_WARD_2016
DELWP Web Feature Service	datavic:VMPROP_PARCEL_PROPERTY
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_100Y_ARI
DELWP Web Feature Service	datavic:WATER_ISC2010_FRAGMENTATION
DELWP Web Feature Service	datavic:WATER_FAULTS_LATROBE_GP
DELWP Web Feature Service	datavic:MINERALS_XSEC_COAL
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_NPA_SHED_4
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_ALPINE_RESORT
DELWP Web Feature Service	datavic:UDP_IND2008
DELWP Web Feature Service	datavic:FORESTS_RECWEB_ASSET
DELWP Web Feature Service	datavic:VMLITE_LOCALITY_POLYGON
DELWP Web Feature Service	datavic:MINERALS_PIPELINE
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_NAT_CATCH
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_DAM_BATTER
DELWP Web Feature Service	datavic:PTV_TRAIN_CORRIDOR_CENTRELINE
DELWP Web Feature Service	datavic:CATCHMENTS_LANDUSE100_2005
DELWP Web Feature Service	datavic:MINERALS_EIIA
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATERCOURSE
DELWP Web Feature Service	datavic:CATCHMENTS_BASIN100
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_6_1
DELWP Web Feature Service	datavic:COASTS_SLR00CM_2009
DELWP Web Feature Service	datavic:VMTRANS_BICENTENNIAL_NATIONAL
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_PLANTATION
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_LIGHT
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS
DELWP Web Feature Service	datavic:VMELEV_GROUND_TYPE_ROCK_OC
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_NATURAL_FEAT
DELWP Web Feature Service	datavic:FORESTS_OG100
DELWP Web Feature Service	datavic:VMELEV_EL_CONTOUR_1TO5M
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_CLOSED
DELWP Web Feature Service	datavic:FLOOD_EXTENT_PMF

DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_CMNWTH_LAND
DELWP Web Feature Service	datavic:WATER_GDE_TERR_NCCMA
DELWP Web Feature Service	datavic:WATER_ESTUARIES
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_19_1
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_SOFTWOOD_SU3
DELWP Web Feature Service	datavic:WATER_AQUIFER_SAL_BASAL
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_TOLLWAYS
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_MARINE_SANC
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OVERLAYS_NCA
DELWP Web Feature Service	datavic:UDP_MINOR_INFILL_SUPPLY2009
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_5_2
DELWP Web Feature Service	datavic:VMLITE_HY_WATERCOURSE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_4_1
DELWP Web Feature Service	datavic:WATER_RWA
DELWP Web Feature Service	datavic:MINERALS_INSPECT
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_SERVICE_UTIL
DELWP Web Feature Service	datavic:WATER_GDE_TERR_MCMA
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_6_1
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_MARSHALLING
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_ROAD_BRIDGE
DELWP Web Feature Service	datavic:WATER_GW_SW_INTERACTION_FLUX
DELWP Web Feature Service	datavic:MINERALS_STRLINE100
DELWP Web Feature Service	datavic:FIRE_BURNPLAN13
DELWP Web Feature Service	datavic:PLANNING_HERITAGE_INVENTORY
DELWP Web Feature Service	datavic:CATCHMENTS_CMA100
DELWP Web Feature Service	datavic:UDP_BH2010_ESTATES
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_PORT_COAST_FAC
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_HIGHWAY
DELWP Web Feature Service	datavic:WATER_FARM_DAMS_POINT
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_3_1
DELWP Web Feature Service	datavic:COASTS_SLR47CM_2070
DELWP Web Feature Service	datavic:UDP_IND2016
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SWAMPS
DELWP Web Feature Service	datavic:WATER_GWR
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_PARKRES_SU5
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_COLLECTOR
DELWP Web Feature Service	datavic:WATER_ISC2010_VEGETATION_WIDTH

DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_18_2
DELWP Web Feature Service	datavic:COASTS_SLR82CM_ST_2100
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_SU3
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_MARINE_NP
DELWP Web Feature Service	datavic:MINERALS_SPRINGS
DELWP Web Feature Service	datavic:MINERALS_GPSTRLINE100
DELWP Web Feature Service	datavic:MINERALS_SEISMIC_ARC
DELWP Web Feature Service	datavic:UDP_MAJOR_INFILL2009
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_SPECIAL
DELWP Web Feature Service	datavic:VMLITE_GEO_AREA_LABEL
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_SERVICE_UTIL
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_5_1
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_DWO
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_14_2
DELWP Web Feature Service	datavic:MINERALS_FOSSILS
DELWP Web Feature Service	datavic:FORESTS_FCOV500_87_PRESENT
DELWP Web Feature Service	datavic:MINERALS_RRREGO100_POLYGON
DELWP Web Feature Service	datavic:MINERALS_STRLINE250
DELWP Web Feature Service	datavic:WATER_BORES_BSE_ALL
DELWP Web Feature Service	datavic:MINERALS_EL
DELWP Web Feature Service	datavic:UDP_HDD_STOCK2014
DELWP Web Feature Service	datavic:MINERALS_COAL_BDY
DELWP Web Feature Service	datavic:FORESTS_RECWEB_HISTORIC_RELIC
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_RAILWAY_BRIDGE
DELWP Web Feature Service	datavic:MINERALS_PET_WELLS
DELWP Web Feature Service	datavic:FLORAFAUNA1_WETLANDDIR
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_7_1
DELWP Web Feature Service	datavic:UDP_HDD_PROJECTS2005TO2014
DELWP Web Feature Service	datavic:UDP_BH2011_ESTATES
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_6_2
DELWP Web Feature Service	datavic:CROWNLAND_PLM25
DELWP Web Feature Service	datavic:UDP_MRS2016
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_10_2
DELWP Web Feature Service	datavic:MINERALS_GEOL100_POLYGON
DELWP Web Feature Service	datavic:WATER_IRRIGATION_SYSTEM_ALLOCATION_
DELWP Web Feature Service	datavic:MINERALS_SEISMIC_POINT

DELWP Web Feature Service	datavic:VMPLAN_PLAN_CODELIST
DELWP Web Feature Service	datavic:MINERALS_RRRADSIG100_POLYGON
DELWP Web Feature Service	datavic:MINERALS_SHAFT
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_FOREST_PARK
DELWP Web Feature Service	datavic:MINERALS_SHALWK100_ARC
DELWP Web Feature Service	datavic:WATER_BU_UTER
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_7_2
DELWP Web Feature Service	datavic:WATER_BU_MTER
DELWP Web Feature Service	datavic:WATER_DW_POINTS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_20_1
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_MARINA
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_TRAM
DELWP Web Feature Service	datavic:VMFEAT_GEOMARK_LINE
DELWP Web Feature Service	datavic:MINERALS_MINERAL
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_H_A_C_FEAT_RES
DELWP Web Feature Service	datavic:VMADMIN_POSTCODE_POLYGON
DELWP Web Feature Service	datavic:MINERALS_GRATMIN
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SALT_PAN
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_100D
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_13_3
DELWP Web Feature Service	datavic:WATER_MELBOURNE_WATER_RETAILER
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_16_2
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_FOOTBRIDGE
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_WILDERNESS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_14_1
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_9_1
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_11_1
DELWP Web Feature Service	datavic:CATCHMENTS_COASTAL_ACID_SULPHATE_SO-ILS
DELWP Web Feature Service	datavic:UDP_IND2016_PROPOSED_AREAS
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_SU5
DELWP Web Feature Service	datavic:VMTRANS_TR_FERRY_ROUTE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_16_1
DELWP Web Feature Service	datavic:MINERALS_MINHST
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_30SA4
DELWP Web Feature Service	datavic:VMCLTENURE_CL_TENURE_VIEW
DELWP Web Feature Service	datavic:MINERALS_DEEPLD250_POLYGON

DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_FORDS
DELWP Web Feature Service	datavic:VMADMIN_DEPI_REGION
DELWP Web Feature Service	datavic:VMFEAT_EMERGENCY_FACILITY
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_TRAIL
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_DAM_WALL
DELWP Web Feature Service	datavic:MINERALS_FACILITY
DELWP Web Feature Service	datavic:UDP_IND2011_NODES
DELWP Web Feature Service	datavic:VMADMIN_CFA_TFB_DISTRICT
DELWP Web Feature Service	datavic:WATER_DAM__
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_UNMAINTAINED
DELWP Web Feature Service	datavic:FIRE_FIRE_HISTORY
DELWP Web Feature Service	datavic:MINERALS_RRDURI100_POLYGON
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_12_1
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_WATER_BODY
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_2_1
DELWP Web Feature Service	datavic:FLOOD_EXTENT_200Y_ARI
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_4_1
DELWP Web Feature Service	datavic:MINERALS_TLHST
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_SPILLWAY
DELWP Web Feature Service	datavic:WATER_ISC_REACH
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_BIKE_PATH
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_16_3
DELWP Web Feature Service	datavic:MINERALS_GPSGEOL1100_POLYGON
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_TUNNEL
DELWP Web Feature Service	datavic:FLOOD_EXTENT_5Y_ARI
DELWP Web Feature Service	datavic:UDP_MRS2010
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_EARTH_RESOURCES
DELWP Web Feature Service	datavic:MINERALS_RRREGO100_ARC
DELWP Web Feature Service	datavic:MINERALS_COAL_ISOPACH
DELWP Web Feature Service	datavic:PTV_TRAIN_STATION
DELWP Web Feature Service	datavic:WATER_GDE_TERR_EGCMA
DELWP Web Feature Service	datavic:UDP_IND2010_PROPOSED_AREAS
DELWP Web Feature Service	datavic:MINERALS_GPMISCL100
DELWP Web Feature Service	datavic:VMINDEX_VICMAP_MAPINDEX_25S
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OVERLAYS_HR
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_COASTAL_RES
DELWP Web Feature Service	datavic:VMCLTENURE_AGRICULTURAL

DELWP Web Feature Service	datavic:VMLITE_TR_RAIL
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_13_1
DELWP Web Feature Service	datavic:MINERALS_DLA
DELWP Web Feature Service	datavic:WATER_UWA
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_COASTAL_W_SU5
DELWP Web Feature Service	datavic:COASTS_SLR47CM_ST_2070
DELWP Web Feature Service	datavic:WATER_BORES_BED_FA
DELWP Web Feature Service	datavic:VMTRANS_TR_AIR_INFRA_POINT
DELWP Web Feature Service	datavic:PTV_TRAM_ROUTE
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_WELL
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_FLOOD_EFFLUENT
DELWP Web Feature Service	datavic:VMTRANS_WALKING_TRACK
DELWP Web Feature Service	datavic:FLORAFAUNA1_RAMSAR25
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_NPA_SHED_3
DELWP Web Feature Service	datavic:VMFEAT_CFA_FIRE_STATION
DELWP Web Feature Service	datavic:MINERALS_ALTERN100_POLYGON
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_NATURE_CONSERV
DELWP Web Feature Service	datavic:WATER_ISC2010_TOP_OF_BANK
DELWP Web Feature Service	datavic:MINERALS_COAL_FLOOR
DELWP Web Feature Service	datavic:VMTRANS_RAIL_STATION_DISMANTLED
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_NATIONAL_P
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_13_3
DELWP Web Feature Service	datavic:WATER_LINEAMENTS_RADIO
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_OPERATIONAL
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_10Y_ARI
DELWP Web Feature Service	datavic:FLOOD_FLOW_DIRECTION
DELWP Web Feature Service	datavic:VMFEAT_FOI_POINT
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_11_2
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_STATE_FOREST_SU3
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_DRAIN
DELWP Web Feature Service	datavic:MINERALS_COAL_ROOF
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_MANAGEMENT_VEHICL-ES
DELWP Web Feature Service	datavic:PTV_BUS_ROUTE_METRO
DELWP Web Feature Service	datavic:MINERALS_DIGSURV
DELWP Web Feature Service	datavic:VMELEV_EL_GRND_SURFACE_POINT
DELWP Web Feature Service	datavic:WATER_GMA

DELWP Web Feature Service	datavic:MINERALS_GEOL4M_POLYGON
DELWP Web Feature Service	datavic:WATER_FARM_DAMS
DELWP Web Feature Service	datavic:WATER_GMB
DELWP Web Feature Service	datavic:WATER_FAULTS_STRZELECKI_GP
DELWP Web Feature Service	datavic:VMELEV_GROUND_TYPE_SAND
DELWP Web Feature Service	datavic:WATER_GDE_TERR_NECMA
DELWP Web Feature Service	datavic:MINERALS_DURI100_POLYGON
DELWP Web Feature Service	datavic:VMTRANS_ROUNDABOUT
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_R
DELWP Web Feature Service	datavic:VMLITE_TR_AIRPORT
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_UNCAT_PUBLIC
DELWP Web Feature Service	datavic:VMTRANS_RAIL_STATION_OPERATIONAL
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_TRACKS
DELWP Web Feature Service	datavic:MINERALS_PETROLPRO
DELWP Web Feature Service	datavic:CROWNLAND_PARKRES
DELWP Web Feature Service	datavic:UDP_BH2010
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_STATE_FOREST_SU5
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE
DELWP Web Feature Service	datavic:FLOOD_EXTENT_50Y_ARI
DELWP Web Feature Service	datavic:COASTS_SLR82CM_2100
DELWP Web Feature Service	datavic:MINERALS_NUGGET
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_PONDAGE
DELWP Web Feature Service	datavic:FLORAFAUNA1_WETLAND_1788
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OVERLAYS
DELWP Web Feature Service	datavic:VMCLTENURE_PIPELINES
DELWP Web Feature Service	datavic:VMPLAN_PLAN_OVERLAY
DELWP Web Feature Service	datavic:WATER_GW_BORES_CL
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_CHANNEL
DELWP Web Feature Service	datavic:MINERALS_GEOL250_ARC
DELWP Web Feature Service	datavic:UDP_IND2010_NODES
DELWP Web Feature Service	datavic:WATER_ISC2010_BARE_GROUND
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_OVERLAYS_RNA
DELWP Web Feature Service	datavic:VMADMIN_STATE_ASSEMBLY_2001
DELWP Web Feature Service	datavic:VMTRANS_LEVEL_CROSSING
DELWP Web Feature Service	datavic:VMADMIN_WARD_2012
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_LIMITS
DELWP Web Feature Service	datavic:VMFEAT_GEOMARK_INDEX_EXTENT

DELWP Web Feature Service	datavic:CATCHMENTS_LSYS250
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_NATURAL_FEAT
DELWP Web Feature Service	datavic:WATER_IRRIGATION_SYSTEM_ALLOCATION
DELWP Web Feature Service	datavic:MINERALS_ANASURV
DELWP Web Feature Service	datavic:UDP_IND2009_NODES
DELWP Web Feature Service	datavic:VMPROP_PROPERTY_MP
DELWP Web Feature Service	datavic:WATER_FAULTS_NWMURRAY_BASIN
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_19_2
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_4WD
DELWP Web Feature Service	datavic:VMLITE_LOCALITY
DELWP Web Feature Service	datavic:MINERALS_SITES
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_FREEWAY
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_5_3
DELWP Web Feature Service	datavic:PLANNING_BUSHFIRE_PRONE_AREA
DELWP Web Feature Service	datavic:VMADMIN_DELWP_REGION
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_SYPHON
DELWP Web Feature Service	datavic:WATER_EST_CATCH
DELWP Web Feature Service	datavic:UDP_IND2009_PROPOSED_AREAS
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_OCCUPATION_CROSSING
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_19_2
DELWP Web Feature Service	datavic:VMFEAT_GEOMARK_POLYGON
DELWP Web Feature Service	datavic:UDP_MAJOR_INFILL2011
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_11_1
DELWP Web Feature Service	datavic:VMELEV_EL_CONTOUR
DELWP Web Feature Service	datavic:FORESTS_FCOV500_72_PRESENT
DELWP Web Feature Service	datavic:VMTRANS_SURF_COAST_WALK
DELWP Web Feature Service	datavic:FORESTS_SVEG100
DELWP Web Feature Service	datavic:VMCLTENURE_RESERVE_STATUS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_17_3
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_ALPINE_RESORT
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_MARINE_PARKRES_SU3
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_BRIDGE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_5_2
DELWP Web Feature Service	datavic:VMCLTENURE_LEASE
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_LOCK
DELWP Web Feature Service	datavic:UDP_BH2011
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_DRAIN_OUTFALL

DELWP Web Feature Service	datavic:WATER_GMA_ZONE
DELWP Web Feature Service	datavic:MINERALS_MISCL100
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_WATER_PLACE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_17_2
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_REGIONAL_P
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_RIVER
DELWP Web Feature Service	datavic:PTV_BUS_STOP
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_OTHER_SU3
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_EARTH_RESOURCES
DELWP Web Feature Service	datavic:FORESTS_FCOV500_87_ABSENT
DELWP Web Feature Service	datavic:VMFEAT_GEOMARK_POINT
DELWP Web Feature Service	datavic:WATER_EWSP
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_17_2
DELWP Web Feature Service	datavic:VMTRANS_GREAT_DIVIDING_TRAIL
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_OTHER_BRIDGE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_8_1
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_PLANTATION
DELWP Web Feature Service	datavic:WATER_PRIORITY_RIVERS
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_17_4
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_18_1
DELWP Web Feature Service	datavic:MINERALS_GRAT100KM
DELWP Web Feature Service	datavic:WATER_ISC2010_LARGE_TREES
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_13_2
DELWP Web Feature Service	datavic:UDP_IND2010
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_STRUCT_AREA_TANK
DELWP Web Feature Service	datavic:FORESTS_FCOV1000_1869_ABSENT
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_SUB_A
DELWP Web Feature Service	datavic:MINERALS_ELHIST
DELWP Web Feature Service	datavic:WATER_FAULTS_GOLDEN_BEACH_FM
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_SEASONAL
DELWP Web Feature Service	datavic:VMLITE_PUBLIC_LAND_PARKRES_SU3
DELWP Web Feature Service	datavic:VMPROP_PROPERTY_VIEW
DELWP Web Feature Service	datavic:MINERALS_SHALLD100_POLYGON
DELWP Web Feature Service	datavic:CATCHMENTS_LANDUSE_2014
DELWP Web Feature Service	datavic:VMADMIN_MFB_DISTRICT
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_15_2

DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_FOREST_PARK
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_17_4
DELWP Web Feature Service	datavic:VMFEAT_FOI_POLYGON
DELWP Web Feature Service	datavic:WATER_ISC2010_TOE_OF_BANK
DELWP Web Feature Service	datavic:FORESTS_OG100_OGONLY
DELWP Web Feature Service	datavic:WATER_RURAL_WATER_CORP
DELWP Web Feature Service	datavic:MINERALS_MINSITE
DELWP Web Feature Service	datavic:PTV_TRAM_STOP
DELWP Web Feature Service	datavic:MINERALS_BORES_V_PUBLIC
DELWP Web Feature Service	datavic:MINERALS_STRUC
DELWP Web Feature Service	datavic:VMHYDRO_WATERFALL
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_NATIONAL_P
DELWP Web Feature Service	datavic:MINERALS_GRAVITY
DELWP Web Feature Service	datavic:UDP_IND2011
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_BREAKWATER
DELWP Web Feature Service	datavic:VMTRANS_BIKE_BRIDGES
DELWP Web Feature Service	datavic:VMADMIN_STATE_COUNCIL_2005
DELWP Web Feature Service	datavic:MINERALS_EWA
DELWP Web Feature Service	datavic:VMADMIN_MFB_REGION
DELWP Web Feature Service	datavic:VMFEAT_POLICE_STATION
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_CULVERT
DELWP Web Feature Service	datavic:MINERALS_RRRADSIG100_ARC
DELWP Web Feature Service	datavic:VMELEV_EL_GRND_TYPE_POINT
DELWP Web Feature Service	datavic:VMFEAT_FOI_INDEX_EXTENT
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_PIPE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_17_1
DELWP Web Feature Service	datavic:ENERGY_ELECTRICITY_DISTRIBUTOR
DELWP Web Feature Service	datavic:FLOOD_CONTOUR_20Y_ARI
DELWP Web Feature Service	datavic:WATER_BORES_SED_FA
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_15_2
DELWP Web Feature Service	datavic:WATER_SDL_CATCH
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_ARTERIAL
DELWP Web Feature Service	datavic:MINERALS_EXC
DELWP Web Feature Service	datavic:FLOOD_FLOODWAY
DELWP Web Feature Service	datavic:PUBLICLANDUSE_VEAC_METRO_OPEN_SPACE
DELWP Web Feature Service	datavic:OWOF_IRRIGATION_DISTRICT
DELWP Web Feature Service	datavic:WATER_LINEAMENTS_TMI

DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_V
DELWP Web Feature Service	datavic:VMFEAT_GNR
DELWP Web Feature Service	datavic:COASTS_SLR00CM_ST_2009
DELWP Web Feature Service	datavic:VMLITE_VICTORIA_POLYGON_SU5
DELWP Web Feature Service	datavic:VMLITE_LGA
DELWP Web Feature Service	datavic:WATER_BFI_UNREG_RIVERS_1889_2012
DELWP Web Feature Service	datavic:UDP_BH2009_ESTATES
DELWP Web Feature Service	datavic:FORESTS_RECWEB_CARPARK
DELWP Web Feature Service	datavic:WATER_AQUIFER_SAL_SHALLOW
DELWP Web Feature Service	datavic:WATER_GEOL_SED_GOULBURN_MURRAY
DELWP Web Feature Service	datavic:MINERALS_GSVMI
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_PORT_COAST_FAC
DELWP Web Feature Service	datavic:MINERALS_RRDURI100_ARC
DELWP Web Feature Service	datavic:WATER_GDE_TERR_GBCMA
DELWP Web Feature Service	datavic:VMVEG_TREE_DENSITY
DELWP Web Feature Service	datavic:FLORAFAUNA1_WETLAND_1994
DELWP Web Feature Service	datavic:VMLITE_BUILT_UP_AREA
DELWP Web Feature Service	datavic:VMADMIN_CFA_DISTRICT
DELWP Web Feature Service	datavic:WATER_WSPA_ZONE
DELWP Web Feature Service	datavic:MINERALS_GOLDFLD100_POLYGON
DELWP Web Feature Service	datavic:WATER_ISC2010_WATER_BODIES
DELWP Web Feature Service	datavic:VMADMIN_VICGOV_REGION
DELWP Web Feature Service	datavic:FLORAFAUNA1_WETLAND_LANDSCAPE
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_UNDERGROUND
DELWP Web Feature Service	datavic:WATER_FAULTS_WANGERRIP_GP
DELWP Web Feature Service	datavic:UDP_IND2011_PROPOSED_AREAS
DELWP Web Feature Service	datavic:VMTRANS_TR_ROAD_LOCAL
DELWP Web Feature Service	datavic:FLOOD_STRUCTURE_DAM_RESERVOIR
DELWP Web Feature Service	datavic:WATER_GW_FLOW_IMPACT_STRUCT
DELWP Web Feature Service	datavic:FORESTS_RECWEB_POI
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_10_2
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_INNUNDATION
DELWP Web Feature Service	datavic:COASTS_SLR20CM_2040
DELWP Web Feature Service	datavic:VMTRANS_TR_RAIL_DISMANTLED
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_MARINE_NP
DELWP Web Feature Service	datavic:VMVEG_TREE_DENSITY_SCATTERED
DELWP Web Feature Service	datavic:FORESTS_RECWEB_HUT

DELWP Web Feature Service	datavic:VMLITE_FOREST_SU3
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_15_1
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_16_2
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SEWAGE
DELWP Web Feature Service	datavic:VMLITE_TR_RAIL_STATION
DELWP Web Feature Service	datavic:WATER_STORAGE
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV1750_EVCBCS_12_1
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_NPA_SHED_3
DELWP Web Feature Service	datavic:FLORAFAUNA1_NV2005_EVCBCS_1_1

D.2 What feature types have a similar string in its name?

DELWP Web Feature Service	Water Body -Public Land Management
DELWP Web Feature Service	ANZVI0803005036, WATER Surface, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_ISC2010_TOP_OF_BANK
DELWP Web Feature Service	ANZVI0803005023, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_WELL
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	ANZVI0803005139, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_DRAIN
DELWP Web Feature Service	datavic:WATER_GMA
DELWP Web Feature Service	datavic:WATER_LINEAMENTS_RADIO
DELWP Web Feature Service	WATER, AGRICULTURE, TOPOGRAPHY, ANZVI0803002498
DELWP Web Feature Service	ANZVI0803005005, WATER Groundwater, GEOSCIENCES Geophysics, GEOSCIENCES Geology
DELWP Web Feature Service	datavic:WATER_GDE_TERR_EGCMA

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	WATER.UWA
DELWP Web Feature Service	datavic:WATER_ISC_REACH
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:WATER_BORES_BED_FA
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	ANZVI0803004996, GEOSCIENCES Geology, WATER Hydrochemistry, WATER Groundwater
DELWP Web Feature Service	datavic:WATER_UWA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA
DELWP Web Feature Service	ANZVI0803005114, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	WATER, ANZVI0803002490, MAPPING, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_CHANNEL
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	ANZVI0803003705, WATER
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_PONDAGE
DELWP Web Feature Service	datavic:WATER_GW_BORES_CL
DELWP Web Feature Service	datavic:WATER_IRRIGATION_SYSTEM_ALLOCATION
DELWP Web Feature Service	ANZVI0803003054, WATER Monitoring

DELWP Web Feature Service	datavic:WATER_FAULTS_NWMURRAY_BASIN
DELWP Web Feature Service	ArcSDE, WATER.ISC2010_VEGETATION_OVERHANG
DELWP Web Feature Service	datavic:WATER_ISC2010_BARE_GROUND
DELWP Web Feature Service	ANZVI0803003029, WATER Management
DELWP Web Feature Service	ANZVI0803005013, GEOSCIENCES Geophysics, GEOSCIENCES Hydrology, WATER Hydrology
DELWP Web Feature Service	datavic:WATER_GMB
DELWP Web Feature Service	datavic:WATER_FAULTS_STRZELECKI_GP
DELWP Web Feature Service	ANZVI0803002923, WATER Groundwater, WATER Management
DELWP Web Feature Service	Groundwater Management Areas
DELWP Web Feature Service	datavic:WATER_FARM_DAMS
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	WATER.ISC2010_LARGE_TREES, ArcSDE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA
DELWP Web Feature Service	WATER, ANZVI0803002490, MAPPING, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_GDE_TERR_NECMA
DELWP Web Feature Service	ANZVI0803005014, GEOSCIENCES Geophysics, GEOSCIENCES Hydrology, WATER Hydrology
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_GWR
DELWP Web Feature Service	ANZVI0803004999, GEOSCIENCES Geology, WATER Hydrochemistry, WATER Groundwater
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SWAMPS
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	Groundwater Resources

DELWP Web Feature Service	ANZVI0803005164, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_ISC2010_VEGETATION_-WIDTH
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA
DELWP Web Feature Service	WATER_CORP
DELWP Web Feature Service	ANZVI0803005165, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	Rural Water Corporation Boundaries
DELWP Web Feature Service	ANZVI0803002928, WATER Management
DELWP Web Feature Service	datavic:WATER_RWA
DELWP Web Feature Service	Groundwater-Surface Water Interaction Flux
DELWP Web Feature Service	datavic:WATER_GW_SW_INTERACTION_-FLUX
DELWP Web Feature Service	datavic:WATER_FARM_DAMS_POINT
DELWP Web Feature Service	ANZVI0803003051, WATER Production, WATER Groundwater, WATER Quality, WATER Salinity
DELWP Web Feature Service	datavic:WATER_GDE_TERR_MCMA
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	MELBOURNE_WATER_RETAILER, features
DELWP Web Feature Service	MELBOURNE_WATER_RETAILER
DELWP Web Feature Service	datavic:WATER_MELBOURNE_WATER_R-ETAILER

DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_MA-RINA
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICUL-TURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SALT_-PAN
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZ-ARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_WATER_-BODY
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_SPI-LLWAY
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_DA-M_WALL
DELWP Web Feature Service	ANZVI0803003052, WATER Production, WATER Groundwater, WATER Quality, WA-TER Salinity
DELWP Web Feature Service	datavic:WATER_DAM__
DELWP Web Feature Service	datavic:WATER_IRRIGATION_SYSTEM_AL-LOCATION_
DELWP Web Feature Service	ANZVI0803002376, WATER Wetlands, ECOLOGY Habitat, ECOLOGY Ecosystem
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICUL-TURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_BORES_BSE_ALL
DELWP Web Feature Service	ANZVI0803004995, GEOSCIENCES Ge-ology, WATER Hydrochemistry, WATER Groundwater
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features
DELWP Web Feature Service	ANZVI0803005162, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hy-drogeology
DELWP Web Feature Service	datavic:WATER_DW_POINTS
DELWP Web Feature Service	Groundwater Management Basins (GMB)
DELWP Web Feature Service	datavic:WATER_BU_MTER
DELWP Web Feature Service	datavic:WATER_BU_UTER

DELWP Web Feature Service	ANZVI0803003049, WATER Surface, WATER
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite
DELWP Web Feature Service	datavic:WATER_BFI_UNREG_RIVERS_18-89_2012
DELWP Web Feature Service	datavic:WATER_AQUIFER_SAL_SHALLOW
DELWP Web Feature Service	ANZVI0803004998, GEOSCIENCES Geology, WATER Hydrochemistry, WATER Groundwater
DELWP Web Feature Service	ANZVI0803005166, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	ANZVI0803005007, WATER Groundwater, GEOSCIENCES Geophysics, GEOSCIENCES Geology
DELWP Web Feature Service	ANZVI0803002490, TOPOGRAPHY, AGRICULTURE, WATER
DELWP Web Feature Service	ANZVI0803005003, GEOSCIENCES Hydrogeology, WATER Groundwater, WATER Salinity
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803005163, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_GEOL_SED_GOULBURN_-MURRAY
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)

DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_BR-EAKWATER
DELWP Web Feature Service	datavic:VMHYDRO_WATERFALL
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803002925, WATER Surface, WA-TER Management
DELWP Web Feature Service	datavic:WATER_SDL_CATCH
DELWP Web Feature Service	datavic:WATER_LINEAMENTS_TMI
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_PIPE
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_BORES_SED_FA
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICUL-TURE, TOPOGRAPHY
DELWP Web Feature Service	WATER_STORAGE, features
DELWP Web Feature Service	RURAL_WATER_CORP
DELWP Web Feature Service	Water Supply Protection Area (Groundwa-ter and Surface Water) Zone within Victo-ria
DELWP Web Feature Service	datavic:WATER_STORAGE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosys-tem (GDE) Mapping for the North East CMA
DELWP Web Feature Service	WATER_STORAGE
DELWP Web Feature Service	ANZVI0803005008, GEOSCIENCES Geol-ogy, WATER Groundwater, GEOSCIENCES Geophysics
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_INNU-NDATION
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SEWAGE

DELWP Web Feature Service	Potential Impact of Geological Structures on Groundwater Flow Systems
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803001066, WATER Wetlands
DELWP Web Feature Service	datavic:WATER_GDE_TERR_GBCMA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA
DELWP Web Feature Service	ANZVI0803004914, WATER Groundwater
DELWP Web Feature Service	datavic:WATER_FAULTS_WANGERRIP_GP
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_GW_FLOW_IMPACT_STRUCT
DELWP Web Feature Service	datavic:WATER_WSPA_ZONE
DELWP Web Feature Service	RURAL_WATER_CORP, features
DELWP Web Feature Service	datavic:WATER_ISC2010_WATER_BODIES
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803005373, WATER Supply
DELWP Web Feature Service	ANZVI0803005118, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_LOCK
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_WATER_PLACE
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_RIVER
DELWP Web Feature Service	ANZVI0803002945, WATER Groundwater
DELWP Web Feature Service	Groundwater Management Area Zones
DELWP Web Feature Service	datavic:WATER_GMA_ZONE

DELWP Web Feature Service	ANZVI0803005170, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	Department of Environment, Land, Water and Planning Regional Boundaries - Vicmap Admin
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803005021, GEOSCIENCES Geophysics, GEOSCIENCES Hydrology, WATER Hydrology
DELWP Web Feature Service	ANZVI0803005122, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	ANZVI0803004933, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	ANZVI0803005001, GEOSCIENCES Hydrogeology, WATER Groundwater, WATER Salinity
DELWP Web Feature Service	datavic:WATER_EST_CATCH
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	ANZVI0803005017, GEOSCIENCES Geophysics, GEOSCIENCES Hydrology, WATER Hydrology
DELWP Web Feature Service	datavic:WATER_ISC2010_TOE_OF_BANK
DELWP Web Feature Service	datavic:WATER_FAULTS_GOLDEN_BEACH_FM

DELWP Web Feature Service	WATER, ANZVI0803002490, MAPPING, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	ANZVI0803003704, WATER
DELWP Web Feature Service	ANZVI0803002493, TOPOGRAPHY, AGRICULTURE, WATER
DELWP Web Feature Service	ANZVI0803002498, TOPOGRAPHY, AGRICULTURE, WATER
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_RURAL_WATER_CORP
DELWP Web Feature Service	WATER.ISC2010_FRAGMENTATION, ArcSDE
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	datavic:WATER_PRIORITY_RIVERS
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	Emergency Water Supply Points
DELWP Web Feature Service	datavic:WATER_EWSP
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_STRUCT-_AREA_TANK
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803003050, WATER Production, WATER Groundwater, WATER Quality, WATER Salinity
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA
DELWP Web Feature Service	datavic:WATER_ISC2010_LARGE_TREES
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_POINT

DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_DAM_WALL_ROAD
DELWP Web Feature Service	datavic:WATER_SPRING_LOCATIONS
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_UG_PIPE
DELWP Web Feature Service	datavic:WATER_DAM
DELWP Web Feature Service	ANZVI0803005167, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:WATER_PWSC100
DELWP Web Feature Service	datavic:WATER_GDE_TERR_WGCMA
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	ANZVI0803005161, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	ANZVI0803001039, WATER Management
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System
DELWP Web Feature Service	datavic:WATER_ISC2010_BANKFULL_WIDTH_R
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA
DELWP Web Feature Service	ArcSDE, WATER.FARM_DAMS
DELWP Web Feature Service	Groundwater-Surface Water Interaction
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_GDE_TERR_CORCMA

DELWP Web Feature Service	datavic:WATER_GW_SW_INTERACTION
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803004904, GEOSCIENCES Hydrogeology, WATER Surface, WATER Rivers
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_WATER_P-ROD
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Water Production -Public Land Management
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_AREA_P-OLYGON
DELWP Web Feature Service	HY_WATER_AREA_POLYGON, features, ANZVI0803002491
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803005100, WATER Wetlands
DELWP Web Feature Service	ANZVI0803004936, WATER Hydrogeology, WATER Surface, WATER Groundwater
DELWP Web Feature Service	features, OWOF_WATER_CORPORATION
DELWP Web Feature Service	ANZVI0803004923, WATER Groundwater, WATER Surface, WATER Rivers
DELWP Web Feature Service	Designated Water Supply Catchments
DELWP Web Feature Service	datavic:WATER_SDL_BASEFLOWS
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning

DELWP Web Feature Service	ANZVI0803005168, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_ISC2010_VEGETATION_OVERHANG
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	datavic:WATER_GDE_TERR_PPCMA
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)
DELWP Web Feature Service	datavic:WATER_GDE_TERR_GHCMA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport CMA
DELWP Web Feature Service	ANZVI0803004924, ECOLOGY Ecosystem, WATER Rivers, WATER Surface, WATER Hydrology
DELWP Web Feature Service	datavic:WATER_FLOWS_RIVER_REACHES
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	MELBOURNE_WATER_CORP, features
DELWP Web Feature Service	datavic:WATER_MELBOURNE_WATER_CORP
DELWP Web Feature Service	MELBOURNE_WATER_CORP
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	ANZVI0803004218, ECOLOGY, BOUNDARIES, WATER
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management
DELWP Web Feature Service	ANZVI0803005024, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_LINEAMENTS_GRAVITY
DELWP Web Feature Service	ANZVI0803005006, WATER Surface, WATER Groundwater, GEOSCIENCES Hydrogeology

DELWP Web Feature Service	datavic:CROWNLAND_PLMGEN_WATER_-PROD
DELWP Web Feature Service	ANZVI0803005113, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	datavic:WATER_BU_LTER
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_ISC2010_CHANNEL_TRANSECTS
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	WATER_CORP, features
DELWP Web Feature Service	datavic:WATER_GEOL_BSE_PERMIAN
DELWP Web Feature Service	datavic:WATER_GEOL_STRUCT_GOULBURN_MURRAY
DELWP Web Feature Service	ANZVI0803005169, ECOLOGY Ecosystem, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_CORP
DELWP Web Feature Service	ANZVI0803003056, WATER Groundwater
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_SALT_-LAKE
DELWP Web Feature Service	ANZVI0803005112, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	ANZVI0803005022, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)
DELWP Web Feature Service	datavic:WATER_BORES_VOLC_FA
DELWP Web Feature Service	datavic:WATER_IRRIGATION_DISTRICT

DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_GDE_TERR_WCMA
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA
DELWP Web Feature Service	ANZVI0803004935, WATER Surface, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_GC
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803005031, WATER Hydrology, WATER Surface, WATER Rivers
DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_DAM_BATTER
DELWP Web Feature Service	ANZVI0803001069, WATER Hydrology, WATER Supply
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATERCOURSE
DELWP Web Feature Service	ANZVI0803001065, WATER Wetlands
DELWP Web Feature Service	ANZVI0803004342, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	WATER, ANZVI0803002490, MAPPING, AGRICULTURE, TOPOGRAPHY

DELWP Web Feature Service	ANZVI0803005043, WATER Surface, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_WHARF
DELWP Web Feature Service	ANZVI0803002924, WATER Management
DELWP Web Feature Service	datavic:WATER_WSPA
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_FAULTS_LATROBE_GP
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite
DELWP Web Feature Service	datavic:CROWNLAND_PLM25_WATER_BODY
DELWP Web Feature Service	datavic:WATER_ISC2010_FRAGMENTATION
DELWP Web Feature Service	datavic:WATER_AQUIFER_SAL_BASAL
DELWP Web Feature Service	ANZVI0803005002, GEOSCIENCES Hydrogeology, WATER Groundwater, WATER Salinity
DELWP Web Feature Service	ANZVI0803005110, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	WATER_STORAGE
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	ANZVI0803002935, WATER Rivers, ISC, LiDAR, PHYSICAL FORM, RIPARIAN, ELEVATION
DELWP Web Feature Service	Groundwater Catchments (GC)
DELWP Web Feature Service	datavic:VMLITE_HY_WATERCOURSE
DELWP Web Feature Service	ANZVI0803004913, BOUNDARIES Administrative, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	WATER_STORAGE, features

DELWP Web Feature Service	ANZVI0803004341, HAZARDS, FLOOD, WATER, RIVERS, HYDROLOGY
DELWP Web Feature Service	datavic:WATER_GDE_TERR_NCCMA
DELWP Web Feature Service	ANZVI0803003710, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	ANZVI0803005009, GEOSCIENCES Geophysics, GEOSCIENCES Hydrology, WATER Hydrology
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:WATER_MODIFIED_RIVERS
DELWP Web Feature Service	ANZVI0803003703, WATER Wetlands
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management
DELWP Web Feature Service	datavic:WATER_STORAGE_
DELWP Web Feature Service	datavic:WATER_URBAN_WATER_CORP
DELWP Web Feature Service	datavic:WATER_ESTUARIES
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_TANK
DELWP Web Feature Service	features, URBAN_WATER_CORP
DELWP Web Feature Service	URBAN_WATER_CORP
DELWP Web Feature Service	ANZVI0803002497, TOPOGRAPHY, AGRICULTURE, WATER
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:VMHYDRO_HY_WATER_STRUCT_POINT
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:VMHYDRO_WATER_AREA_LAKES_DAMS
DELWP Web Feature Service	ANZVI0803002927, WATER Management
DELWP Web Feature Service	datavic:WATER_GMA_SUBZONE
DELWP Web Feature Service	ANZVI0803001064, WATER Wetlands
DELWP Web Feature Service	Groundwater Management Area Subzones
DELWP Web Feature Service	datavic:VMLITE_HY_WATER_AREA
DELWP Web Feature Service	ANZVI0803005025, WATER Groundwater, GEOSCIENCES Hydrogeology

DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite
DELWP Web Feature Service	OWOF_WATER_CORPORATION
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:OWOF_WATER_CORPORATION
DELWP Web Feature Service	datavic:WATER_GEOL_STRUCT_OVENS_-VALLEY
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_CONNECTOR
DELWP Web Feature Service	ANZVI0803004341, WATER surface, HAZARDS flood, HUMAN ENVIRONMENT Planning
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_RAMP
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite
DELWP Web Feature Service	WATER, AGRICULTURE, TOPOGRAPHY, ANZVI0803002496
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	datavic:VMHYDRO_WATERCOURSE_STREAM
DELWP Web Feature Service	ANZVI0803003053, WATER Production, WATER Groundwater, WATER Quality, WATER Salinity
DELWP Web Feature Service	ANZVI0803004192, WATER Groundwater, GEOSCIENCES Hydrogeology
DELWP Web Feature Service	datavic:WATER_BU_WTABLE
DELWP Web Feature Service	WATER, ANZVI0803002491, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_GW_SITES

DELWP Web Feature Service	ANZVI0803005178, WATER Groundwater, WATER Management
DELWP Web Feature Service	datavic:VMHYDRO_WATER_STRUCT_CAUSEWAY
DELWP Web Feature Service	datavic:WATER_EST_FLUV
DELWP Web Feature Service	WATER, ANZVI0803002490, MAPPING, AGRICULTURE, TOPOGRAPHY
DELWP Web Feature Service	datavic:WATER_AQUIFER_SAL_BED
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)
LINZ Data Service	NZ Auckland Island Waterfall Points (Topo, 1:50k)
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Cook Islands Breakwater Centrelines (Topo, 1:25k, Zone4)
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:250k)
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)

LINZ Data Service	NZ Waterfall Edges (Topo, 1:50k)
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:500k)
LINZ Data Service	NZ Waterfall Polygons (Topo, 1:50k)
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)
LINZ Data Service	Tokelau Breakwater Centrelines (Topo, 1:25k)
LINZ Data Service	NZ Waterfall Points (Topo, 1:250k)
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)
LINZ Data Service	NZ Chatham Is Breakwater Centrelines (Topo, 1:250k)
LINZ Data Service	NZ Chatham Island Breakwater Centrelines (Topo, 1:50k)
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)

LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:50k)
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)
LINZ Data Service	Cook Islands Waterfall Points (Topo, 1:25k, Zone4)
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Breakwater Centrelines (Topo, 1:50k)
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)
LINZ Data Service	NZ Breakwater Centrelines (Topo, 1:250k)
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)
LINZ Data Service	NZ Waterfall Points (Topo, 1:50k)
LINZ Data Service	NZ Campbell Is Waterfall Points (Topo, 1:50k)
LINZ Data Service	NZ Antipodes Island Waterfall Points (Topo, 1:25k)
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Waterfall Centrelines (Topo, 1:50k)
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Waterlogging Risk (DAFWA-016)
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Irrigation Districts (HARWA-002)
SLIP Public Web Feature Service - EPSG 4283	Water Tank Reservoir, Dam (WCORP-007)

SLIP Public Web Feature Service - EPSG 4283	DPAW Managed Lands and Waters (DPAW-026)
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Water Erosion (DAFWA-014)
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Soil Water Storage (DAFWA-045)
SLIP Public Web Feature Service - EPSG 4283	Water Pipe (WCORP-002)
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)
SLIP Public Web Feature Service - EPSG 4283	Water Meter (WCORP-006)
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Water Repellence (DAFWA-015)

D.3 What are the metadata assigned with specific feature types?

service_name	name_value	metadata_name
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	USAGE
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	OBJECTID

DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	STATE
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	ZONE55_NORTHING
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	OBJECTID
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	ORIGIN
DELWP Web Feature Service	Rural Water Corporation Boundaries	NAME
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	DESCRIPTIO
DELWP Web Feature Service	Groundwater Catchments (GC)	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Groundwater Catchments (GC)	GCU_NAME
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	GMU
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	TOL_MED
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Water Body -Public Land Management	PRIMS_ID
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	UFI
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	HIERARCHY
DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	GMU

DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	BIOEVC
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	GW_TDS
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID

DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	USAGE
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	UFI
DELWP Web Feature Service	WATER.UWA	OBJECTID
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	SCALE_USE_CODE
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	FEATURE_TYPE_CODE

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Water Body -Public Land Management	REC_CAT
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	TOTAL_SCREEN_LENGTH
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	WATER_STORAGE	WATERCORP_TYPE
DELWP Web Feature Service	MELBOURNE_WATER_RETAILER	OBJECTID
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	NAME

DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Emergency Water Supply Points	TANK_FITTING_OTHER
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	WATER.UWA	NAME
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	USAGE
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	OBJECTID
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	RURAL_WATER_CORP	WATERCORP_NAME
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION

DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	UFI
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	OBJECTID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	GW_TDS
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	LOCATION_DATE
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Groundwater Management Areas	RWC
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	GMU

DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	LOWER_INTERVAL
DELWP Web Feature Service	Water Body -Public Land Management	LU_CODE
DELWP Web Feature Service	Water Body -Public Land Management	STUDY_AREA
DELWP Web Feature Service	Groundwater-Surface Water Interaction Flux	OBJECTID
DELWP Web Feature Service	Groundwater-Surface Water Interaction Flux	REPORTINGAREA
DELWP Web Feature Service	Groundwater Management Basins (GMB)	AQUIFER_FRAMEWORK_BASIN_NAME
DELWP Web Feature Service	Water Body -Public Land Management	IMPL_STAT
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	ANABRANCHID

DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Water Body -Public Land Management	SCHED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	SUR_GEOLGY
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	SHAPE_NUMBER
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	DTW_MAJOR
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	GW_TDS
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	OBJECTID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	AREA_HA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	GWI_CODE

DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	OBJECTID
DELWP Web Feature Service	Water Body -Public Land Management	LABELSHORT
DELWP Web Feature Service	Water Body -Public Land Management	REC_CODE
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Groundwater Resources	BORE_YIELD
DELWP Web Feature Service	Groundwater Resources	UNIQUE_
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	OBJECTID

DELWP Web Feature Service	Groundwater Resources	GROUNDWATER_SALINITY
DELWP Web Feature Service	Groundwater Resources	OBJECTID
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	OBJECTID
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	USE
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	LONGITUDE
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	COMMENCE
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	EASTING
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	NORTHING
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	ZONE
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	SITE
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	UPPER_INTERVAL
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	SUR_GEOLGY
DELWP Web Feature Service	Water Body -Public Land Management	LABEL
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	GMS_ALIAS_
DELWP Web Feature Service	Water Body -Public Land Management	PKAREA_TY
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	RURAL_WATER_CORP	URL
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	DEPTH
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	LOCATION_DESC
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	BIOREGION_NO
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	MONITORING_FREQUENCY
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_CODE
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	APPROVED
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	PCV
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	OBJECTID
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	FULLNAME
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	NAME

DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	TO_DEPTH
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	PATYPE
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	HIERARCHY
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI

DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Emergency Water Supply Points	OBJECTID
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	USAGE
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	AREA_HA

DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_BCS
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	TOL_MED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	OBJECTID
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	WATER_STORAGE	URL
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	DTW_MAJOR
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	LABELSHORT
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	GW_TDS
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Emergency Water Supply Points	TANK_PRESENT
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Water Body -Public Land Management	REC_SBCAT

DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	DTW_MAJOR
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	PFI

DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Groundwater Catchments (GC)	OBJECTID
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Groundwater-Surface Water Interaction Flux	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	SITE_CODE
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	TOL_MED

DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	AREA_HA
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_BCS_DESC
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	WATER_CORP	WATERCORP_ID
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	SITE_NAME
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	LONGITUDE
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	WATER_STORAGE	CURRENT_VOLUME_DATE

DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	MONITORING_STATUS
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	ZONE55_EASTING
DELWP Web Feature Service	Groundwater-Surface Water Interaction Flux	RIVERNAME
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	WATER_STORAGE	STORAGE_ID
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	SITE_STATUS

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	SUR_GEOLGY
DELWP Web Feature Service	Groundwater Resources	AQUIFER_LITHOLOGY
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	WATER_CORP	URL
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	BORE_TYPE
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE

DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	GMU
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	ROTATION
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	ROTATION

DELWP Web Feature Service	Potential Impact of Geological Structures on Groundwater Flow Systems	NAME
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	ZONE54_NORTHING
DELWP Web Feature Service	WATER_STORAGE	BASIN_NO
DELWP Web Feature Service	Potential Impact of Geological Structures on Groundwater Flow Systems	TYPE
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	GMU

DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_FITTING_CFA
DELWP Web Feature Service	Emergency Water Supply Points	LGA
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Water Body -Public Land Management	DATE_EST
DELWP Web Feature Service	Groundwater Management Basins (GMB)	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Emergency Water Supply Points	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE

DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	SUBSTANCE_EXTRACTED
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_PERMITS
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite	UFI_CREATED
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite	STATE
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	WATER.UWA	SE_ANNO_CAD_DATA

DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	OBJECTID
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite	FEATURE_TYPE_CODE
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite	PUBLIC_LAND_GROUP
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite	OBJECTID
DELWP Web Feature Service	WATER_CORP	ANNUAL_WATER_OUTLOOK_URL
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	BORE_DECOMMISSIONED
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	NAME

DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_DELIVERY_RATE
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	WATER_STORAGE	LAST_MONTH_VOLUME_PC
DELWP Web Feature Service	Groundwater Management Area Zones	ZONE
DELWP Web Feature Service	Groundwater Management Area Zones	RWC
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_GP
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID

DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	USAGE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	GWI_CODE
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	HIERARCHY
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	SCALE
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_TYPE
DELWP Web Feature Service	Water Body -Public Land Management	AREA_HA
DELWP Web Feature Service	Emergency Water Supply Points	QUALITY
DELWP Web Feature Service	Water Body -Public Land Management	AREA_CODE

DELWP Web Feature Service	Emergency Water Supply Points	CONTACT_ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	DTW_MAJOR
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	GW_TDS
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_QUALITY
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	PFI

DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Water Body -Public Land Management	NAME
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	X_EVCNAME
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Groundwater Management Areas	DEPTH
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_BCS_SRC
DELWP Web Feature Service	WATER_CORP	WATERCORP_TYPE_ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	GMU

DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Groundwater Management Areas	APPROVED
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_RESTRICTIONS
DELWP Web Feature Service	Groundwater Management Areas	FULLNAME
DELWP Web Feature Service	Groundwater Management Areas	OBJECTID
DELWP Web Feature Service	Groundwater Management Areas	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Groundwater Management Areas	TO_DEPTH
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	BIOREGION
DELWP Web Feature Service	Department of Environment, Land, Water and Planning Regional Boundaries - Vicmap Admin	UFI_CREATED
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Body -Public Land Management	PERIMETER

DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Department of Environment, Land, Water and Planning Regional Boundaries - Vicmap Admin	OBJECTID
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	PFI

DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	GW_TDS
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Water Body -Public Land Management	MNG_GROUP
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	HIERARCHY
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	OBJECTID

DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	UFI
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	USAGE
DELWP Web Feature Service	Groundwater Management Areas	FROM_DEPTH
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite	OBJECTID
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	PFI

DELWP Web Feature Service	MELBOURNE_WATER_RETAILER	URL
DELWP Web Feature Service	MELBOURNE_WATER_RETAILER	ANNUAL_WATER_OUTLOOK_URL
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	MELBOURNE_WATER_RETAILER	WATERCORP_ID
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_METERED
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	MELBOURNE_WATER_RETAILER	WATERCORP_NAME
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_GO
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	SUR_GEOLGY
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	GWI_CODE
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	ELEVATION

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	ZONE54_EASTING
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	DESCRIPTIO
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	GWI_CODE
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Emergency Water Supply Points	STATUS
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	SHAPE_NUMBER
DELWP Web Feature Service	Water Body -Public Land Management	ADDTL_ACTS
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	TOL_MED

DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	CATCHMENT
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	LITHOLOGICAL_DATA_AVAILABLE
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Marina - Water Structure 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	DTW_MAJOR
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	FORMATION_MONITORED

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	SHAPE_NUMBER
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	SITE_ID
DELWP Web Feature Service	Water Body -Public Land Management	POLY_SOURC
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	SUBSTANCE_EXTRACTED
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	DTW_MAJOR
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	GWI_CODE
DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	PCV
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	TOL_MED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	GMU

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	DESCRIPTIO
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	OBJECTID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	AREA_HA
DELWP Web Feature Service	WATER_STORAGE	WATERCORP_NAME
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Emergency Water Supply Points	OHS_ISSUES
DELWP Web Feature Service	Emergency Water Supply Points	COMMENTS
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_FITTING_OTHER
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Emergency Water Supply Points	ADDRESS
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	TOL_MED
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	BORE_DEPTH

DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Water Body -Public Land Management	LGA_CODE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	SHAPE_NUMBER
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	UFI
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_PRESENT
DELWP Web Feature Service	Emergency Water Supply Points	SITE_NAME
DELWP Web Feature Service	Emergency Water Supply Points	TANK_CONDITION
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_INSTRUCTIONS
DELWP Web Feature Service	Emergency Water Supply Points	IMAGE_NAME
DELWP Web Feature Service	Emergency Water Supply Points	FLOW_PERCENT_AVERAGE
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_LOG_BOOK
DELWP Web Feature Service	Emergency Water Supply Points	URL
DELWP Web Feature Service	Emergency Water Supply Points	ACCESS_SECURITY

DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	MMGT_ONGEN
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	MNG_GROUP
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	MNG_SPEC
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	LU_CODE
DELWP Web Feature Service	Emergency Water Supply Points	DATE_INSTALLED
DELWP Web Feature Service	Emergency Water Supply Points	CASING_COND
DELWP Web Feature Service	Water Body -Public Land Management	DATE_LCCAP
DELWP Web Feature Service	Water Body -Public Land Management	ACT
DELWP Web Feature Service	Groundwater Management Area Zones	GMU
DELWP Web Feature Service	Department of Environment, Land, Water and Planning Regional Boundaries - Vicmap Admin	DELWP_REGION
DELWP Web Feature Service	Emergency Water Supply Points	SUITABLE_USE
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	AREA_M2
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_DIRECTIONS

DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_YEAR_MANUFACTURE
DELWP Web Feature Service	Emergency Water Supply Points	NEAR_TOWN
DELWP Web Feature Service	Water Body -Public Land Management	RES_DATE
DELWP Web Feature Service	Emergency Water Supply Points	DATE_EWSP_CHECKED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	GWI_CODE
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_PRESENT
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	REC_SBCAT
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	LABEL
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	MMGT_ONGRD
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	PERIMETER
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	REC_CAT
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_POWER_SOURCE
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	MMTGEN

DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	NAME
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_code
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	areasqm
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	bioregion
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_go_desc
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	hectares
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	bioregion_code
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	shape_area
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_mut
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_go
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_bcs

DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	x_subgroupname
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_bcs_src
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	scale
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	shape_length
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	x_evcname
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	x_groupname
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	veg_code
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	MELBOURNE_WATER_CORP	URL
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	MELBOURNE_WATER_CORP	WATERCORP_ID

DELWP Web Feature Service	MELBOURNE_WATER_CORP	ANNUAL_WATER_OUTLOOK_URL
DELWP Web Feature Service	MELBOURNE_WATER_CORP	WATERCORP_NAME
DELWP Web Feature Service	MELBOURNE_WATER_CORP	OBJECTID
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_gp
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_subgp
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	bioregion_no
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	bioevc
DELWP Web Feature Service	Water Body -Public Land Management	MMGT_ONGRD
DELWP Web Feature Service	Water Body -Public Land Management	GENER_TYPE
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_1750)	evc_bcs_desc
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	MMTGEN
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	MMGT_ONGRD
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	ROTATION

DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	PERIMETER
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	REC_CAT
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	MNG_SPEC
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	VERS_DATE
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	REC_SBCAT
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	AREA_HA
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	SITE_TYPE

DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Water Body -Public Land Management	LGA_NAME
DELWP Web Feature Service	Rural Water Corporation Boundaries	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Water Body (Generalised) - Public Land Management	VERS_DATE
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Emergency Water Supply Points	TANK_FITTING_CFA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	DESCRIPTIO
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	AREA_HA
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	NAME

DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	LABEL
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	LABELSHORT
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	MNG_GROUP
DELWP Web Feature Service	Salt Pans - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	LU_CODE
DELWP Web Feature Service	Water Production (Generalised) - Public Land Management	MMGT_ONGEN
DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Water Body -Public Land Management	STGAME_RES
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN

DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	LLDATUM
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	DATE_COMPLETED
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN

DELWP Web Feature Service	Causeway - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	DEPTH
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Potential Impact of Geological Structures on Groundwater Flow Systems	OBJECTID
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite	FEATURE_TYPE_CODE
DELWP Web Feature Service	Department of Environment, Land, Water and Planning Regional Boundaries - Vicmap Admin	DELWP_REGION_CODE
DELWP Web Feature Service	Pondages - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Body -Public Land Management	PLM_ID
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	PAV

DELWP Web Feature Service	WateringPlace - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Production -Public Land Management	MMGT_ONGEN
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Water Body -Public Land Management	MMTGEN
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Channels - Watercourse Network 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	OBJECTID
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Groundwater-Surface Water Interaction Flux	INTERACTION
DELWP Web Feature Service	WATER_CORP	WATERCORP_NAME
DELWP Web Feature Service	Connector Watercourse - Watercourse Network 1:25,000 - Vicmap Hydro	ORIGIN

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	SUR_GEOLGY
DELWP Web Feature Service	RURAL_WATER_CORP	OBJECTID
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Groundwater Management Area Zones	SE_ANNO_CAD_DATA
DELWP Web Feature Service	RURAL_WATER_CORP	WATERCORP_ID
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	UFI
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	GW_TDS
DELWP Web Feature Service	Water Body -Public Land Management	GENER_DESC
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_FITTING_50MM
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	WATER_STORAGE	CURRENT_VOLUME_PC
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	SHAPE_NUMBER

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	DESCRIPTIO
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	GWI_CODE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	DTW_MAJOR
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	TOL_MED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	AREA_HA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Wimmera CMA	GMU
DELWP Web Feature Service	Groundwater Management Area Subzones	GMU
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	FROM_DEPTH
DELWP Web Feature Service	Groundwater Management Area Subzones	SUBZONE
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Salt Lakes - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Groundwater Management Area Subzones	PCV
DELWP Web Feature Service	Groundwater Management Area Subzones	ZONE

DELWP Web Feature Service	Groundwater Management Area Subzones	RWC
DELWP Web Feature Service	Groundwater Management Area Subzones	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Swamps - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	SUBSTANCE_EXTRACTED

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	CASING_DIAMETER
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	AREA_HA
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	WATER_STORAGE	OBJECTID
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	REACHID
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	URBAN_WATER_CORP	WATERCORP_NAME
DELWP Web Feature Service	URBAN_WATER_CORP	WATERCORP_ID
DELWP Web Feature Service	Groundwater Management Area Subzones	DEPTH
DELWP Web Feature Service	Groundwater Management Area Subzones	OBJECTID
DELWP Web Feature Service	URBAN_WATER_CORP	OBJECTID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	DESCRIPTIO
DELWP Web Feature Service	URBAN_WATER_CORP	URL
DELWP Web Feature Service	URBAN_WATER_CORP	ANNUAL_WATER_OUTLOOK_URL
DELWP Web Feature Service	WATER_STORAGE	UFI_CREATED
DELWP Web Feature Service	WATER_STORAGE	CAPACITY_ML

DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Designated Water Supply Catchments	CATCH_ID
DELWP Web Feature Service	WATER_STORAGE	STORAGE_NAME
DELWP Web Feature Service	WATER_STORAGE	UFI
DELWP Web Feature Service	WATER_STORAGE	CURRENT_VOLUME_ML
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro	UFI

DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	TOL_MED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	SUR_GEOLGY
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Rural Water Corporation Boundaries	OBJECTID
DELWP Web Feature Service	Water Production -Public Land Management	VERS_DATE
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	SUR_GEOLGY
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	GWI_CODE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	DTW_MAJOR
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	TOL_MED

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	DESCRIPTIO
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	AREA_HA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	OBJECTID
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Designated Water Supply Catchments	CATCH_NAME
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	SHAPE_NUMBER
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	GW_TDS
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA	GMU

DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Mallee CMA	DESCRIPTIO
DELWP Web Feature Service	Emergency Water Supply Points	QUALITY_EC_UNIT
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	OBJECTID
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_GO_DESC
DELWP Web Feature Service	Water Tank - Water Structure Point 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Groundwater Management Areas	NAME
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Water Production -Public Land Management	PLM_ID
DELWP Web Feature Service	Groundwater Resources	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	NAMED_FEATURE_ID

DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	OBJECTID
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	WATERBODY_STATE
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	PFI
DELWP Web Feature Service	Potential Impact of Geological Structures on Groundwater Flow Systems	SE_ANNO_CAD_DATA

DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	MATERIALS_CONVEYED
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Pipe - Water Structure 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI

DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	ROTATION
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	AREA_HA
DELWP Web Feature Service	Emergency Water Supply Points	PUMP_CONDITION
DELWP Web Feature Service	Water Body -Public Land Management	IUCN_CAT
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	GW_TDS
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	FEATURE_TYPE_CODE
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite	STATE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	SHAPE_NUMBER

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the East Gippsland CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	VARIETY
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	GMU
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	NAME
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	UFI_CREATED
DELWP Web Feature Service	WATER_CORP	WATERCORP_TYPE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	OWOF_WATER_CORPORATION	CENTROID_LON
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	OWOF_WATER_CORPORATION	CENTROID_LAT
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE
DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION

DELWP Web Feature Service	Rivers - Watercourse Network 1:25,000 - Vicmap Hydro	HIERARCHY
DELWP Web Feature Service	Sewage Filtration Beds - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	WATERBODY_STATE
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite	UFI_CREATED
DELWP Web Feature Service	Water Body -Public Land Management	PLU_CODE
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	X_GROUPNAME
DELWP Web Feature Service	OWOF_WATER_CORPORATION	WATER_CORP_NAME
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	NAME
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport CMA	GW_TDS
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport CMA	SHAPE_NUMBER
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	SCALE_USE_CODE

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Western-port CMA	GMU
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Western-port CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Western-port CMA	TOL_MED
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Western-port CMA	SUR_GEOLGY
DELWP Web Feature Service	Designated Water Supply Catchments	PWSC
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	HIERARCHY
DELWP Web Feature Service	Breakwater - Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	AREASQM
DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	RWC

DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	PIPELINE_FUNCTION
DELWP Web Feature Service	Launching Ramp - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	OBJECTID
DELWP Web Feature Service	Stream - Watercourse Network 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	ROTATION
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the West Gippsland CMA	DESCRIPTON
DELWP Web Feature Service	Statewide Water Areas, Polygon - 1:250k to 1 :5M - Vicmap Lite	STATE
DELWP Web Feature Service	Emergency Water Supply Points	STATUS_NOTES
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Western-port CMA	AREA_HA
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Western-port CMA	DTW_MAJOR

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport CMA	DESCRIPTIO
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport CMA	OBJECTID
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport CMA	GWI_CODE
DELWP Web Feature Service	Water Production -Public Land Management	PLU_CODE
DELWP Web Feature Service	Water Production -Public Land Management	MNG_SPEC
DELWP Web Feature Service	Water Production -Public Land Management	RES_DATE
DELWP Web Feature Service	Water Production -Public Land Management	LU_CODE
DELWP Web Feature Service	Water Production -Public Land Management	LGA_CODE
DELWP Web Feature Service	Water Production -Public Land Management	LABEL
DELWP Web Feature Service	Water Production -Public Land Management	MNG_GROUP
DELWP Web Feature Service	Water Production -Public Land Management	GENER_TYPE
DELWP Web Feature Service	Water Production -Public Land Management	PERIMETER

DELWP Web Feature Service	Water Production -Public Land Management	POLY_SOURC
DELWP Web Feature Service	Water Production -Public Land Management	STGAME_RES
DELWP Web Feature Service	Water Production -Public Land Management	NAME_SOURC
DELWP Web Feature Service	Water Production -Public Land Management	ADDTL_ACTS
DELWP Web Feature Service	Water Production -Public Land Management	LGA_NAME
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	VEG_CODE
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	HECTARES
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_MUT
DELWP Web Feature Service	Water Body -Public Land Management	MNG_SPEC
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	BIOREGION_CODE
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	X_SUBGROUPNAME
DELWP Web Feature Service	Wetlands - Freshwater - Native Vegetation (EVCBCS_2005)	EVC_SUBGP
DELWP Web Feature Service	Water Production -Public Land Management	SCHED
DELWP Web Feature Service	Water Production -Public Land Management	IUCN_CAT
DELWP Web Feature Service	Water Production -Public Land Management	STUDY_AREA
DELWP Web Feature Service	Water Production -Public Land Management	NAME

DELWP Web Feature Service	Water Production -Public Land Management	REC_SBCAT
DELWP Web Feature Service	Water Production -Public Land Management	LABELSHORT
DELWP Web Feature Service	Water Production -Public Land Management	REC_CAT
DELWP Web Feature Service	Emergency Water Supply Points	TANK_SIZE
DELWP Web Feature Service	Potential Impact of Geological Structures on Groundwater Flow Systems	ID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	GWI_CODE
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Groundwater Sites of the Groundwater Management System	LATITUDE
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite	SCALE_USE_CODE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Emergency Water Supply Points	POINT_TYPE
DELWP Web Feature Service	OWOF_WATER_CORPORATION	URL
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	PFI

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	SHAPE_NUMBER
DELWP Web Feature Service	OWOF_WATER_CORPORATION	WATER_CORP_TYPE_ID
DELWP Web Feature Service	Water Production -Public Land Management	PRIMS_ID
DELWP Web Feature Service	Water Production -Public Land Management	DATE_LCCAP
DELWP Web Feature Service	Water Production -Public Land Management	MMTGEN
DELWP Web Feature Service	Water Production -Public Land Management	GENER_DESC
DELWP Web Feature Service	Water Production -Public Land Management	REC_CODE
DELWP Web Feature Service	Water Production -Public Land Management	MMGT_ONGRD
DELWP Web Feature Service	Water Production -Public Land Management	DATE_EST
DELWP Web Feature Service	WATER_CORP	OBJECTID
DELWP Web Feature Service	Water Production -Public Land Management	ACT
DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	LATITUDE
DELWP Web Feature Service	Water Production -Public Land Management	AREA_CODE
DELWP Web Feature Service	Water Production -Public Land Management	AREA_HA
DELWP Web Feature Service	Water Production -Public Land Management	PKAREA_TY
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	ROTATION
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Goulburn Broken CMA	SUR_GEOLGY

DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Water Body -Public Land Management	VERS_DATE
DELWP Web Feature Service	Dam Batter - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Groundwater-Surface Water Interaction	SEGMENTNO
DELWP Web Feature Service	Groundwater-Surface Water Interaction	WATERBODYS
DELWP Web Feature Service	Groundwater-Surface Water Interaction	PRIORITY_RIVER
DELWP Web Feature Service	OWOF_WATER_CORPORATION	WATER_CORP_ID
DELWP Web Feature Service	Groundwater Management Basins (GMB)	OBJECTID
DELWP Web Feature Service	Groundwater-Surface Water Interaction	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	RURAL_WATER_CORP	ANNUAL_WATER_OUTLOOK_URL
DELWP Web Feature Service	Spillway - Water Structure Point 1:25,000 - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	AREA_HA
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	SUBSTANCE_EXTRACTED
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_UFI
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_TYPE_CODE

DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Water Structure Point 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Groundwater-Surface Water Interaction	CLASS_RELIABILITY
DELWP Web Feature Service	Groundwater-Surface Water Interaction	NAMETRACE
DELWP Web Feature Service	Groundwater-Surface Water Interaction	OBJECTID
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	FEATURE_QUALITY_ID
DELWP Web Feature Service	Groundwater-Surface Water Interaction	INTERACTION_CLASS_BASIS
DELWP Web Feature Service	Water Supply Protection Area (Groundwater and Surface Water) Zone within Victoria	ZONE
DELWP Web Feature Service	Groundwater Management Area Zones	OBJECTID
DELWP Web Feature Service	Groundwater Management Areas	PCV
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Groundwater-Surface Water Interaction	SEGMNTTYPE
DELWP Web Feature Service	Groundwater-Surface Water Interaction	HIERCHYTR
DELWP Web Feature Service	Water Body -Public Land Management	MMGT_ONGEN
DELWP Web Feature Service	Groundwater-Surface Water Interaction	GW_SW_INTERACTION

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	OWNER_ID
DELWP Web Feature Service	Groundwater-Surface Water Interaction	AUSHYDRO_ID
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	OBJECTID
DELWP Web Feature Service	Lakes and Dams - Water Area (polygon) 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	BASINID
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	GROUND_RELATIONSHIP
DELWP Web Feature Service	Water Body -Public Land Management	NAME_SOURC
DELWP Web Feature Service	Groundwater-Surface Water Interaction	PERENLTYTR
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	SUPERCEDED_PFI
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	NAME
DELWP Web Feature Service	Bore or Water Well - Water Structure Point 1:25,000 - Vicmap Hydro	STRUCTURE_TYPE

DELWP Web Feature Service	Area Subject to Innundation - Water Area (polygon) 1:25,000 - Vicmap Hydro	CREATE_DATE_PFI
DELWP Web Feature Service	Statewide Watercourse Network, Line - 1:250k to 1 :5M - Vicmap Lite	UFI_CREATED
DELWP Web Feature Service	Water Production -Public Land Management	IMPL_STAT
DELWP Web Feature Service	Tank Polygon - Water Structure - Vicmap Hydro	CONSTRUCTION_TYPE
DELWP Web Feature Service	Dam Wall - Water Structure Point 1:25,000 - Vicmap Hydro	PLATFORM_TYPE
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	WATER_USE_FUNCTION
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North East CMA	DTW_MAJOR
DELWP Web Feature Service	Watercourse Network 1:25,000 - Vicmap Hydro	CONSTRUCTION
DELWP Web Feature Service	Waterfall - Water Point 1:25,000 - Vicmap Hydro	ORIGIN
DELWP Web Feature Service	Designated Water Supply Catchments	OBJECTID
DELWP Web Feature Service	Designated Water Supply Catchments	STATUS_DATE
DELWP Web Feature Service	Designated Water Supply Catchments	SE_ANNO_CAD_DATA
DELWP Web Feature Service	Designated Water Supply Catchments	AREASQM
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Glenelg Hopkins CMA	SHAPE_NUMBER
DELWP Web Feature Service	Groundwater Management Area Zones	DEPTH
DELWP Web Feature Service	Emergency Water Supply Points	SIGN_CONTACT
DELWP Web Feature Service	Groundwater Management Area Zones	PCV

DELWP Web Feature Service	Monitoring points from the Victorian Water Resources Data Warehouse (obsolete - please use GW_SITES)	ELEVATION_DATE
DELWP Web Feature Service	Designated Water Supply Catchments	HECTARES
DELWP Web Feature Service	Designated Water Supply Catchments	GAZETTED
DELWP Web Feature Service	Designated Water Supply Catchments	STATUS
DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite	SCALE_USE_CODE
DELWP Web Feature Service	Drain - Watercourse Network 1:25,000 - Vicmap Hydro	OBJECTID
DELWP Web Feature Service	Water Point 1:25,000 - Vicmap Hydro	NAME
DELWP Web Feature Service	Lock - Water Structure Point 1:25,000 - Vicmap Hydro	NAMED_FEATURE_ID
DELWP Web Feature Service	2010 Index of Stream Condition - Water Body polygon features	UNIQUEID
DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the North Central CMA	SUR_GEOLGY
DELWP Web Feature Service	Water Supply Protection Areas (Groundwater and Surface Water) within Victoria	RWC
DELWP Web Feature Service	Dam Wall Road - Water Structure Point 1:25,000 - Vicmap Hydro	NAME

DELWP Web Feature Service	Coastal Waters - Statewide Public Land Classification Boundaries - 1:1M to 1 :5M - Vicmap Lite	PUBLIC_LAND_GROUP
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	nobjnm
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	colour
LINZ Data Service	NZ Antipodes Island Waterfall Points (Topo, 1:25k)	name_ascii
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	txtdsc
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	NZ Waterfall Points (Topo, 1:50k)	name_ascii
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	nobjnm

LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	verlen
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	nobjnm
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	ntxtds
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	nobjnm
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	natcon
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	status
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	picrep

LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	elevat
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	veracc
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	colour
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	datend
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	conrad
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	ninfom

LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	convis
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:50k)	name
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	bcnshp
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	sorind
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	NZ Antipodes Island Waterfall Points (Topo, 1:25k)	name
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	ntxtds
LINZ Data Service	NZ Waterfall Edges (Topo, 1:50k)	t50_fid
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	veracc

LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	picrep
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	condtn
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	NZ Waterfall Points (Topo, 1:50k)	height
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	NZ Auckland Island Waterfall Points (Topo, 1:50k)	height
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	sordat
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	inform
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	txtdsc

LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	ninfom
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	Cook Islands Breakwater Centrelines (Topo, 1:25k, Zone4)	UFID
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	NZ Waterfall Points (Topo, 1:50k)	macronated
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:500k)	status
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:500k)	name
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	natqua
LINZ Data Service	Cook Islands Waterfall Points (Topo, 1:25k, Zone4)	name_ascii
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	sordat
LINZ Data Service	NZ Waterfall Points (Topo, 1:50k)	name

LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	ntxtds
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	quasou
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	marsys
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	sordat
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	natcon
LINZ Data Service	Cook Islands Waterfall Points (Topo, 1:25k, Zone4)	UFID
LINZ Data Service	Cook Islands Waterfall Points (Topo, 1:25k, Zone4)	macronated
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	catwat
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	verlen
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	marsys
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	datend

LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	picrep
LINZ Data Service	NZ Waterfall Edges (Topo, 1:50k)	name
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	catwat
LINZ Data Service	NZ Waterfall Centrelines (Topo, 1:50k)	name_ascii
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	catwat
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	NZ Campbell Is Waterfall Points (Topo, 1:50k)	name_ascii
LINZ Data Service	NZ Waterfall Edges (Topo, 1:50k)	macronated
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	persta
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	catwat
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	colour
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	natcon
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	inform

LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	tecsou
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	perend
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	inform
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	watlev
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	status
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	quasou
LINZ Data Service	NZ Antipodes Island Waterfall Points (Topo, 1:25k)	height
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	natqua

LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	natsur
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	verdat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	tecsou
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	souacc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	valsou
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	boyshp
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	datsta
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	quasou

LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	status
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	verdat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	verdat
LINZ Data Service	NZ Waterfall Centrelines (Topo, 1:50k)	name
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	persta
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	veracc
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	watlev
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	catsea

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	valsou
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	conrad
LINZ Data Service	NZ Waterfall Points (Topo, 1:50k)	t50_fid
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	tecsou
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:50k)	macronated
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	objnam
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	colour
LINZ Data Service	NZ Campbell Is Waterfall Points (Topo, 1:50k)	macronated
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	verlen

LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	natsur
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	watlev
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:50k)	t50_fid
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	ninfom
LINZ Data Service	NZ Waterfall Edges (Topo, 1:50k)	height
LINZ Data Service	NZ Auckland Island Waterfall Points (Topo, 1:50k)	name
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	datend
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	inform
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	perend
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	conrad

LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	verdat
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	perend
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	boyshp
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	ninfom
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	persta
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	scamin
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	objnam
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	datsta
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	catwat
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	fidn

LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	status
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	colpat
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	sorind
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	NZ Waterfall Polygons (Topo, 1:50k)	t50_fid
LINZ Data Service	NZ Waterfall Polygons (Topo, 1:50k)	name_ascii
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	fidn
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	objnam

LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	status
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	status
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	expsou
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	catsea
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	ntxtds
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	scamin
LINZ Data Service	NZ Waterfall Centrelines (Topo, 1:50k)	height
LINZ Data Service	NZ Waterfall Polygons (Topo, 1:50k)	macronated
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	catwat
LINZ Data Service	NZ Waterfall Polygons (Topo, 1:50k)	height

LINZ Data Service	NZ Waterfall Polygons (Topo, 1:50k)	name
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	inform
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	veracc
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	colpat
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	persta
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	expsou
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	nobjnm

LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	NZ Auckland Island Waterfall Points (Topo, 1:50k)	macronated
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	convis
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	natcon
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	veracc
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	colpat
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	marsys
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	datend
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	elevat
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	NZ Waterfall Points (Topo, 1:250k)	macronated
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	perend
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	condtn
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	colour
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	catwat
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	sorind

LINZ Data Service	Cook Islands Waterfall Points (Topo, 1:25k, Zone4)	name
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	perend
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	status
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	NZ Waterfall Points (Topo, 1:250k)	height
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	datsta
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	txtdsc

LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	ninfom
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	objnam
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	valsou
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	nobjnm
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	verdat
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	scamin

LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	NZ Chatham Is Breakwater Centrelines (Topo, 1:250k)	t250_fid
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	sordat
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	ninfom
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	catwat
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	ntxtds
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	inform
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	sorind
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	txtdsc
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	fidn

LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	convis
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)	veracc
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	datsta
LINZ Data Service	NZ Chatham Island Breakwater Centrelines (Topo, 1:50k)	t50_fid
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	quasou
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	sorind
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	verdat
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	scamin

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	fidn
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	objnam
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	marsys
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	objnam
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	catsea
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	ninfom
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	sordat
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	objnam
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	objnam
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	nobjnm

LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	valsou
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	scamin
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	objnam
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	nobjnm
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	sordat
LINZ Data Service	Water turbulence points (Hydro, 1:350k - 1:1,500k)	ninfom
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	inform
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	scamin
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	ntxtds

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	txtdsc
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	nobjnm
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	scamin
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:1.5mil and smaller)	sorind
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	expsou
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	catwat
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	datsta
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	height
LINZ Data Service	NZ Waterfall Edges (Topo, 1:50k)	name_ascii
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	fidn

LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	boyshp
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	picrep
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	tecsou
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	natsur
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	quasou
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	souacc
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	scamin

LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	souacc
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	natqua
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	watlev
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	ntxtds
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	ninfom
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	sorind
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	NZ Waterfall Centrelines (Topo, 1:50k)	macronated

LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	catwat
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	sordat
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	txtdsc
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:50k)	name_ascii
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	convis
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	scamin
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	inform
LINZ Data Service	Water turbulence points (Hydro, 1:1.5mil and smaller)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	sordat
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	veracc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	objnam

LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	catwat
LINZ Data Service	NZ Antipodes Island Waterfall Points (Topo, 1:25k)	macronated
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	objnam
LINZ Data Service	Water turbulence points (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	souacc
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	objnam
LINZ Data Service	NZ Waterfall Centrelines (Topo, 1:50k)	t50_fid
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	catsea
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	catsea
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	verlen
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	catwat

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	txtdsc
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	inform
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	objnam
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	scamin
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	ntxtds
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	sorind
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	nobjnm
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	inform
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	txtdsc

LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	catwat
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	nobjnm
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	verdat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	watlev
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	natsur

LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	souacc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	txtdsc
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	catwat
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	ninfom
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	perend
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	colpat
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	valsou
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	objnam

LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	tecsou
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	colpat
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	natcon
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	natqua
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	scamin

LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	scamin
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	sordat
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	catsea
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	ntxtds
LINZ Data Service	NZ Breakwater Centrelines (Topo, 1:250k)	t250_fid
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	persta
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	colour
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	height
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	fidn
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	ninfom

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	veracc
LINZ Data Service	NZ Campbell Is Waterfall Points (Topo, 1:50k)	height
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	expsou
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	natqua
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	scamin
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	scamin
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	txtdsc
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	ninfom

LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	inform
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	Sea area/named water area points (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	marsys
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	expsou
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	verlen
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	objnam
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	datend

LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	txtdsc
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	picrep
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	status
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	condtn
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	conrad
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	bcnshp
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	colpat
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	convis
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	sorind
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	scamin
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	elevat
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	natcon
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	txtdsc
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	inform
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	sordat

LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	sorind
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	ninfom
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	scamin
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Sea area/named water area polygons (Hydro, 1:4k - 1:22k)	catsea
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	catsea
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	nobjnm
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	inform

LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	txtdsc
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	ntxtds
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	ninfom
LINZ Data Service	Sea area/named water area points (Hydro, 1:1.5mil and smaller)	sordat
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	inform
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	nobjnm
LINZ Data Service	Sea area/named water area points (Hydro, 1:22k - 1:90k)	catsea
LINZ Data Service	Water turbulence polyline (Hydro, 1:22k - 1:90k)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	ntxtds
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	scamin
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	ninfom
LINZ Data Service	Underwater/awash rock points (Hydro, 1:22k - 1:90k)	status

LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	bcnshp
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	verlen
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	verdat
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:250k)	name_ascii
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	fidn
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	datsta
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	status
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	picrep
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	conrad
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Beacon, safe water points (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	scamin
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	ninfom
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:50k)	status

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	catsea
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:350k - 1:1,500k)	sordat
LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	sordat
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	sordat
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Sea area/named water area points (Hydro, 1:90k - 1:350k)	sorind
LINZ Data Service	NZ Waterfall Points (Topo, 1:250k)	t250_fid
LINZ Data Service	NZ Waterfall Points (Topo, 1:250k)	name
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	ninfom
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	datend
LINZ Data Service	Water turbulence polygon (Hydro, 1:90k - 1:350k)	objnam

LINZ Data Service	Sea area/named water area polygon (Hydro, 1:22k - 1:90k)	nobjnm
LINZ Data Service	Underwater/awash rock points (Hydro, 1:350k - 1:1,500k)	scamin
LINZ Data Service	Water turbulence polygons (Hydro, 1:4k - 1:22k)	objnam
LINZ Data Service	Cook Islands Waterfall Points (Topo, 1:25k, Zone4)	height
LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	nobjnm
LINZ Data Service	Water turbulence polyline (Hydro, 1:90k - 1:350k)	ntxtds
LINZ Data Service	Water turbulence polyline (Hydro, 1:4k - 1:22k)	nobjnm
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	verlen
LINZ Data Service	NZ Waterfall Points (Topo, 1:250k)	name_ascii
LINZ Data Service	Underwater/awash rock points (Hydro, 1:90k - 1:350k)	natsur
LINZ Data Service	Buoy, safe water points (Hydro, 1:22k - 1:90k)	status
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	scamin
LINZ Data Service	Beacon, safe water points (Hydro, 1:90k - 1:350k)	height

LINZ Data Service	Underwater/awash rock points (Hydro, 1:1.5mil and smaller)	sorind
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	objnam
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	inform
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	sorind
LINZ Data Service	Water turbulence polygon (Hydro, 1:22k - 1:90k)	objnam
LINZ Data Service	NZ Auckland Island Waterfall Points (Topo, 1:50k)	name_ascii
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	scamin
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	scamin
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	objnam
LINZ Data Service	Water turbulence points (Hydro, 1:22k - 1:90k)	ntxtds
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	persta
LINZ Data Service	Water turbulence points (Hydro, 1:90k - 1:350k)	objnam
LINZ Data Service	Water turbulence polygon (Hydro, 1:350k - 1:1,500k)	ntxtds
LINZ Data Service	Sea area/named water area points (Hydro, 1:350k - 1:1,500k)	sorind

LINZ Data Service	Water turbulence polyline (Hydro, 1:1.5mil and smaller)	txtdsc
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:250k)	t250_fid
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:250k)	macronated
LINZ Data Service	NZ Campbell Is Waterfall Points (Topo, 1:50k)	name
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:250k)	status
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	fidn
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)	marsys
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)	verlen
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)	conrad
LINZ Data Service	NZ Water Race Centrelines (Topo, 1:250k)	name
LINZ Data Service	NZ Breakwater Centrelines (Topo, 1:50k)	t50_fid
LINZ Data Service	Water turbulence polygon (Hydro, 1:1.5mil and smaller)	sorind
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Irrigation Districts (HARWA-002)	shape_area
SLIP Public Web Feature Service - EPSG 4283	Water Meter (WCORP-006)	gid
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	enabled
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	pipelines_
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Irrigation Districts (HARWA-002)	gid
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	ar_no

SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Waterlogging Risk (DAFWA-016)	id
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Water Repellence (DAFWA-015)	id
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Irrigation Districts (HARWA-002)	shape_leng
SLIP Public Web Feature Service - EPSG 4283	Water Tank Reservoir, Dam (WCORP-007)	gid
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Soil Water Storage (DAFWA-045)	id
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Water Erosion (DAFWA-014)	gid
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	shape_leng
SLIP Public Web Feature Service - EPSG 4283	DPAW Managed Lands and Waters (DPAW-026)	legal_area
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Water Erosion (DAFWA-014)	id
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	size
SLIP Public Web Feature Service - EPSG 4283	DPAW Managed Lands and Waters (DPAW-026)	gid
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	gid
SLIP Public Web Feature Service - EPSG 4283	Harvey Water Pipelines (HARWA-001)	length
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Waterlogging Risk (DAFWA-016)	gid
SLIP Public Web Feature Service - EPSG 4283	DPAW Managed Lands and Waters (DPAW-026)	pin

SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Soil Water Storage (DAFWA-045)	gid
SLIP Public Web Feature Service - EPSG 4283	Water Pipe (WCORP-002)	gid
SLIP Public Web Feature Service - EPSG 4283	Soil landscape land quality - Water Repellence (DAFWA-015)	gid

D.4 What feature types lie within a certain bounding box?

DELWP Web Feature Service	Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Corangamite CMA
DELWP Web Feature Service	Permian Geological Basement, Goulburn-Murray Area
DELWP Web Feature Service	Underground Pipe - Water Structure Point 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Lowland Forests - Native Vegetation (EVCBCS_2005)
DELWP Web Feature Service	PTV Tram Track Centreline
DELWP Web Feature Service	Heathlands - Sandy and/or well drained - Native Vegetation (EVCBCS_1750)
DELWP Web Feature Service	Geological Chert Horizon (1:100,000)
DELWP Web Feature Service	Sustainable Diversion Limit (SDL) Catchment Baseflows
DELWP Web Feature Service	Water Area (polygon) 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	DAM_JOIN
DELWP Web Feature Service	Mineral Points (1:1,000,000)
DELWP Web Feature Service	Broadhectare Housing Estates 2010
DELWP Web Feature Service	Baseflow Separation Analysis for Unregulated Rivers (1889 to 2012)
DELWP Web Feature Service	Nature Conservation Reserve -Public Land Management
DELWP Web Feature Service	Urban Development Program - Proposed Industrial Areas 2010
DELWP Web Feature Service	Mallee - Sandstone ridges and rises - Native Vegetation (EVCBCS_1750)
DELWP Web Feature Service	Exploration Graticules with 100km intervals
DELWP Web Feature Service	Locality Boundaries (Property) (polygon) - Vicmap Admin
DELWP Web Feature Service	Heathlands - Not well drained - Native Vegetation (EVCBCS_1750)
DELWP Web Feature Service	PTV Train Track Centreline
DELWP Web Feature Service	Flood Effluet Structure - Flood Height Measurement Structures
DELWP Web Feature Service	Natural Features Reserve -Public Land Management
DELWP Web Feature Service	URBAN_WATER_CORP
DELWP Web Feature Service	Groundwater Management Area Subzones
DELWP Web Feature Service	Local Government Areas for Victoria prior to the 1994 amalgamations - Vicmap Admin
DELWP Web Feature Service	Modified Rivers

DELWP Web Feature Service	Rail Station (disused) - Rail Network - Vicmap Transport
DELWP Web Feature Service	Wharf - Water Structure 1:25,000 - Vicmap Hydro
DELWP Web Feature Service	Channel Regulator - Flood Height Measurement Structures
DELWP Web Feature Service	WATER_STORAGE
DELWP Web Feature Service	Petroleum Permits
DELWP Web Feature Service	Geological Structures, Ovens Valley
DELWP Web Feature Service	Geologically Significant Features
DELWP Web Feature Service	Marine Parks and Reserves - Statewide Public Land Classification Boundaries - 1:250K to 1 :1M - Vicmap Lite
LINZ Data Service	Buoy, safe water points (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Antipodes Island Descriptive Texts (Topo, 1:25k)
LINZ Data Service	NZ Cemetery Polygons (Topo, 1:50k)
LINZ Data Service	Gridiron polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Mooring/Warping facility points (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	Floating dock polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Dock area polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Dumping ground points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Rescue station points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Local magnetic anomaly polygon (Hydro, 1:22k - 1:90k)
LINZ Data Service	Wellington 1953 to NZGD2000 Conversion
LINZ Data Service	Beacon, safe water points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Pipeline, submarine/on land points (Hydro, 1:4k - 1:22k)
LINZ Data Service	New object points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Berth polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Runway points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Buoy, safe water points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Waterfall points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Local magnetic anomaly points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Fog signal points (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Rock Points (Topo, 1:500k)
LINZ Data Service	NZ Snares Island Lake Polygons (Topo, 1:25k)
LINZ Data Service	Fog signal points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Cable, overhead polyline (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Antipodes Island Waterfall Points (Topo, 1:25k)
LINZ Data Service	Conveyor polygons (Hydro, 1:4k - 1:22k)

LINZ Data Service	NZ Auckland Island Cemetery Points (Topo, 1:50k)
LINZ Data Service	Dam polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Snares Island Building Points (Topo, 1:25k)
LINZ Data Service	Military practice area points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Waterfall points (Hydro, 1:22k - 1:90k)
LINZ Data Service	NZ Building Outlines (Pilot)
LINZ Data Service	NZ Scrub Polygons (Topo, 1:50k)
LINZ Data Service	Northland 0.4m Rural Aerial Photos Index Tiles (2014-16)
LINZ Data Service	NZ Ice Polygons (Topo, 1:500k)
LINZ Data Service	Gisborne 0.4m Rural Aerial Photos Index Tiles (2012-2013)
LINZ Data Service	New object points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Radar station points (Hydro, 1:22k - 1:90k)
LINZ Data Service	NZ Cave Points (Topo, 1:50k)
LINZ Data Service	Buoy, installation points (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	Beacon, isolated danger points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Bridge polyline (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Moraine Wall Polygons (Topo, 1:50k)
LINZ Data Service	NZ Dam Centrelines (Topo, 1:500k)
LINZ Data Service	Waimakariri 0.075m Urban Aerial Photos Index Tiles (2013-14)
LINZ Data Service	Pontoon polyline (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Mangrove Polygons (Topo, 1:50k)
LINZ Data Service	NZ Stockyard Points (Topo, 1:50k)
LINZ Data Service	NZ Windmill Points (Topo, 1:500k)
LINZ Data Service	Cable area polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Production/storage area points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Buoy, installation points (Hydro, 1:22k - 1:90k)
LINZ Data Service	NZ Antipodes Island Contours (Topo, 1:25k)
LINZ Data Service	Sea-plane landing area points (Hydro, 1:4k - 1:22k)
LINZ Data Service	NZ Snares Island Descriptive Texts (Topo, 1:25k)
LINZ Data Service	Gate polyline (Hydro, 1:22k - 1:90k)
LINZ Data Service	Radar transponder beacon points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Buoy, installation points (Hydro, 1:90k - 1:350k)
LINZ Data Service	Small craft facility polygons (Hydro, 1:4k - 1:22k)

LINZ Data Service	Radar transponder beacon points (Hydro, 1:350k - 1:1,500k)
LINZ Data Service	Dam polyline (Hydro, 1:4k - 1:22k)
LINZ Data Service	Gate polygons (Hydro, 1:4k - 1:22k)
LINZ Data Service	Airport/airfield points (Hydro, 1:4k - 1:22k)
LINZ Data Service	Hulk points (Hydro, 1:22k - 1:90k)
LINZ Data Service	Dock area polygon (Hydro, 1:22k - 1:90k)
LINZ Data Service	Signal station, warning points (Hydro, 1:4k - 1:22k)

APPENDIX E GROUND TRUTH RESULTS

This appendix shows the results of the ground truth for the broker's evaluation for each query.

E.1 Results of Query 1: Retrieve Roads that are Lanes


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   govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.
   opengis.net/gml" xmlns:xsi="http://www.w3.org/2001/
   XMLSchema-instance" xsi:schemaLocation="http://data.linz.
   govt.nz https://data.linz.govt.nz/services;key=41
   b3c3b90c0247b587f512e1a4741498/wfs?service=WFS&amp;version
   =1.0.0&amp;request=DescribeFeatureType&amp;typeName=data.
   linz.govt.nz%3Alayer-50329 http://www.opengis.net/wfs http
   ://schemas.opengis.net/wfs/1.0.0/WFS-basic.xsd">
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    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
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          nz:name_ascii>
      <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
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      <data.linz.govt.nz:name>ROPA LANE</data.linz.govt.nz:
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            1751755.995600001,5424910.5430000005
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            1751777.9478000011,5424949.7422
            1751777.0301646963,5424960.610032867
            1751776.4105142765,5424967.948740477</gml:
            coordinates>
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            1748601.3697930006,5426391.704751998</gml:
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        </gml:LineString>
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</wfs:FeatureCollection>
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Ground Truth Result 1 for LINZ


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    www.opengis.net/gml" xmlns:datavic="http://land.vic.gov.au
    /datavic" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance" xsi:schemaLocation="http://land.vic.gov.au/
    datavic http://services.land.vic.gov.au/catalogue/
    publicproxy/guest/dv_geoserver/datavic/wfs?service=WFS&amp
    ;version=1.0.0&amp;request=DescribeFeatureType&amp;
    typeName=datavic%3AVMTRANS_TR_ROAD_LOCAL http://www.
```

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  opengis.net/wfs http://schemas.opengis.net/wfs/1.0.0/WFS-
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  <gml:null>unknown</gml:null>
</gml:boundedBy>
<gml:featureMember>
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        EZI_ROAD_NAME_LABEL>
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            145.27202026,-37.82525284
            145.27208071,-37.82531797</gml:coordinates>
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                145.29342593,-37.78882311
                145.29385992,-37.78879073
                145.2943232,-37.78885015
                145.29427948,-37.78910916</gml:coordinates>
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            145.32236814,-37.80242701</gml:coordinates>
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              145.32087034,-37.80262759</gml:coordinates>
        </gml:LineString>
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              145.319331,-37.80283371</gml:coordinates>
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            145.32546075,-37.84655362
            145.32541239,-37.84654648
            145.32532358,-37.84653336</gml:coordinates>
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              145.3240772,-37.8463493
              145.32388052,-37.84632025
              145.32375804,-37.84630216
              145.32304918,-37.84619746
              145.32015265,-37.84489301
              145.31810107,-37.844947
              145.31776704,-37.84493819</gml:coordinates>
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    EZI_ROAD_NAME_LABEL>
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<datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
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        145.31745187,−37.84532966</gml:coordinates>
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    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
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            145.31575294,-37.84739856
            145.31398447,-37.84715186
            145.31345655,-37.8470782</gml:coordinates>
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      <datavic:EZI_ROAD_NAME_LABEL>Chandlers Lane</datavic:
          EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>CHANDLERS</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>KILSYTH SOUTH</datavic:
          LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>KILSYTH SOUTH</datavic:
          RIGHT_LOCALITY>
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>U</datavic:DIV_RD>
      <datavic:FROM_UFI>38502630</datavic:FROM_UFI>
      <datavic:TO_UFI>2325445</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>2244</datavic:
          FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2010-10-19T14:35:56</datavic:
          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>5690891</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2010-10-19T14:35:56</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>1211522</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.31169188,-37.84197807
```

```xml
                145.31343807,-37.84224916
                145.31367915,-37.84217117
                145.31820232,-37.84281354</gml:coordinates>
            </gml:LineString>
        </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
</gml:featureMember>
<gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
        fid--7418b020_161f96c8780_-2fb5">
        <datavic:PFI>5690042</datavic:PFI>
        <datavic:UFI>1401149</datavic:UFI>
        <datavic:FEATURE_TYPE_CODE>road</datavic:
            FEATURE_TYPE_CODE>
        <datavic:EZI_ROAD_NAME>LILLYPILLY LANE</datavic:
            EZI_ROAD_NAME>
        <datavic:EZI_ROAD_NAME_LABEL>Lillypilly Lane</datavic:
            EZI_ROAD_NAME_LABEL>
        <datavic:ROAD_NAME>LILLYPILLY</datavic:ROAD_NAME>
        <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
        <datavic:LEFT_LOCALITY>KILSYTH SOUTH</datavic:
            LEFT_LOCALITY>
        <datavic:RIGHT_LOCALITY>KILSYTH SOUTH</datavic:
            RIGHT_LOCALITY>
        <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
        <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
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        <datavic:DIV_RD>U</datavic:DIV_RD>
        <datavic:FROM_UFI>2323782</datavic:FROM_UFI>
        <datavic:TO_UFI>2324690</datavic:TO_UFI>
        <datavic:FEATURE_QUALITY_ID>590</datavic:
            FEATURE_QUALITY_ID>
        <datavic:CREATE_DATE_PFI>2000-12-17T21:05:00</datavic:
            CREATE_DATE_PFI>
        <datavic:CREATE_DATE_UFI>2000-12-17T21:05:00</datavic:
            CREATE_DATE_UFI>
        <datavic:OBJECTID>44727</datavic:OBJECTID>
        <datavic:SHAPE>
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<gml:coordinates xmlns:gml="http://www.opengis.net/
    gml" decimal="." cs="," ts=" ">
    145.31205613,−37.83931791
    145.31494105,−37.83969143
    145.31502323,−37.83970621
    145.31513107,−37.83973117
    145.31521038,−37.83975377
    145.31528808,−37.83977964
    145.31538883,−37.83981908
    145.31546198,−37.83985226
    145.31555591,−37.83990113
    145.31562342,−37.83994113
    145.31570915,−37.83999871
    145.31577001,−37.84004493
    145.31584626,−37.84011037
    145.31589957,−37.84016212
    145.31596519,−37.84023444
    145.31601015,−37.84029096
    145.31614888,−37.84048373
    145.31621346,−37.84055603
    145.31626593,−37.84060787
    145.31638063,−37.84070472
    145.31644256,−37.8407495
    145.31652953,−37.84080514
    145.3165978,−37.84084367
    145.31669258,−37.8408906
    145.31684181,−37.84095103
    145.31691918,−37.84097656
    145.31702474,−37.84100563
    145.31710542,−37.8410236
    145.31721462,−37.84104237
    145.31853463,−37.8412085</gml:coordinates>
  </gml:LineString>
 </datavic:SHAPE>
</datavic:VMTRANS_TR_ROAD_LOCAL>
</gml:featureMember>
<gml:featureMember>
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    fid−−7418b020_161f96c8780_−2fb4">
 <datavic:PFI>14959956</datavic:PFI>
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```
      <datavic:UFI>45197169</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
         FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>CHANDLERS LANE</datavic:
         EZI_ROAD_NAME>
      <datavic:EZI_ROAD_NAME_LABEL>Chandlers Lane</datavic:
         EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>CHANDLERS</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>KILSYTH SOUTH</datavic:
         LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>KILSYTH SOUTH</datavic:
         RIGHT_LOCALITY>
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>U</datavic:DIV_RD>
      <datavic:FROM_UFI>45208358</datavic:FROM_UFI>
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         FEATURE_QUALITY_ID>
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         CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>5690891</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2013-06-11T11:09:30</datavic:
         CREATE_DATE_UFI>
      <datavic:OBJECTID>1997006</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.31161969,-37.84204934
              145.31169188,-37.84197807</gml:coordinates>
        </gml:LineString>
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
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    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
```

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fid--7418b020_161f96c8780_-2fb3">
    <datavic:PFI>16954765</datavic:PFI>
    <datavic:UFI>46636323</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE>road</datavic:
        FEATURE_TYPE_CODE>
    <datavic:EZI_ROAD_NAME>CHERRY LANE</datavic:
        EZI_ROAD_NAME>
    <datavic:EZI_ROAD_NAME_LABEL>Cherry Lane</datavic:
        EZI_ROAD_NAME_LABEL>
    <datavic:ROAD_NAME>CHERRY</datavic:ROAD_NAME>
    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LEFT_LOCALITY>MONTROSE</datavic:LEFT_LOCALITY>
    <datavic:RIGHT_LOCALITY>MONTROSE</datavic:RIGHT_LOCALITY
        >
    <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
    <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
    <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
    <datavic:RESTRICTIONS>5</datavic:RESTRICTIONS>
    <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
    <datavic:DIV_RD>ND</datavic:DIV_RD>
    <datavic:FROM_UFI>46636838</datavic:FROM_UFI>
    <datavic:TO_UFI>46636837</datavic:TO_UFI>
    <datavic:FEATURE_QUALITY_ID>5888</datavic:
        FEATURE_QUALITY_ID>
    <datavic:CREATE_DATE_PFI>2014-08-20T14:39:49</datavic:
        CREATE_DATE_PFI>
    <datavic:CREATE_DATE_UFI>2014-08-20T14:39:49</datavic:
        CREATE_DATE_UFI>
    <datavic:OBJECTID>2119006</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:LineString srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.33402924,-37.8129711
            145.33423404,-37.81293251
            145.33515336,-37.81257861</gml:coordinates>
      </gml:LineString>
    </datavic:SHAPE>
  </datavic:VMTRANS_TR_ROAD_LOCAL>
</gml:featureMember>
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<gml:featureMember>
  <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
     fid--7418b020_161f96c8780_-2fb2">
    <datavic:PFI>16954723</datavic:PFI>
    <datavic:UFI>46636164</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE>road</datavic:
       FEATURE_TYPE_CODE>
    <datavic:EZI_ROAD_NAME>ONE TREE LANE</datavic:
       EZI_ROAD_NAME>
    <datavic:EZI_ROAD_NAME_LABEL>One Tree Lane</datavic:
       EZI_ROAD_NAME_LABEL>
    <datavic:ROAD_NAME>ONE TREE</datavic:ROAD_NAME>
    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LEFT_LOCALITY>MONTROSE</datavic:LEFT_LOCALITY>
    <datavic:RIGHT_LOCALITY>MONTROSE</datavic:RIGHT_LOCALITY
       >
    <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
    <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
    <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
    <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
    <datavic:DIV_RD>ND</datavic:DIV_RD>
    <datavic:FROM_UFI>46636838</datavic:FROM_UFI>
    <datavic:TO_UFI>39405254</datavic:TO_UFI>
    <datavic:FEATURE_QUALITY_ID>5807</datavic:
       FEATURE_QUALITY_ID>
    <datavic:CREATE_DATE_PFI>2014-08-20T14:39:47</datavic:
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    <datavic:SUPERCEDED_PFI>15149376</datavic:SUPERCEDED_PFI
       >
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       CREATE_DATE_UFI>
    <datavic:OBJECTID>2118848</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:LineString srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.33402924,-37.8129711
            145.33377913,-37.81238301</gml:coordinates>
      </gml:LineString>
    </datavic:SHAPE>
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    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
        fid--7418b020_161f96c8780_-2fb1">
      <datavic:PFI>15149378</datavic:PFI>
      <datavic:UFI>42605601</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
          FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>ONE TREE LANE</datavic:
          EZI_ROAD_NAME>
      <datavic:EZI_ROAD_NAME_LABEL>One Tree Lane</datavic:
          EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>ONE TREE</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>MONTROSE</datavic:LEFT_LOCALITY>
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          >
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>ND</datavic:DIV_RD>
      <datavic:FROM_UFI>39405254</datavic:FROM_UFI>
      <datavic:TO_UFI>39405252</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>5807</datavic:
          FEATURE_QUALITY_ID>
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          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2011-12-20T08:07:19</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>1835638</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.33377913,-37.81238301
              145.33366973,-37.81212577</gml:coordinates>
        </gml:LineString>
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      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
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        fid-−7418b020_161f96c8780_−2fb0">
      <datavic:PFI>5693422</datavic:PFI>
      <datavic:UFI>45622097</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
          FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>PAVITT LANE</datavic:
          EZI_ROAD_NAME>
      <datavic:EZI_ROAD_NAME_LABEL>Pavitt Lane</datavic:
          EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>PAVITT</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>MOUNT DANDENONG</datavic:
          LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>MOUNT DANDENONG</datavic:
          RIGHT_LOCALITY>
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      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:RESTRICTIONS>1</datavic:RESTRICTIONS>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>U</datavic:DIV_RD>
      <datavic:NRE_ROUTE>V51776</datavic:NRE_ROUTE>
      <datavic:FROM_UFI>35099217</datavic:FROM_UFI>
      <datavic:TO_UFI>45623922</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>3298</datavic:
          FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2000−12−17T00:00:00</datavic:
          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2013−08−29T12:08:05</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>2032524</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
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            gml" decimal="." cs="," ts=" ">
            145.33282881,-37.8474349
            145.33305096,-37.84746068</gml:coordinates>
        </gml:LineString>
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
        fid--7418b020_161f96c8780_-2faf">
      <datavic:PFI>5692975</datavic:PFI>
      <datavic:UFI>35098433</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
          FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>PAVITT LANE</datavic:
          EZI_ROAD_NAME>
      <datavic:EZI_ROAD_NAME_LABEL>Pavitt Lane</datavic:
          EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>PAVITT</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>MONTROSE</datavic:LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>THE BASIN</datavic:
          RIGHT_LOCALITY>
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:RESTRICTIONS>1</datavic:RESTRICTIONS>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>U</datavic:DIV_RD>
      <datavic:FROM_UFI>2327333</datavic:FROM_UFI>
      <datavic:TO_UFI>35099214</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>2014</datavic:
          FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2000-12-17T00:00:00</datavic:
          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2009-08-14T08:52:23</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>943566</datavic:OBJECTID>
      <datavic:SHAPE>
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```xml
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/gml" decimal="." cs="," ts=" ">
            145.32601691,-37.84663575
            145.32627162,-37.84666564</gml:coordinates>
        </gml:LineString>
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.fid--7418b020_161f96c8780_-2fae">
      <datavic:PFI>5705763</datavic:PFI>
      <datavic:UFI>45622045</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>WOODS LANE</datavic:EZI_ROAD_NAME>
      <datavic:EZI_ROAD_NAME_LABEL>Woods Lane</datavic:EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>WOODS</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>FERNY CREEK</datavic:LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>FERNY CREEK</datavic:RIGHT_LOCALITY>
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
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      <datavic:FROM_UFI>16176820</datavic:FROM_UFI>
      <datavic:TO_UFI>45623985</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>253</datavic:FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2000-12-17T00:00:00</datavic:CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2013-08-29T12:08:05</datavic:CREATE_DATE_UFI>
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```xml
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      <datavic:SHAPE>
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              gml" decimal="." cs="," ts=" ">
              145.34189064,-37.86958962
              145.34325428,-37.86934645</gml:coordinates>
        </gml:LineString>
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
        fid--7418b020_161f96c8780_-2fad">
      <datavic:PFI>11561233</datavic:PFI>
      <datavic:UFI>15052192</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
          FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>GIDDENS LANE</datavic:
          EZI_ROAD_NAME>
      <datavic:EZI_ROAD_NAME_LABEL>Giddens Lane</datavic:
          EZI_ROAD_NAME_LABEL>
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      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
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  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
        fid--7418b020_161f96c8780_-2f99">
      <datavic:PFI>5670543</datavic:PFI>
      <datavic:UFI>1381584</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
```

```
        FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>EMERY LANE</datavic:EZI_ROAD_NAME
        >
      <datavic:EZI_ROAD_NAME_LABEL>Emery Lane</datavic:
        EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>EMERY</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>MONTROSE</datavic:LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>MONTROSE</datavic:RIGHT_LOCALITY
        >
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>U</datavic:DIV_RD>
      <datavic:FROM_UFI>2306955</datavic:FROM_UFI>
      <datavic:TO_UFI>2307626</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>838</datavic:
        FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2000-12-17T20:33:45</datavic:
        CREATE_DATE_PFI>
      <datavic:CREATE_DATE_UFI>2000-12-17T20:33:45</datavic:
        CREATE_DATE_UFI>
      <datavic:OBJECTID>34070</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.34450598,-37.802692
            145.34416095,-37.80410231</gml:coordinates>
        </gml:LineString>
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
      fid--7418b020_161f96c8780_-2f98">
      <datavic:PFI>5676865</datavic:PFI>
      <datavic:UFI>1387946</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE>road</datavic:
```

```
        FEATURE_TYPE_CODE>
      <datavic:EZI_ROAD_NAME>ERITH LANE</datavic:EZI_ROAD_NAME
        >
      <datavic:EZI_ROAD_NAME_LABEL>Erith Lane</datavic:
        EZI_ROAD_NAME_LABEL>
      <datavic:ROAD_NAME>ERITH</datavic:ROAD_NAME>
      <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
      <datavic:LEFT_LOCALITY>KALORAMA</datavic:LEFT_LOCALITY>
      <datavic:RIGHT_LOCALITY>KALORAMA</datavic:RIGHT_LOCALITY
        >
      <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
      <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
      <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
      <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
      <datavic:DIV_RD>U</datavic:DIV_RD>
      <datavic:FROM_UFI>2313070</datavic:FROM_UFI>
      <datavic:TO_UFI>2312713</datavic:TO_UFI>
      <datavic:FEATURE_QUALITY_ID>266</datavic:
        FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2000-12-17T20:47:25</datavic:
        CREATE_DATE_PFI>
      <datavic:CREATE_DATE_UFI>2000-12-17T20:47:25</datavic:
        CREATE_DATE_UFI>
      <datavic:OBJECTID>40234</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:LineString srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.37299614,-37.81534698
              145.37416304,-37.81462154
              145.37430815,-37.81463334</gml:coordinates>
        </gml:LineString>
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
        fid--7418b020_161f96c8780_-2f97">
      <datavic:PFI>5677188</datavic:PFI>
      <datavic:UFI>1388271</datavic:UFI>
```

```
<datavic:FEATURE_TYPE_CODE>road</datavic:
    FEATURE_TYPE_CODE>
<datavic:EZI_ROAD_NAME>ERITH LANE</datavic:EZI_ROAD_NAME
    >
<datavic:EZI_ROAD_NAME_LABEL>Erith Lane</datavic:
    EZI_ROAD_NAME_LABEL>
<datavic:ROAD_NAME>ERITH</datavic:ROAD_NAME>
<datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
<datavic:LEFT_LOCALITY>KALORAMA</datavic:LEFT_LOCALITY>
<datavic:RIGHT_LOCALITY>KALORAMA</datavic:RIGHT_LOCALITY
    >
<datavic:CLASS_CODE>5</datavic:CLASS_CODE>
<datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
<datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
<datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
<datavic:DIV_RD>U</datavic:DIV_RD>
<datavic:FROM_UFI>2313271</datavic:FROM_UFI>
<datavic:TO_UFI>2313070</datavic:TO_UFI>
<datavic:FEATURE_QUALITY_ID>266</datavic:
    FEATURE_QUALITY_ID>
<datavic:CREATE_DATE_PFI>2000-12-17T20:47:46</datavic:
    CREATE_DATE_PFI>
<datavic:CREATE_DATE_UFI>2000-12-17T20:47:46</datavic:
    CREATE_DATE_UFI>
<datavic:OBJECTID>40989</datavic:OBJECTID>
<datavic:SHAPE>
  <gml:LineString srsName="EPSG:4283">
    <gml:coordinates xmlns:gml="http://www.opengis.net/
        gml" decimal="." cs="," ts=" ">
        145.36941832,-37.81581349
        145.3697539,-37.81591313
        145.37086729,-37.81595032
        145.37204572,-37.81587652
        145.37208244,-37.815915
        145.37299614,-37.81534698</gml:coordinates>
  </gml:LineString>
</datavic:SHAPE>
</datavic:VMTRANS_TR_ROAD_LOCAL>
</gml:featureMember>
<gml:featureMember>
```

```
<datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
   fid--7418b020_161f96c8780_-2f96">
  <datavic:PFI>6302573</datavic:PFI>
  <datavic:UFI>16176303</datavic:UFI>
  <datavic:FEATURE_TYPE_CODE>road</datavic:
      FEATURE_TYPE_CODE>
  <datavic:EZI_ROAD_NAME>DINGLEY LANE</datavic:
      EZI_ROAD_NAME>
  <datavic:EZI_ROAD_NAME_LABEL>Dingley Lane</datavic:
      EZI_ROAD_NAME_LABEL>
  <datavic:ROAD_NAME>DINGLEY</datavic:ROAD_NAME>
  <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
  <datavic:LEFT_LOCALITY>OLINDA</datavic:LEFT_LOCALITY>
  <datavic:RIGHT_LOCALITY>MOUNT DANDENONG</datavic:
      RIGHT_LOCALITY>
  <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
  <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
  <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
  <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
  <datavic:DIV_RD>U</datavic:DIV_RD>
  <datavic:FROM_UFI>2323129</datavic:FROM_UFI>
  <datavic:TO_UFI>2324536</datavic:TO_UFI>
  <datavic:FEATURE_QUALITY_ID>1278</datavic:
      FEATURE_QUALITY_ID>
  <datavic:CREATE_DATE_PFI>2001-09-04T00:00:00</datavic:
      CREATE_DATE_PFI>
  <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
  <datavic:CREATE_DATE_UFI>2006-01-25T15:58:15</datavic:
      CREATE_DATE_UFI>
  <datavic:OBJECTID>354534</datavic:OBJECTID>
  <datavic:SHAPE>
    <gml:LineString srsName="EPSG:4283">
      <gml:coordinates xmlns:gml="http://www.opengis.net/
          gml" decimal="." cs="," ts=" ">
          145.36830634,-37.83767074
          145.3682837,-37.8376866
          145.36786145,-37.83848082
          145.36805074,-37.84077968</gml:coordinates>
    </gml:LineString>
  </datavic:SHAPE>
```

```
  </datavic:VMTRANS_TR_ROAD_LOCAL>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMTRANS_TR_ROAD_LOCAL fid="VMTRANS_TR_ROAD_LOCAL.
      fid--7418b020_161f96c8780_-2f95">
    <datavic:PFI>6302572</datavic:PFI>
    <datavic:UFI>7719780</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE>road</datavic:
        FEATURE_TYPE_CODE>
    <datavic:EZI_ROAD_NAME>DINGLEY LANE</datavic:
        EZI_ROAD_NAME>
    <datavic:EZI_ROAD_NAME_LABEL>Dingley Lane</datavic:
        EZI_ROAD_NAME_LABEL>
    <datavic:ROAD_NAME>DINGLEY</datavic:ROAD_NAME>
    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LEFT_LOCALITY>MOUNT DANDENONG</datavic:
        LEFT_LOCALITY>
    <datavic:RIGHT_LOCALITY>MOUNT DANDENONG</datavic:
        RIGHT_LOCALITY>
    <datavic:CLASS_CODE>5</datavic:CLASS_CODE>
    <datavic:DIRECTION_CODE>B</datavic:DIRECTION_CODE>
    <datavic:HEIGHT_LIMIT>0</datavic:HEIGHT_LIMIT>
    <datavic:ROAD_SEAL>1</datavic:ROAD_SEAL>
    <datavic:DIV_RD>U</datavic:DIV_RD>
    <datavic:FROM_UFI>2323093</datavic:FROM_UFI>
    <datavic:TO_UFI>2323129</datavic:TO_UFI>
    <datavic:FEATURE_QUALITY_ID>2437</datavic:
        FEATURE_QUALITY_ID>
    <datavic:CREATE_DATE_PFI>2001-09-04T11:26:31</datavic:
        CREATE_DATE_PFI>
    <datavic:CREATE_DATE_UFI>2001-09-04T11:26:31</datavic:
        CREATE_DATE_UFI>
    <datavic:OBJECTID>116123</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:LineString srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.36686009,-37.83759341
            145.36830634,-37.83767074</gml:coordinates>
      </gml:LineString>
```

```
      </datavic:SHAPE>
    </datavic:VMTRANS_TR_ROAD_LOCAL>
  </gml:featureMember>
</wfs:FeatureCollection>
```


Ground Truth Result 1 for DELWP

E.2 Results of Query 2: Retrieve Height Points that have an Elevation between 120 and 140


```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
    xmlns:wfs="http://www.opengis.net/wfs" xmlns:data.linz.
    govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.
    opengis.net/gml" xmlns:xsi="http://www.w3.org/2001/
    XMLSchema-instance" xsi:schemaLocation="http://data.linz.
    govt.nz https://data.linz.govt.nz/services;key=41
    b3c3b90c0247b587f512e1a4741498/wfs?service=WFS&amp;version
    =1.0.0&amp;request=DescribeFeatureType&amp;typeName=data.
    linz.govt.nz%3Alayer-50284 http://www.opengis.net/wfs http
    ://schemas.opengis.net/wfs/1.0.0/WFS-basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387789">
      <data.linz.govt.nz:t50_fid>2387789</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>121</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1748819.3882832266,5421763.8292005705</gml:
              coordinates>
        </gml:Point>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50284>
  </gml:featureMember>
  <gml:featureMember>
```

```
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387852">
      <data.linz.govt.nz:t50_fid>2387852</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>126</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1748326.106784665,5424909.203376672</gml:
              coordinates>
        </gml:Point>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50284>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387853">
      <data.linz.govt.nz:t50_fid>2387853</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>134</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1749705.085024001,5424213.0010170005</gml:
              coordinates>
        </gml:Point>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50284>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387854">
      <data.linz.govt.nz:t50_fid>2387854</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>133</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
```

```
                gml" decimal="." cs="," ts=" ">
                1749730.9122330006,5426023.844434001</gml:
                coordinates>
            </gml:Point>
          </data.linz.govt.nz:GEOMETRY>
        </data.linz.govt.nz:layer-50284>
      </gml:featureMember>
    </wfs:FeatureCollection>
```

Ground Truth Result 2 for LINZ

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
   xmlns:wfs="http://www.opengis.net/wfs" xmlns:gml="http://
   www.opengis.net/gml" xmlns:datavic="http://land.vic.gov.au
   /datavic" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
   instance" xsi:schemaLocation="http://land.vic.gov.au/
   datavic http://services.land.vic.gov.au/catalogue/
   publicproxy/guest/dv_geoserver/datavic/wfs?service=WFS&amp
   ;version=1.0.0&amp;request=DescribeFeatureType&amp;
   typeName=datavic%3AVMELEV_EL_GRND_SURFACE_POINT_1TO5M http
   ://www.opengis.net/wfs http://schemas.opengis.net/wfs
   /1.0.0/WFS-basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.12488">
      <datavic:UFI>33808</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>135.7</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.26138528,-37.79782115</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
```

```xml
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.12487">
    <datavic:UFI>33805</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>135.6</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.26064599,-37.7975848</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.23044">
    <datavic:UFI>10531</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>124.8</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.2693092,-37.82413013</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.23045">
    <datavic:UFI>10532</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>129.2</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
```

```xml
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.2698805,-37.82305052</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.22984">
      <datavic:UFI>10448</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>136.1</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.26389897,-37.80767653</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.12489">
      <datavic:UFI>33811</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>137.5</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.26366772,-37.80760937</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
```

```
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
     VMELEV_EL_GRND_SURFACE_POINT_1TO5M.37274">
    <datavic:UFI>33806</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>136.1</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
           gml" decimal="." cs="," ts=" ">
           145.26058753,-37.80855614</gml:coordinates>
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            145.31472533,-37.84368717</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.32507">
    <datavic:UFI>26101</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>139.7</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
```

```xml
        <datavic:SHAPE>
          <gml:Point srsName="EPSG:4283">
            <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.32284991,-37.83937757</gml:coordinates>
          </gml:Point>
        </datavic:SHAPE>
      </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
    </gml:featureMember>
    <gml:featureMember>
      <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
          VMELEV_EL_GRND_SURFACE_POINT_1TO5M.9551">
        <datavic:UFI>26107</datavic:UFI>
        <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
        <datavic:ALTITUDE>139.8</datavic:ALTITUDE>
        <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
        <datavic:SHAPE>
          <gml:Point srsName="EPSG:4283">
            <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.32348036,-37.8390949</gml:coordinates>
          </gml:Point>
        </datavic:SHAPE>
      </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
    </gml:featureMember>
    <gml:featureMember>
      <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
          VMELEV_EL_GRND_SURFACE_POINT_1TO5M.9549">
        <datavic:UFI>26100</datavic:UFI>
        <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
        <datavic:ALTITUDE>139.8</datavic:ALTITUDE>
        <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
        <datavic:SHAPE>
          <gml:Point srsName="EPSG:4283">
            <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.32248485,-37.83906111</gml:coordinates>
          </gml:Point>
        </datavic:SHAPE>
      </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
```

```
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
     VMELEV_EL_GRND_SURFACE_POINT_1TO5M.9548">
    <datavic:UFI>26097</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>134.1</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.3187219,-37.83888178</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
     VMELEV_EL_GRND_SURFACE_POINT_1TO5M.32504">
    <datavic:UFI>26096</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>133.7</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.31899958,-37.83870218</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
     VMELEV_EL_GRND_SURFACE_POINT_1TO5M.9512">
    <datavic:UFI>26039</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>133.3</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
```

```
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.32909795,-37.81720751</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.32402">
      <datavic:UFI>25822</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>138.5</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.36757506,-37.79564033</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.9375">
      <datavic:UFI>25821</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>137.3</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.36777352,-37.79610657</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
```

```
    </gml:featureMember>
</wfs:FeatureCollection>
```

Ground Truth Result 2 for DELWP

E.3 Results of Query 3: Retrieve Mines that are underneath a Lake

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
    xmlns:wfs="http://www.opengis.net/wfs" xmlns:data.linz.
    govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.
    opengis.net/gml" xmlns:xsi="http://www.w3.org/2001/
    XMLSchema-instance" xsi:schemaLocation="http://data.linz.
    govt.nz https://data.linz.govt.nz/services;key=41
    b3c3b90c0247b587f512e1a4741498/wfs?service=WFS&amp;version
    =1.0.0&amp;request=DescribeFeatureType&amp;typeName=data.
    linz.govt.nz%3Alayer-50284 http://www.opengis.net/wfs http
    ://schemas.opengis.net/wfs/1.0.0/WFS-basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387789">
      <data.linz.govt.nz:t50_fid>2387789</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>121</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1748819.3882832266,5421763.8292005705</gml:
              coordinates>
        </gml:Point>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50284>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387852">
      <data.linz.govt.nz:t50_fid>2387852</data.linz.govt.nz:
          t50_fid>
```

```
      <data.linz.govt.nz:elevation>126</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1748326.106784665,5424909.203376672</gml:
              coordinates>
        </gml:Point>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50284>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387853">
      <data.linz.govt.nz:t50_fid>2387853</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>134</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1749705.085024001,5424213.0010170005</gml:
              coordinates>
        </gml:Point>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50284>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50284 fid="layer-50284.2387854">
      <data.linz.govt.nz:t50_fid>2387854</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:elevation>133</data.linz.govt.nz:
          elevation>
      <data.linz.govt.nz:GEOMETRY>
        <gml:Point srsName="EPSG:2193">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              1749730.9122330006,5426023.844434001</gml:
              coordinates>
```

```
            </gml:Point>
          </data.linz.govt.nz:GEOMETRY>
        </data.linz.govt.nz:layer-50284>
      </gml:featureMember>
    </wfs:FeatureCollection>
```


Ground Truth Result 3 for LINZ


```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
    xmlns:wfs="http://www.opengis.net/wfs" xmlns:gml="http://
    www.opengis.net/gml" xmlns:datavic="http://land.vic.gov.au
    /datavic" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance" xsi:schemaLocation="http://land.vic.gov.au/
    datavic http://services.land.vic.gov.au/catalogue/
    publicproxy/guest/dv_geoserver/datavic/wfs?service=WFS&amp
    ;version=1.0.0&amp;request=DescribeFeatureType&amp;
    typeName=datavic%3AVMELEV_EL_GRND_SURFACE_POINT_1TO5M http
    ://www.opengis.net/wfs http://schemas.opengis.net/wfs
    /1.0.0/WFS-basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.12488">
      <datavic:UFI>33808</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>135.7</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.26138528,-37.79782115</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
```

```
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.12487">
    <datavic:UFI>33805</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>135.6</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.26064599,-37.7975848</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.23044">
    <datavic:UFI>10531</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>124.8</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.2693092,-37.82413013</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
      VMELEV_EL_GRND_SURFACE_POINT_1TO5M.23045">
    <datavic:UFI>10532</datavic:UFI>
    <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
    <datavic:ALTITUDE>129.2</datavic:ALTITUDE>
    <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
```

```
                gml" decimal="." cs="," ts=" ">
                145.2698805,-37.82305052</gml:coordinates>
            </gml:Point>
          </datavic:SHAPE>
        </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
      </gml:featureMember>
      <gml:featureMember>
        <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
            VMELEV_EL_GRND_SURFACE_POINT_1TO5M.22984">
          <datavic:UFI>10448</datavic:UFI>
          <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
          <datavic:ALTITUDE>136.1</datavic:ALTITUDE>
          <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
          <datavic:SHAPE>
            <gml:Point srsName="EPSG:4283">
              <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.26389897,-37.80767653</gml:coordinates>
            </gml:Point>
          </datavic:SHAPE>
        </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
      </gml:featureMember>
      <gml:featureMember>
        <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
            VMELEV_EL_GRND_SURFACE_POINT_1TO5M.12489">
          <datavic:UFI>33811</datavic:UFI>
          <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
          <datavic:ALTITUDE>137.5</datavic:ALTITUDE>
          <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
          <datavic:SHAPE>
            <gml:Point srsName="EPSG:4283">
              <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.26366772,-37.80760937</gml:coordinates>
            </gml:Point>
          </datavic:SHAPE>
        </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
      </gml:featureMember>
      <gml:featureMember>
        <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
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        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.37274">
      <datavic:UFI>33806</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>136.1</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.26058753,-37.80855614</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.22973">
      <datavic:UFI>10433</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>135.7</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.29238523,-37.79728729</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
        VMELEV_EL_GRND_SURFACE_POINT_1TO5M.22946">
      <datavic:UFI>10395</datavic:UFI>
      <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
      <datavic:ALTITUDE>132.9</datavic:ALTITUDE>
      <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
      <datavic:SHAPE>
        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
```

```
                gml" decimal="." cs="," ts=" ">
                145.27352551,-37.80091336</gml:coordinates>
          </gml:Point>
        </datavic:SHAPE>
      </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
    </gml:featureMember>
    <gml:featureMember>
      <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
          VMELEV_EL_GRND_SURFACE_POINT_1TO5M.22977">
        <datavic:UFI>10438</datavic:UFI>
        <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
        <datavic:ALTITUDE>121.8</datavic:ALTITUDE>
        <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
        <datavic:SHAPE>
          <gml:Point srsName="EPSG:4283">
            <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.29754108,-37.79510257</gml:coordinates>
          </gml:Point>
        </datavic:SHAPE>
      </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
    </gml:featureMember>
    <gml:featureMember>
      <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
          VMELEV_EL_GRND_SURFACE_POINT_1TO5M.22974">
        <datavic:UFI>10434</datavic:UFI>
        <datavic:FEATURE_TYPE_CODE> </datavic:FEATURE_TYPE_CODE>
        <datavic:ALTITUDE>128.8</datavic:ALTITUDE>
        <datavic:UFI_CREATED>2011-05-31</datavic:UFI_CREATED>
        <datavic:SHAPE>
          <gml:Point srsName="EPSG:4283">
            <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.29289857,-37.79286309</gml:coordinates>
          </gml:Point>
        </datavic:SHAPE>
      </datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M>
    </gml:featureMember>
    <gml:featureMember>
      <datavic:VMELEV_EL_GRND_SURFACE_POINT_1TO5M fid="
```

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</wfs:FeatureCollection>
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Ground Truth Result 3 for DELWP

E.4 Results of Query 4: Retrieve Buildings within 500m of a Water Tank

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    govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.
    opengis.net/gml" xmlns:xsi="http://www.w3.org/2001/
    XMLSchema-instance" xsi:schemaLocation="http://data.linz.
    govt.nz https://data.linz.govt.nz/services;key=41
    b3c3b90c0247b587f512e1a4741498/wfs?service=WFS&amp;version
    =1.0.0&amp;request=DescribeFeatureType&amp;typeName=data.
    linz.govt.nz%3Alayer-50293 http://www.opengis.net/wfs http
    ://schemas.opengis.net/wfs/1.0.0/WFS-basic.xsd">
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    <gml:null>unknown</gml:null>
  </gml:boundedBy>
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Ground Truth Result 4 for LINZ


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    www.opengis.net/gml" xmlns:datavic="http://land.vic.gov.au
    /datavic" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance" xsi:schemaLocation="http://land.vic.gov.au/
    datavic http://services.land.vic.gov.au/catalogue/
    publicproxy/guest/dv_geoserver/datavic/wfs?service=WFS&amp
    ;version=1.0.0&amp;request=DescribeFeatureType&amp;
    typeName=datavic%3AVMHYDRO_WATER_AREA_LAKES_DAMS http://
    www.opengis.net/wfs http://schemas.opengis.net/wfs/1.0.0/
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    <gml:null>unknown</gml:null>
  </gml:boundedBy>
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                    147.8769205,−36.069929
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                147.8692085,-36.071837
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                147.868814,-36.0719595
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            FEATURE_TYPE_CODE>
        <datavic:ORIGIN>1</datavic:ORIGIN>
```

```
<datavic:WATER_USE_FUNCTION>7</datavic:
    WATER_USE_FUNCTION>
<datavic:WATERBODY_STATE>1</datavic:WATERBODY_STATE>
<datavic:FEATURE_QUALITY_ID>4762</datavic:
    FEATURE_QUALITY_ID>
<datavic:CREATE_DATE_PFI>2001-04-05T13:26:05</datavic:
    CREATE_DATE_PFI>
<datavic:CREATE_DATE_UFI>2001-04-05T13:26:05</datavic:
    CREATE_DATE_UFI>
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<datavic:SHAPE>
  <gml:MultiPolygon srsName="EPSG:4283">
    <gml:polygonMember>
      <gml:Polygon>
        <gml:outerBoundaryIs>
          <gml:LinearRing>
            <gml:coordinates xmlns:gml="http://www.
                opengis.net/gml" decimal="." cs="," ts="
                ">147.95313372,-36.13645521
                147.95331049,-36.13641219
                147.95362867,-36.13631181
                147.95394687,-36.13629739
                147.9539822,-36.13621143
                147.95392918,-36.13613983
                147.95369937,-36.13608259
                147.95339885,-36.13612566
                147.95318673,-36.13619734
                147.95300997,-36.13632633
                147.9529923,-36.13645525
                147.95313372,-36.13645521</gml:
                coordinates>
          </gml:LinearRing>
        </gml:outerBoundaryIs>
      </gml:Polygon>
    </gml:polygonMember>
  </gml:MultiPolygon>
</datavic:SHAPE>
</datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
</gml:featureMember>
<gml:featureMember>
```

```xml
<datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
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  <datavic:PFI>8126869</datavic:PFI>
  <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
      FEATURE_TYPE_CODE>
  <datavic:ORIGIN>1</datavic:ORIGIN>
  <datavic:WATER_USE_FUNCTION>7</datavic:
      WATER_USE_FUNCTION>
  <datavic:WATERBODY_STATE>1</datavic:WATERBODY_STATE>
  <datavic:FEATURE_QUALITY_ID>4762</datavic:
      FEATURE_QUALITY_ID>
  <datavic:CREATE_DATE_PFI>2001-04-05T13:26:04</datavic:
      CREATE_DATE_PFI>
  <datavic:CREATE_DATE_UFI>2001-04-05T13:26:04</datavic:
      CREATE_DATE_UFI>
  <datavic:OBJECTID>6721</datavic:OBJECTID>
  <datavic:SHAPE>
    <gml:MultiPolygon srsName="EPSG:4283">
      <gml:polygonMember>
        <gml:Polygon>
          <gml:outerBoundaryIs>
            <gml:LinearRing>
              <gml:coordinates xmlns:gml="http://www.
                  opengis.net/gml" decimal="." cs="," ts="
                  ">147.95359328,-36.1358964
                  147.95377004,-36.1358677
                  147.95394682,-36.13582467
                  147.95408822,-36.13572436
                  147.95405286,-36.13566706
                  147.95391145,-36.13563847
                  147.95377002,-36.13566714
                  147.95362862,-36.13573882
                  147.95354024,-36.13583913
                  147.95359328,-36.1358964</gml:
                  coordinates>
            </gml:LinearRing>
          </gml:outerBoundaryIs>
        </gml:Polygon>
      </gml:polygonMember>
    </gml:MultiPolygon>
```

```
      </datavic:SHAPE>
    </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
        VMHYDRO_WATER_AREA_LAKES_DAMS.44585352">
      <datavic:PFI>16464297</datavic:PFI>
      <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
          FEATURE_TYPE_CODE>
      <datavic:NAMED_FEATURE_ID>0</datavic:NAMED_FEATURE_ID>
      <datavic:ORIGIN>2</datavic:ORIGIN>
      <datavic:WATER_USE_FUNCTION>1</datavic:
          WATER_USE_FUNCTION>
      <datavic:FEATURE_QUALITY_ID>5856</datavic:
          FEATURE_QUALITY_ID>
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          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2013-01-21T12:04:55</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>408820</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:MultiPolygon srsName="EPSG:4283">
          <gml:polygonMember>
            <gml:Polygon>
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates xmlns:gml="http://www.
                      opengis.net/gml" decimal="." cs="," ts="
                      ">147.928325,-36.197855
                      147.928323,-36.1976735
                      147.92826199,-36.1974975
                      147.928138,-36.1974365
                      147.927962,-36.1975145
                      147.9279585,-36.1977005
                      147.9280485,-36.197857
                      147.9281965,-36.1979275
                      147.928325,-36.197855</gml:coordinates>
                </gml:LinearRing>
              </gml:outerBoundaryIs>
```

```
            </gml:Polygon>
          </gml:polygonMember>
        </gml:MultiPolygon>
      </datavic:SHAPE>
    </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
        VMHYDRO_WATER_AREA_LAKES_DAMS.44584851">
      <datavic:PFI>16463815</datavic:PFI>
      <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
          FEATURE_TYPE_CODE>
      <datavic:NAMED_FEATURE_ID>0</datavic:NAMED_FEATURE_ID>
      <datavic:ORIGIN>2</datavic:ORIGIN>
      <datavic:WATER_USE_FUNCTION>1</datavic:
          WATER_USE_FUNCTION>
      <datavic:FEATURE_QUALITY_ID>5856</datavic:
          FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2013-01-21T12:04:21</datavic:
          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2013-01-21T12:04:21</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>408320</datavic:OBJECTID>
      <datavic:SHAPE>
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          <gml:polygonMember>
            <gml:Polygon>
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates xmlns:gml="http://www.
                      opengis.net/gml" decimal="." cs="," ts="
                      ">147.9210675,-36.1859705
                      147.921078,-36.1858515
                      147.920692,-36.1855535
                      147.920412,-36.18578
                      147.92052,-36.1859365
                      147.9208805,-36.1860915
                      147.9210675,-36.1859705</gml:coordinates
                      >
```

```
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:polygonMember>
      </gml:MultiPolygon>
    </datavic:SHAPE>
  </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
      VMHYDRO_WATER_AREA_LAKES_DAMS.41058624">
    <datavic:PFI>14504932</datavic:PFI>
    <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
        FEATURE_TYPE_CODE>
    <datavic:ORIGIN>2</datavic:ORIGIN>
    <datavic:WATER_USE_FUNCTION>1</datavic:
        WATER_USE_FUNCTION>
    <datavic:WATERBODY_STATE>2</datavic:WATERBODY_STATE>
    <datavic:FEATURE_QUALITY_ID>5761</datavic:
        FEATURE_QUALITY_ID>
    <datavic:CREATE_DATE_PFI>2010-03-29T00:00:00</datavic:
        CREATE_DATE_PFI>
    <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
    <datavic:CREATE_DATE_UFI>2011-07-11T22:40:32</datavic:
        CREATE_DATE_UFI>
    <datavic:OBJECTID>275323</datavic:OBJECTID>
    <datavic:SHAPE>
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        <gml:polygonMember>
          <gml:Polygon>
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates xmlns:gml="http://www.
                    opengis.net/gml" decimal="." cs="," ts="
                    ">147.9518257,-36.20127062
                    147.95212439,-36.2008107
                    147.95184391,-36.20065546
                    147.95151014,-36.20064029
                    147.95145014,-36.20113396
                    147.9518257,-36.20127062</gml:
```

```
                        coordinates>
                    </gml:LinearRing>
                  </gml:outerBoundaryIs>
                </gml:Polygon>
              </gml:polygonMember>
            </gml:MultiPolygon>
          </datavic:SHAPE>
        </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
      </gml:featureMember>
      <gml:featureMember>
        <datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
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          <datavic:PFI>8128144</datavic:PFI>
          <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
              FEATURE_TYPE_CODE>
          <datavic:ORIGIN>2</datavic:ORIGIN>
          <datavic:WATER_USE_FUNCTION>1</datavic:
              WATER_USE_FUNCTION>
          <datavic:WATERBODY_STATE>2</datavic:WATERBODY_STATE>
          <datavic:FEATURE_QUALITY_ID>4762</datavic:
              FEATURE_QUALITY_ID>
          <datavic:CREATE_DATE_PFI>2001-04-05T13:27:19</datavic:
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          <datavic:CREATE_DATE_UFI>2001-04-05T13:27:19</datavic:
              CREATE_DATE_UFI>
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                    <gml:LinearRing>
                      <gml:coordinates xmlns:gml="http://www.
                          opengis.net/gml" decimal="." cs="," ts="
                          ">147.95416885,-36.1957323
                          147.95434561,-36.19567497
                          147.95445164,-36.19554607
                          147.9544162,-36.19537424
                          147.95416872,-36.19540296
                          147.95402733,-36.1954746
```

```
                        147.95406273,-36.1956321
                        147.95416885,-36.1957323</gml:
                        coordinates>
                    </gml:LinearRing>
                  </gml:outerBoundaryIs>
                </gml:Polygon>
              </gml:polygonMember>
            </gml:MultiPolygon>
          </datavic:SHAPE>
        </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
      </gml:featureMember>
      <gml:featureMember>
        <datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
           VMHYDRO_WATER_AREA_LAKES_DAMS.44585533">
          <datavic:PFI>16464469</datavic:PFI>
          <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
              FEATURE_TYPE_CODE>
          <datavic:NAMED_FEATURE_ID>0</datavic:NAMED_FEATURE_ID>
          <datavic:ORIGIN>2</datavic:ORIGIN>
          <datavic:WATER_USE_FUNCTION>1</datavic:
              WATER_USE_FUNCTION>
          <datavic:FEATURE_QUALITY_ID>5856</datavic:
              FEATURE_QUALITY_ID>
          <datavic:CREATE_DATE_PFI>2013-01-21T12:05:08</datavic:
              CREATE_DATE_PFI>
          <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
          <datavic:CREATE_DATE_UFI>2013-01-21T12:05:08</datavic:
              CREATE_DATE_UFI>
          <datavic:OBJECTID>409000</datavic:OBJECTID>
          <datavic:SHAPE>
            <gml:MultiPolygon srsName="EPSG:4283">
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                <gml:Polygon>
                  <gml:outerBoundaryIs>
                    <gml:LinearRing>
                      <gml:coordinates xmlns:gml="http://www.
                        opengis.net/gml" decimal="." cs="," ts="
                         ">147.950288,-36.202
                        147.9503215,-36.2018025
                        147.9503965,-36.201626
```

```
                    147.9504425,−36.20147
                    147.95042,−36.201208
                    147.9502435,−36.201184
                    147.950093,−36.20142
                    147.94994449,−36.2018455
                    147.949927,−36.202084
                    147.9501605,−36.2021385
                    147.950288,−36.202</gml:coordinates>
                </gml:LinearRing>
              </gml:outerBoundaryIs>
            </gml:Polygon>
          </gml:polygonMember>
        </gml:MultiPolygon>
      </datavic:SHAPE>
    </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
  </gml:featureMember>
  <gml:featureMember>
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       VMHYDRO_WATER_AREA_LAKES_DAMS.3857778">
      <datavic:PFI>8128066</datavic:PFI>
      <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
         FEATURE_TYPE_CODE>
      <datavic:ORIGIN>2</datavic:ORIGIN>
      <datavic:WATER_USE_FUNCTION>1</datavic:
         WATER_USE_FUNCTION>
      <datavic:WATERBODY_STATE>2</datavic:WATERBODY_STATE>
      <datavic:FEATURE_QUALITY_ID>4762</datavic:
         FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2001−04−05T13:27:14</datavic:
         CREATE_DATE_PFI>
      <datavic:CREATE_DATE_UFI>2001−04−05T13:27:14</datavic:
         CREATE_DATE_UFI>
      <datavic:OBJECTID>7340</datavic:OBJECTID>
      <datavic:SHAPE>
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            <gml:Polygon>
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates xmlns:gml="http://www.
```

```
                    opengis.net/gml" decimal="." cs="," ts="
                     ">147.9527003,−36.19246784
                    147.95294777,−36.19245344
                    147.9530538,−36.19238182
                    147.95296538,−36.19225297
                    147.95273553,−36.19218143
                    147.95261181,−36.19223874
                    147.95254116,−36.19238196
                    147.9527003,−36.19246784</gml:
                    coordinates>
                </gml:LinearRing>
              </gml:outerBoundaryIs>
            </gml:Polygon>
          </gml:polygonMember>
        </gml:MultiPolygon>
      </datavic:SHAPE>
    </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
  </gml:featureMember>
  <gml:featureMember>
    <datavic:VMHYDRO_WATER_AREA_LAKES_DAMS fid="
        VMHYDRO_WATER_AREA_LAKES_DAMS.44585289">
      <datavic:PFI>16464235</datavic:PFI>
      <datavic:FEATURE_TYPE_CODE>wb_lake</datavic:
          FEATURE_TYPE_CODE>
      <datavic:NAMED_FEATURE_ID>0</datavic:NAMED_FEATURE_ID>
      <datavic:ORIGIN>2</datavic:ORIGIN>
      <datavic:WATER_USE_FUNCTION>1</datavic:
          WATER_USE_FUNCTION>
      <datavic:FEATURE_QUALITY_ID>5856</datavic:
          FEATURE_QUALITY_ID>
      <datavic:CREATE_DATE_PFI>2013−01−21T12:04:51</datavic:
          CREATE_DATE_PFI>
      <datavic:SUPERCEDED_PFI>0</datavic:SUPERCEDED_PFI>
      <datavic:CREATE_DATE_UFI>2013−01−21T12:04:51</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>408757</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:MultiPolygon srsName="EPSG:4283">
          <gml:polygonMember>
            <gml:Polygon>
```

```
                        <gml:outerBoundaryIs>
                          <gml:LinearRing>
                            <gml:coordinates xmlns:gml="http://www.
                                opengis.net/gml" decimal="." cs="," ts="
                                ">147.950983,−36.196017
                                147.950935,−36.1959125
                                147.9508445,−36.195756
                                147.9509005,−36.1955025
                                147.950718,−36.1954895
                                147.9505865,−36.195834
                                147.9505175,−36.1959635
                                147.9506425,−36.196096
                                147.9508785,−36.196137
                                147.950983,−36.196017</gml:coordinates>
                          </gml:LinearRing>
                        </gml:outerBoundaryIs>
                      </gml:Polygon>
                    </gml:polygonMember>
                  </gml:MultiPolygon>
                </datavic:SHAPE>
              </datavic:VMHYDRO_WATER_AREA_LAKES_DAMS>
            </gml:featureMember>
          </wfs:FeatureCollection>
```


Ground Truth Result 4 for DELWP

E.5 Results of Query 5: Retrieve Addresses that are within 500m from a Water Tank AND whose Road is a Lane


```
<?xml version="1.0" encoding="UTF−8"?>
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
    xmlns:wfs="http://www.opengis.net/wfs" xmlns:data.linz.
    govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.
    opengis.net/gml" xmlns:xsi="http://www.w3.org/2001/
    XMLSchema−instance" xsi:schemaLocation="http://data.linz.
    govt.nz https://data.linz.govt.nz/services;key=41
    b3c3b90c0247b587f512e1a4741498/wfs?service=WFS&amp;version
    =1.0.0&amp;request=DescribeFeatureType&amp;typeName=data.
    linz.govt.nz%3Alayer−50246 http://www.opengis.net/wfs http
    ://schemas.opengis.net/wfs/1.0.0/WFS−basic.xsd">
  <gml:boundedBy>
```

```
  <gml:null>unknown</gml:null>
</gml:boundedBy>
<gml:featureMember>
  <data.linz.govt.nz:layer-50246 fid="layer-50246.4916917">
    <data.linz.govt.nz:t50_fid>4916917</data.linz.govt.nz:
        t50_fid>
    <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
        macronated>
    <data.linz.govt.nz:GEOMETRY>
      <gml:MultiPolygon srsName="EPSG:2193">
        <gml:polygonMember>
          <gml:Polygon srsName="EPSG:2193">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates xmlns:gml="http://www.
                    opengis.net/gml" decimal="." cs="," ts="
                     ">1751687.560263805,5424276.983441306
                    1751669.6116933469,5424430.044861583
                    1751745.1184576266,5424438.899074983
                    1751749.1234279731,5424404.745577855
                    1751737.3464431427,5424403.364563347
                    1751747.2311631031,5424319.069868122
                    1751758.124050253,5424320.347209937
                    1751762.1829304006,5424285.733982016
                    1751687.560263805,5424276.983441306</gml
                    :coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:polygonMember>
      </gml:MultiPolygon>
    </data.linz.govt.nz:GEOMETRY>
  </data.linz.govt.nz:layer-50246>
</gml:featureMember>
<gml:featureMember>
  <data.linz.govt.nz:layer-50246 fid="layer-50246.4926285">
    <data.linz.govt.nz:t50_fid>4926285</data.linz.govt.nz:
        t50_fid>
    <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
        macronated>
```

```
        <data.linz.govt.nz:GEOMETRY>
          <gml:MultiPolygon srsName="EPSG:2193">
            <gml:polygonMember>
              <gml:Polygon srsName="EPSG:2193">
                <gml:outerBoundaryIs>
                  <gml:LinearRing>
                    <gml:coordinates xmlns:gml="http://www.
                        opengis.net/gml" decimal="." cs="," ts="
                         ">1751533.9007796505,5424352.6825799085
                         1751511.6955848522,5424354.70123398
                        1751516.2875930183,5424397.5627434645
                        1751501.5906673362,5424399.200003484
                        1751507.6352488482,5424454.578844253
                        1751526.3775070403,5424453.176178465
                        1751521.398139421,5424407.237733519
                        1751538.0273998603,5424405.725982571
                        1751533.9007796505,5424352.6825799085</
                        gml:coordinates>
                  </gml:LinearRing>
                </gml:outerBoundaryIs>
              </gml:Polygon>
            </gml:polygonMember>
          </gml:MultiPolygon>
        </data.linz.govt.nz:GEOMETRY>
      </data.linz.govt.nz:layer-50246>
    </gml:featureMember>
    <gml:featureMember>
      <data.linz.govt.nz:layer-50246 fid="layer-50246.4926362">
        <data.linz.govt.nz:t50_fid>4926362</data.linz.govt.nz:
            t50_fid>
        <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
            macronated>
        <data.linz.govt.nz:GEOMETRY>
          <gml:MultiPolygon srsName="EPSG:2193">
            <gml:polygonMember>
              <gml:Polygon srsName="EPSG:2193">
                <gml:outerBoundaryIs>
                  <gml:LinearRing>
                    <gml:coordinates xmlns:gml="http://www.
                        opengis.net/gml" decimal="." cs="," ts="
```

```
                    ">1751643.388542721,5424199.426428419
                    1751720.7614732906,5424210.01314719
                    1751722.2190095969,5424197.988472653
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      <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
          macronated>
      <data.linz.govt.nz:GEOMETRY>
        <gml:MultiPolygon srsName="EPSG:2193">
          <gml:polygonMember>
            <gml:Polygon srsName="EPSG:2193">
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates xmlns:gml="http://www.
                      opengis.net/gml" decimal="." cs="," ts="
                       ">1751816.1141619682,5424729.719794907
                      1751807.5848172586,5424716.305198025
                      1751745.0459676543,5424754.917338684
                      1751808.1866862588,5424861.982035451
                      1751828.0897388645,5424851.687353069
                      1751799.264628197,5424801.9297215585
                      1751844.314799481,5424774.072578967
                      1751849.795415001,5424782.692262
                      1751890.3379489062,5424842.812567143
                      1751917.4937970005,5424883.081828001
                      1751955.143649483,5424860.831269267
                      1751886.832374189,5424761.469414297
                      1752026.3106407989,5424679.642483999
                      1752065.373207341,5424744.909105134
                      1752120.7467411011,5424710.235957828
                      1752082.1220780006,5424646.899902001
                      1752067.9607556462,5424622.776825067
                      1752080.2915010005,5424615.196356
                      1752111.8401010009,5424596.400181001
```

```
                    1752095.191742001,5424569.455666001
                    1752052.5359890005,5424518.126113999
                    1752015.6193440007,5424539.7317160005
                    1751949.932949001,5424578.213882999
                    1751895.6521921344,5424609.939058662
                    1751929.3207822805,5424664.667289808
                    1751816.1141619682,5424729.719794907</
                    gml:coordinates>
                </gml:LinearRing>
              </gml:outerBoundaryIs>
            </gml:Polygon>
          </gml:polygonMember>
        </gml:MultiPolygon>
      </data.linz.govt.nz:GEOMETRY>
    </data.linz.govt.nz:layer-50246>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-50246 fid="layer-50246.4916133">
      <data.linz.govt.nz:t50_fid>4916133</data.linz.govt.nz:
          t50_fid>
      <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
          macronated>
      <data.linz.govt.nz:GEOMETRY>
        <gml:MultiPolygon srsName="EPSG:2193">
          <gml:polygonMember>
            <gml:Polygon srsName="EPSG:2193">
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates xmlns:gml="http://www.
                    opengis.net/gml" decimal="." cs="," ts="
                     ">1751840.7748227464,5424563.342728305
                    1751840.1588273942,5424562.259041253
                    1751766.5929323826,5424607.993264217
                    1751776.959873001,5424665.056207
                    1751782.138263001,5424676.283921001
                    1751874.3413495542,5424622.394489708
                    1751851.044001381,5424581.408734659
                    1751885.1834063763,5424561.008358503
                    1751870.1752133826,5424534.493884214
                    1751889.1855911743,5424523.9881491205
```

```
                        1751875.678217481,5424500.975586531
                        1751896.7165521784,5424488.157262071
                        1751822.2084060702,5424362.069208937
                        1751800.6372525143,5424374.906765386
                        1751816.1986599648,5424399.238595169
                        1751780.0190810002,5424420.186049
                        1751795.4698477406,5424446.926286769
                        1751776.944301445,5424456.591789182
                        1751841.1593735944,5424563.009450902
                        1751840.7748227464,5424563.342728305</
                        gml:coordinates>
                    </gml:LinearRing>
                  </gml:outerBoundaryIs>
                </gml:Polygon>
              </gml:polygonMember>
            </gml:MultiPolygon>
          </data.linz.govt.nz:GEOMETRY>
        </data.linz.govt.nz:layer-50246>
      </gml:featureMember>
      <gml:featureMember>
        <data.linz.govt.nz:layer-50246 fid="layer-50246.4916918">
          <data.linz.govt.nz:t50_fid>4916918</data.linz.govt.nz:
              t50_fid>
          <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
              macronated>
          <data.linz.govt.nz:GEOMETRY>
            <gml:MultiPolygon srsName="EPSG:2193">
              <gml:polygonMember>
                <gml:Polygon srsName="EPSG:2193">
                  <gml:outerBoundaryIs>
                    <gml:LinearRing>
                      <gml:coordinates xmlns:gml="http://www.
                        opengis.net/gml" decimal="." cs="," ts="
                         ">1751915.3818744123,5425045.9969845805
                         1751926.7621260006,5425061.255562001
                        1751919.9382258262,5425101.324108879
                        1751966.1526472988,5425134.520383457
                        1751983.2544050002,5425111.805271999
                        1752031.0555650005,5425131.771208
                        1752017.326782221,5425109.611211383
```

```
                        1751953.2579862382,5425037.304998775
                        1751907.494560537,5424974.609105565
                        1751898.4582834523,5424997.17893373
                        1751915.3818744123,5425045.9969845805</
                        gml:coordinates>
                    </gml:LinearRing>
                  </gml:outerBoundaryIs>
                </gml:Polygon>
              </gml:polygonMember>
            </gml:MultiPolygon>
          </data.linz.govt.nz:GEOMETRY>
        </data.linz.govt.nz:layer-50246>
      </gml:featureMember>
      <gml:featureMember>
        <data.linz.govt.nz:layer-50246 fid="layer-50246.4926370">
          <data.linz.govt.nz:t50_fid>4926370</data.linz.govt.nz:
              t50_fid>
          <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
              macronated>
          <data.linz.govt.nz:GEOMETRY>
            <gml:MultiPolygon srsName="EPSG:2193">
              <gml:polygonMember>
                <gml:Polygon srsName="EPSG:2193">
                  <gml:outerBoundaryIs>
                    <gml:LinearRing>
                      <gml:coordinates xmlns:gml="http://www.
                        opengis.net/gml" decimal="." cs="," ts="
                         ">1751819.1950870007,5424550.389547001
                        1751775.7972090011,5424554.948619001
                        1751777.2237400003,5424568.675825001
                        1751820.6298640007,5424564.116752999
                        1751819.1950870007,5424550.389547001</
                        gml:coordinates>
                    </gml:LinearRing>
                  </gml:outerBoundaryIs>
                </gml:Polygon>
              </gml:polygonMember>
            </gml:MultiPolygon>
          </data.linz.govt.nz:GEOMETRY>
        </data.linz.govt.nz:layer-50246>
```

```
</gml:featureMember>
<gml:featureMember>
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    <data.linz.govt.nz:t50_fid>4926222</data.linz.govt.nz:
        t50_fid>
    <data.linz.govt.nz:macronated>N</data.linz.govt.nz:
        macronated>
    <data.linz.govt.nz:GEOMETRY>
      <gml:MultiPolygon srsName="EPSG:2193">
        <gml:polygonMember>
          <gml:Polygon srsName="EPSG:2193">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates xmlns:gml="http://www.
                    opengis.net/gml" decimal="." cs="," ts="
                     ">1751135.7424195586,5424332.256446519
                    1751134.3864812646,5424298.551694627
                    1751114.8690460743,5424298.866491969
                    1751092.5184348086,5424298.866491969
                    1751092.5184348086,5424299.181289311
                    1751099.7587736687,5424417.230292473
                    1751119.276208859,5424415.656305763
                    1751120.8501955671,5424438.636511712
                    1751181.291285187,5424435.488538295
                    1751180.1009250004,5424417.266644001
                    1751174.9745265106,5424330.347453604
                    1751135.7424195586,5424332.256446519</
                    gml:coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:polygonMember>
      </gml:MultiPolygon>
    </data.linz.govt.nz:GEOMETRY>
  </data.linz.govt.nz:layer-50246>
</gml:featureMember>
</wfs:FeatureCollection>
```


Ground Truth Result 5 for LINZ


```
<?xml version="1.0" encoding="UTF-8"?>
```

```
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
    xmlns:wfs="http://www.opengis.net/wfs" xmlns:gml="http://
    www.opengis.net/gml" xmlns:datavic="http://land.vic.gov.au
    /datavic" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance" xsi:schemaLocation="http://land.vic.gov.au/
    datavic http://services.land.vic.gov.au/catalogue/
    publicproxy/guest/dv_geoserver/datavic/wfs?service=WFS&amp
    ;version=1.0.0&amp;request=DescribeFeatureType&amp;
    typeName=datavic%3AVMFEAT_BUILDING_POLYGON http://www.
    opengis.net/wfs http://schemas.opengis.net/wfs/1.0.0/WFS-
    basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
    <datavic:VMFEAT_BUILDING_POLYGON fid="
        VMFEAT_BUILDING_POLYGON.52438241">
      <datavic:PFI>11121</datavic:PFI>
      <datavic:FEATURE_TYPE>building</datavic:FEATURE_TYPE>
      <datavic:FEATURE_SUBTYPE>undefined_building</datavic:
          FEATURE_SUBTYPE>
      <datavic:STATE>VIC</datavic:STATE>
      <datavic:CREATE_DATE_PFI>2009-05-20</datavic:
          CREATE_DATE_PFI>
      <datavic:CREATE_DATE_UFI>2017-01-11</datavic:
          CREATE_DATE_UFI>
      <datavic:OBJECTID>273253</datavic:OBJECTID>
      <datavic:SHAPE>
        <gml:MultiPolygon srsName="EPSG:4283">
          <gml:polygonMember>
            <gml:Polygon>
              <gml:outerBoundaryIs>
                <gml:LinearRing>
                  <gml:coordinates xmlns:gml="http://www.
                      opengis.net/gml" decimal="." cs="," ts="
                       ">145.33427451,-37.8080898
                      145.33446918,-37.80745573
                      145.3339883,-37.80737439
                      145.33380005,-37.80800879
                      145.33427451,-37.8080898</gml:
```

```
                        coordinates>
                    </gml:LinearRing>
                </gml:outerBoundaryIs>
            </gml:Polygon>
        </gml:polygonMember>
    </gml:MultiPolygon>
  </datavic:SHAPE>
</datavic:VMFEAT_BUILDING_POLYGON>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMFEAT_BUILDING_POLYGON fid="
      VMFEAT_BUILDING_POLYGON.52441516">
    <datavic:PFI>13391</datavic:PFI>
    <datavic:FEATURE_TYPE>building</datavic:FEATURE_TYPE>
    <datavic:FEATURE_SUBTYPE>undefined_building</datavic:
        FEATURE_SUBTYPE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:CREATE_DATE_PFI>2009-05-20</datavic:
        CREATE_DATE_PFI>
    <datavic:CREATE_DATE_UFI>2017-01-11</datavic:
        CREATE_DATE_UFI>
    <datavic:OBJECTID>261421</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:MultiPolygon srsName="EPSG:4283">
        <gml:polygonMember>
          <gml:Polygon>
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates xmlns:gml="http://www.
                    opengis.net/gml" decimal="." cs="," ts="
                    ">145.37035994,-37.85239576
                    145.37085745,-37.85235351
                    145.37085203,-37.8522829
                    145.37035259,-37.85232291
                    145.37035994,-37.85239576</gml:
                    coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:polygonMember>
```

```
      </gml:MultiPolygon>
    </datavic:SHAPE>
  </datavic:VMFEAT_BUILDING_POLYGON>
</gml:featureMember>
<gml:featureMember>
  <datavic:VMFEAT_BUILDING_POLYGON fid="
     VMFEAT_BUILDING_POLYGON.52514084">
    <datavic:PFI>13438</datavic:PFI>
    <datavic:FEATURE_TYPE>building</datavic:FEATURE_TYPE>
    <datavic:FEATURE_SUBTYPE>undefined_building</datavic:
       FEATURE_SUBTYPE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:CREATE_DATE_PFI>2009-05-20</datavic:
       CREATE_DATE_PFI>
    <datavic:CREATE_DATE_UFI>2017-01-13</datavic:
       CREATE_DATE_UFI>
    <datavic:OBJECTID>277714</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:MultiPolygon srsName="EPSG:4283">
        <gml:polygonMember>
          <gml:Polygon>
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates xmlns:gml="http://www.
                   opengis.net/gml" decimal="." cs="," ts="
                    ">145.36654319,-37.85488902
                   145.36675011,-37.85485165
                   145.36673089,-37.85477132
                   145.36682928,-37.85475149
                   145.36684397,-37.85479509
                   145.36701033,-37.85475439
                   145.36702798,-37.8548106
                   145.36717265,-37.854778
                   145.36707811,-37.85439705
                   145.36691605,-37.85442855
                   145.36696624,-37.85462247
                   145.3665886,-37.85469711
                   145.36661511,-37.8547889
                   145.36651964,-37.85480986
                   145.36654319,-37.85488902</gml:
```

```
                    coordinates>
                </gml:LinearRing>
              </gml:outerBoundaryIs>
            </gml:Polygon>
          </gml:polygonMember>
        </gml:MultiPolygon>
      </datavic:SHAPE>
    </datavic:VMFEAT_BUILDING_POLYGON>
  </gml:featureMember>
</wfs:FeatureCollection>
```


Ground Truth Result 5 for DELWP

E.6 Results of Query 6: Retrieve Roads that are either of Type Lane OR Street


```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection xmlns="http://www.opengis.net/wfs"
    xmlns:wfs="http://www.opengis.net/wfs" xmlns:data.linz.
    govt.nz="http://data.linz.govt.nz" xmlns:gml="http://www.
    opengis.net/gml" xmlns:xsi="http://www.w3.org/2001/
    XMLSchema-instance" xsi:schemaLocation="http://data.linz.
    govt.nz https://data.linz.govt.nz/services;key=41
    b3c3b90c0247b587f512e1a4741498/wfs?service=WFS&amp;version
    =1.0.0&amp;request=DescribeFeatureType&amp;typeName=data.
    linz.govt.nz%3Alayer-53353 http://www.opengis.net/wfs http
    ://schemas.opengis.net/wfs/1.0.0/WFS-basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
    <data.linz.govt.nz:layer-53353 fid="layer-53353.1522190">
      <data.linz.govt.nz:address_id>1522190</data.linz.govt.nz
          :address_id>
      <data.linz.govt.nz:change_id>1324707</data.linz.govt.nz:
          change_id>
      <data.linz.govt.nz:address_type>Road</data.linz.govt.nz:
          address_type>
      <data.linz.govt.nz:address_number>16</data.linz.govt.nz:
          address_number>
      <data.linz.govt.nz:suburb_locality>Miramar</data.linz.
```

```
      govt.nz:suburb_locality>
    <data.linz.govt.nz:town_city>Wellington</data.linz.govt.
      nz:town_city>
    <data.linz.govt.nz:full_address_number>16</data.linz.
      govt.nz:full_address_number>
    <data.linz.govt.nz:full_road_name>Ropa Lane</data.linz.
      govt.nz:full_road_name>
    <data.linz.govt.nz:full_address>16 Ropa Lane, Miramar,
      Wellington</data.linz.govt.nz:full_address>
    <data.linz.govt.nz:road_section_id>81205</data.linz.govt
      .nz:road_section_id>
    <data.linz.govt.nz:gd2000_xcoord>174.81265278</data.linz
      .govt.nz:gd2000_xcoord>
    <data.linz.govt.nz:gd2000_ycoord>-41.31332312</data.linz
      .govt.nz:gd2000_ycoord>
    <data.linz.govt.nz:suburb_locality_ascii>Miramar</data.
      linz.govt.nz:suburb_locality_ascii>
    <data.linz.govt.nz:town_city_ascii>Wellington</data.linz
      .govt.nz:town_city_ascii>
    <data.linz.govt.nz:full_road_name_ascii>Ropa Lane</data.
      linz.govt.nz:full_road_name_ascii>
    <data.linz.govt.nz:full_address_ascii>16 Ropa Lane,
      Miramar, Wellington</data.linz.govt.nz:
      full_address_ascii>
    <data.linz.govt.nz:shape>
      <gml:Point srsName="EPSG:4167">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
          gml" decimal="." cs="," ts=" ">
          174.8126527833,-41.3133231167</gml:coordinates>
      </gml:Point>
    </data.linz.govt.nz:shape>
  </data.linz.govt.nz:layer-53353>
</gml:featureMember>
<gml:featureMember>
  <data.linz.govt.nz:layer-53353 fid="layer-53353.382834">
    <data.linz.govt.nz:address_id>382834</data.linz.govt.nz:
      address_id>
    <data.linz.govt.nz:change_id>340314</data.linz.govt.nz:
      change_id>
    <data.linz.govt.nz:address_type>Road</data.linz.govt.nz:
```

```
        address_type>
      <data.linz.govt.nz:address_number>7</data.linz.govt.nz:
        address_number>
      <data.linz.govt.nz:suburb_locality>Miramar</data.linz.
        govt.nz:suburb_locality>
      <data.linz.govt.nz:town_city>Wellington</data.linz.govt.
        nz:town_city>
      <data.linz.govt.nz:full_address_number>7</data.linz.govt
        .nz:full_address_number>
      <data.linz.govt.nz:full_road_name>Ropa Lane</data.linz.
        govt.nz:full_road_name>
      <data.linz.govt.nz:full_address>7 Ropa Lane, Miramar,
        Wellington</data.linz.govt.nz:full_address>
      <data.linz.govt.nz:road_section_id>81205</data.linz.govt
        .nz:road_section_id>
      <data.linz.govt.nz:gd2000_xcoord>174.81305398</data.linz
        .govt.nz:gd2000_xcoord>
      <data.linz.govt.nz:gd2000_ycoord>-41.31312468</data.linz
        .govt.nz:gd2000_ycoord>
      <data.linz.govt.nz:suburb_locality_ascii>Miramar</data.
        linz.govt.nz:suburb_locality_ascii>
      <data.linz.govt.nz:town_city_ascii>Wellington</data.linz
        .govt.nz:town_city_ascii>
      <data.linz.govt.nz:full_road_name_ascii>Ropa Lane</data.
        linz.govt.nz:full_road_name_ascii>
      <data.linz.govt.nz:full_address_ascii>7 Ropa Lane,
        Miramar, Wellington</data.linz.govt.nz:
        full_address_ascii>
      <data.linz.govt.nz:shape>
        <gml:Point srsName="EPSG:4167">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              174.8130539833,-41.3131246833</gml:coordinates>
        </gml:Point>
      </data.linz.govt.nz:shape>
    </data.linz.govt.nz:layer-53353>
  </gml:featureMember>
  <gml:featureMember>
    <data.linz.govt.nz:layer-53353 fid="layer-53353.382811">
      <data.linz.govt.nz:address_id>382811</data.linz.govt.nz:
```

```
    address_id>
  <data.linz.govt.nz:change_id>340292</data.linz.govt.nz:
    change_id>
  <data.linz.govt.nz:address_type>Road</data.linz.govt.nz:
    address_type>
  <data.linz.govt.nz:address_number>5</data.linz.govt.nz:
    address_number>
  <data.linz.govt.nz:suburb_locality>Miramar</data.linz.
    govt.nz:suburb_locality>
  <data.linz.govt.nz:town_city>Wellington</data.linz.govt.
    nz:town_city>
  <data.linz.govt.nz:full_address_number>5</data.linz.govt
    .nz:full_address_number>
  <data.linz.govt.nz:full_road_name>Ropa Lane</data.linz.
    govt.nz:full_road_name>
  <data.linz.govt.nz:full_address>5 Ropa Lane, Miramar,
    Wellington</data.linz.govt.nz:full_address>
  <data.linz.govt.nz:road_section_id>81205</data.linz.govt
    .nz:road_section_id>
  <data.linz.govt.nz:gd2000_xcoord>174.81323907</data.linz
    .govt.nz:gd2000_xcoord>
  <data.linz.govt.nz:gd2000_ycoord>-41.31290310</data.linz
    .govt.nz:gd2000_ycoord>
  <data.linz.govt.nz:suburb_locality_ascii>Miramar</data.
    linz.govt.nz:suburb_locality_ascii>
  <data.linz.govt.nz:town_city_ascii>Wellington</data.linz
    .govt.nz:town_city_ascii>
  <data.linz.govt.nz:full_road_name_ascii>Ropa Lane</data.
    linz.govt.nz:full_road_name_ascii>
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</data.linz.govt.nz:layer-53353>
```

```
</gml:featureMember>
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        :address_id>
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    <data.linz.govt.nz:address_number>11</data.linz.govt.nz:
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    <data.linz.govt.nz:suburb_locality>Miramar</data.linz.
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    <data.linz.govt.nz:town_city>Wellington</data.linz.govt.
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    <data.linz.govt.nz:road_section_id>81205</data.linz.govt
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        .govt.nz:town_city_ascii>
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        full_address_ascii>
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```
            174.8122528,-41.3139854</gml:coordinates>
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    </gml:featureMember>
</wfs:FeatureCollection>
```


Ground Truth Result 6 for LINZ


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    xmlns:wfs="http://www.opengis.net/wfs" xmlns:gml="http://
    www.opengis.net/gml" xmlns:datavic="http://land.vic.gov.au
    /datavic" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance" xsi:schemaLocation="http://land.vic.gov.au/
    datavic http://services.land.vic.gov.au/catalogue/
    publicproxy/guest/dv_geoserver/datavic/wfs?service=WFS&amp
    ;version=1.0.0&amp;request=DescribeFeatureType&amp;
    typeName=datavic%3AVMADD_ADDRESS http://www.opengis.net/
    wfs http://schemas.opengis.net/wfs/1.0.0/WFS-basic.xsd">
  <gml:boundedBy>
    <gml:null>unknown</gml:null>
  </gml:boundedBy>
  <gml:featureMember>
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      <datavic:PROPERTY_PFI>221778024</datavic:PROPERTY_PFI>
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        </gml:Point>
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      <datavic:UFI_CREATED>2011-06-01</datavic:UFI_CREATED>
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              gml" decimal="." cs="," ts=" ">
              145.33346128,-37.81201666</gml:coordinates>
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  </gml:featureMember>
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        datavic:EZI_ADDRESS>
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    <datavic:SOURCE_VERIFIED>2011-05-22</datavic:
        SOURCE_VERIFIED>
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    <datavic:PROPERTY_STATUS>A</datavic:PROPERTY_STATUS>
    <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
    <datavic:DISTANCE_RELATED_FLAG>N</datavic:
        DISTANCE_RELATED_FLAG>
    <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
    <datavic:HOUSE_NUMBER_1>14</datavic:HOUSE_NUMBER_1>
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    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LOCALITY_NAME>MONTROSE</datavic:LOCALITY_NAME>
    <datavic:LGA_CODE>377</datavic:LGA_CODE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:POSTCODE>3765</datavic:POSTCODE>
    <datavic:MESH_BLOCK>20657990000</datavic:MESH_BLOCK>
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    <datavic:NUM_ADDRESS>14</datavic:NUM_ADDRESS>
    <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
    <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
    <datavic:OUTSIDE_PROPERTY>N</datavic:OUTSIDE_PROPERTY>
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            gml" decimal="." cs="," ts=" ">
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    </datavic:SHAPE>
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      <datavic:PROPERTY_PFI>216511219</datavic:PROPERTY_PFI>
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      </gml:Point>
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    <datavic:PROPERTY_PFI>1330705</datavic:PROPERTY_PFI>
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    <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
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    <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
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    <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
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    <datavic:SHAPE>
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      <datavic:PROPERTY_PFI>1330710</datavic:PROPERTY_PFI>
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      <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
      <datavic:DISTANCE_RELATED_FLAG>N</datavic:
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      <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
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      <datavic:LGA_CODE>377</datavic:LGA_CODE>
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          <datavic:PROPERTY_PFI>1330712</datavic:PROPERTY_PFI>
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          <datavic:LABEL_ADDRESS>Y</datavic:LABEL_ADDRESS>
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          <datavic:SHAPE>
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          gml" decimal="." cs="," ts=" ">
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    <datavic:PROPERTY_PFI>1330706</datavic:PROPERTY_PFI>
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    <datavic:SOURCE>LGO</datavic:SOURCE>
    <datavic:SOURCE_VERIFIED>2009−12−08</datavic:
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    <datavic:IS_PRIMARY>Y</datavic:IS_PRIMARY>
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        DISTANCE_RELATED_FLAG>
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    <datavic:LOCALITY_NAME>OLINDA</datavic:LOCALITY_NAME>
    <datavic:LGA_CODE>377</datavic:LGA_CODE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:POSTCODE>3788</datavic:POSTCODE>
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    <datavic:NUM_ADDRESS>5</datavic:NUM_ADDRESS>
    <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
    <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
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          </gml:Point>
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    </gml:featureMember>
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        <datavic:PFI>51701984</datavic:PFI>
        <datavic:PROPERTY_PFI>1330713</datavic:PROPERTY_PFI>
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        <datavic:SOURCE>LGO</datavic:SOURCE>
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        <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
        <datavic:DISTANCE_RELATED_FLAG>N</datavic:
            DISTANCE_RELATED_FLAG>
        <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
        <datavic:HOUSE_NUMBER_1>14</datavic:HOUSE_NUMBER_1>
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        <datavic:LOCALITY_NAME>OLINDA</datavic:LOCALITY_NAME>
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        <datavic:MESH_BLOCK>20650840000</datavic:MESH_BLOCK>
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        <datavic:NUM_ADDRESS>14</datavic:NUM_ADDRESS>
        <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
        <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
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        </gml:Point>
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    </datavic:VMADD_ADDRESS>
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      <datavic:PROPERTY_PFI>1330708</datavic:PROPERTY_PFI>
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      <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
      <datavic:DISTANCE_RELATED_FLAG>N</datavic:
          DISTANCE_RELATED_FLAG>
      <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
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      <datavic:POSTCODE>3788</datavic:POSTCODE>
      <datavic:MESH_BLOCK>20650840000</datavic:MESH_BLOCK>
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      <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
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      <datavic:LABEL_ADDRESS>Y</datavic:LABEL_ADDRESS>
      <datavic:UFI_CREATED>2008-07-23</datavic:UFI_CREATED>
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        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMADD_ADDRESS>
  </gml:featureMember>
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    <datavic:VMADD_ADDRESS fid="VMADD_ADDRESS.460363792">
      <datavic:PFI>51701276</datavic:PFI>
      <datavic:PROPERTY_PFI>1330709</datavic:PROPERTY_PFI>
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      <datavic:SOURCE_VERIFIED>2009-12-08</datavic:SOURCE_VERIFIED>
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      <datavic:DISTANCE_RELATED_FLAG>N</datavic:DISTANCE_RELATED_FLAG>
      <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
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      <datavic:NUM_ADDRESS>9</datavic:NUM_ADDRESS>
      <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
      <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
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              gml" decimal="." cs="," ts=" ">
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        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMADD_ADDRESS>
  </gml:featureMember>
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      <datavic:PFI>51701980</datavic:PFI>
      <datavic:PROPERTY_PFI>1330714</datavic:PROPERTY_PFI>
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      <datavic:SOURCE_VERIFIED>2009-12-08</datavic:
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        </gml:Point>
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  <gml:featureMember>
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      </datavic:SHAPE>
    </datavic:VMADD_ADDRESS>
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  <gml:featureMember>
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    <datavic:POSTCODE>3788</datavic:POSTCODE>
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        <gml:Point srsName="EPSG:4283">
          <gml:coordinates xmlns:gml="http://www.opengis.net/
              gml" decimal="." cs="," ts=" ">
              145.36602002,-37.85326675</gml:coordinates>
        </gml:Point>
      </datavic:SHAPE>
    </datavic:VMADD_ADDRESS>
  </gml:featureMember>
  <gml:featureMember>
```

```xml
  <datavic:VMADD_ADDRESS fid="VMADD_ADDRESS.461356370">
    <datavic:PFI>51702000</datavic:PFI>
    <datavic:PROPERTY_PFI>1331586</datavic:PROPERTY_PFI>
    <datavic:EZI_ADDRESS>8 CHARLEMONT LANE OLINDA 3788</
        datavic:EZI_ADDRESS>
    <datavic:SOURCE>LGO</datavic:SOURCE>
    <datavic:SOURCE_VERIFIED>2009-12-08</datavic:
        SOURCE_VERIFIED>
    <datavic:IS_PRIMARY>Y</datavic:IS_PRIMARY>
    <datavic:PROPERTY_STATUS>A</datavic:PROPERTY_STATUS>
    <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
    <datavic:DISTANCE_RELATED_FLAG>N</datavic:
        DISTANCE_RELATED_FLAG>
    <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
    <datavic:HOUSE_NUMBER_1>8</datavic:HOUSE_NUMBER_1>
    <datavic:ROAD_NAME>CHARLEMONT</datavic:ROAD_NAME>
    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LOCALITY_NAME>OLINDA</datavic:LOCALITY_NAME>
    <datavic:LGA_CODE>377</datavic:LGA_CODE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:POSTCODE>3788</datavic:POSTCODE>
    <datavic:MESH_BLOCK>20649570000</datavic:MESH_BLOCK>
    <datavic:NUM_ROAD_ADDRESS>8 CHARLEMONT LANE</datavic:
        NUM_ROAD_ADDRESS>
    <datavic:NUM_ADDRESS>8</datavic:NUM_ADDRESS>
    <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
    <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
    <datavic:OUTSIDE_PROPERTY>N</datavic:OUTSIDE_PROPERTY>
    <datavic:LABEL_ADDRESS>Y</datavic:LABEL_ADDRESS>
    <datavic:UFI_CREATED>2008-07-23</datavic:UFI_CREATED>
    <datavic:OBJECTID>174660</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.36561585,-37.85369327</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMADD_ADDRESS>
</gml:featureMember>
```

```xml
<gml:featureMember>
  <datavic:VMADD_ADDRESS fid="VMADD_ADDRESS.461356371">
    <datavic:PFI>51701280</datavic:PFI>
    <datavic:PROPERTY_PFI>1331587</datavic:PROPERTY_PFI>
    <datavic:EZI_ADDRESS>6 CHARLEMONT LANE OLINDA 3788</
        datavic:EZI_ADDRESS>
    <datavic:SOURCE>LGO</datavic:SOURCE>
    <datavic:SOURCE_VERIFIED>2009-12-08</datavic:
        SOURCE_VERIFIED>
    <datavic:IS_PRIMARY>Y</datavic:IS_PRIMARY>
    <datavic:PROPERTY_STATUS>A</datavic:PROPERTY_STATUS>
    <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
    <datavic:DISTANCE_RELATED_FLAG>N</datavic:
        DISTANCE_RELATED_FLAG>
    <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
    <datavic:HOUSE_NUMBER_1>6</datavic:HOUSE_NUMBER_1>
    <datavic:ROAD_NAME>CHARLEMONT</datavic:ROAD_NAME>
    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LOCALITY_NAME>OLINDA</datavic:LOCALITY_NAME>
    <datavic:LGA_CODE>377</datavic:LGA_CODE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:POSTCODE>3788</datavic:POSTCODE>
    <datavic:MESH_BLOCK>20649570000</datavic:MESH_BLOCK>
    <datavic:NUM_ROAD_ADDRESS>6 CHARLEMONT LANE</datavic:
        NUM_ROAD_ADDRESS>
    <datavic:NUM_ADDRESS>6</datavic:NUM_ADDRESS>
    <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
    <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
    <datavic:OUTSIDE_PROPERTY>N</datavic:OUTSIDE_PROPERTY>
    <datavic:LABEL_ADDRESS>Y</datavic:LABEL_ADDRESS>
    <datavic:UFI_CREATED>2008-07-23</datavic:UFI_CREATED>
    <datavic:OBJECTID>1867314</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.3655971,-37.85351277</gml:coordinates>
      </gml:Point>
    </datavic:SHAPE>
  </datavic:VMADD_ADDRESS>
```

```
</gml:featureMember>
<gml:featureMember>
  <datavic:VMADD_ADDRESS fid="VMADD_ADDRESS.461356372">
    <datavic:PFI>52128999</datavic:PFI>
    <datavic:PROPERTY_PFI>52439554</datavic:PROPERTY_PFI>
    <datavic:EZI_ADDRESS>3-5 CHARLEMONT LANE OLINDA 3788</
        datavic:EZI_ADDRESS>
    <datavic:SOURCE>LGO</datavic:SOURCE>
    <datavic:SOURCE_VERIFIED>2009-12-08</datavic:
        SOURCE_VERIFIED>
    <datavic:IS_PRIMARY>Y</datavic:IS_PRIMARY>
    <datavic:PROPERTY_STATUS>A</datavic:PROPERTY_STATUS>
    <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
    <datavic:DISTANCE_RELATED_FLAG>N</datavic:
        DISTANCE_RELATED_FLAG>
    <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
    <datavic:HOUSE_NUMBER_1>3</datavic:HOUSE_NUMBER_1>
    <datavic:HOUSE_NUMBER_2>5</datavic:HOUSE_NUMBER_2>
    <datavic:ROAD_NAME>CHARLEMONT</datavic:ROAD_NAME>
    <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
    <datavic:LOCALITY_NAME>OLINDA</datavic:LOCALITY_NAME>
    <datavic:LGA_CODE>377</datavic:LGA_CODE>
    <datavic:STATE>VIC</datavic:STATE>
    <datavic:POSTCODE>3788</datavic:POSTCODE>
    <datavic:MESH_BLOCK>20651162000</datavic:MESH_BLOCK>
    <datavic:NUM_ROAD_ADDRESS>3-5 CHARLEMONT LANE</datavic:
        NUM_ROAD_ADDRESS>
    <datavic:NUM_ADDRESS>3-5</datavic:NUM_ADDRESS>
    <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
    <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
    <datavic:OUTSIDE_PROPERTY>N</datavic:OUTSIDE_PROPERTY>
    <datavic:LABEL_ADDRESS>Y</datavic:LABEL_ADDRESS>
    <datavic:UFI_CREATED>2008-07-23</datavic:UFI_CREATED>
    <datavic:OBJECTID>2479954</datavic:OBJECTID>
    <datavic:SHAPE>
      <gml:Point srsName="EPSG:4283">
        <gml:coordinates xmlns:gml="http://www.opengis.net/
            gml" decimal="." cs="," ts=" ">
            145.36574234,-37.85254057</gml:coordinates>
      </gml:Point>
```

```
        </datavic:SHAPE>
      </datavic:VMADD_ADDRESS>
    </gml:featureMember>
    <gml:featureMember>
      <datavic:VMADD_ADDRESS fid="VMADD_ADDRESS.460363785">
        <datavic:PFI>51702479</datavic:PFI>
        <datavic:PROPERTY_PFI>1331585</datavic:PROPERTY_PFI>
        <datavic:EZI_ADDRESS>4 CHARLEMONT LANE OLINDA 3788</
            datavic:EZI_ADDRESS>
        <datavic:SOURCE>LGO</datavic:SOURCE>
        <datavic:SOURCE_VERIFIED>2009-12-08</datavic:
            SOURCE_VERIFIED>
        <datavic:IS_PRIMARY>Y</datavic:IS_PRIMARY>
        <datavic:PROPERTY_STATUS>A</datavic:PROPERTY_STATUS>
        <datavic:GEOCODE_FEATURE>V</datavic:GEOCODE_FEATURE>
        <datavic:DISTANCE_RELATED_FLAG>N</datavic:
            DISTANCE_RELATED_FLAG>
        <datavic:HSA_FLAG>N</datavic:HSA_FLAG>
        <datavic:HOUSE_NUMBER_1>4</datavic:HOUSE_NUMBER_1>
        <datavic:ROAD_NAME>CHARLEMONT</datavic:ROAD_NAME>
        <datavic:ROAD_TYPE>LANE</datavic:ROAD_TYPE>
        <datavic:LOCALITY_NAME>OLINDA</datavic:LOCALITY_NAME>
        <datavic:LGA_CODE>377</datavic:LGA_CODE>
        <datavic:STATE>VIC</datavic:STATE>
        <datavic:POSTCODE>3788</datavic:POSTCODE>
        <datavic:MESH_BLOCK>20649570000</datavic:MESH_BLOCK>
        <datavic:NUM_ROAD_ADDRESS>4 CHARLEMONT LANE</datavic:
            NUM_ROAD_ADDRESS>
        <datavic:NUM_ADDRESS>4</datavic:NUM_ADDRESS>
        <datavic:ADDRESS_CLASS>S</datavic:ADDRESS_CLASS>
        <datavic:ADD_ACCESS_TYPE>L</datavic:ADD_ACCESS_TYPE>
        <datavic:OUTSIDE_PROPERTY>N</datavic:OUTSIDE_PROPERTY>
        <datavic:LABEL_ADDRESS>Y</datavic:LABEL_ADDRESS>
        <datavic:UFI_CREATED>2008-07-23</datavic:UFI_CREATED>
        <datavic:OBJECTID>1428064</datavic:OBJECTID>
        <datavic:SHAPE>
          <gml:Point srsName="EPSG:4283">
            <gml:coordinates xmlns:gml="http://www.opengis.net/
                gml" decimal="." cs="," ts=" ">
                145.36543162,-37.85277147</gml:coordinates>
```

```
        &lt;/gml:Point&gt;
      &lt;/datavic:SHAPE&gt;
    &lt;/datavic:VMADD_ADDRESS&gt;
  &lt;/gml:featureMember&gt;
&lt;/wfs:FeatureCollection&gt;
```

Ground Truth Result 6 for DELWP

APPENDIX F EVALUATION RESULTS

This appendix shows the results of the broker evaluation for each query. They are in JSON format as used in the implemented system.

F.1 Results of query 1: Retrieve Roads that are lanes


```
{
  "https://data.linz.govt.nz/services;key=41
     b3c3b90c0247b587f512e1a4741498/wfs": [{
    "geom": "<LineString srsName=\"EPSG:2193\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">1751750.8016000008,5424882.063599999
        1751749.7699000007,5424897.283400001
        1751755.995600001,5424910.5430000005
        1751770.055300001,5424928.126099999
        1751776.902900001,5424941.354100001
        1751777.9478000011,5424949.7422
        1751777.0301646963,5424960.610032867
        1751776.4105142765,5424967.948740477</coordinates></
        LineString>",
    "name": "ROPA LANE"
  },
  {
    "geom": "<LineString srsName=\"EPSG:2193\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">1748569.6645210003,5426405.691905
        1748601.3697930006,5426391.704751998</coordinates></
        LineString>",
    "name": "HILL LANE"
  },
  {
    "geom": "<LineString srsName=\"EPSG:2193\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">1752012.9229530003,5423658.741039
        1752134.4666980011,5423660.300722
        1752167.4500750005,5423651.042606001</coordinates></
        LineString>",
    "name": "FIFE LANE"
  }],
  "http://services.land.vic.gov.au/catalogue/publicproxy/guest
     /dv_geoserver/datavic/wfs": [{
```

```
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "BRIENS",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.28153219,-37.79833516 145.2814088,-37.79832089
        145.28061894,-37.79821482</coordinates></LineString>"
},
{
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "HARRY LACEY",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.28321896,-37.79437979 145.28332248,-37.79431888
         145.28336,-37.79424883 145.28338148,-37.7941605</
        coordinates></LineString>"
},
{
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "PARK",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.27437052,-37.80794288
        145.27427689,-37.80841324</coordinates></LineString>"
},
{
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "PARK",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\" \">145.27456598,-37.806961
        145.27437052,-37.80794288</coordinates></LineString>"
},
{
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "THOMAS BREW",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\" \">145.2825932,-37.79511621
         145.2822672,-37.79557287 145.28226373,-37.79561863
        145.28192377,-37.79609227</coordinates></LineString>"
},
{
```

```
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "HARRY LACEY",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.28247449,-37.79510166 145.28260352,-37.79492765
         145.28281982,-37.79482028 145.28299235,-37.79481057
        145.28308503,-37.79476371 145.28325792,-37.79472986
        145.2833299,-37.79450521 145.28321896,-37.79437979</
        coordinates></LineString>"
  },
  {
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "EMMERSON",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.29708642,-37.80050222
        145.29735611,-37.79919972</coordinates></LineString>"
  },
  {
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "EMMERSON",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.29706036,-37.80062805
        145.29708642,-37.80050222</coordinates></LineString>"
  },
  {
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "JENKINS",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.29029994,-37.80540191 145.29087682,-37.80547321
         145.29098428,-37.80549238</coordinates></LineString>"
  },
  {
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "JENKINS",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\"
        \">145.28877392,-37.80506539 145.28892671,-37.80514383
```

```
        145.2890395,−37.80516343 145.28921512,−37.80524498
        145.28935302,−37.80528439 145.289566,−37.8053112
        145.29029994,−37.80540191</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "OAK",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
      =\",\" decimal=\".\" ts=\" \">145.26836923,−37.8160121
        145.26924522,−37.81610419</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "GREENRIDGE",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
      =\",\" decimal=\".\" ts=\"
      \">145.28096363,−37.81842044
      145.28145034,−37.81848229</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "BLUEGUM",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
      =\",\" decimal=\".\" ts=\"
      \">145.27632929,−37.81802367
      145.27626313,−37.81841217</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "FAIR",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
      =\",\" decimal=\".\" ts=\"
      \">145.26897807,−37.82096562
      145.27026575,−37.82101136</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "FERNHILL",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
      =\",\" decimal=\".\" ts=\"
```

```
\">145.27174647,-37.82498088 145.27202026,-37.82525284
   145.27208071,-37.82531797</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "NEWHAVEN",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
     \">145.29203255,-37.78866378 145.29342593,-37.78882311
      145.29385992,-37.78879073 145.2943232,-37.78885015
     145.29427948,-37.78910916</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "EOTHEN",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
     \">145.32087034,-37.80262759
     145.32236814,-37.80242701</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "EOTHEN",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\" \">145.319331,-37.80283371
     145.32087034,-37.80262759</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "EOTHEN",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
     \">145.31780873,-37.80390721 145.31845535,-37.80295096
      145.319331,-37.80283371</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "PAVITT",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
```

```
    \">145.32601691,-37.84663575 145.32546075,-37.84655362
     145.32541239,-37.84654648 145.32532358,-37.84653336</
    coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "PAVITT",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
    =\",\" decimal=\".\" ts=\"
    \">145.32532358,-37.84653336 145.3240772,-37.8463493
    145.32388052,-37.84632025 145.32375804,-37.84630216
    145.32304918,-37.84619746 145.32015265,-37.84489301
    145.31810107,-37.844947 145.31776704,-37.84493819</
    coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "DOBSON",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
    =\",\" decimal=\".\" ts=\"
    \">145.31776704,-37.84493819 145.31753173,-37.84523242
     145.31745187,-37.84532966</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "PAVITT",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
    =\",\" decimal=\".\" ts=\"
    \">145.31776704,-37.84493819
    145.31749782,-37.84481663</coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "DOBSON",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
    =\",\" decimal=\".\" ts=\"
    \">145.31745187,-37.84532966 145.31575294,-37.84739856
     145.31398447,-37.84715186 145.31345655,-37.8470782</
    coordinates></LineString>"
},
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```
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "CHANDLERS",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
     \">145.31169188,-37.84197807 145.31343807,-37.84224916
      145.31367915,-37.84217117 145.31820232,-37.84281354</
     coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "LILLYPILLY",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
     \">145.31205613,-37.83931791 145.31494105,-37.83969143
      145.31502323,-37.83970621 145.31513107,-37.83973117
     145.31521038,-37.83975377 145.31528808,-37.83977964
     145.31538883,-37.83981908 145.31546198,-37.83985226
     145.31555591,-37.83990113 145.31562342,-37.83994113
     145.31570915,-37.83999871 145.31577001,-37.84004493
     145.31584626,-37.84011037 145.31589957,-37.84016212
     145.31596519,-37.84023444 145.31601015,-37.84029096
     145.31614888,-37.84048373 145.31621346,-37.84055603
     145.31626593,-37.84060787 145.31638063,-37.84070472
     145.31644256,-37.8407495 145.31652953,-37.84080514
     145.3165978,-37.84084367 145.31669258,-37.8408906
     145.31684181,-37.84095103 145.31691918,-37.84097656
     145.31702474,-37.84100563 145.31710542,-37.8410236
     145.31721462,-37.84104237 145.31853463,-37.8412085</
     coordinates></LineString>"
},
{
  "ROAD_TYPE": "LANE",
  "ROAD_NAME": "CHANDLERS",
  "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
     =\",\" decimal=\".\" ts=\"
     \">145.31161969,-37.84204934
     145.31169188,-37.84197807</coordinates></LineString>"
},
{
```

```
    "ROAD_TYPE": "LANE",
    "ROAD_NAME": "CHERRY",
    "geom": "<LineString srsName=\"EPSG:4283\"><coordinates cs
        =\",\" decimal=\".\" ts=\" \">145.33402924,-37.8129711
         145.33423404,-37.81293251 145.33515336,-37.81257861</
        coordinates></LineString>"
  },
  {
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        coordinates></LineString>"
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Evaluation Result for Query 1

F.2 Results of query 2: Retrieve height points that have an elevation between 120 and 140


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Evaluation Result for Query 2

F.3 Results of query 3: Retrieve mines that are underneath a lake


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Evaluation Result for Query 3

F.4 Results of query 4: Retrieve buildings within 500m of a water tank


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Evaluation Result for Query 4

F.5 Results of query 5: Retrieve addresses that are within 500m from a water tank AND whose road is a lane


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Evaluation Result for Query 5

Results of query 6: Retrieve roads that are either of type lane OR street


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Evaluation Result for Query 6