INCOSADA

Integrated Corporate Spatial And Attribute Database

Standard Positional Spatial Data Types and their representation in IGDS Format

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Ministry of Forests
Information Systems Branch

Table of Contents

1. Purpose **2**
2. Scope **2**
3. Intended Audience **2**
4. Related Documents **3**
5. Positional versus Representational Data **3**
6. General File Format Specifications **3**
7. Spatial Data Types **4**
7.1 Point Features **4**
7.1.1 Point Features 4
7.1.2 DEM Points 4
7.1.3 Polygon Inside Points 4
7.2 Linear Features **5**
7.3 Text **5**
7.4 Polygons **5**
7.4.1 General Rules 6
7.4.2 Polygon Neatlines 6
7.4.3 Type 1: Overlapping Polygons 6
7.4.4 Type 2: Non-Overlapping Polygons (Continuous and Discontinuous Coverages) 7
8. Feature Codes and Feature IDs **8**
8.1 IGDS Attribute Linkage Overview **8**
8.2 Feature Code **9**
8.3 Feature ID **10**
9. Topology **11**
9.1 Continuity Rule **11**
9.2 Polygon Closure Rule **11**
9.3 Right Hand Rule **11**
9.4 Connectivity and Network Rule **11**
9.5 Downstream Rule **11**
9.6 Horizontal Feature Rule **11**
10. Related Issues **11**
11. Glossary **12**

1. Purpose

The purpose of this document is to specify the standard spatial datatypes used to represent Ministry of Forests positional spatial data. The document also specifies how these spatial datatypes will be represented in IGDS-format files.

Standardizing the format of positional spatial data is intended to accomplish the following goals:

- ensure a complete and topologically correct spatial data store
- allow the Ministry's data to be easily exchanged between MOF business areas and translated into future GIS and interchange formats
- provide an unambiguous specification for developers of software that processes spatial data
- reduce the complexity of spatial data processing software by reducing the number of ways spatial data types are represented.
- minimize changes to existing Ministry file formats and spatial processing software as much as is consistent with the above goals.

Note that the rules detailed in the following sections cannot be guaranteed unless quality assured through software. Therefore, a quality control methodology must be developed which utilizes automated rather than manual processes.

2. Scope

This document covers the following aspects of positional spatial data:

- how spatial features are represented in IGDS format
- how spatial features are assigned keys to distinguish them and link them to external attribute data
- how topology is represented

This document covers positional spatial data only; it does not cover standards for representational data (see below for a discussion of the difference between representational and positional data).

There are many other spatial data file formats in use in the Ministry of Forests (e.g. MOEP , SAIF, Pamap, Arc/Info, etc.). While some of the concepts and standards stated in this document may apply to spatial data in other formats, this document does not explicitly deal with these other formats.

This document does not deal with digitizing methods and standards. Any such standards must ensure the resulting data meets the format standards specified in this document.

This document does not deal with standards for the geographic accuracy of spatial data. Standards for accuracy can be found in documents produced by the custodians of the data. (See Related Documents below).

3. Intended Audience

Anyone in the Ministry of Forests involved in creating, updating, using, translating or archiving positional spatial data files in IGDS format.

4. Related Documents

Other documents dealing with spatial data formats have been prepared by data custodians within the Ministry of Forests and within other Ministries. This standard is intended to supersede other spatial data formats within the Ministry of Forests. However, the other Ministry manuals may address areas not covered by this standard (e.g. digitizing standards and procedures).

- **Forest Inventory Manual, Volume 5: Preparation and Creation of FRGIS Data Files;** *Resources Inventory Branch, Ministry of Forests*

- **FAMAP Positional File Specifications and Procedures**; *Resource Tenures and Engineering Branch, Ministry of Forests*

- **Range Manual: Resource Stewardship ((Vol. 2)***; Range, Recreation, and Forest Practices Branch, Ministry of Forests*

- **Recreation Manual: Resource Stewardship ((Vol. 2)***; Range, Recreation, and Forest Practices Branch, Ministry of Forests*

- **Specifications and Guidelines - 1:20,000 Digital Mapping**; *Surveys and Resource Mapping Branch, Ministry of Environment, Lands, and Parks*

Other relevant documents which were still in preparation at the time this report was released are:

- **INCOSADA Spatial Data Dictionary**; *Information Systems Branch, Ministry of Forests*
  Describes all spatial features used within the Ministry of Forests and the corresponding Feature Codes.

- **INCOSADA Control ID Table**; *Business Design Branch, Ministry of Forests*
  Lists all valid Control IDs for organizational units and programs.

5. Positional versus Representational Data

Positional data is data for which each data point is positioned to a specified accuracy in a specified map projection coordinate system. In contrast *Representational data* may have data points moved from their positional geographic location or completely deleted in order to make printed copies of the map more readable. Representational data is useless for spatial analysis purposes! For this reason it is important that the master copy of Ministry spatial data is positionally correct. If necessary representational data files may be generated as needed from the master positional data. This standard specifies how positional spatial data will be represented in IGDS format; it does not address representational data formats.

6. General File Format Specifications

- All IGDS data files will be 3D files. Where the z-coordinate (height) is not available or is irrelevant, a 0 z-coordinate will be used.

7. Spatial Data Types

This section defines the standard positional spatial data types and specifies how they should be stored in IGDS format.

7.1 Point Features

7.1.1 Point Features

Description & Rules This includes all zero-dimensional or point data features other than DEM points or polygon inside points. A point feature has a geographic location. It may also have the following two values optionally associated with it:

- an **alignment** or orientation. The alignment is a counterclockwise angle from the positive x direction (i.e. Grid East).
- a **scale**.

Examples Sample plots. Examples of point features that would have an alignment associated with them are rapids and bridges.

IGDS Representation Point features will be represented as cells (IGDS Element Type 2). The alignment is stored as an angle in the transformation matrix. Features with no alignment will carry an angle of 0.0. The scale is also represented in the transformation matrix.

Feature Codes & Ids Feature Code and Feature ID will be present for all point features.

7.1.2 DEM Points

Description & Rules DEM (Digital Elevation Model) points are elevations measured at specific locations.

Examples TRIM DEM points.

IGDS Representation DEM points will be represented as zero-length 3-D IGDS lines (IGDS Element Type 3).

Feature Codes & Ids DEM Points will carry a Feature Code but will not carry a Feature ID.

7.1.3 Polygon Inside Points

Description & Rules Polygon inside points are also known as point-in-polygon or representative-point-in-area. They are used to indicate the presence of a polygon formed by a surrounding set of linework. The polygon inside point may optionally carry representational labeling information for the polygon (which typically contains the key and possibly some attribute information in human-readable format).

Examples Polygon inside points are digitized for each Forest Cover Polygon (Type 2 Polygons).

IGDS Representation Polygon inside points will be represented as IGDS text node headers (IGDS Element Type 7).

Feature Codes & Ids Feature Code and Feature ID will be present for all polygon inside points.

Comments See also **Polygon Features** below.

7.2 Linear Features

Description & Rules	A feature whose spatial geometry is one-dimensional . This includes splines and arcs, which will be approximated by lines. All linear features such as roads must be digitized on the center line of the road. Road features must not be coded as construction lines. Linear features that cross map-sheet boundaries must be edge-tied between mapsheets. This can be done exactly between mapsheets in the same UTM zone, and must be done to the nearest UOR across zone boundaries.
Examples	Roads, streams
IGDS Representation	Lines (IGDS Element Type 3) and Linestrings (IGDS Element Type 4) will be used to represent linear features.
Feature Codes & Ids	Feature Code and Feature ID will be present for all line or linestring elements that are part of the linear feature.
Comments	Patterning or other representational techniques must not be applied to linear features in positional files.

7.3 Text

Description & Rules	Text is generally used to represent attributes of features in a human-readable format.
Examples	Forest Cover Polygon labels; Tenure polygon labels
IGDS Representation	Text will be represented as Text elements (IGDS Element Type 17). IGDS allows Text elements to have the following attributes: • font • length and height (meters at ground scale) • rotation angle • justification • origin (x,y,(z optional) lower left corner of the text) • actual text string As per the IGDS specification, text that spans more than one line will be represented as a set of Text elements (Type 17) attached to a Text Node element (Type 7). Text that is an intrinsic part of a feature (e.g. polygon labels) will *always* be represented as a Text Node element with attached Text elements, even if the text occupies only a single line.
.	
Feature Codes & Ids	Feature Code and Feature ID will be present for any Text or Text Node element that is an intrinsic part of a feature (e.g. polygon labels).

7.4 Polygons

Levels containing polygons are classified as one of two types:

- Type 1: used to represent polygons that may overlap. This type is used to represent Forest Atlas tenure boundaries and Silviculture openings.

- Type 2: represents non-overlapping polygons. This type is used to represent Inventory's forest cover polygons.

Different rules apply to each of these polygon types so they are presented separately along with some general rules that apply to all three.

7.4.1 General Rules

- No shapes or complex shapes will be used in positional files. All polygons will be defined by one or more lines or linestrings (IGDS Element Types 3 & 4) that are connected as per topology rules defined later.
- Polygon inside points and labels must carry a Feature Code and the same Feature ID as the containing polygon.
- Polygons that cross map-sheet boundaries must be edge-tied between mapsheets. This can be done exactly between mapsheets in the same UTM zone, and must be done to the nearest UOR across zone boundaries. Polygons that cross map-sheet boundaries must **not** be closed along the neatline; instead, the **Polygon Neatline** must be noded and the endpoints of the polygon linework snapped to it.

7.4.2 Polygon Neatlines

Description & Rules	In order to provide explicit closing of polygons that cross map-sheet boundaries, a special feature called a Polygon Neatline will be present in each mapsheet that contains polygons. This feature consists of a set of Line elements which outlines the area of the map. Where a polygon edge crosses the mapsheet boundary the Polygon Neatline will be noded and the polygon vertex snapped to it. Note that the Polygon Neatline should never be a distance of more than one-half a UOR from the standard MoF Mapsheet Neatline.
IGDS Representation	The Polygon Neatline is represented by a set of Line elements (IGDS Element Type 3).
Feature Codes & Ids	The Polygon Neatline elements will carry a Feature Code. They will not carry a Feature ID.

7.4.3 Type 1: Overlapping Polygons

Description & Rules	Polygons will be captured as complete objects, including holes (excluded areas) if applicable. (This implies duplicate line work may be present, if the edges of two polygons happen to coincide). Polygons will contain an inside point and conform to the Right Hand Rule or Downstream Rule. Polygons may contain holes, which are represented by polygons contained entirely inside the parent polygon and which do *not* contain an inside point. Holes will obey the Right Hand Rule. Polygons that extend outside the map sheet neat line will be noded at the neatline. The linestrings lying outside the neatline will not appear in the file. As specified in section 6.4.2, the neatline will be noded where it intersects the polygon. There may be more than one polygon with the same Feature ID; this corresponds to the idea of polygon sets. Polygon sets are used to represent tenures or regions that consist of one or more disjoint parcels or areas.
Examples	Forest Atlas tenures, Silviculture openings
IGDS Representation	An overlapping polygon or set of polygons is represented by one or more linestrings (IGDS Element Type 4). The linestrings forming the polygon(s) must

intersect only at endpoints. Holes are represented by polygons contained entirely inside the parent polygon and which do *not* contain an inside point. Holes carry the same Feature Code and Feature ID as the parent. Each polygon will contain an inside point, which will be represented as a text node (IGDS Element Type 7).

Feature Codes & Ids

Each linestring that makes up a polygon (including polygon holes) will have a Feature Code and a Feature ID.

Holes carry the same Feature Code and Feature ID as the parent polygon.

The polygon inside point will have a Feature Code (*not necessarily* the same as the containing polygon) and the same Feature ID as the containing polygon.

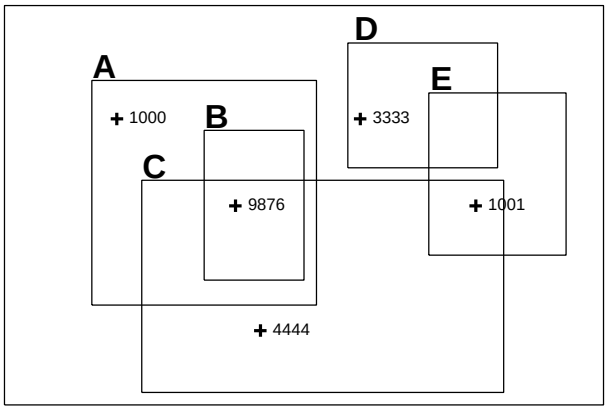

Figure 1: An example of a level with Overlapping Polygons. The text node element with label 9876 is associated with polygon B through having the same FeatureID, as is the case with text node element 1001 and polygon E.

7.4.4 Type 2: Non-Overlapping Polygons (Continuous and Discontinuous Coverages)

Description & Rules

Represents non-overlapping polygons. A coverage of non-overlapping polygons may be either continous or discontinous, i.e. may completely cover the area of the map or may contain holes. A coverage of non-overlapping polygons consists of:

- a set of edges, i.e. non-interesecting linestrings which meet at endpoints only. These form the boundaries of the polygons
- a set of polygon inside points (which may have text labels attached)

Thus polygons are single-line digitized (i.e. shared lines are not duplicated). Each polygon is a closed sequence of linestrings that contains an inside point. Polygon holes are implied. A closed sequence of linestrings that do not contain an inside point form a hole in the coverage. If this occurs the coverage is said to be discontinous. A coverage is continous if and only if every closed area contains an inside point.

Examples

Forest Cover polygons form a continuous coverage. For an example of a discontinuous coverage, if there was a lake inside a forest cover polygon then there would be no text node inside the lake but a boundary representing the outside of the lake will be present.

IGDS Representation Polygons will contain an inside point represented as a text node (Type 7).

Feature Codes & Ids Each linestring will have a Feature Code. Linestrings will not have a Feature ID (since a single linestring may be associated with more than one polygon).

Each inside point will have a Feature Code and a Feature ID.

Each text label will have a Feature Code and a Feature ID.

Comments

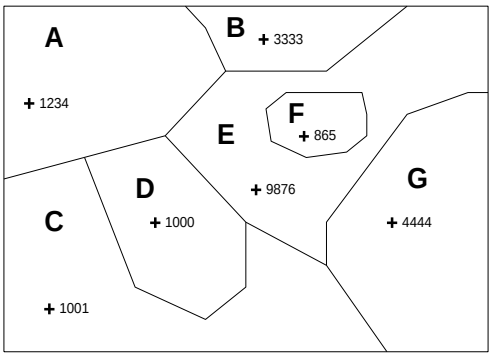

Figure 2: An example of a level with Non-Overlapping Polygons With Continuous Coverage. Areas A, B, C, D, E, F and G contain text node elements and are polygons in the coverage.

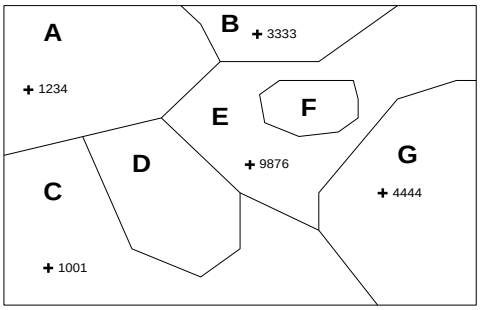

Figure 3: An example of a level with Non-Overlapping Polygons With Non-Continuous Coverage. Areas A, B, C, E, and G contain text node elements and are polygons in the coverage. Areas D and F do not contain text node elements and are holes in the coverage.

8. Feature Codes and Feature IDs

In order to provide a way of referencing each feature (e.g. to link attribute data to spatial data) each spatial feature must be assigned a unique key, the **Feature ID**. In addition, each feature carries a **Feature Code**, which specifies what *type* of feature it is (e.g. Exhibit A, Forest Cover Polygon, Forest Service Road). The Feature ID key and the Feature Code are attached to features in the IGDS file using the *attribute linkage* facility of IGDS. The following sections contain an overview of the IGDS attribute linkage facility followed by specifications for how it is used to store the Feature ID and Feature Code information.

8.1 IGDS Attribute Linkage Overview

The mechanism for attaching user-defined key data to features in IGDS files is called the *attribute linkage* facility. Any number of attribute linkages may be attached to an IGDS element. There are two types of attribute linkages: Database Linkages and User Data Linkages. The following table shows the data fields in the two types of linkages.

Field	Data Size (bytes)	Description
Database Linkage		
Entity Number	2	the type of the attribute linkage (typically specifies which table the attribute record lies in)
MSLINK key	4	the value of the attribute linkage (the key for the attribute record)
User Data Linkage		
Linkage ID	2	the type of the user data linkage
User-defined data	arbitrary	user-defined data

Note that while Feature Codes are stored in a Database Linkage and Feature IDs are stored in a User Data Linkage, this does not preclude other linkages being present. For example, the Generated Number field of the Feature ID may be duplicated into a Database Linkage to allow direct linking of IGDS files to an attribute database. These extra linkages are not guaranteed to be preserved by software processing the files, however.

8.2 Feature Code

Description & Rules

Each feature stored by the Ministry must have a **Feature Code** that determines the *type* of the feature (e.g. Forest Cover Inside Point, Forest Service Road, Special Use Permit). Feature Codes are unique on a province-wide basis. Feature Codes will be assigned using the Canadian Council on Surveying and Mapping (CCSM) feature code specifications (as used by GDBC).

CCSM Feature Codes are 12-character alphanumeric strings in the form AANNNNNNNNNN. To facilitate storing Feature Codes in GIS files that cannot handle alphanumeric keys a **Feature Code Number** will be used represent them. Feature Code Numbers are unsigned 32-bit integers (e.g. 0 to greater than 4 billion). Each Feature Code will have an associated Feature Code Number.

Examples

The Feature Code of a River/Stream (Definite) is GA24850000. The Feature Code Number associated with this *might* be 1206.

IGDS Representation

Feature Code Numbers are represented using Database Linkages. Entity Number 1 and its MSLINK number is reserved for storing Feature Code Numbers. The Feature Code Number is stored in the MSLINK key field.

The exact data layout for the Feature Code Database Linkage is given in the following C code (for Intel x86 and compatible architectures):

```
typedef struct {
    unsigned short words   :8;      // words to follow: MUST = 7
    unsigned short class   :4;      //                  MUST = 0
    unsigned short user    :1;      // user linkage;  MUST = 0
    unsigned short modified:1;      // boolean;  MUST = 0
    unsigned short remote  :1;      // boolean;  MUST = 0
    unsigned short info    :1;      // boolean;  MUST = 0
    unsigned short primary_id;      // database type indicator
    unsigned short secondary_id;    // ALWAYS 0x0f81
    unsigned short entity;          // MUST = 1
    unsigned long  FeatureCodeNum;  // Feature Code Number
    short          pad[2];          // filler
} FeatureCodeLinkage;
```

Comments

Feature Codes will need to be assigned with reference to the CCSM and GDBC standards. The ISB Data Administration Section is the custodian of Feature Codes. ISB is the custodian of Feature Code Numbers.

8.3 Feature ID

Description & Rules

In order to uniquely identify features stored by the Ministry it is important that each feature have a unique key. This unique key is called the **Feature ID**. There is also a requirement that feature keys must able to be assigned by different business areas and locations independently. For this reason the Feature ID is a concatenated key consisting of Control ID and Generated Number. Each business area or location may have one or more Control IDs and can then freely assign Generated Numbers under each Control ID. Each Generated Number identifies one instance of a feature within a business area. (e.g. Special Use Permit S12345 vs. S12356).

Control IDs and Generated Numbers are unsigned 32-bit integers (e.g. 0 to greater than 4 billion).

Examples

Special Use Permit #S12345:

Feature Code Number:	10
Control ID:	4
Generated No.:	25335

Special Use Permit #S12356

Feature Code Number:	10
Control ID:	4
Generated No.:	18776

IGDS Representation

Feature IDs are stored using User Data Linkages.

The Linkage ID will be the Ministry of Forests Linkage ID code registered with Bentley Microsystems.

The user-defined data portion of the User Data Linkage will contain two fields:

- Control ID : 4-byte integer
- Generated Number : 4 byte integer

In order to accomodate software which needs to link to external databases via Database Linkages, the Generated Number may OPTIONALLY be copied into the MSLINK field of a Database Linkage with Entity Number 2. This Database Linkage is NOT guaranteed to be preserved by software processing the IGDS file, however.

The exact data layout for the Feature ID User Data Linkage is given in the following C code (for Intel x86 and compatible architectures):

```
typedef struct {
    unsigned short words   :8;     // words to follow: MUST = 7
    unsigned short class   :4;     //                  MUST = 0
    unsigned short user    :1;     // user linkage;  MUST = 0
    unsigned short modified:1;     // boolean;  MUST = 0
    unsigned short remote  :1;     // boolean;  MUST = 0
    unsigned short info    :1;     // boolean;  MUST = 0
    unsigned short owner_id;       // assigned by Bentley Systems
    unsigned long  reserved;       // for future use
    unsigned long  GenNum;         // Generated Number
    unsigned long  ControlID;      // Control ID
} FeatureIDLinkage;
```

Comments

The Business Design Branch is the custodian of Feature Ids. They will be establishing processes to control the allocation of Control IDs and Generated Numbers.

9. Topology

All data will conform to the following set of topological rules. These rules conform to rules used by the TRIM project.

9.1 Continuity Rule

Linear features will not be "broken" (i.e. have gaps inserted) where they cross other features. (e.g. roads will not be broken for labels, rivers will not be broken for bridges, etc.). Gaps are used for representational purposes only and must not appear in positional files.

9.2 Polygon Closure Rule

All polygonal features will be explicitly closed polygonal areas, with right hand or downstream rule applied in the case of Type 1 polygons, except where a polygonal feature meets a mapsheet boundary. In this case the polygon will be closed to the Polygon Neatline.

9.3 Right Hand Rule

Right Hand Rule requires data captured in a manner which ensures that the feature being bounded resides to the right side relative to the orientation of the line. (In other words, the points are stored in clockwise order around the featurre.) This rule applies to Overlapping Polygons as defined in section 2.6.3. This rule obviously does not apply to linework for Non-overlapping Polygons.

9.4 Connectivity and Network Rule

All lines of like Feature Codes which intersect or close on themselves will do so at numerically and mathematically exact nodes (e.g. where 2 roads intersect, where two lines forming part of the boundary of two forest cover polygons meet, or where a tenure boundary intersects itself.)

9.5 Downstream Rule

Hydrographic features having a gradient will be digitized in a down stream direction. For example, rivers (which have a gradient) are digitized using the Downstream rule. For hydrographic features that have a gradient and are digitized using polygons (e.g. double line rivers) Right Hand Rule is superseded by downstream rule.

9.6 Horizontal Feature Rule

Features such as lakes and shoreline that by their nature are horizontal (i.e. have the same elevation at each point) must have the same z-value for each point (when z-values are present, as in 3-D IGDS files).

10. Related Issues

- All patterning or other representational techniques must not be applied to positional files. These features must be copied to a representational file and have patterns applied there for output purposes.

11. Glossary

attribute linkage — the mechanism that IGDS uses to allow attribute data to be attached to elements. There are two types of attribute linkages: Database Linkages and User Data Linkages. Database Linkages are used to link elements to external databases; User Data Linkages are used to store user-defined data with elements.

CCSM — Canadian Council on Surveying and Mapping, the custodian of national feature codes.

Control ID — see **Feature ID**

DEM — Digital Elevation Model - a set of points with elevations used to approximate a three-dimensional terrrain surface.

edge-tied — Lines that cross mapsheet boundaries are edge-tied when the endpoints of the two halves of the line that lie on the boundaries have the same map projection coordinates. Edge-tied features are necessary when assembling data from mapsheets into a seamless spatial database.

element — (*also* **IGDS element**) The basic units of an IGDS design. Types of elements include points, linestrings, text nodes, and cells. Elements may be aggregated into **complex elements.** One or more elements are used to represent the standard spatial features in an IGDS design file.

entity number — the *type* of a Database Linkage attached to an IGDS element. Typically indicates which external database contains the attribute data for the element.

feature — (*also* **spatial feature**) A business item of interest that, as part of its vital information, is directly associated with a geographic location: i.e. a geographic object or unit of geographic data. Every distinct item of geographic data of interest to the Ministry of Forests is a feature. Features have a type (which is specified by the **Feature Code**), a unique identifier (the **Feature ID**) and some associated spatial and attribute data. For example, a Forest Cover Polygon would have a Feature Code, a Feature ID, associated linework and an inside point, and some associated attribute data such as Leading Tree Species Type.

Feature Code — A unique alphanumeric code used to classify the geographic type of a feature. Feature codes are issued by the Data Administration group within the Information Systems Branch of the Ministry of Forests (in consultation with GDBC), and are used to help standardize the use of a single coding structure for source features. This ensures agreement throughout the ministry on the definition of official **Features**, at a business level. Physically, other identifiers may be used to represent a Feature Code on specific physical GIS platforms (see **Feature Code Number**). Examples of geographic types identified by Feature Codes in the Ministry of Forests include Forest Cover Polygons, Forest Service Road, Special Use Permit, Sample Plot.

Feature Code Number — A numeric code issued by the Ministry of Forests, used to represent the **Feature Code** within GIS data files for those platforms that cannot handle the Feature Code directly (due to a limitation in GIS software to handle

	alphanumeric feature codes — e.g. Microstation's "MS-Link key" requires a numeric code).
Feature ID	the unique identifier or key of a feature within the Ministry of Forests. A Feature ID is a concatenated key consisting of Control ID and Generated Number. The Control ID indicates the business area which created the feature (e.g. a "program" such as Silviculture Practices), location which created the feature (e.g. a district such as Chilliwack), or combination of both. The Generated Number identifies the particular instance of the feature within the business area (e.g. Special Use Permit S12345, vs. Special Use Permit S12356).
Generated Number	see **Feature ID**
GDBC	Geographic data B.C., the branch of the Ministry of Environment, Lands and Parks responsible for provincal mapping standards and the TRIM project.
hole	**1) hole in a polygon:** an area enclosed within a polygon but not covered by the polygon **2) hole in a coverage:** an area within a coverage which is not contained inside any polygon in the coverage. In IGDS files, indicated by an area bounded by linestrings but not containing an inside point.
IGDS	(*also* **IGDS design file**) the file format used by Microstation, the standard CAD tool used by the Ministry of Forests. (IGDS stands for Interactive Graphics Design System.)
INCOSADA	the **Integrated Corporate Spatial and Attribute Database** is a project intended to standardize and streamline the handling of spatial data within the Ministry of Forests.
label	some text associated with a feature in an IGDS file.
MS-Link key	the *value* of a Database linkage attached to an IGDS element. Must be a numeric value which is typically the key for the attribute record for the element stored in an external database.
polygon inside point	(*also* **point-in-polygon** *or* **representative-point-in-area**) A Polygon inside points is a point located within a polygonal area. It is used by spatial processing software to identify the inside of a polygon.
positional data	spatial data for which each data point is correctly positioned in the geographic coordinate system, and which has not been broken or displaced for cartographic reasons.
representational data	spatial data which may have data points moved from their actual geographic location or completely deleted in order to make printed copies of the map more readable.
seamless spatial database	a spatial database which has a coordinate system and storage space large enough to contain all the data in the province. Current MoF spatial data is generally mapsheet-based, and thus not seamless.

text node	an IGDS element used to represent the position of text within a design file. If a text node has text associated with it, the text is contained in text elements. Text nodes are sometimes used without associated text to represent point data.
topology	topological relationships between spatial entities are relationships which do not depend on distance measurements, e.g. adjacency, connectivity, and containment.
TRIM	the Terrain Resource Inventory Mapping program is a initiative coordinated by GDBC to produce digital basline thematic data for the entire province.
UOR	Unit of Resolution - the units of the coordinate system in an IGDS design file.