



Datum Transformation

Standard Operating Procedure (SOP)

From DrukRef03 to DrukRef23

Version 2.1



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1. Purpose

This Standard Operating Procedure (SOP) provides guidance on the recommended methodology for transforming existing spatial datasets referenced to the legacy DrukRef03 datum to the new national geodetic datum DrukRef23, including the associated change in map projection.

The SOP has been developed to assist all stakeholders in carrying out datum and projection transformations in a consistent, accurate, and efficient manner. While there may be multiple technical approaches to performing the transformation, this document outlines the recommended workflow and best practices adopted by the National Land Commission Secretariat (NLCS) to achieve reliable and consistent results.

The objective is to ensure that all spatial datasets are successfully migrated to the DrukRef23 reference framework and the Bhutan National Grid 2023 (BNG2023) projection, thereby supporting the nationwide rollout of DrukRef23 and maintaining consistency across all geospatial information.

2. Scope

This SOP applies to all spatial datasets currently maintained in DrukRef03 that require conversion to DrukRef23, including but not limited to:

- Spatial data for cadastral parcels
- Topographic survey datasets (points, contours, planimetric features)
- Control point networks, including Secondary Control Points (SCPs)
- Infrastructure, utility, and thematic GIS layers maintained by Dzongkhag or national agencies

This SOP covers the desk-based transformation of spatial datasets, including both individual shapefile layers and geodatabases (GeoDB), using **QGIS** and **ArcGIS Pro**, as well as the associated field verification activity of static GNSS observation on backup control points.

It does not cover the technical derivation of the DrukRef23 datum itself or the design of the NTV2 grid file.

3. Datum Transformation in ArcGIS Pro (v3.6.0)

Required files:

- GeoDB to be transformed
- NTV2 file
- Projection files

Get the required files:

1. https://miranet.nlcs.gov.bt/public/datum_transformation/ — Download: **DrukRef23_BNG2023.prj**
2. <https://miranet.nlcs.gov.bt/public/ntv2/> — Download: **d03tod23.gsb**

Phase I — Installation of the NTv2 File

Step 1. Locate the following path:

```
C:\Program Files\ArcGIS\Pro\Resources\pedata\ntv2
```

If you installed ArcGIS Pro for “current user only,” it may be located in your AppData folder instead.

Step 2. Create a new folder inside the ntv2 folder and rename it ‘bhutan’ (use lowercase, no spaces).

Step 3. Copy and paste the NTv2 file (.gsb file) into the newly created folder.

Phase II — Preparing ArcGIS Pro

Step 1. Open ArcGIS Pro and create a new project/map.

Step 2. In the Contents pane, right-click on the map and select Properties.

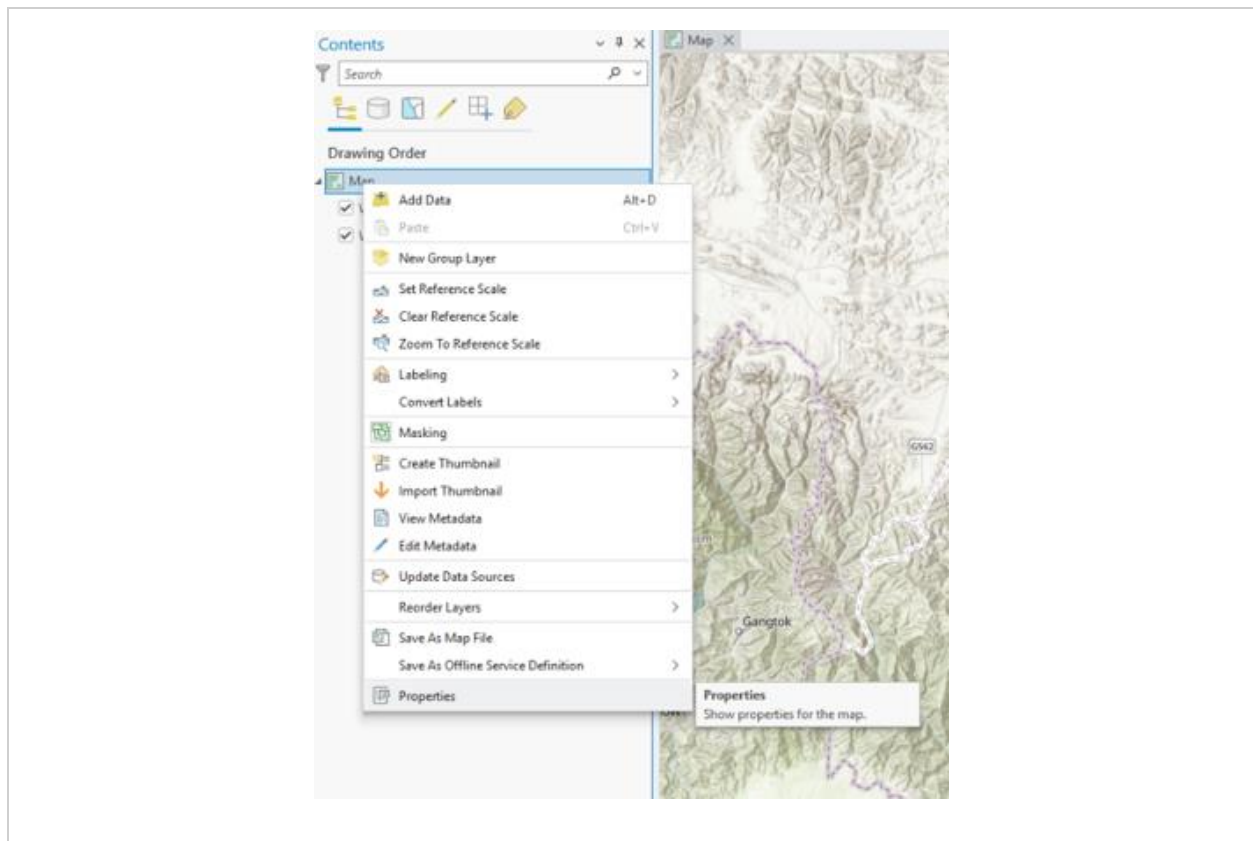


Figure 1. Accessing Map Properties from the Contents pane.

Step 3. Under the Coordinate Systems tab, click “Add Coordinate System” and select the Import Coordinate System option.

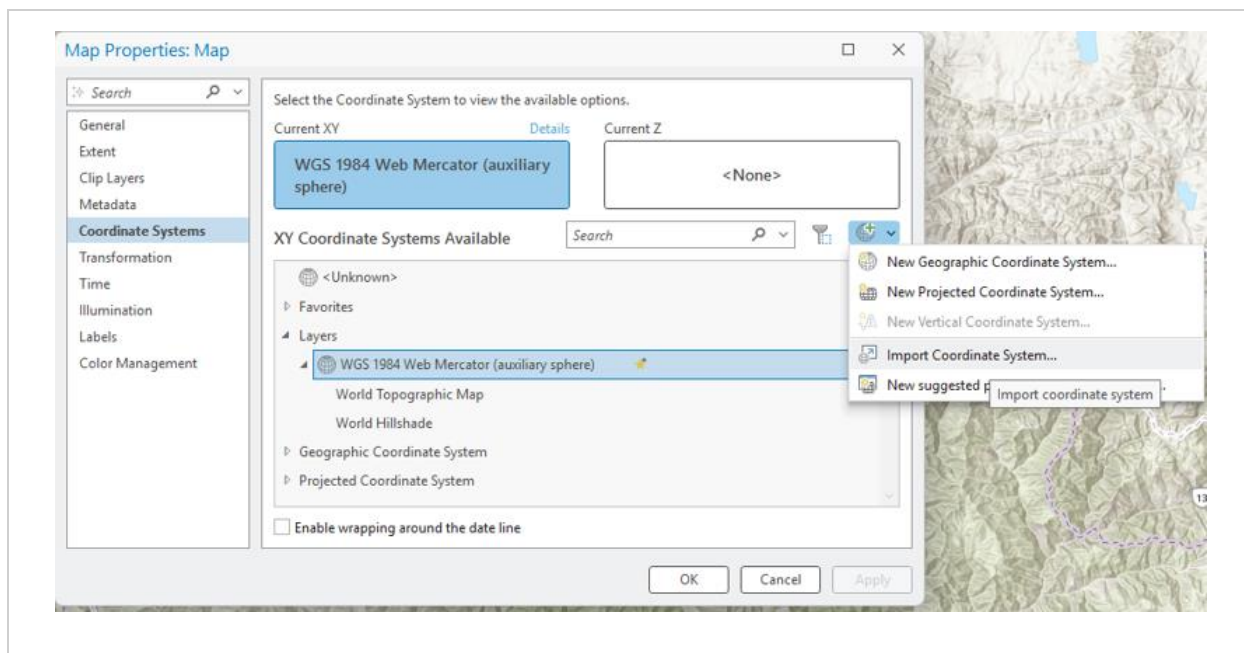


Figure 2. Importing a coordinate system in Map Properties.

Step 4. Select the DrukRef23 .prj file, mark it as a favorite, and set the map coordinate system to DrukRef23.

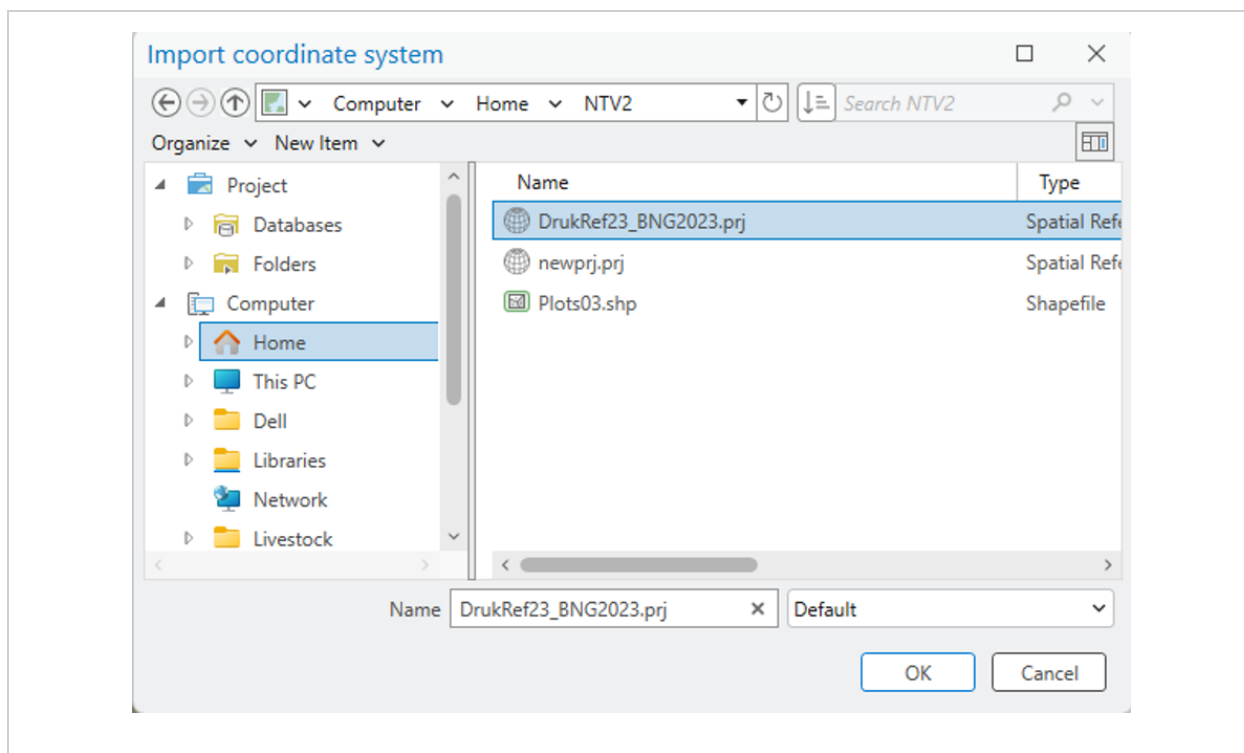


Figure 3. Selecting the DrukRef23_BNG2023.prj file.

✓ **Check #1:** After setting the map coordinate system to DrukRef23, zoom out on the map viewer — the map should display correctly as shown below.



Figure 4. Map view confirming the DrukRef23 coordinate system is active.

Step 5. Go to the Analysis tab and click Tools. Search for ‘Create Custom Geographic Transformation’.

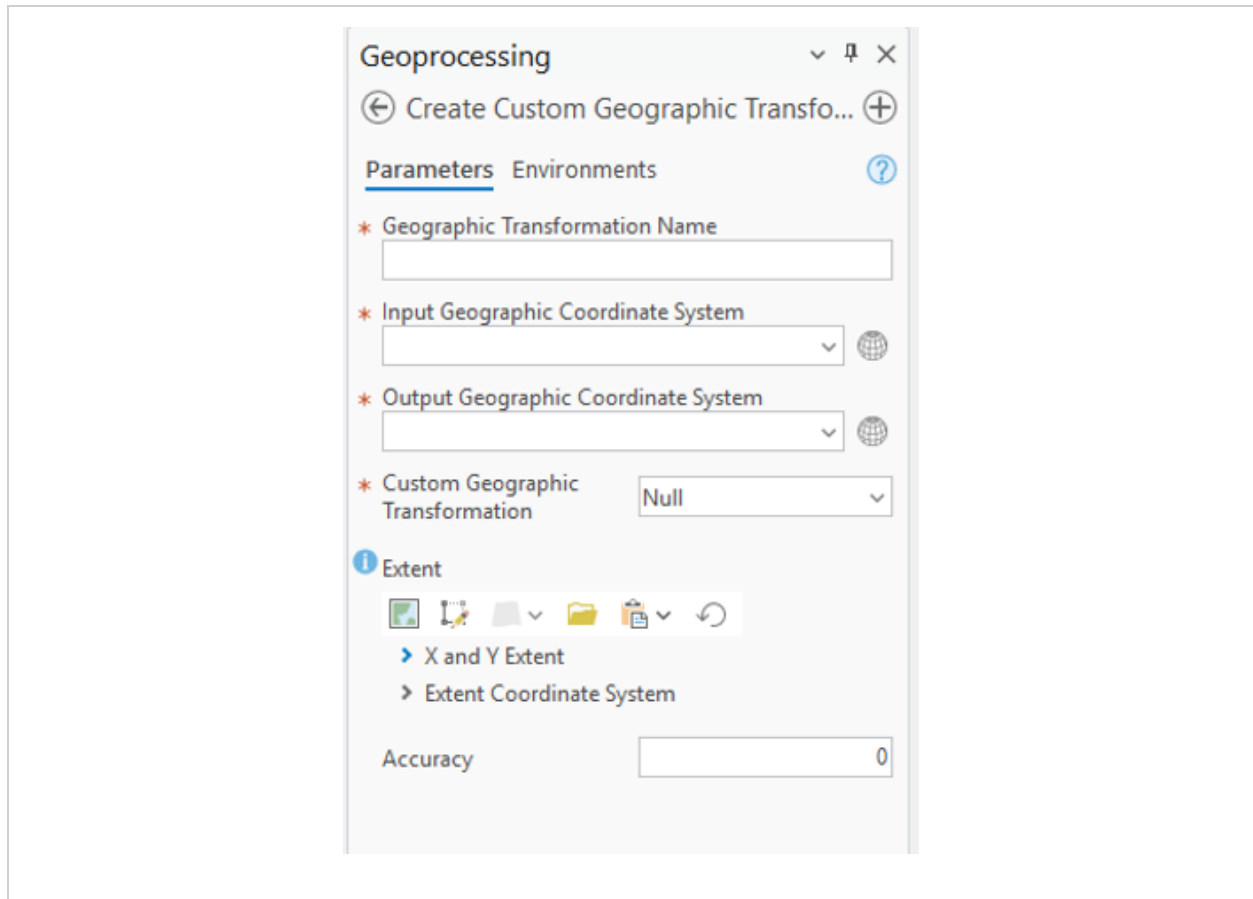


Figure 5. Create Custom Geographic Transformation tool.

Step 6. Fill in the parameters:

- **Geographic Transformation Name:** give it a clear name, e.g. DrukRef03_To_DrukRef23_NTv2 (use underscores, no spaces).
- **Input Geographic Coordinate System:** select DrukRef03 (or its EPSG equivalent) — from the Geographic Coordinate System list, not the Projected Coordinate System list.
- **Output Geographic Coordinate System:** select DrukRef23, or select “current map”.
- **Custom Geographic Transformation Method:** choose NTv2 from the dropdown menu, then choose the .gsb file from the bhutan folder.
- **Press RUN.**

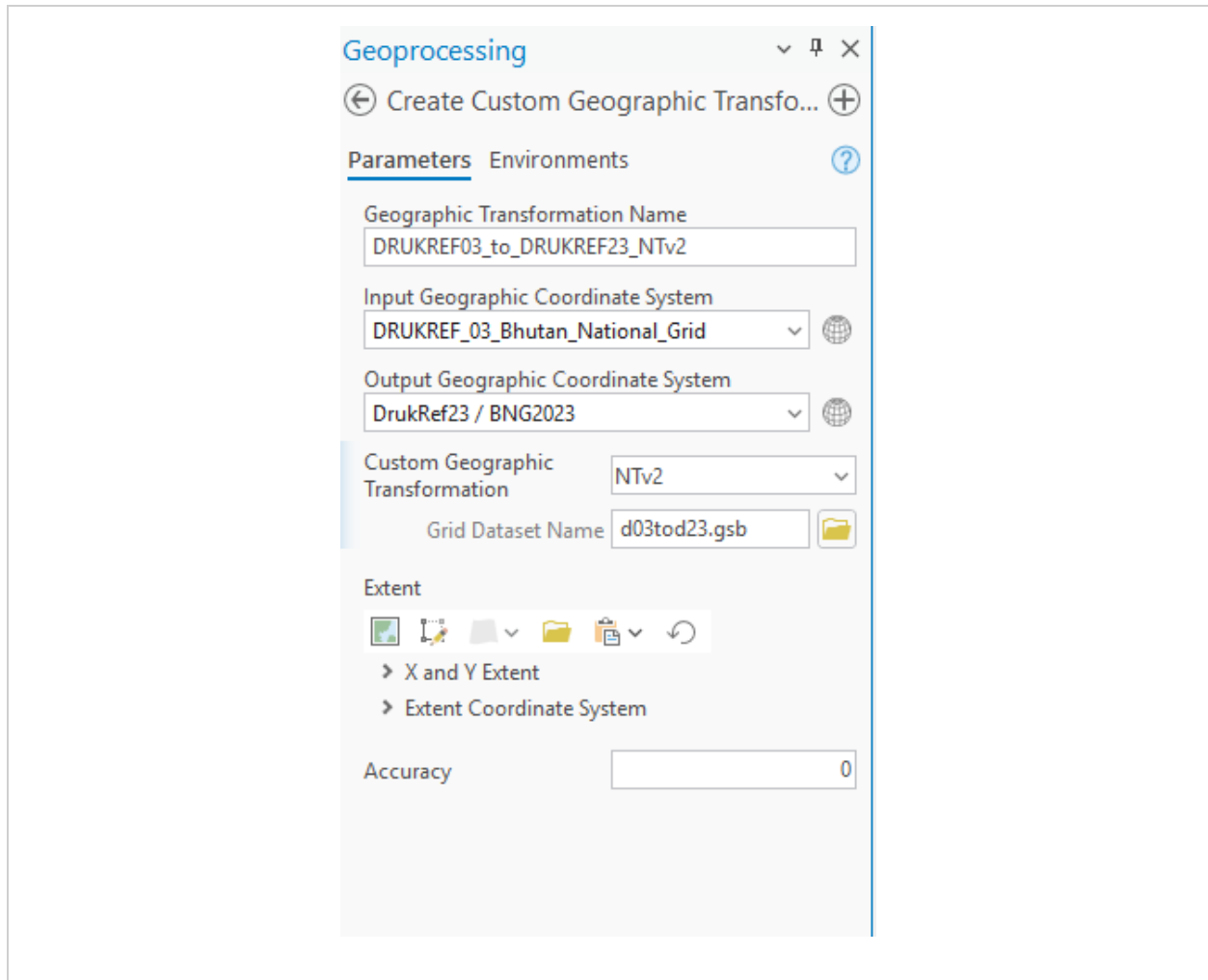


Figure 6. Custom Geographic Transformation parameters.

Phase III — Transforming the Geodatabase

Step 1. In the Catalog pane, add the geodatabase (.gdb) file to be transformed by right-clicking on Databases.

Step 2. Create a new geodatabase file to store the transformed features, also via right-click on Databases.

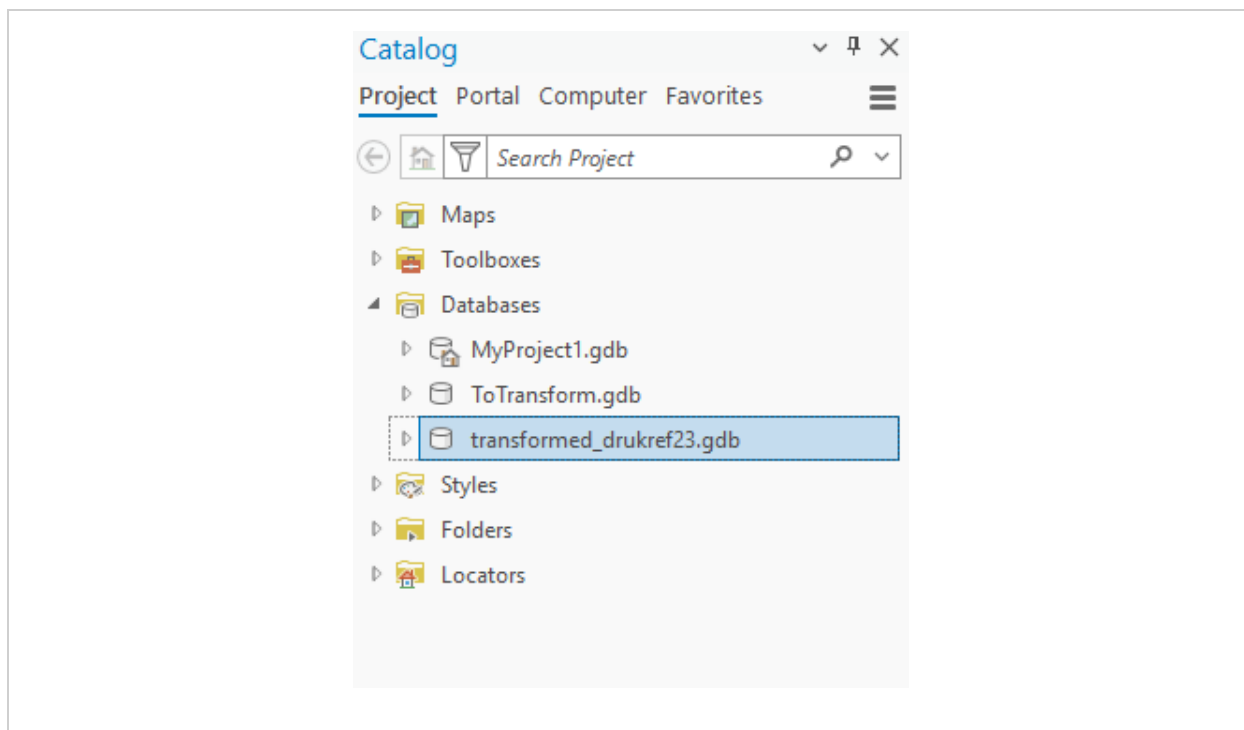


Figure 7. Creating a new geodatabase to store transformed features.

Step 3. From the Analysis tab, open the Batch Project tool from Tools.

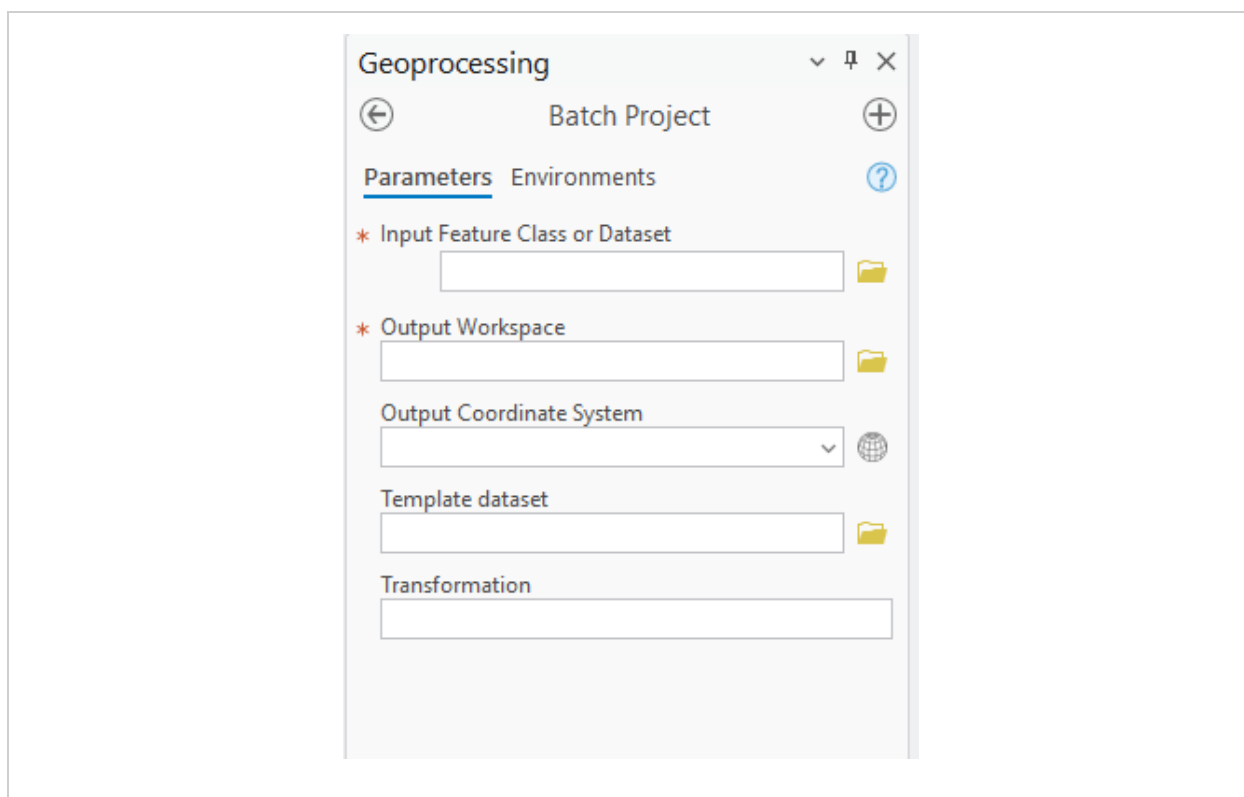


Figure 8. Opening the Batch Project tool.

Step 4. Fill in the parameters:

- **Input Feature Class or Dataset:** locate the .gdb file to be transformed and select all feature classes inside it.
- **Output Workspace:** select the newly created .gdb file.
- **Output Coordinate System:** select DrukRef23 from Favorites, or select [current map].
- **Template Dataset:** leave blank.
- **Transformation:** enter the exact name given in Phase II, Step 6a.
- **Hit Run.**

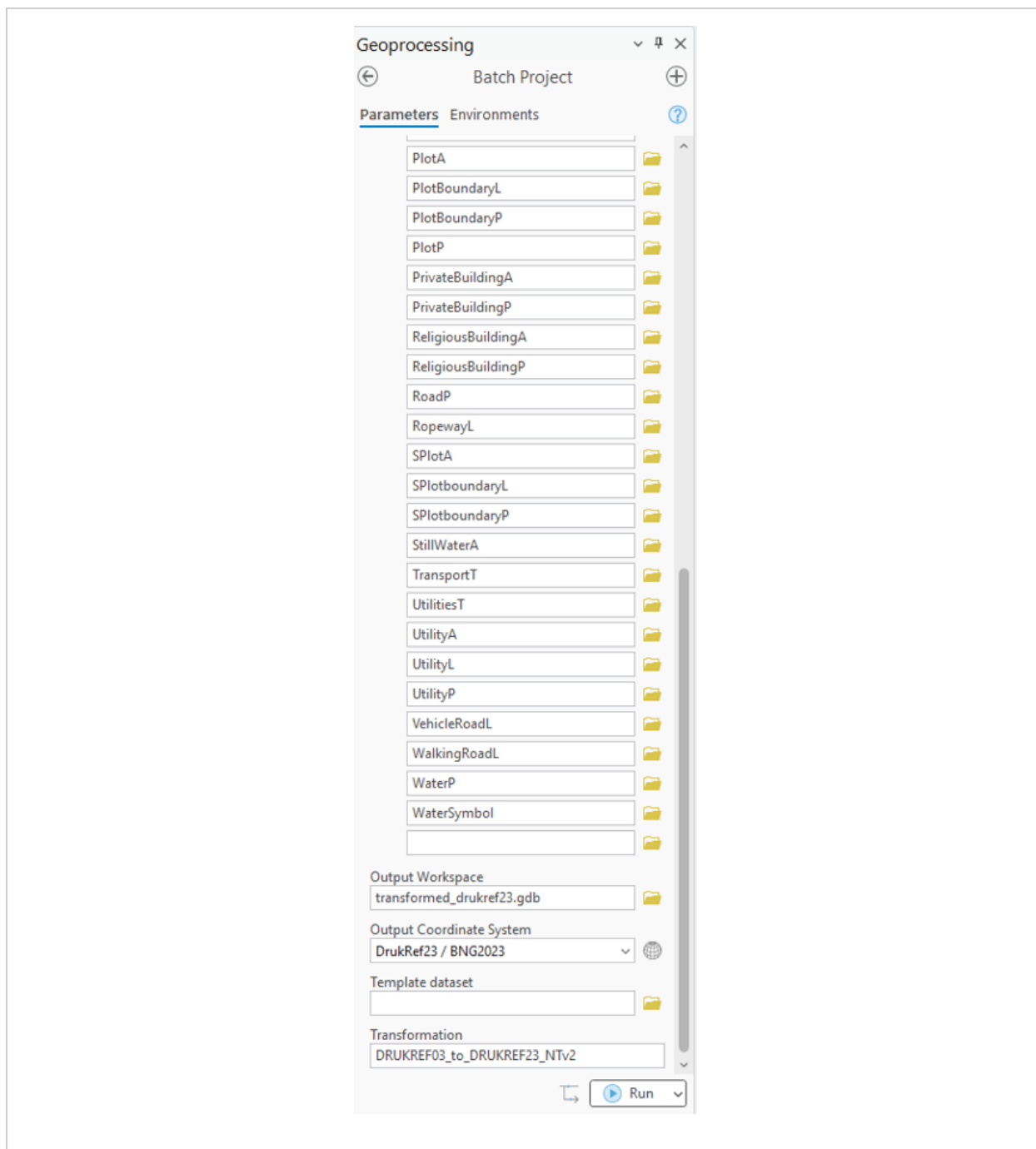


Figure 9. Batch Project tool parameters.

Tip: If your input data consists of separate shapefiles instead of a GeoDB, click the Import button and navigate to select — or drag and drop — the layer from the layer panel.

Step 5. Once the process is complete, all transformed feature classes and layers will be available in the new geodatabase file.

✓ **Check #2:** Import one layer from the transformed geodatabase and one from the original geodatabase, then compare them.

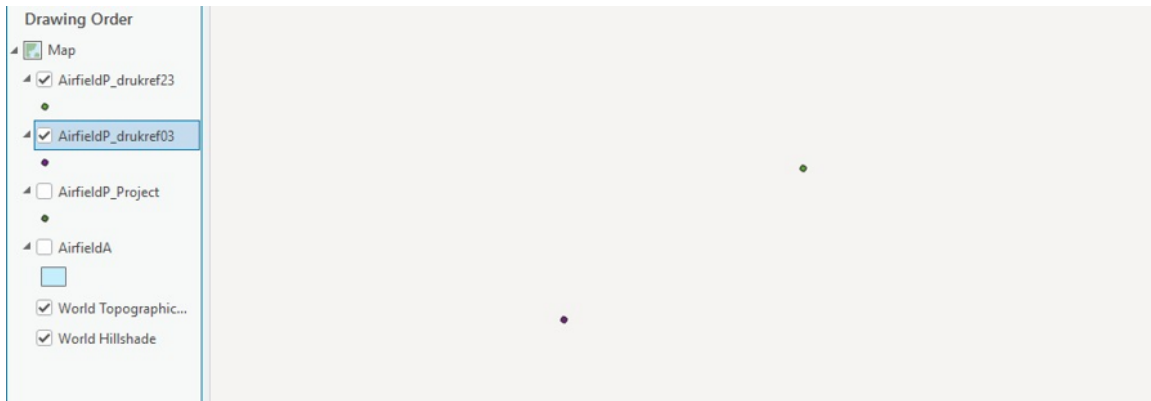


Figure 10. Comparing the transformed layer with the original layer.

Right-click on the transformed layer and open its properties. Check the coordinate system information — it should read DrukRef23 / BNG2023.

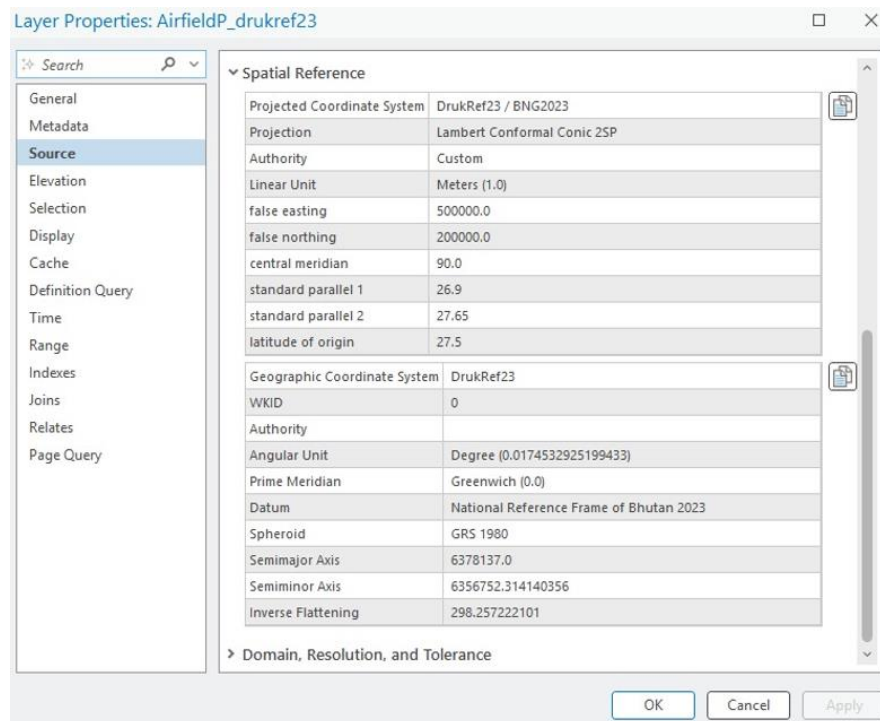


Figure 11. Confirming the coordinate system of the transformed layer is DrukRef23 / BNG2023.

Once this is complete, your spatial data will be transformed into DrukRef23.

4. Datum Transformation in QGIS

The workflow relies primarily on QGIS and its bundled GDAL utilities (`ogr2ogr`, `gdalwarp`) to handle both raster and vector formats, including ESRI products such as shapefiles, rasters, and File Geodatabases. QGIS provides an accessible interface for visualization and validation, while GDAL offers powerful command-line tools for precise control over coordinate reference systems (CRS), transformations, and file conversions.

4.1 Environment Setup (Software and Drivers)

1. Install QGIS (includes GDAL/PROJ and Python)



Figure 12. QGIS official download page.

<https://qgis.org/>

- Download and install the latest LTR QGIS Standalone version (64-bit) if you don't already have one.
- This installation also provides the OSGeo4W Shell and GDAL/PROJ tools.
- Always run commands inside the OSGeo4W Shell (64-bit), not the standard Windows CMD.

2. Open the OSGeo4W Shell

Locate the OSGeo4W Shell (64-bit) shortcut. It is usually available in one of these places:

- Start Menu → QGIS 3.x → OSGeo4W Shell (64-bit)
- Windows Desktop folder: `C:\Users\Public\Desktop\QGIS 3.x\`
- Installation folder: `C:\Program Files\QGIS 3.x\` (look for OSGeo4W Shell, QGIS Desktop, QGIS Python Console, GRASS GIS)

Double-click OSGeo4W Shell (see figure below). Open preferably as Administrator. This opens a command window that is already pre-configured with all the GDAL, PROJ, and Python paths.

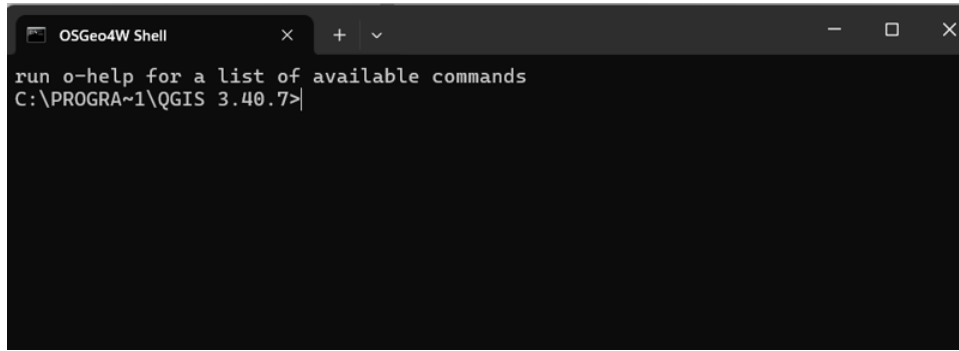


Figure 13. OSGeo4W Shell window, pre-configured with GDAL, PROJ, and Python paths.



Tip!

To avoid searching for the OSGeo4W Shell every time, you can create a shortcut:

- **Option 1:** Right-click the *OSGeo4W Shell (64-bit)* icon → *Pin to Start* or *Pin to Taskbar*.
- **Option 2:** Copy the shortcut from:
C:\Users\Public\Desktop\QGIS 3.x\
and place it directly on your Desktop.

Figure 14. Tip — pinning the OSGeo4W Shell shortcut for quick access.

3. Verify GDB drivers are installed

- The OpenFileGDB driver is open-source and included with GDAL by default; it can read and write most geodatabase contents.
- The FileGDB driver is based on Esri's FileGDB API and requires an extra installation step. It provides full read/write access to File Geodatabases and is better at maintaining feature datasets, domains, field properties, and other Esri-specific metadata.

To verify the existence of the drivers, run the following command in the OSGeo4W Shell.

Note: All commands demonstrated in this SOP are compiled in the script `Commands.txt`. Users can open this file and copy/paste the commands directly into the OSGeo4W Shell for testing.

Run in the OSGeo4W Shell (copy and paste the command below):

```
ogrinfo --formats | findstr /I "FileGDB"
```

Figure 15. Running the ogrinfo driver-check command.

Expected output:

```
OpenFileGDB -raster,vector- (rw+uv): ESRI FileGeodatabase (using OpenFileGDB) (*.gdb)
FileGDB -vector- (rw+): ESRI FileGDB (*.gdb)
```

Figure 16. Expected output confirming the FileGDB driver.



```
Administrator: OSGeo4W Shell
run o-help for a list of available commands
C:\Windows\System32>ogrinfo --formats | findstr /I "FileGDB"
OpenFileGDB -raster,vector- (rw+uv): ESRI FileGeodatabase (using OpenFileGDB) (*.gdb)
FileGDB -vector- (rw+): ESRI FileGDB (*.gdb)
C:\Windows\System32>
```

Figure 17. Driver list output in the OSGeo4W Shell.

If FileGDB is missing, follow the next steps to install the plugin gdal-filegdb via OSGeo4W Setup:

- Close QGIS / the Shell.
- Start Menu → select OSGeo4W Setup (the installer GUI).

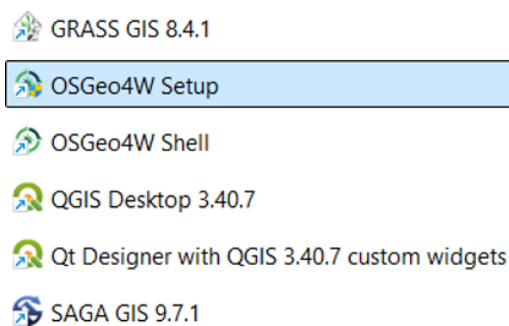


Figure 18. Launching OSGeo4W Setup.

Choose Advanced Install →

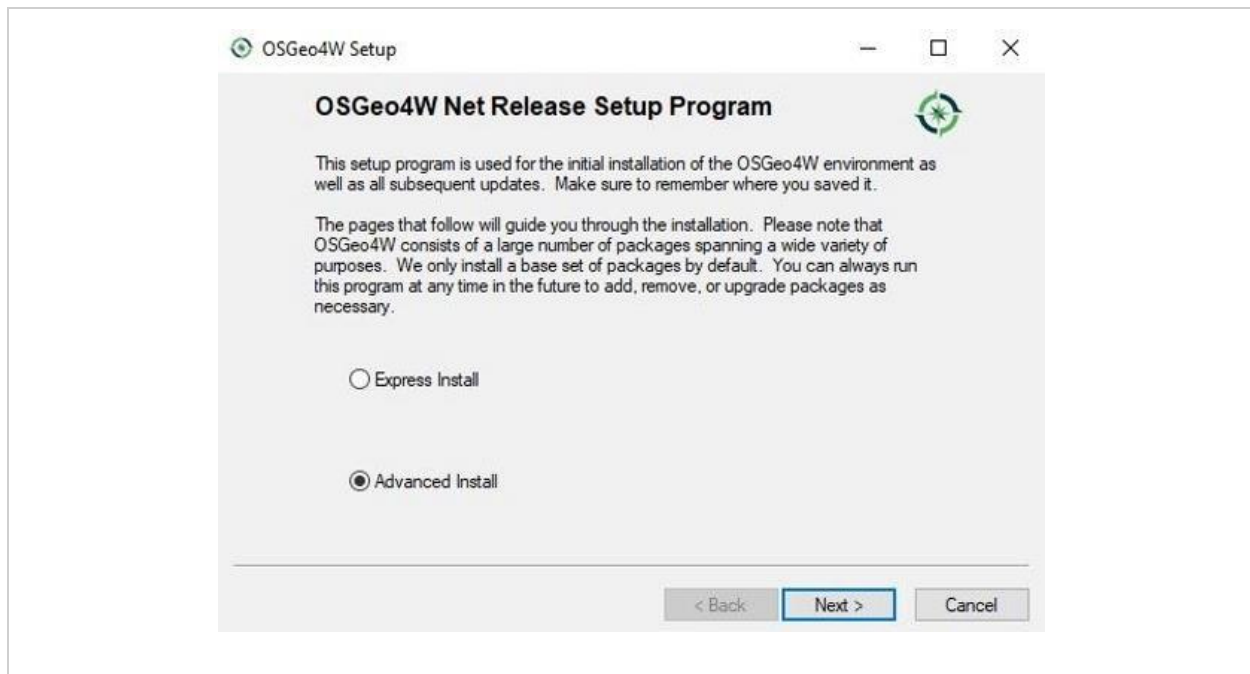


Figure 19. Selecting Advanced Install.

Next →

Select “Install from Internet” and continue →

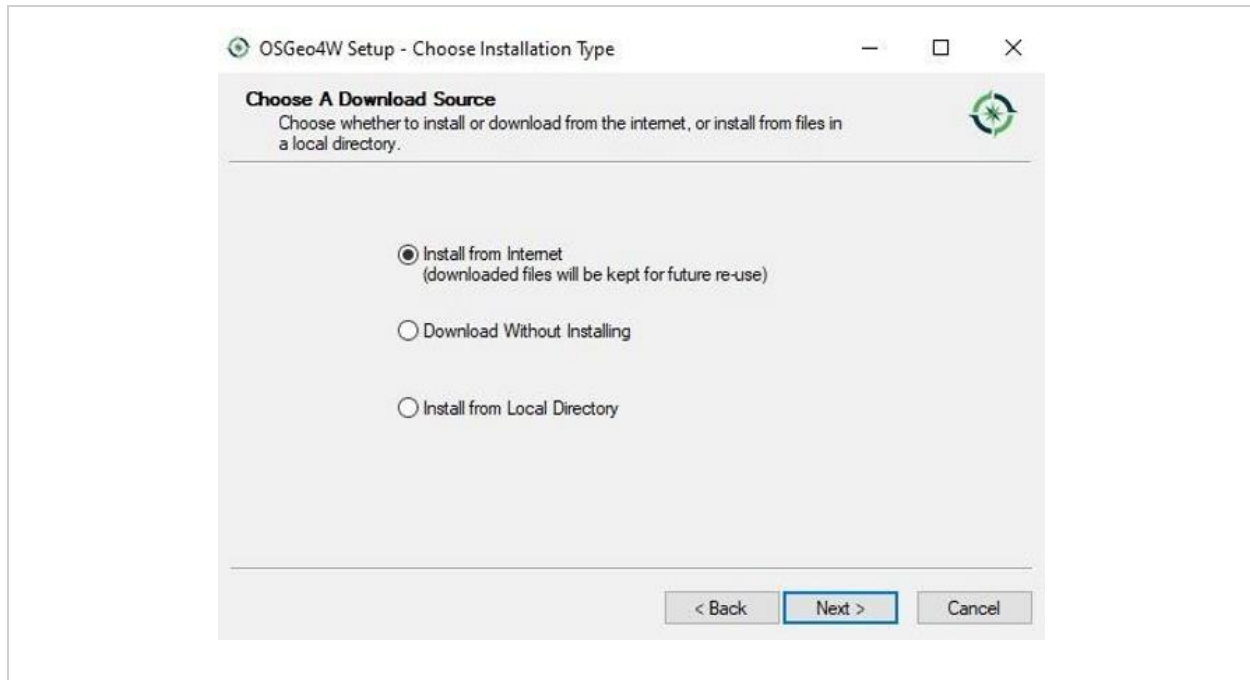


Figure 20. Advanced installation wizard.

Select Yes to continue → Next

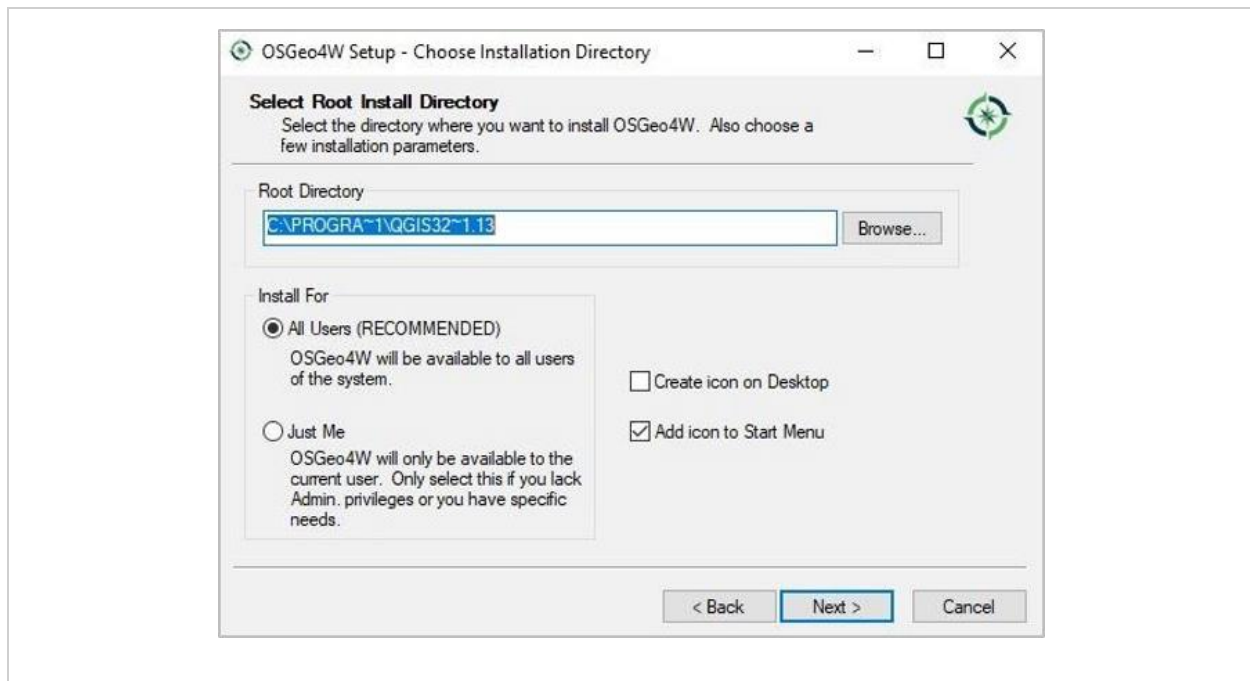


Figure 21. Root install directory confirmation.

Next →

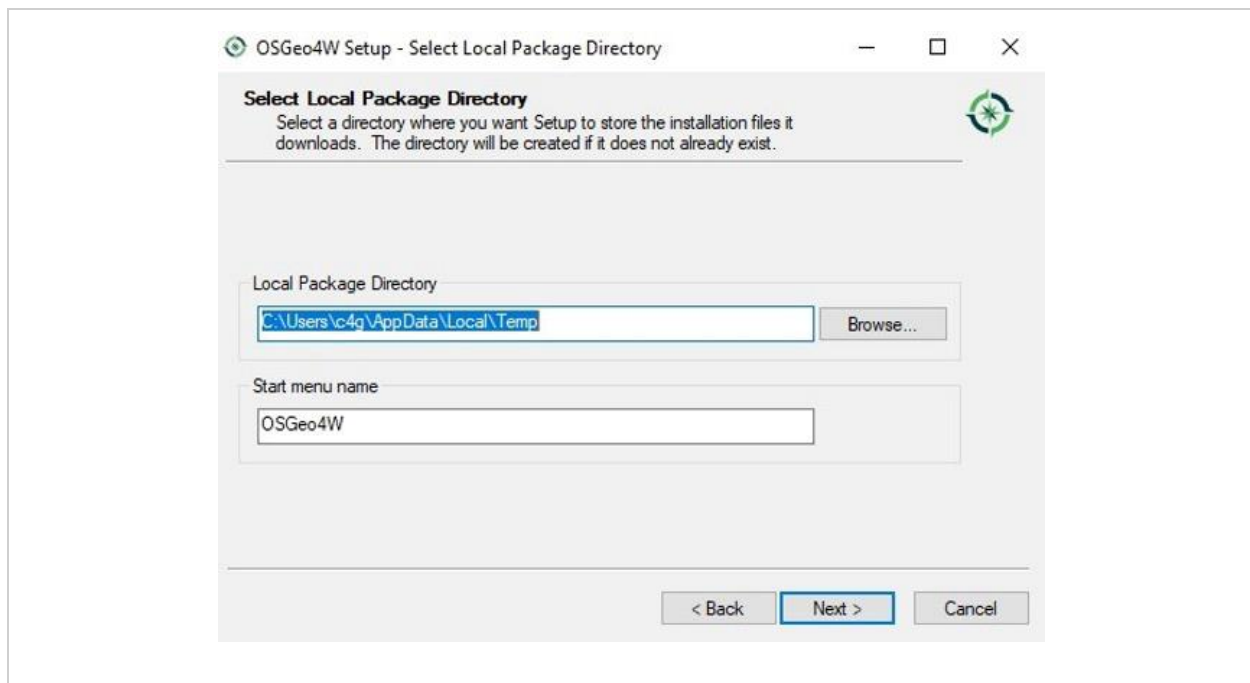


Figure 22. Local package directory selection.

Next →

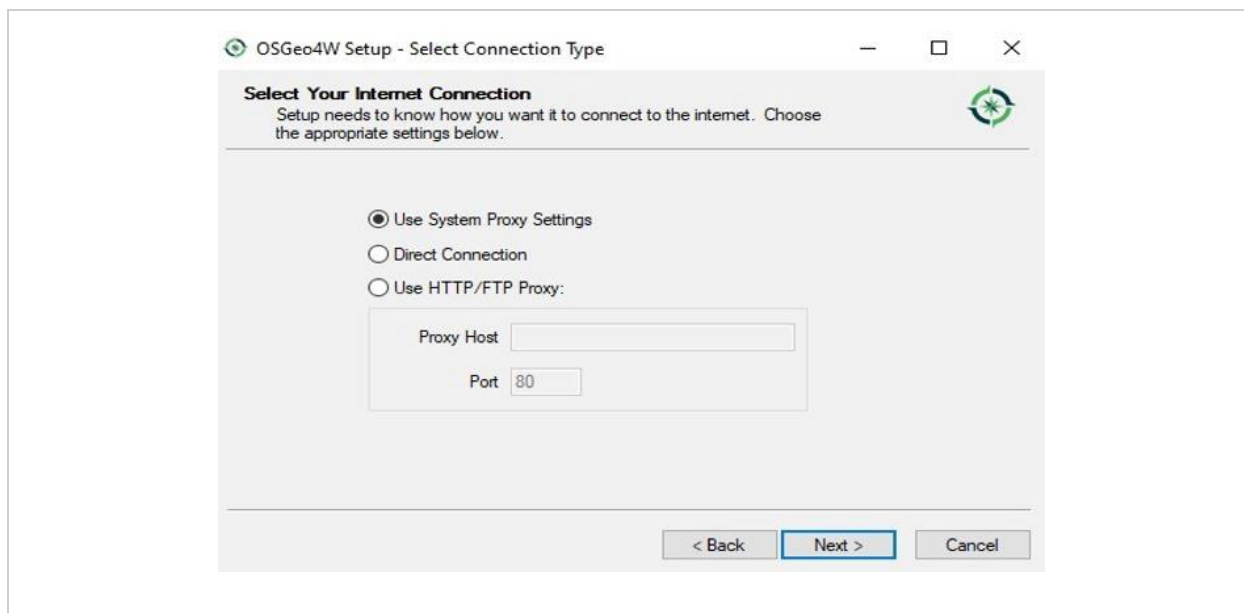


Figure 23. Internet connection settings.

Select a mirror (download server — selected by default) → Next

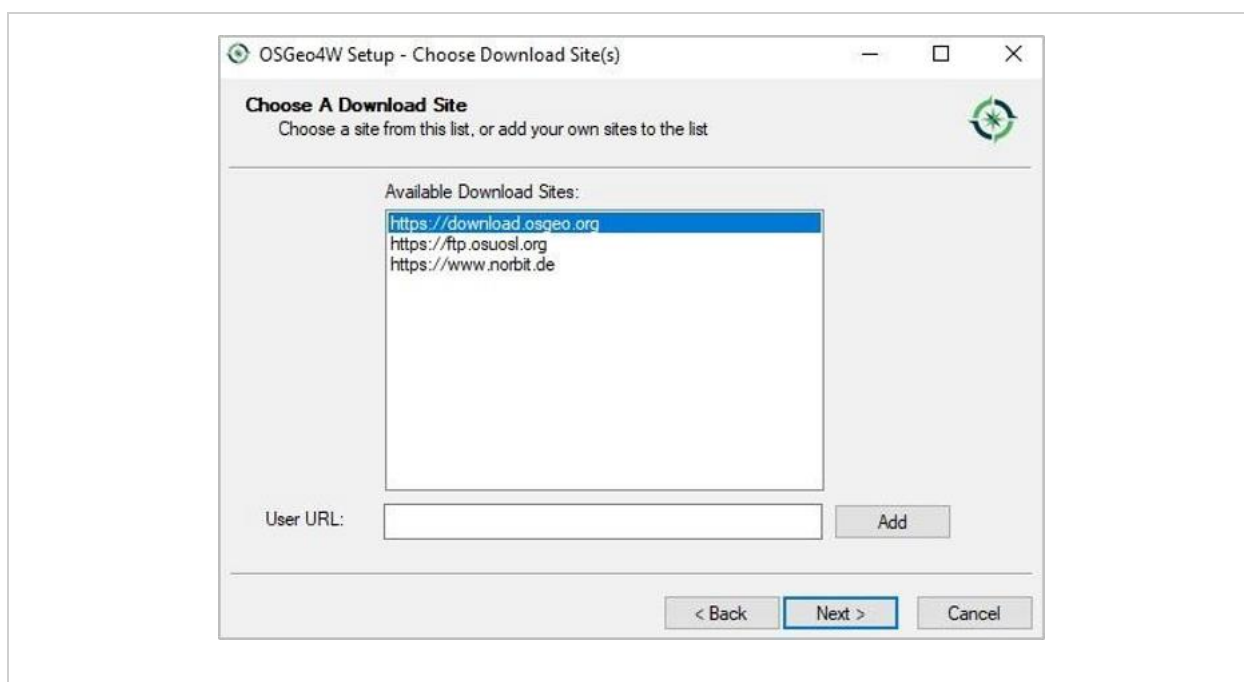


Figure 24. Download-site mirror selection.

In “Select Packages”, search for filegdb. In the gdal-filegdb row, click Skip until a version number appears (e.g. 3.11.3-1).

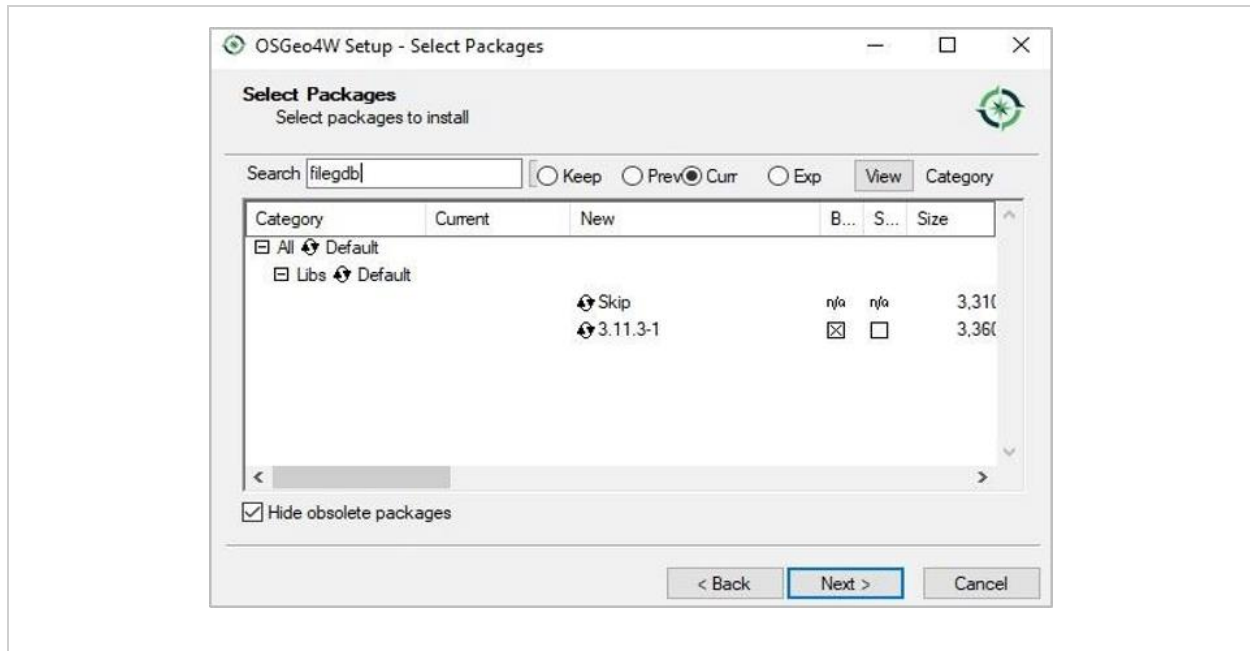


Figure 25. Selecting the gdal-filegdb package for installation.

Next → Install → Finish.

Once the FileGDB driver has been installed, verify that it is active by running the previous command again.

4. Directory Structure and Files

To perform the transformation, several elements are required:

- **Source / input file in DrukRef03:** can be a shapefile, a raster (such as a GeoTIFF), or a File Geodatabase.
- **Output file:** created after the process; contains the same dataset expressed in the new reference system.
- **NTv2 grid file (.gsb):** defines the corrections needed to move between the two datums.
- **Source CRS (–s_srs):** ensures the input file is interpreted correctly, even where metadata is incomplete or inconsistent.
- **Target CRS (–t_srs):** specifies the system into which the data will be transformed. When no EPSG code is available, the .prj file works as a temporary, descriptive label for the output — it does not replace an official EPSG code, which should be used once available.
- **Coordinate transformation pipeline (–ct):** explicitly calls the NTv2 file. This is the technical step that enforces the datum shift using the provided grid.

4.2 Transformation of a Single Vector, Raster, or Geodatabase File

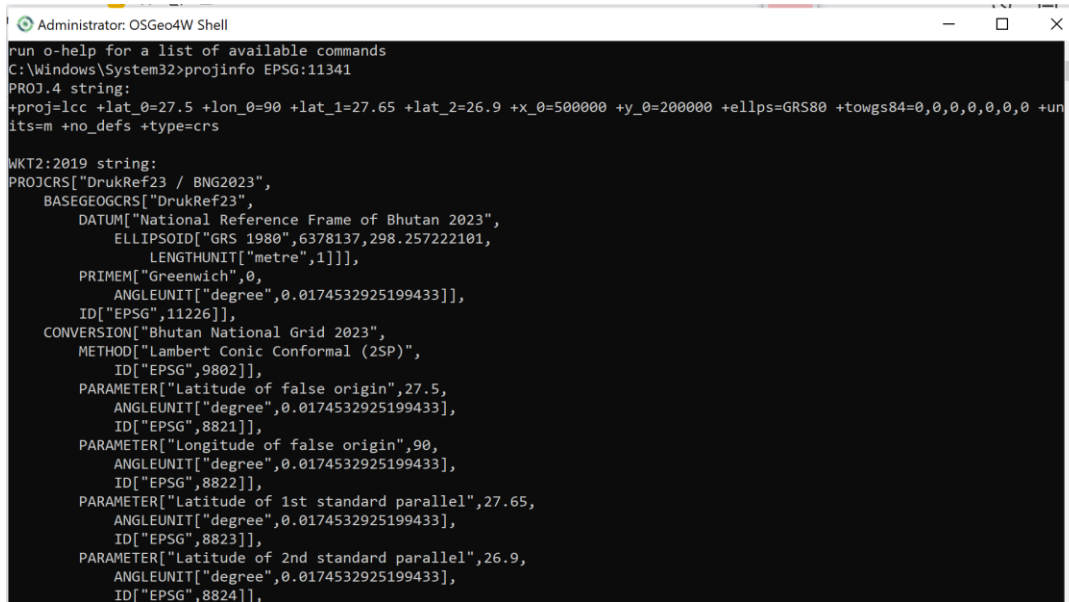
Note: The EPSG code for DrukRef23 is 11341.

Since the official EPSG code for DrukRef23 is already released, this SOP is prepared considering the availability of the EPSG code. Applying the transformation of simple files in vector, raster, or geodatabase formats is done using the OSGeo4W Shell. Before running the commands, it is essential to verify that the required drivers are properly installed.

Check the projection

Open the OSGeo4W Shell and run the following command:

```
projinfo EPSG:11341
```



```
Administrator: OSGeo4W Shell
run o-help for a list of available commands
C:\Windows\System32\projinfo EPSG:11341
PROJ.4 string:
+proj=lcc +lat_0=27.5 +lon_0=90 +lat_1=27.65 +lat_2=26.9 +x_0=500000 +y_0=200000 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs +type=crs

WKT2:2019 string:
PROJCRS["DrukRef23 / BNG2023",
  BASEGEOGCRS["DrukRef23",
    DATUM["National Reference Frame of Bhutan 2023",
      ELLIPSOID["GRS 1980",6378137,298.257222101,
        LENGTHUNIT["metre",1]],
    PRIMEM["Greenwich",0,
      ANGLEUNIT["degree",0.0174532925199433]],
    ID["EPSG",11226]],
  CONVERSION["Bhutan National Grid 2023",
    METHOD["Lambert Conic Conformal (2SP)",
      ID["EPSG",9802]],
    PARAMETER["Latitude of false origin",27.5,
      ANGLEUNIT["degree",0.0174532925199433],
      ID["EPSG",8821]],
    PARAMETER["Longitude of false origin",90,
      ANGLEUNIT["degree",0.0174532925199433],
      ID["EPSG",8822]],
    PARAMETER["Latitude of 1st standard parallel",27.65,
      ANGLEUNIT["degree",0.0174532925199433],
      ID["EPSG",8823]],
    PARAMETER["Latitude of 2nd standard parallel",26.9,
      ANGLEUNIT["degree",0.0174532925199433],
      ID["EPSG",8824]]],
  ID["EPSG",11341]]]
```

Figure 26. Output of the projinfo EPSG:11341 command.

The latest version of QGIS should already include this EPSG code. If your QGIS is an older version, install the gdal plugin with OSGeo4W Setup by following the steps described earlier — type gdal instead of filegdb.

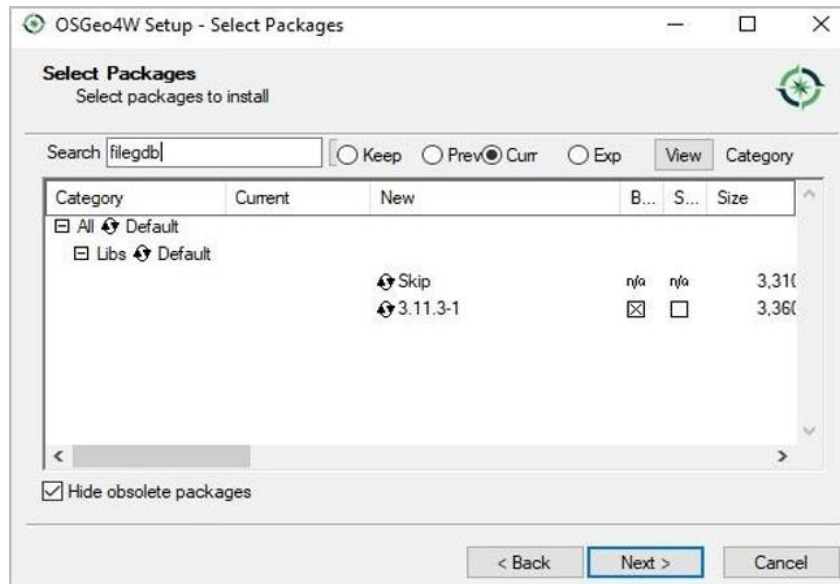


Figure 27. Selecting a package for installation via OSGeo4W Setup.

Open the OSGeo4W Shell and run the following commands (copy and paste one by one):

```
ogr2ogr --version
gdalwarp --version
```

```
ogr2ogr --version
gdalwarp --version
```

Figure 28. ogr2ogr --version and gdalwarp --version commands.

```
C:\Windows\System32>ogr2ogr --version
GDAL 3.12.2 "Chicoutimi", released 2026/02/03

C:\Windows\System32>gdalwarp --version
GDAL 3.12.2 "Chicoutimi", released 2026/02/03

C:\Windows\System32>
```

Figure 29. Terminal output confirming the installed GDAL version.

Both commands should return the GDAL version (e.g. GDAL 3.12.2).

General considerations

Before running any transformation command, users must ensure the following conditions are met:

- Create a separate folder with no spaces in its name — this can be created directly under the D: drive (example: D:\transoformed23).
- Place all input files (shapefiles, geodatabases, TIFFs) in this folder.
- NTV2 files may be kept in the same folder, or in a different folder.
- Output files will also be added to the same folder after the transformation.

4.2.1 Vector Single File (Shapefile) Transformation

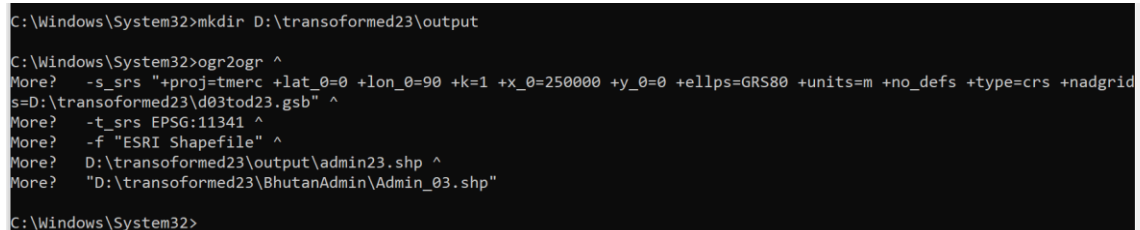
Users only need to run the following two scripts in the OSGeo4W Shell in sequence:

```
mkdir D:\transoformed23\output

ogr2ogr -s_srs "+proj=tmerc +lat_0=0 +lon_0=90 +k=1 +x_0=250000 +y_0=0 +ellps=GRS80
+units=m +no_defs +type=crs +nadgrids=D:\transoformed23\d03tod23.gsb" -t_srs
EPSG:11341 -f "ESRI Shapefile" "D:\transoformed23\output\admin23.shp"
"D:\transoformed23\BhutanAdmin\Admin_03.shp"
```

Before running, edit the highlighted parts based on the location and names of your input and output files:

- **D:\transoformed23\output** — creates the output folder location; overwrites it if it already exists.
- **D:\transoformed23\d03tod23.gsb** — location of your NTV2 file.
- **D:\transoformed23\output\admin23.shp** — location and name of the output (transformed) file.
- **D:\transoformed23\BhutanAdmin\Admin_03.shp** — location and name of the input file (DrukRef03).



```
C:\Windows\System32>mkdir D:\transoformed23\output
C:\Windows\System32>ogr2ogr ^
More? -s_srs "+proj=tmerc +lat_0=0 +lon_0=90 +k=1 +x_0=250000 +y_0=0 +ellps=GRS80 +units=m +no_defs +type=crs +nadgrid
s=D:\transoformed23\d03tod23.gsb" ^
More? -t_srs EPSG:11341 ^
More? -f "ESRI Shapefile" ^
More? D:\transoformed23\output\admin23.shp ^
More? "D:\transoformed23\BhutanAdmin\Admin_03.shp"
C:\Windows\System32>
```

Figure 30. Running the shapefile transformation command in the OSGeo4W Shell.

Copy and paste the script. The transformation is successful if it returns nothing. You can check the result in the output folder specified in the script.

4.2.2 Raster Single File Transformation

In the OSGeo4W Shell, change the directory to where the TIFF to be transformed is located. For example, the command below changes to the transformed23 folder under the D: drive.

```
D:
cd \transformed23
```

```
D:\transformed23>cd \transformed23
```

Figure 31. Changing directory in the OSGeo4W Shell.

Then edit and run the script below:

```
gdalwarp -s_srs "+proj=tmerc +lat_0=0 +lon_0=90 +k=1 +x_0=250000 +y_0=0 +ellps=GRS80
+units=m +no_defs +type=crs +nadgrids= D:\transformed23\d03tod23.gsb" -t_srs
EPSG:11341 -of GTiff thimphu.tif Output2233.tif
```

```
D:\transformed23>gdalwarp ^
More? -s_srs "+proj=tmerc +lat_0=0 +lon_0=90 +k=1 +x_0=250000 +y_0=0 +ellps=GRS80 +units=m +no_defs +type=crs +nadgrid
s=D:\transformed23\d03tod23.gsb" ^
More? -t_srs EPSG:11341 ^
More? -of GTiff ^
More? thimphu.tif Output2233.tif
Creating output file that is 60681P x 52227L.
Using internal nodata values (e.g. 255) for image thimphu.tif.
Copying nodata values from source thimphu.tif to destination Output2233.tif.
Processing thimphu.tif [1/1] : 0. - estimated remaining time: 00:13:00
0...10...20...30...40...50...60...70...80...90...100 - done in 00:15:43.
```

Figure 32. Running the raster transformation command in the OSGeo4W Shell.

Edit the highlighted parts as follows:

- **thimphu.tif** — name of your input raster.
- **Output2233.tif** — name of your output TIFF. The output is written to the same folder (here, transformed23).

✓ **Check the result:** A new raster file named Output2233.tif will be created in the same folder.

4.2.3 File Geodatabase (GDB) Transformation

Since a geodatabase (GDB) is organized into feature datasets and feature classes, this process aims to transform the GDB components while preserving as much of their original characteristics as possible. This requires specific inputs and a carefully structured workflow.

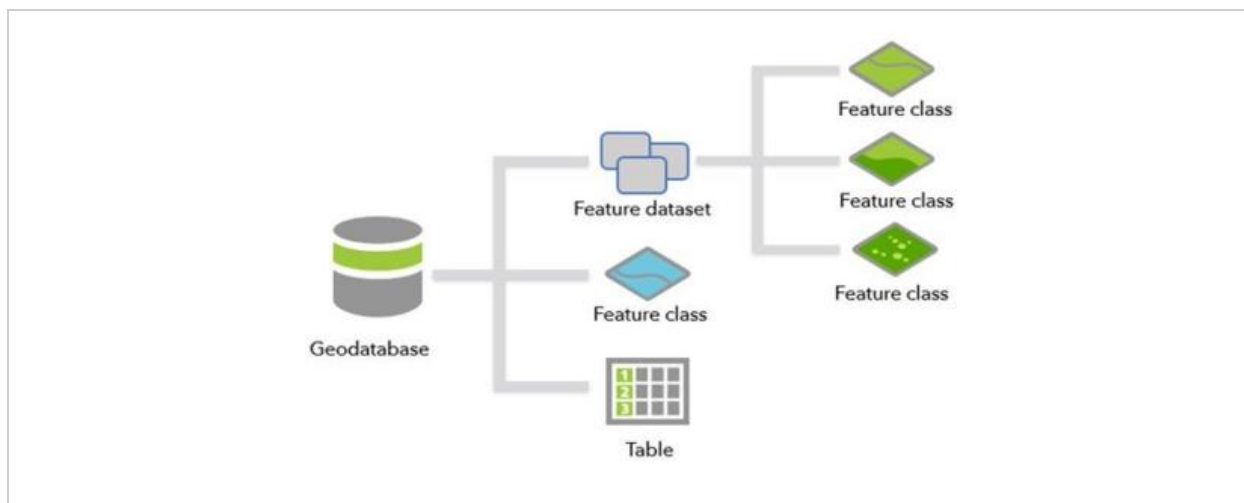


Figure 33. Structure of a File Geodatabase (feature datasets and feature classes).

Folder preparation

Create a folder that contains the following:

1. The .gdb geodatabase that needs to be transformed
2. The NTV2 file
3. The Python script file [script.py](#)

Get the required files:

1. https://miranet.nlcs.gov.bt/public/datum_transformation/
- Download: **gdb_to_gdb_ntv2_drukref23_LCC.py**

Running the script

In the OSGeo4W Shell, change to your working directory (example given below):

```
D:
cd \transoformed23
```

Now modify the highlighted parts of the script below and run it:

```
python gdb_to_gdb_ntv2_drukref23_LCC.py "MyProject12.gdb" "drukref23_FGDB.gdb"
"D:\transformed23\d03tod23.gsb" EPSG:11341 --src-epsg EPSG:5266 --driver FileGDB
```

Changes to be made:

- **MyProject12.gdb** — name of your input geodatabase.
- **drukref2233_FGDB.gdb** — name of your output geodatabase.
- **D:\transformed23\d03tod23.gsb** — location of your NTV2 file.

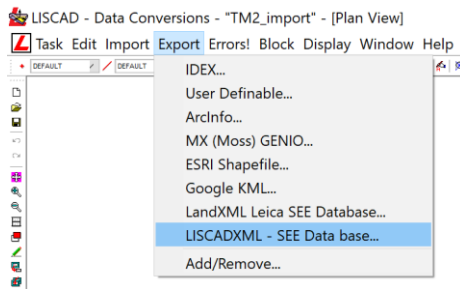
Check the output in the same working folder.

5. Transformation of SEE Map data

5.1 Transformation of LISCADXML

If you have your survey data in DrukRef03 in SEE map, follow the steps below to perform the transformation.

Step1: From SEE map create xml file by using the export of data conversion.

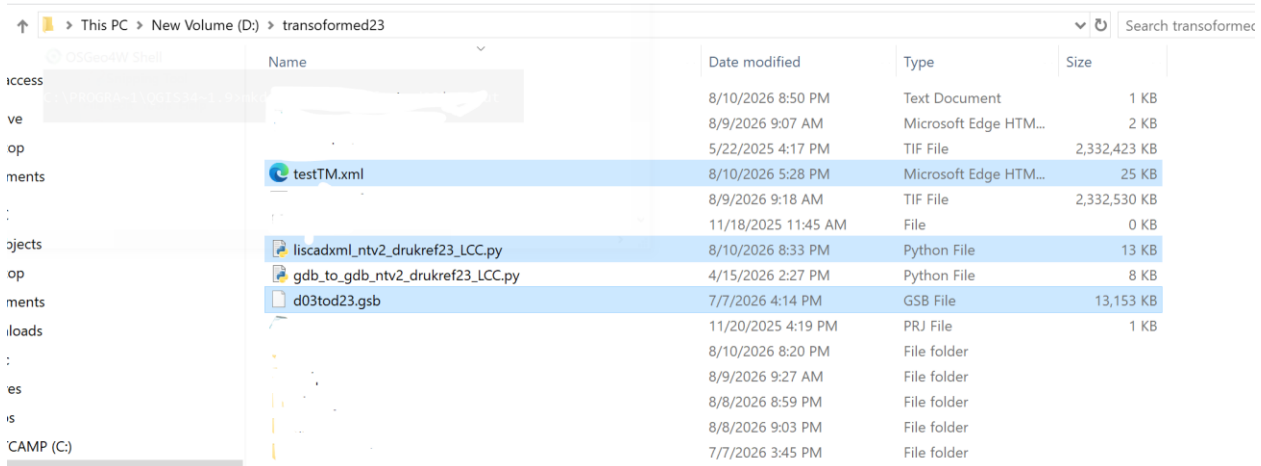


Step2: Prepare your input files. You need following files in a folder.

Get the required files:

1. Input xml file from SEE map
2. https://miranet.nlcs.gov.bt/public/datum_transformation/ — Download: **liscadxml_ntv2_drukref23_LCC.py**
3. <https://miranet.nlcs.gov.bt/public/ntv2/> — Download: **d03tod23.gsb**

Save the above files in a folder as shown below example.



Step3: Open you Osgeo4W shell as administrator and create the output folder.

For example, below script creates folder name output under D:\transoformed23

```
mkdir D:\transoformed23\xml_output
```

OSGeo4W Shell

Snipping Tool

```
C:\PROGRA~1\QGIS34~1.9>mkdir D:\transoformed23\output
```

Step3: run the given script.

For example, below script creates folder name output under D:\transoformed23

```
python -u D:\transoformed23\liscadxml_ntv2_drukref23_LCC.py  
"D:\transoformed23\testTM.xml" "D:\transoformed23\xml_output\testTM_DrukRef23.xml"  
"D:\transoformed23\d03tod23.gsb" EPSG:11341 --src-epsg EPSG:5266
```

Before, running the script, make the following changes based on your folder location and file names:

D:\transoformed23 : Location of python file

D:\transoformed23\testTM.xml : Location of xml file to be transformed

D:\transoformed23\xml_output\testTM_DrukRef23.xml :Location and name of transformed xml file

D:\transoformed23\ : Location of NTV2 file

OSGeo4W Shell

```
C:\PROGRA~1\QGIS34~1.9>python -u D:\transoformed23\liscadxml_ntv2_drukref23_LCC.py "D:\transoformed23\testTM.xml" "D:\transoformed23\xml_output\testTM_DrukRef23.xml" "D:\transoformed23\d03tod23.gsb" EPSG:11341 --src-epsg EPSG:5266  
===== LISCAD SEEDB XML: DrukRef03 TM -> DrukRef23 LCC =====  
Input XML : D:\transoformed23\testTM.xml  
Output XML : D:\transoformed23\xml_output\testTM_DrukRef23.xml  
Grid : D:\transoformed23\d03tod23.gsb  
Source CRS: EPSG:5266  
Target CRS: EPSG:11341  
  
GDAL version: GDAL 3.12.2 "Chicoutimi", released 2026/02/03  
C:\PROGRA~1\QGIS34~1.9\apps\Python312\Lib\site-packages\osgeo\osr.py:424: FutureWarning: Neither osr.UseExceptions() nor osr.DontUseExceptions() has been explicitly called. In GDAL 4.0, exceptions will be enabled by default.  
  warnings.warn(  
NTV2 transformation pipeline:  
+proj=pipeline +step +inv +proj=tmerc +lat_0=0 +lon_0=90 +k=1 +x_0=250000 +y_0=0 +ellps=GRS80 +units=m +no_defs +step +proj=hgridshift +grids=D:/transoformed23/d03tod23.gsb +step +proj=lcc +lat_0=27.5 +lon_0=90 +lat_1=27.65 +lat_2=26.9 +x_0=500000 +y_0=200000 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs  
  
Transformation completed.  
Points transformed : 10  
StraightLine lengths set : 9  
Polygon areas set : 1  
  
NOTE: The <Projection>/<TransverseMercator>/<Ellipsoid> metadata block still describes the source DrukRef03 TM definition. This script deliberately leaves it untouched, since rewriting it to an LCC definition uses a different LISCAD projection element and could make the file unreadable by LISCAD. Reset the projection to DrukRef23 LCC / BNG2023 (EPSG:11341) manually inside LISCAD after import, or via Job Properties.  
  
Output:  
D:\transoformed23\xml_output\testTM_DrukRef23.xml  
===== C:\PROGRA~1\QGIS34~1.9>
```

Step5: Check the transformed xml file

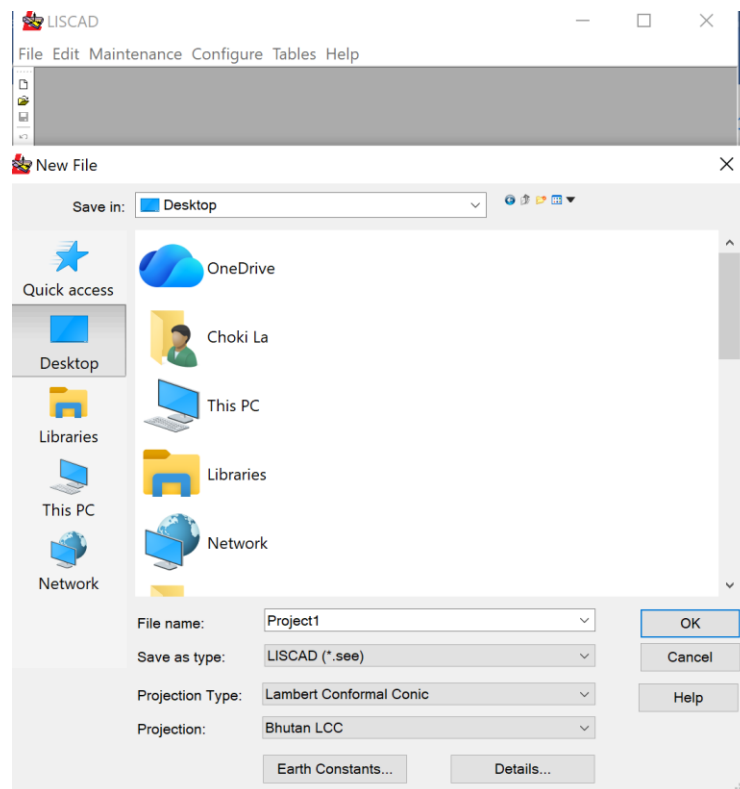
Check the output folder

This PC > New Volume (D:) > transoformed23 > xml_output				
	Name	Date modified	Type	Si
SS	 testTM_DrukRef23.xml	8/11/2026 9:27 AM	Microsoft Edge HTM...	

5.2 Import xml file to SEE map

Following steps need to be performed to import the transformed xml file to SEE map

Step1: Create/open the existing project with LCC projection

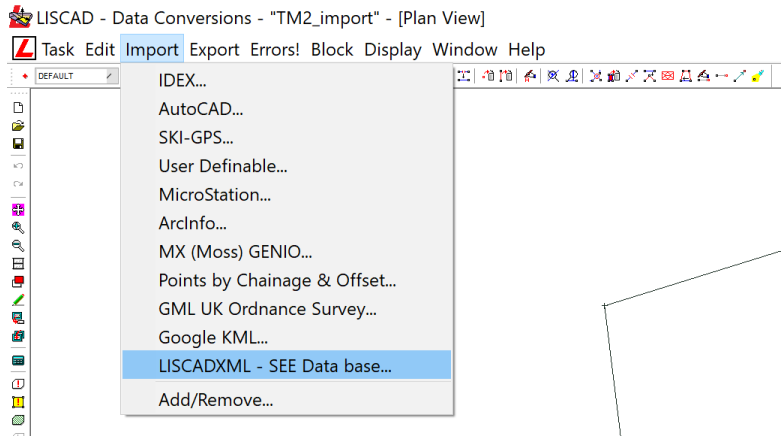


Make sure you have replaced your project.dat file in LisCAD. If not replace your project.dat file which has LCC projection defined.

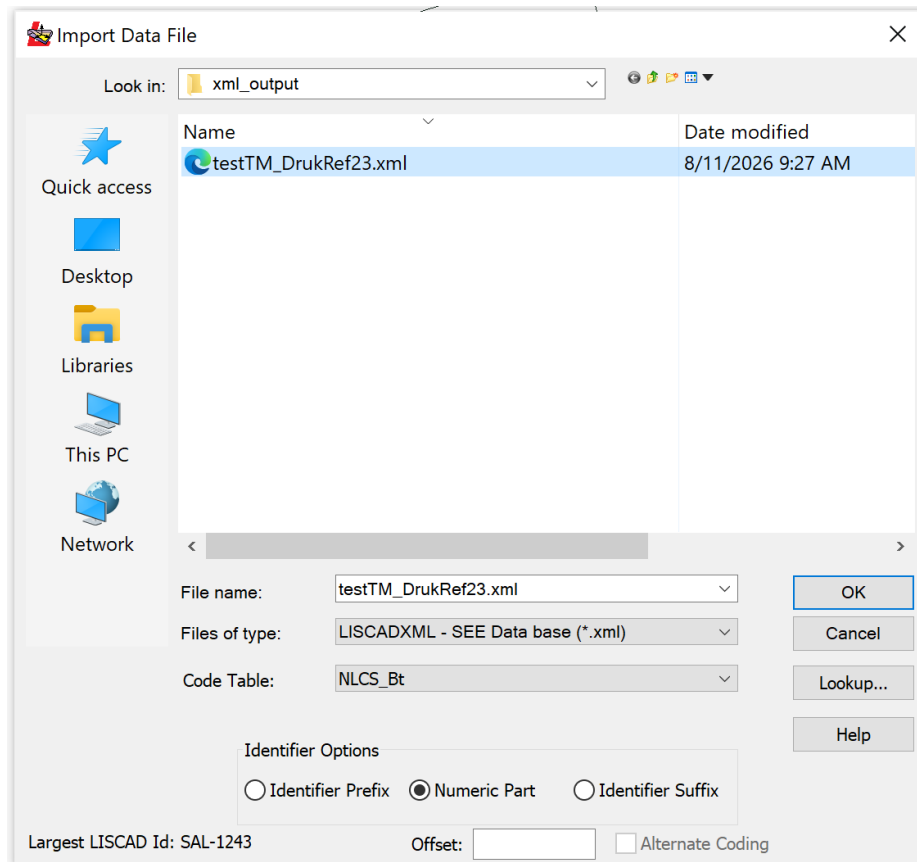
Get the projection file from https://miranet.nlcs.gov.bt/public/datum_transformation/ —
Download: projection.dat

Step1: import xml file

Import the xml file using import tool under the Data conversion tool:



Select your xml file and code table of NLCS and click OK



Check the projection of the imported file: Task>Utility>Edit>Detials

