

Department of the Interior
U.S. Geological Survey

USER GUIDE

LANDSAT QUALITY ASSESSMENT (QA) TOOLS

LANDSAT QA BAND SUPPORT

Version 1.4

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Document History

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1.0	07/12/2013	Initial Version
1.1	12/11/2013	Corrected typographical errors, added information regarding Polar Stereographic scenes
1.2	12/09/2014	Added descriptions of QA bit fields
1.3	03/03/2017	Added Collection 1 L-LDOPE tool information and separated appropriate sections. Corrected typographical errors.
1.4	04/13/2017	Tool name changed from L-LDOPE Tool to Landsat QA Tools. All instances of "L-LDOPE" replaced with "Landsat QA"

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Section 1 Introduction

A Quality Assessment (QA) band is included in select Landsat Level-1 data products. Each pixel in the QA band contains a decimal value that represents bit-packed combinations of surface, atmosphere, and sensor conditions that can affect the overall usefulness of a given pixel.

All Landsat 8 Operational Land Imager (OLI) **Pre-Collection** data products include a QA band, as do Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 OLI **Collection 1** products.

The bit-packed information in a QA band is a decimal translation of binary strings. For example, the decimal value “1” translates to the binary value “0001.” The binary value “0001” has 4 bits (0, 1, 2, and 3), written right to left as bits 0 (“1”), 1 (“0”), 2 (“0”), and 3 (“0”). Each of the bits 0-3 represents a condition that can affect the calculation of a physical value. Bit 0 may be used to identify fill values, bit 1 may be used to identify a cloud, bit 2 may be used to indicate water, and bit 3 may be used identify snow. If the condition is true, the bit is set to “1,” and “0” if false.

In the example, “0001” means the pixel contains a fill value, and should likely be ignored.

- Bit 0 = 1 = fill
- Bit 1 = 0 = no cloud
- Bit 2 = 0 = land
- Bit 3 = 0 = no snow

Rigorous science applications seeking to optimize the value of pixels used in a study will find QA bits useful as a first level indicator of certain conditions. Otherwise, users are advised that this file contains information that can be easily misinterpreted and it is not recommended for general use. More generalized quality band information is available in the [LandsatLook Quality Image](#).

National Aeronautics and Space Administration (NASA) funded the MODIS Land Data Operational Product Evaluation (LDOPE) team to develop manipulation, visualization, and analysis tools for the MODIS user community. The resulting MODIS LDOPE Toolbox has been distributed without restriction since 2004 from the Land Processes Distributed Active Archive Center (LP DAAC).

When the USGS created the original Landsat LDOPE (L-LDOPE) Toolbelt, which was derived from the MODIS LDOPE Toolbox, it contained a specific tool developed to support the Landsat 8 OLI Pre-Collection QA band. With the arrival of Collection 1 data, the addition of QA bands for Landsat 4-5 TM and Landsat 7 ETM+, and an altered QA band for Landsat 8 OLI, a new tool set, called Landsat QA Tools, was created to support QA band extraction for all Collection 1 data, regardless of sensor, as well as Landsat 8 Pre-Collection data products. This User Guide contains information pertaining

to both Landsat QA tools and appropriate sections are separated accordingly.

All original code and documentation are used with permission from LDOPE and are available from LP DAAC at https://lpdaac.usgs.gov/tools/ldope_tools.

Section 2 Data Characteristics

Landsat 8 Pre-Collection and Landsat 4-8 Collection 1 Level-1 data products include a 16-bit QA file in Geographic Tagged Image File Format (GeoTIFF). Robust image processing software capable of handling 16-bit data is necessary to compute statistics of the number of pixels containing each of the designated bits.

Used effectively, QA bits improve the integrity of science investigations by indicating which pixels might be affected by instrument artifacts or subject to cloud contamination. For example, NDVI calculated over pixels containing clouds will show anomalous values. If such pixels were included in a phenology study, the results might not show the true characteristics of seasonal vegetation growth. Cloud contaminated pixels will lower NDVI values, and measures like the timing of 'green up' or peak maturity would appear later than they actually occurred. A worse consequence would be that the reported reduction of vegetation growth would be taken as an indicator of environmental change, potentially prompting unnecessary land management policies or practices.

2.1 Pre-Collection QA Band Characteristics

The pixel values in the Landsat 8 OLI Pre-Collection QA file must be translated to 16-bit binary form to be used effectively. The gray shaded areas in the table below show the bits that are currently being populated in the Level-1 QA Band, and the conditions each describe.

Landsat 8 OLI, OLI/TIRS Pre-Collection QA band bits: Read RIGHT to LEFT, starting with Bit 0																
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DESCRIPTION	Cloud Confidence		Cirrus Confidence		Snow/Ice Confidence		Vegetation Confidence		Reserved		Water Confidence		Reserved	Terrain Occlusion	Dropped Frame	Designated Fill

An explanation of each bit is as follows:

- Bit 0 Designated Fill: Areas which are not imaged or could not be populated with data, but are part of the image's grid
- Bit 1 Dropped Frame: An error has occurred during acquisition, and erroneous data have been populated into those pixels
- Bit 2 Terrain Occlusion: Due to the off-nadir angle of the sensor, a ground feature is blocked by terrain features in the foreground
- Bit 3 Reserved: Bit is unused, but reserved for future applications. Landsat QA Tool output will not be valid for this bit
- Bits 4-5 Water Confidence: Confidence in the pixel containing water

- Bits 6-7 Reserved: Bits are unused, but reserved for future applications. Landsat QA Tool output will not be valid for these bits
- Bits 8-9 Vegetation Confidence: Confidence in the pixel containing vegetation
- Bits 10-11 Snow/Ice Confidence: Confidence in the pixel containing snow and/or ice
- Bits 12-13 Cirrus Confidence: Confidence in the pixel containing cirrus cloud
- Bits 14-15 Cloud Confidence: Confidence in the pixel containing any type of cloud

For the single bits (0, 1, 2, and 3):

- 0 = No, this condition does not exist
- 1 = Yes, this condition exists

The double bits (4-5, 6-7, 8-9, 10-11, 12-13, and 14-15), read left to right, represent levels of confidence that a condition exists:

- 00 = Algorithm did not determine the status of the condition
- 01 = Algorithm has low confidence that this condition exists
- 10 = Algorithm has medium confidence that this condition exists
- 11 = Algorithm has high confidence that this condition exists

For example, a QA pixel value of “58384” translates to the 16-bit binary string:

1110 0100 0001 0000

Using the table above as an interpretation legend, this pixel is:

- Bit 0 = 0 = Not fill
- Bit 1 = 0 = Not a dropped frame
- Bit 2 = 0 = Not terrain occluded
- Bit 3 = 0 = Reserved
- Bits 4-5 = 01 = Low confidence that this pixel contains water
- Bits 6-7 = 0 = Reserved
- Bits 8-9 = 0 = Vegetation confidence not determined
- Bits 10-11 = 01 = Low confidence that this pixel contains snow and/or ice
- Bits 12-13 = 10 = Medium confidence that this pixel contains cirrus cloud
- Bits 14-15 = 11 = High confidence that this pixel contains cloud

Certain decimal values occur regularly and can be interpreted without unpacking them into 16-bit strings and using the table above as a reference. Some common Landsat 8 OLI Pre-Collection QA pixel values and their meanings are included in Appendix A.

2.2 Collection 1 QA Band Characteristics

The pixel values in the Collection 1 QA file must be translated to 16-bit binary form to be used effectively. The gray shaded areas in the table below show the bits that are currently being populated in the Level-1 QA Band, and the conditions each describe.

Landsat 4-5 TM, Landsat 7 ETM+ Collection 1 QA band bits: Read from RIGHT to LEFT, starting with Bit 0																
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DESCRIPTION	Reserved					Snow/Ice Confidence	Cloud Shadow Confidence	Cloud Confidence	Cloud	Radiometric Saturation	Dropped Pixel	Designated Fill				

Landsat 8 OLI, OLI/TIRS Collection 1 QA band bits: Read RIGHT to LEFT, starting with Bit 0																
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DESCRIPTION	Reserved			Cirrus Confidence	Snow/Ice Confidence	Cloud Shadow Confidence	Cloud Confidence	Cloud	Radiometric Saturation	Terrain Occlusion	Designated Fill					

An explanation of each bit for the Landsat 4-7 QA band is as follows:

- Bit 0 Designated Fill: Areas which are not imaged or could not be populated with data but are a part of the image's grid
- Bit 1 Dropped Pixel: An error has occurred during acquisition and erroneous data have been populated into this pixel
- Bits 2-3 Radiometric Saturation: Indicates how many bands contain saturation
- Bit 4 Cloud: Indicates whether or not the pixel contains cloud
- Bits 5-6 Cloud Confidence: Confidence in the pixel containing any type of cloud
- Bits 7-8 Cloud Shadow Confidence: Confidence in the pixel containing cloud shadow
- Bits 9-10 Snow/Ice Confidence: Confidence in the pixel containing snow and/or ice.
- Bits 11-15 Reserved: Bits are unused, but reserved for future applications. Landsat QA Tool output will not be valid for these bits

An explanation of each bit for the Landsat 8 QA band is as follow:

- Bit 0 Designated Fill: Areas which are not imaged or could not be populated with data but are a part of the image's grid
- Bit 1 Terrain Occlusion: Due to the off-nadir angle of the sensor, a ground feature is blocked by terrain features in the foreground
- Bits 2-3 Radiometric Saturation: Indicates how many bands contain saturation
- Bit 4 Cloud: Indicates whether or not the pixel contains cloud
- Bits 5-6 Cloud Confidence: Confidence in the pixel containing any type of cloud
- Bits 7-8 Cloud Shadow Confidence: Confidence in the pixel containing cloud shadow
- Bits 9-10 Snow/Ice Confidence: Confidence in the pixel containing snow and/or ice
- Bits 11-12 Cirrus Confidence: Confidence in the pixel containing cirrus cloud
- Bits 13-15 Reserved: Bits are unused, but reserved for future applications. Landsat QA Tool output will not be valid for these bits

For quality data represented by a single bit (Bits 0, 1, and 4), the output values are as follows:

- 0 = No, this condition does not exist
- 1 = Yes, this condition exists

For radiometric saturation (Bits 2-3), read left to right, the interpretation of the bits is:

- 00 = No bands contain radiometric saturation
- 01 = 1-2 bands contain saturation (some)
- 10 = 3-4 bands contain saturation (moderate)
- 11 = 5 or more bands contain saturation (frequent)

The remaining double bits (Bits 5-6, 7-8, 9-10, and 11-12), read left to right, represent levels of confidence that a condition exists:

- 00 = Algorithm did not determine the status of this condition
- 01 = Algorithm has low confidence that this condition exists
- 10 = Algorithm has medium confidence that this condition exists
- 11 = Algorithm has high confidence that this condition exists

For example, a Landsat 8 Collection 1 QA pixel value of "1704" translates to the 16-bit binary string:

0000 0110 1010 1000

Using the table above as an interpretation legend, this pixel is:

- Bit 0 = 0 = not fill
- Bit 1 = 0 = not terrain occluded
- Bits 2-3 = 10 = 3-4 bands contain saturation
- Bit 4 = 0 = no cloud
- Bits 5-6 = 01 = low confidence that this pixel contains any type of cloud
- Bits 7-8 = 01 = low confidence that this pixel contains cloud shadow
- Bits 9-10 = 11 = high confidence that this pixel contains snow and/or ice
- Bits 11-12 = 00 = low confidence that this pixel contains cirrus cloud
- Bits 13-15 = 0 = bits are unused, but reserved for future applications. Landsat QA Tool output will not be valid for these bits.

Certain decimal values occur regularly and can be interpreted without unpacking them into 16-bit strings and using the table above as a reference. Some common Collection 1 pixel values and their meanings are included in Appendix B.

Section 3 **Caveats and Known Issues**

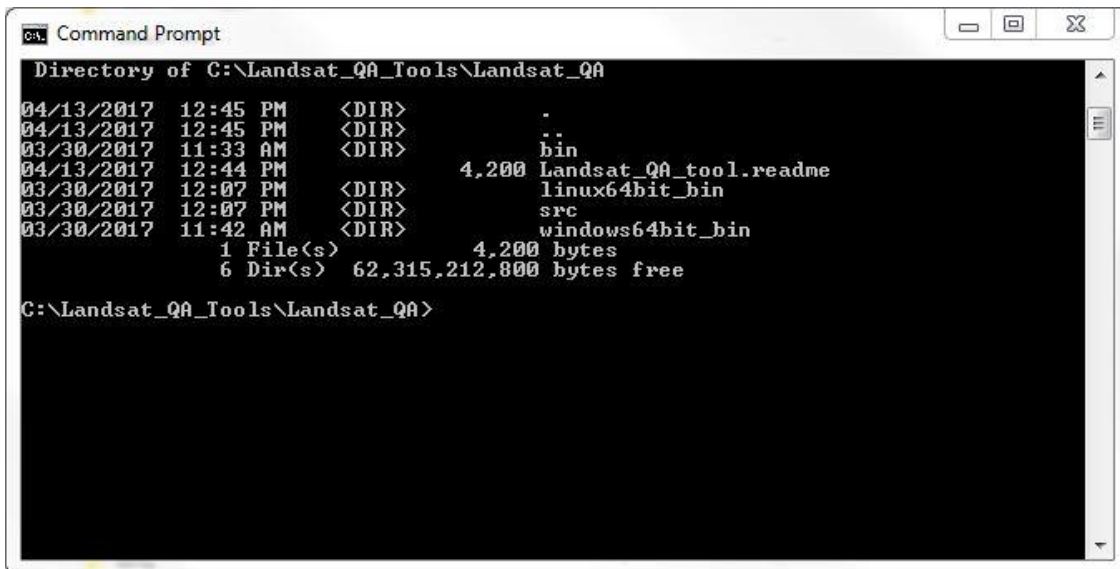
There are currently no caveats against the use of the Landsat QA Tools.

Section 4 Download and Installation

The Landsat QA Tools are available at no cost from the Landsat Web site, where a compressed file can be downloaded directly to a local drive. The software is delivered in a zip file that contains the executables compiled for Linux 64-Bit and Windows 64-Bit systems, accompanied by a binary (“bin”) directory, a source code (“src”) directory, and a readme file. Users can manually build executables by using the source code. Manually built executables will be stored in the “bin” directory. The pre-built executables for Linux 64-bit and Windows 64-bit systems are already stored in their respective bin directories. Installation steps are listed below.

1. Download “Landsat_QA_Tools.zip” from <https://landsat.usgs.gov/landsat-qa-tools>
2. Unzip “Landsat_QA_Tools.zip” to desired local directory, e.g. “C:\Landsat_QA_Tools”
3. Verify directory contents:
Landsat_QA_Tools.zip
Landsat_QA
 bin
 linux64bit_bin
 src
 windows64bit_bin
Landsat_QA_Tools.readme

Each command from Landsat QA tools download can be run directly by typing the executable name and its parameters. The following snapshot shows the directory contents using a command execution from a Windows Command Prompt display.



```
Command Prompt
Directory of C:\Landsat_QA_Tools\Landsat_QA
04/13/2017 12:45 PM <DIR>      .
04/13/2017 12:45 PM <DIR>      ..
03/30/2017 11:33 AM <DIR>      bin
04/13/2017 12:44 PM           4,200 Landsat_QA_tool.readme
03/30/2017 12:07 PM <DIR>      linux64bit_bin
03/30/2017 12:07 PM <DIR>      src
03/30/2017 11:42 AM <DIR>      windows64bit_bin
                1 File(s)          4,200 bytes
                6 Dir(s)  62,315,212,800 bytes free

C:\Landsat_QA_Tools\Landsat_QA>
```

Section 5 Tool Descriptions

Both of the commands in the Landsat QA Tools download are detailed in the sections below. Instruction or guidance is given in the context of name, synopsis, description, arguments, and examples for each tool.

5.1 `unpack_oli_qa` (Pre-Collection)

NAME

`unpack_oli_qa` – Extracts specified bits from the Landsat 8 OLI Pre-Collection QA band and writes them to individual GeoTIFFs or combines them into a single GeoTIFF.

SYNOPSIS

`unpack_oli_qa --help` will print the usage information

```
usage: unpack_oli_qa --ifile=input_QA_filename --
ofile=output_unpacked_QA_filename [--all=conf_level] [--fill] [-
-drop_frame] [--terrain_occl] [--water=conf_level] [--
cloud_shadow=conf_level] [--veg=conf_level] [--
snow_ice=conf_level] [--cirrus=conf_level] [--cloud=conf_level]
[--combine]
```

DESCRIPTION

`unpack_oli_qa` will read the QA band from the Landsat 8 Pre-Collection input product, then unpack this band into individual QA bands stored as GeoTIFFs using the user-specified base output filename. The output bands will refer to the QA bits (from right to left), representing the QA information which is stored in the QA band.

In some cases, a single bit is used to represent quality data in the OLI QA band and in other cases, two bits are used to describe conditions that may affect pixel quality.

For quality data represented by a single bit, the output values are as follows:

- 0 = No, this condition does not exist
- 1 = Yes, this condition exists

For quality data represented by two bits, the user has the option to specify the confidence levels included in the mask. The current confidence levels in the QA band are as follows:

- 00 = Algorithm did not determine the status of this condition
- 01 = Algorithm has low confidence that this condition exists
- 10 = Algorithm has medium confidence that this condition exists

- 11 = Algorithm has high confidence that the condition exists

If the user specifies a confidence level of 'high' for a confidence field, then the output mask will be flagged as "1" (yes) if the 2-bit confidence value is high only. If the user specifies a confidence level of 'med' for the confidence field, then the output mask will be flagged as "1" (yes) if the confidence value is medium or high. And, if the user specifies a confidence level of 'low', then the output mask will be flagged as "1" (yes) if the confidence value is low, medium, or high.

The following table identifies the output quality band and how it correlates to the bits in the individual QA bands, when not using combine bits. The user may select to combine the specified QA bits into one single output file. In that case, if any of the specified QA bits meet the specified confidence level, then the output mask for that pixel will be flagged as "1" (yes).

Landsat 8		
QA Band	QA Bit(s)	Description
_fill.tif	0	Fill
_dropped_frame.tif	1	Dropped Frame
_terrain_occl.tif	2	Terrain Occlusion
N/A	3	Reserved
_water.tif	4-5	Water Confidence
_cloud_shadow.tif	6-7	Cloud Shadow Confidence
_vegetation.tif	8-9	Vegetation Confidence
_snow_ice.tif	10-11	Snow/Ice Confidence
_cirrus.tif	12-13	Cirrus Confidence
_cloud.tif	14-15	Cloud Confidence

The tool command arguments can be specified in any order.

ARGUMENTS

- --help Display this help message.

The following parameters are required:

- --ifile Name of the input QA file (unsigned 16-bit integer GeoTIFF).
- --ofile Basename of the output file if bit combination is not used, otherwise the full name of the output file (unsigned 8-bit integer GeoTIFF to match the user-specified quality bits).

The following command is optional:

- --combine Indicates the specified QA bits will be combined into one single output band, e.g., create an output file with all pixels that are either cloudy or water flagged "1" (yes). Default is false.

The following QA bit parameters are optional. If none are specified, the tool will output all quality bits and will use the default (true) for single bits and the default (medium) confidence level for double bits:

- `--all` Specifies all the quality bits should be output (default is true), using the specified confidence level for 2-bit QA fields
- `--fill` Specifies the fill bit should be output
- `--drop_frame` Specifies the dropped frame bit should be output
- `--terrain_occl` Specifies the terrain occlusion bit should be output
- `--water` Specifies the water bit should be output using the specified confidence level
- `--cloud_shadow` Specifies the cloud shadow confidence should be output using the specified confidence level
- `--veg` Specifies the vegetation confidence should be output using the specified confidence level
- `--snow_ice` Specifies the snow/ice confidence should be output using the specified confidence level
- `--cirrus` Specifies the cirrus confidence should be output using the specified confidence level
- `--cloud` Specifies the cloud bit should be output

where the `conf_level` can be 'low', 'med', or 'high' and the default, if not specified, is medium confidence.

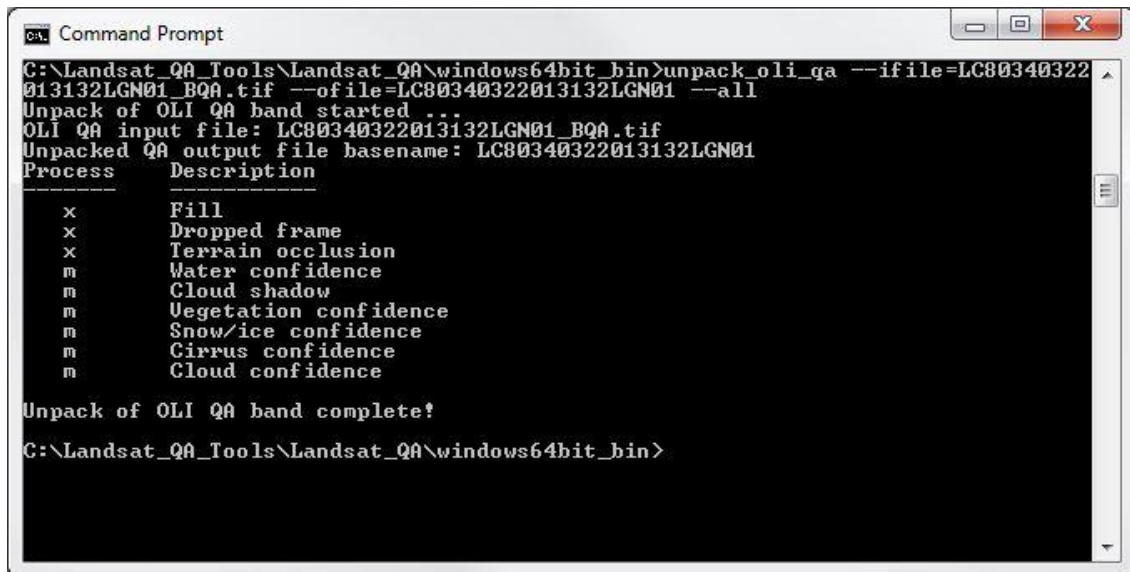
EXAMPLES

Example 1:

The following example will unpack all of the QA bits into their own single-band GeoTIFF files, using the default (medium and above) confidence level for the 2-bit quality fields. The command is typed entirely on one line.

```
unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --  
ofile=LC80340322013132LGN01 --all
```

The individual GeoTIFF files will populate in the same directory as the `unpack_oli_qa` tool. The following snapshot shows this command execution from a Windows Command Prompt display.



```
Command Prompt
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --ofile=LC80340322013132LGN01 --all
Unpack of OLI QA band started ...
OLI QA input file: LC80340322013132LGN01_BQA.tif
Unpacked QA output file basename: LC80340322013132LGN01
Process      Description
-----
x           Fill
x           Dropped frame
x           Terrain occlusion
m           Water confidence
m           Cloud shadow
m           Vegetation confidence
m           Snow/ice confidence
m           Cirrus confidence
m           Cloud confidence

Unpack of OLI QA band complete!
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>
```

Example 2:

The following example will unpack the fill, water, vegetation, snow/ice, and cloud quality fields each into their own GeoTIFF file. The fill field (single-bit) does not require a confidence level. Water pixels will be masked if their confidence is high. Vegetation pixels will be masked if their confidence is low, medium, or high. Snow/ice pixels will be masked if their confidence is medium or high (the default). Cloud pixels will also be masked if their confidence level is medium or high. The command is typed entirely on one line.

```
unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --ofile=
LC80340322013132LGN01 --fill --water=high --veg=low --snow_ice -
-cloud=med
```

The individual GeoTIFF files will populate in the same directory as the `unpack_oli_qa` tool. The following snapshot shows this command execution from a Windows Command Prompt display.


```

C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --ofile=LC80340322013132LGN01 --fill --water=high --veg=low --snow_ice --cloud=med
Unpack of OLI QA band started ...
OLI QA input file: LC80340322013132LGN01_BQA.tif
Unpacked QA output file basename: LC80340322013132LGN01
Process      Description
-----
x           Fill
            Dropped frame
            Terrain occlusion
            Water confidence
            Cloud shadow
h           Vegetation confidence
l           Snow/ice confidence
m           Cirrus confidence
m           Cloud confidence

Unpack of OLI QA band complete!
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>

```

Example 3:

The following example unpack the fill, cloud, and cirrus quality fields each into one combined file. The fill field (single-bit) does not require a confidence level. Cloud pixels will be masked if their confidence level is high. Cirrus pixels will be masked if their confidence is low, medium, or high. The command is typed entirely on one line.

```

unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --ofile=LC80340322013132LGN01 --fill --cloud=high --cirrus=low --combine

```

The combined file will populate in the same directory as the unpack_oli_qa tool. The following snapshot shows this command execution from a Windows Command Prompt display.

```

C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --ofile=LC80340322013132LGN01 --fill --cloud=high --cirrus=low --combine
Unpack of OLI QA band started ...
OLI QA input file: LC80340322013132LGN01_BQA.tif
Unpacked and combined QA output filename: LC80340322013132LGN01
Process      Description
-----
x           Fill
            Dropped frame
            Terrain occlusion
            Water confidence
            Cloud shadow
            Vegetation confidence
            Snow/ice confidence
l           Cirrus confidence
h           Cloud confidence

Unpack of OLI QA band complete!
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>

```

5.2 unpack_collection_qa (Collection 1)

NAME

unpack_collection_qa – Extracts specified bits from the Landsat 4-8 Collection 1 QA band and writes them to individual GeoTIFF files or combines them into a single GeoTIFF.

SYNOPSIS

unpack_collection_qa --help will print the usage information

```
usage: unpack_collection_qa --ifile=input_QA_filename --
ofile=output_unpacked_QA_filename [--all=conf_level] [--fill] [-
-drop_pixel] [--terrain_occl] [--radiometric_sat] [--cloud] [--
cloud_confidence=conf_level] [--cloud_shadow=conf_level] [--
snow_ice=conf_level] [--cirrus=conf_level] [--combine]
```

where --drop_pixel is only available for Landsat 4-7 files
and --terrain_occl and --cirrus are only available for Landsat 8 files

DESCRIPTION

unpack_collection_qa will read the QA band from the Landsat 4-8 Collection 1 input product, then unpack this band into individual QA bands stored as GeoTIFFs using the user-specified base output filename. The output bands will refer to the QA bits (from right to left), representing the QA information which is stored in the QA band.

In some cases, a single bit is used to represent quality data in the QA band and in other cases, two bits are used for the quality info.

For quality data represented by a single bit, the output values are as follows:

- 0 = No, this condition does not exist
- 1 = Yes, this condition exists

For radiometric saturation, the interpretation of the bits is:

- 00 = No bands contain saturation
- 01 = 1-2 bands contain saturation (low)
- 10 = 3-4 bands contain saturation (medium)
- 11 = 5 or more bands contain saturation (high)

For other quality data represented by two bits, the user will be allowed to specify the confidence levels included in the mask. The current confidence levels in the QA band are as follows:

- 00 = Algorithm did not determine the status of this condition
- 01 = Algorithm has low confidence that this condition exists
- 10 = Algorithm has medium confidence that this condition exists
- 11 = Algorithm has high confidence that this condition exists

If the user specifies a confidence level of 'low' for a 2-bit confidence field, the output mask will be flagged as "1" (yes) if the 2-bit confidence value is low, medium, or high. If the user specifies a confidence level of 'med' for the confidence field, the output mask will be flagged if the confidence value is medium or high. And, if the user specifies a confidence level of 'high', the output mask will be flagged if the confidence value is high only.

The following tables identify the output quality band and how it correlates to the bits in the individual QA bands, when not using combined bits. The user may elect to combine the specified QA bits into one single output file. In that case, if any of the QA bits are turned on or meet the specified confidence level, then the output mask for that pixel will be flagged as "1" (yes).

Landsat 4, 5, and 7		
QA Band	QA Bit(s)	Description
_fill.tif	0	Fill
_dropped_pixel.tif	1	Dropped Pixel
_radiometric_sat.tif	2,3	Radiometric Saturation
_cloud.tif	4	Cloud
_cloud_confidence.tif	5,6	Cloud Confidence
_cloud_shadow.tif	7,8	Cloud Shadow Confidence
_snow_ice.tif	9,10	Snow/ice Confidence
N/A	11-15	Reserved

Landsat 8		
QA Band	QA Bit(s)	Description
_fill.tif	0	Fill
_terrain_occl.tif	1	Dropped Pixel
_radiometric_sat.tif	2,3	Radiometric Saturation
_cloud.tif	4	Cloud
_cloud_confidence.tif	5,6	Cloud Confidence
_cloud_shadow.tif	7,8	Cloud Shadow Confidence
_snow_ice.tif	9,10	Snow/ice Confidence
_cirrus.tif	11,12	Cirrus Confidence
N/A	13-15	Reserved

The tool command arguments can be specified in any order.

ARGUMENTS

- `--help` Display the help message.

The following parameters are required:

- `--ifile` Name of the input QA file (unsigned 16-bit integer GeoTIFF).
- `--ofile` Basename of the output file if bit combination is not used, otherwise the full name of the output file (unsigned 8-bit integer GeoTIFF to match the user-specified quality bits).

The following command is optional:

- `--combine` Indicates the specified QA bits will be combined into one single output band, e.g., create an output file with all pixels that are either cloudy or water flagged "1" (yes). Default is false.

The following QA bit parameters are optional. If none are specified, the tool will output all quality bits and will use the default (true) for single bits and the default (medium) confidence level for double bits:

- `--all` Specifies all the quality bits should be output (default is true), using the specified confidence level for 2-bit QA fields
- `--fill` Specifies the fill bit should be output
- `--drop_pixel` Specifies the dropped pixel bit should be output (L4-7 scenes only)
- `--terrain_occl` Specifies the terrain occlusion bit should be output (L8 scenes only)
- `--radiometric_sat` Specifies the radiometric saturation bits should be output
- `--cloud` Specifies the cloud bit should be output
- `--cloud_confidence` Specifies the cloud confidence should be output using the specified confidence level
- `--cloud_shadow` Specifies the cloud shadow confidence should be output using the specified confidence level
- `--snow_ice` Specifies the snow/ice confidence should be output using the specified confidence level

- `--cirrus` Specifies the cirrus confidence should be output using the specified confidence level (L8 scenes only)

where the `conf_level` can be 'low', 'med', or 'high' and the default, if not specified, is medium confidence.

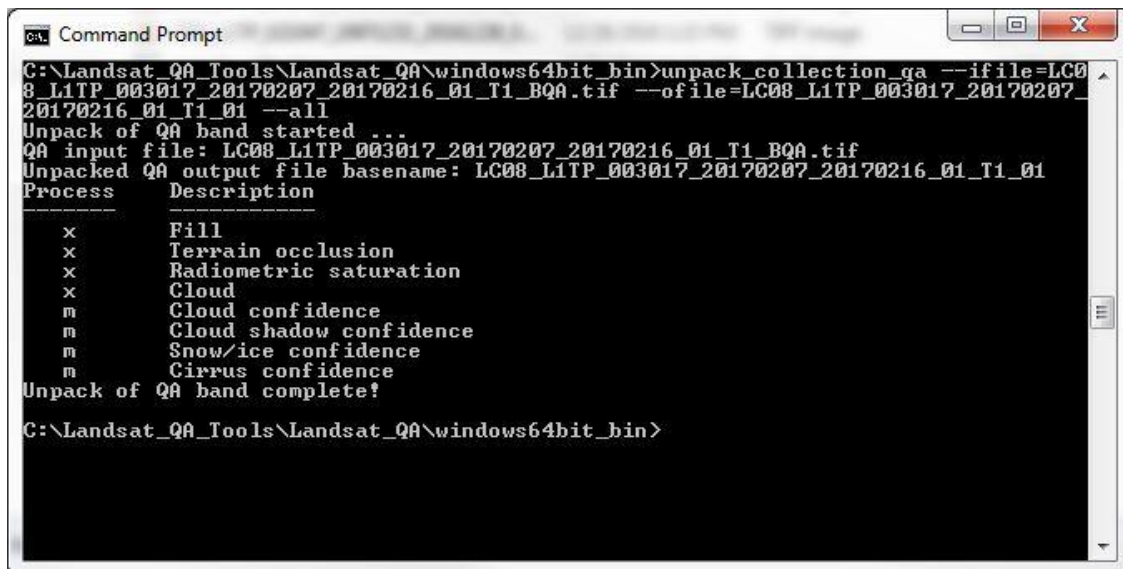
EXAMPLES

Example 1:

The following example will unpack all of the QA bits into their own single-band GeoTIFF files. This will use the default of medium confidence (and above) for the 2-bit quality fields, excluding radiometric saturation, which doesn't use a confidence level. The command is typed entirely on one line.

```
unpack_collection_qa --
ifile=LC08_L1TP_003017_20170207_20170216_01_T1_BQA.tif --
ofile=LC08_L1TP_003017_20170207_20170216_01_T1_01 --all
```

The individual GeoTIFF files will populate in the same directory as the `unpack_collection_qa` tool. The following snapshot shows this command execution from a Windows Command Prompt display.



```

C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>unpack_collection_qa --ifile=LC08_L1TP_003017_20170207_20170216_01_T1_BQA.tif --ofile=LC08_L1TP_003017_20170207_20170216_01_T1_01 --all
Unpack of QA band started ...
QA input file: LC08_L1TP_003017_20170207_20170216_01_T1_BQA.tif
Unpacked QA output file basename: LC08_L1TP_003017_20170207_20170216_01_T1_01
Process      Description
-----
x           Fill
x           Terrain occlusion
x           Radiometric saturation
x           Cloud
m           Cloud confidence
m           Cloud shadow confidence
m           Snow/ice confidence
m           Cirrus confidence
Unpack of QA band complete!

C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>

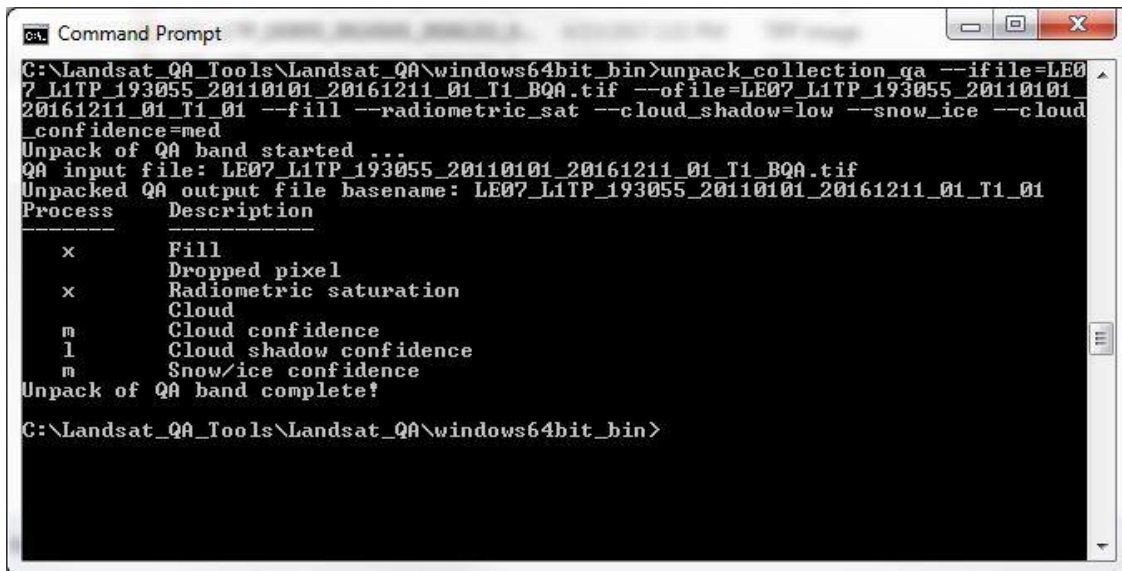
```

Example 2:

The following example will unpack the fill, radiometric saturation, cloud shadow, snow/ice, and cloud confidence fields each into individual GeoTIFF files. The fill field is a single bit field and does not require a confidence level. The radiometric saturation pixels also do not require a confidence level. The cloud shadow pixels will be masked if their confidence level is low, medium, or high. The snow/ice pixels will be masked if their confidence is medium (by default) or high. The cloud confidence pixels will also be masked if their confidence level is medium or high. The command is typed entirely on one line.

```
unpack_collection_qa --
infile=LE07_L1TP_193055_20110101_20161211_01_T1_BQA.tif --
ofile=LE07_L1TP_193055_20110101_20161211_01_T1_01 --fill --
radiometric_sat --cloud_shadow=low --snow_ice --
cloud_confidence=med
```

The individual GeoTIFF files will populate in the same directory as the `unpack_collection_qa` tool. The following snapshot shows this command execution from a Windows Command Prompt display.



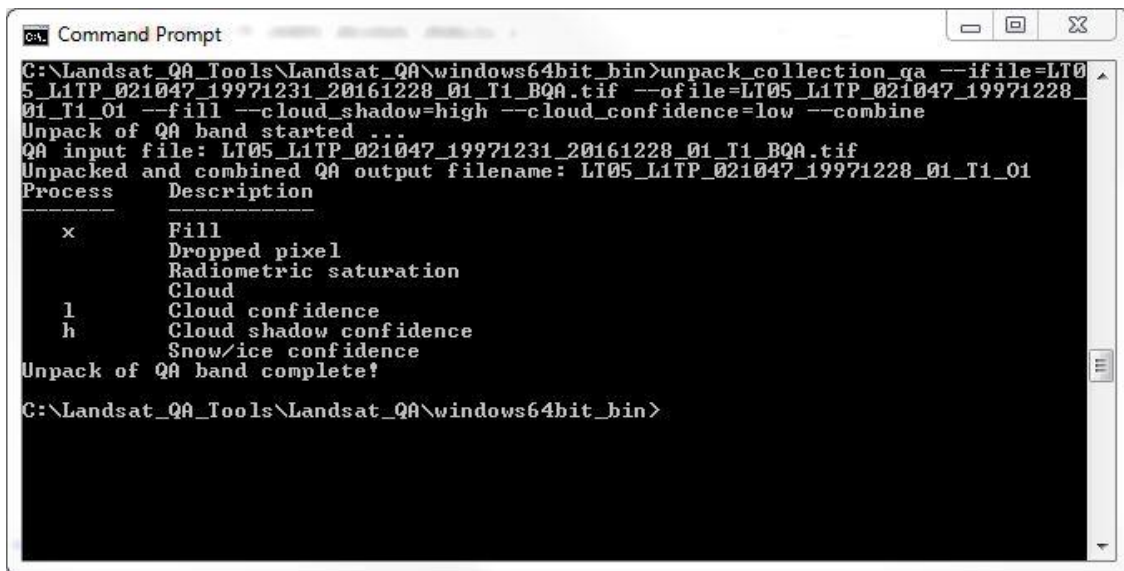
```
Command Prompt
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>unpack_collection_qa --infile=LE07_L1TP_193055_20110101_20161211_01_T1_BQA.tif --ofile=LE07_L1TP_193055_20110101_20161211_01_T1_01 --fill --radiometric_sat --cloud_shadow=low --snow_ice --cloud_confidence=med
Unpack of QA band started ...
QA input file: LE07_L1TP_193055_20110101_20161211_01_T1_BQA.tif
Unpacked QA output file basename: LE07_L1TP_193055_20110101_20161211_01_T1_01
Process      Description
-----
x           Fill
            Dropped pixel
x           Radiometric saturation
            Cloud
m           Cloud confidence
l           Cloud shadow confidence
m           Snow/ice confidence
Unpack of QA band complete!
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>
```

Example 3:

The following example will unpack the fill, cloud shadow, and cirrus quality fields each into one combined file. The fill field is a single bit field and does not require a confidence level. The cloud shadow pixels will be masked if their confidence level is high. The cirrus pixels will be masked if their confidence level is low, medium, or high.

```
unpack_oli_qa --  
ifile=LT05_L1TP_021047_19971231_20161228_01_T1_BQA.tif --  
ofile=LT05_L1TP_021047_19971231_20161228_01_T1_01 --fill --  
cloud_shadow=high --cloud_confidence=low --combine
```

The combined file will populate in the same directory as the `unpack_collection_qa` tool. The following snapshot shows this command execution from a Windows Command Prompt display.



```
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>unpack_collection_qa --ifile=LT05_L1TP_021047_19971231_20161228_01_T1_BQA.tif --ofile=LT05_L1TP_021047_19971228_01_T1_01 --fill --cloud_shadow=high --cloud_confidence=low --combine  
Unpack of QA band started ...  
QA input file: LT05_L1TP_021047_19971231_20161228_01_T1_BQA.tif  
Unpacked and combined QA output filename: LT05_L1TP_021047_19971228_01_T1_01  
Process      Description  
-----  
x           Fill  
            Dropped pixel  
            Radiometric saturation  
            Cloud  
l           Cloud confidence  
h           Cloud shadow confidence  
            Snow/ice confidence  
Unpack of QA band complete!  
C:\Landsat_QA_Tools\Landsat_QA\windows64bit_bin>
```

Section 6 Use and Citation Information

There are no restrictions on the use of the Landsat QA Tools, but please include the following citation in publication or presentation materials based on information derived from this software to credit the original development.

Roy, D.P., Borak, J.S., Devadiga, S., Wolfe, R.E., Zheng, M., Descloitres, J., 2002, The MODIS Land Product Quality Assessment Approach, Remote Sensing of Environment, v. 83, p. 62-76.

If possible, reprints or citations of papers or oral presentations based on information derived from this software are welcome at the User Services addresses included in this guide. Such cooperation will help USGS stay informed of how the software is being used.

Section 7 **User Services**

Landsat data products and associated software tools and interfaces are supported by User Services staff at USGS Earth Resources Observation and Science Center (EROS). Any questions, comments, or problems are welcomed through the Landsat “Contact Us” on-line correspondence form. Electronic mail can also be sent to the customer service address included below, with the same indication of topic.

USGS User Services

<https://landsat.usgs.gov/contact>

custserv@usgs.gov

User support is available Monday through Friday from 8:00 a.m. – 4:00 p.m. Central Time. Inquiries received outside of these hours will be addressed during the next business day.

Appendix A Common Landsat 8 Pre-Collection QA Values

Pixel Value (Decimal)	Cloud	Cirrus	Snow/Ice	Water	Terrain Occlusion	Dropped Frame	Fill
61440	Yes	Yes	Not Determined	Not Determined	No	No	No
59424	Yes	Maybe	Maybe	Maybe	No	No	No
57344	Yes	Maybe	Not Determined	Not Determined	No	No	No
56320	Yes	No	Yes	Not Determined	No	No	No
53248	Yes	No	Not Determined	Not Determined	No	No	No
52256	Yes	Not Determined	Yes	Maybe	No	No	No
52224	Yes	Not Determined	Yes	Not Determined	No	No	No
49184	Yes	Not Determined	Not Determined	Maybe	No	No	No
49152	Yes	Not Determined	Not Determined	Not Determined	No	No	No
48128	Maybe	Yes	Yes	Not Determined	No	No	No
45056	Maybe	Yes	Not Determined	Not Determined	No	No	No
43040	Maybe	Maybe	Maybe	Maybe	No	No	No
39936	Maybe	No	Yes	Not Determined	No	No	No
36896	Maybe	No	Not Determined	Maybe	No	No	No
36864	Maybe	No	Not Determined	Not Determined	No	No	No
32768	Maybe	Not Determined	Not Determined	Not Determined	No	No	No
31744	No	Yes	Yes	Not Determined	No	No	No
28672	No	Yes	Not Determined	Not Determined	No	No	No
28590	No	Maybe	Yes	Maybe	Yes	Yes	No
26656	No	Maybe	Maybe	Maybe	No	No	No

Pixel Value (Decimal)	Cloud	Cirrus	Snow/Ice	Water	Terrain Occlusion	Dropped Frame	Fill
24576	No	Maybe	Not Determined	Not Determined	No	No	No
23552	No	No	Yes	Not Determined	No	No	No
20516	No	No	Not Determined	Maybe	Yes	No	No
20512	No	No	Not Determined	Maybe	No	No	No
20480	No	No	Not Determined	Not Determined	No	No	No
19456	No	Not Determined	Yes	Not Determined	No	No	No
16416	No	Not Determined	Not Determined	Maybe	No	No	No
16384	No	Not Determined	Not Determined	Not Determined	No	No	No
16380	Not Determined	Yes	Yes	Yes	Yes	No	No
13246	Not Determined	Yes	Not Determined	Yes	Yes	Yes	No
6176	Not Determined	No	Maybe	Maybe	No	No	No
6148	Not Determined	No	Maybe	Not Determined	Yes	No	No
2592	Not Determined	Not Determined	Maybe	Maybe	No	No	No
2592	Not Determined	Not Determined	Maybe	Maybe	No	No	No
2308	Not Determined	Not Determined	Maybe	Not Determined	Yes	No	No
2144	Not Determined	Not Determined	Maybe	Maybe	No	No	No
2112	Not Determined	Not Determined	Maybe	Not Determined	No	No	No
2080	Not Determined	Not Determined	Maybe	Maybe	No	No	No
2052	Not Determined	Not Determined	Maybe	Not Determined	Yes	No	No
2048	Not Determined	Not Determined	Maybe	Not Determined	No	No	No

Pixel Value (Decimal)	Cloud	Cirrus	Snow/Ice	Water	Terrain Occlusion	Dropped Frame	Fill
515	Not Determined	Not Determined	Not Determined	Not Determined	No	Yes	Yes
64	Not Determined	Not Determined	Not Determined	Not Determined	No	No	No
32	Not Determined	Not Determined	Not Determined	Maybe	No	No	No
32	Not Determined	Not Determined	Not Determined	Maybe	No	No	No
4	Not Determined	Not Determined	Not Determined	Not Determined	Yes	No	No
0	Not Determined	Not Determined	Not Determined	Not Determined	No	No	No

Appendix B Common Landsat 8 Collection 1 QA Values

Pixel Value	Cirrus Conf.	Snow/Ice Conf.	Cloud Shadow Conf.	Cloud Conf.	Cloud	Radiometric Saturation	Dropped Pixel	Fill	Pixel Description
7072	Yes	No	Yes	No	No	No	No	No	High-confidence cirrus cloud and cloud shadow
6896	Yes	No	No	Yes	Yes	No	No	No	High-confidence cloud and cirrus cloud
6828	Yes	No	No	No	No	5+ bands	No	No	High-confidence cirrus cloud w/ frequent saturation
6824	Yes	No	No	No	No	3-4 bands	No	No	High-confidence cirrus cloud w/ moderate saturation
6820	Yes	No	No	No	No	1-2 bands	No	No	High-confidence cirrus cloud w/ some saturation
6816	Yes	No	No	No	No	No	No	No	High-confidence cirrus cloud
3756	No	Yes	No	No	No	5+ bands	No	No	Snow/Ice terrain w/ frequent saturation
3752	No	Yes	No	No	No	3-4 bands	No	No	Snow/Ice terrain w/ moderate saturation
3748	No	Yes	No	No	No	1-2 bands	No	No	Snow/Ice terrain w/ some saturation
3744	No	Yes	No	No	No	No	No	No	Snow/Ice terrain

Pixel Value	Cirrus Conf.	Snow/Ice Conf.	Cloud Shadow Conf.	Cloud Conf.	Cloud	Radiometric Saturation	Dropped Pixel	Fill	Pixel Description
2976	No	No	Yes	No	No	No	No	No	Cloud shadow terrain
2812	No	No	No	Yes	Yes	5+ bands	No	No	High-confidence cloud w/ frequent saturation
2808	No	No	No	Yes	Yes	3-4 bands	No	No	High-confidence cloud w/ moderate saturation
2804	No	No	No	Yes	Yes	1-2 bands	No	No	High-confidence cloud w/ some saturation
2800	No	No	No	Yes	Yes	No	No	No	High-confidence cloud
2752	No	No	No	Maybe	No	No	No	No	Mid-confidence cloud
2732	No	No	No	No	No	5+ bands	No	No	Clear terrain w/ frequent saturation
2728	No	No	No	No	No	3-4 bands	No	No	Clear terrain w/ moderate saturation
2724	No	No	No	No	No	1-2 bands	No	No	Clear terrain w/ some saturation
2720	No	No	No	No	No	No	No	No	Clear terrain
2	Not Determined	Not Determined	Not Determined	Not Determined	No	Not Determined	Yes	No	Terrain Occlusion
1	Not Determined	Not Determined	Not Determined	Not Determined	No	Not Determined	Not Determined	Yes	Fill

Appendix C Common Landsat 4-7 Collection 1 QA Values

Pixel Value	Snow/Ice Conf.	Cloud Shadow Conf.	Cloud Conf.	Cloud	Radiometric Saturation	Dropped Pixel	Fill	Pixel Description
1708	Yes	No	No	No	5+ bands	No	No	Snow/ice terrain w/ frequent saturation
1704	Yes	No	No	No	3-4 bands	No	No	Snow/ice terrain w/ moderate saturation
1700	Yes	No	No	No	1-2 bands	No	No	Snow/ice terrain w/ some saturation
1696	Yes	No	No	No	No	No	No	Snow/ice terrain
928	No	Yes	No	No	No	No	No	Cloud shadow terrain
764	No	No	Yes	Yes	5+ bands	No	No	High-confidence cloud w/ frequent saturation
760	No	No	Yes	Yes	3-4 bands	No	No	High-confidence cloud w/ moderate saturation
756	No	No	Yes	Yes	1-2 bands	No	No	High-confidence cloud w/ some saturation
752	No	No	Yes	Yes	No	No	No	High-confidence cloud
704	No	No	Maybe	No	No	No	No	Mid-confidence cloud
684	No	No	No	No	5+ bands	No	No	Clear terrain w/ frequent saturation

Pixel Value	Snow/Ice Conf.	Cloud Shadow Conf.	Cloud Conf.	Cloud	Radiometric Saturation	Dropped Pixel	Fill	Pixel Description
680	No	No	No	No	3-4 bands	No	No	Clear terrain w/ moderate saturation
676	No	No	No	No	1-2 bands	No	No	Clear terrain w/ some saturation
672	No	No	No	No	No	No	No	Clear terrain
2	Not Determined	Not Determined	Not Determined	No	Not Determined	Yes	No	Dropped Pixel
1	Not Determined	Not Determined	Not Determined	No	Not Determined	Not Determined	Yes	Fill

Appendix D Acronyms

Acronym	Description
COTS	Commercial Off The Shelf
DAAC	Distributed Active Archive Center
EOS	Earth Observing System
EROS	Earth Resources Observation and Science
ETM+	Enhanced Thematic Mapper Plus
GeoTIFF	Geographic Tagged Image File Format
LDOPE	Land Data Operational Product Evaluation
L-LDOPE	Landsat-LDOPE
LP	Land Processes
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
OLI	Operational Land Imager
QA	Quality Assessment
TM	Thematic Mapper
USGS	U.S. Geological Survey