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Landsat Provisional Aquatic Reflectance Product Guide

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Landsat Provisional Aquatic Reflectance Product Guide

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Executive Summary

This product guide describes the characteristics of the Landsat Provisional Aquatic Reflectance Science Product to facilitate its use in aquatic remote sensing or ocean color applications.

The ocean color, defined as the spectral distribution of reflected visible solar radiation upwelling from beneath the water surface, has revolutionized the field of biological oceanography. The applications of ocean color remote sensing are extensive and fundamental to understanding and monitoring the global ecosystem. The Landsat Provisional Aquatic Reflectance is an *experimental science product* with the potential to make a valuable contribution to aquatic science and environmental monitoring capabilities for aquatic ecosystems, especially in coastal environments and inland waters.

This document is under Landsat Satellites Data System (LSDS) Configuration Control Board (CCB) control. Please submit changes to this document, as well as supportive material justifying the proposed changes, via Change Request (CR) to the Process and Change Management Tool.

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Contents

Executive Summary	iii
Document History	iv
Contents	v
List of Figures	v
List of Tables	v
Section 1 Introduction	1
1.1 Background.....	1
1.2 Purpose and Scope	2
1.3 Document Organization	3
Section 2 Caveats and Constraints	4
Section 3 Product Packaging	5
3.1 Package Filename	5
3.2 Product Filename.....	5
Section 4 Product Characteristics	7
4.1 Available Products	7
4.2 Product Specifications	7
4.2.1 Processing Flags	8
4.2.2 Metadata.....	9
Section 5 Product Access	10
Section 6 Citation Information	11
Section 7 Acknowledgment	12
Section 8 User Services	13
Appendix A Default File Characteristics	14
Appendix B Metadata Fields	15
Appendix C Acronyms	17
References	19

List of Figures

Figure 1-1. Example of Landsat Provisional Aquatic Reflectance: Left, Natural Color Surface Reflectance Image; Right: Aquatic Reflectance Band 2 Image.....	2
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List of Tables

Table 4-1. Landsat Provisional Aquatic Reflectance Product Specifications.....	8
Table 4-2. Landsat Provisional Aquatic Reflectance Processing Flags (I2_flags) Bit Index	9
Table A-1. Example Landsat Provisional Aquatic Reflectance Files	14

Section 1 Introduction

1.1 Background

Landsat satellite data have been produced, archived, and distributed by the U.S. Geological Survey (USGS) since 1972. Users rely upon these data for conducting historical studies of land surface change and monitoring the Earth's surface but have shouldered the burden of post-production processing to create application-ready datasets. To alleviate this burden, the USGS has initiated an effort to produce a collection of Landsat Science Products to support land surface change studies. These products include terrestrial variables such as Surface Reflectance (SR), Surface Temperature (ST), Burned Area (BA), Fractional Snow Covered Area (fSCA), and Dynamic Surface Water Extent (DSWE), as well as aquatic variables such as Aquatic Reflectance that are suitable for monitoring, assessing, and predicting the Earth surface change over time.

This product guide describes the characteristics of the Landsat Provisional Aquatic Reflectance Science Product. Aquatic Reflectance is derived from Landsat Level 1 (L1) reflective bands over water areas. The Top of Atmosphere (TOA) Reflectance and auxiliary atmospheric data are input to an atmospheric correction algorithm to retrieve the water-leaving radiance at visible wavelengths. The water-leaving radiances are then normalized by downwelling solar irradiance to remove the remaining effects of solar orientation and atmospheric attenuation to produce spectral Remote Sensing Reflectance (R_{rs}) bands. Finally, the R_{rs} bands are normalized by the Bidirectional Reflectance Distribution Function (BRDF) of a perfectly reflecting Lambertian surface (multiplied by π) to produce the dimensionless Aquatic Reflectance. The methodologies used in this algorithm are directly derived from the Sea-viewing Wide Field-of-View Sensor (SeaWiFS) Data Analysis System (SeaDAS) package distributed by NASA's Ocean Biology Processing Group. For more information about the atmospheric correction algorithm in SeaDAS please see Mobley et al., 2016 in the References section.

Surface and atmospheric auxiliary data are required for the successful processing of the Landsat Aquatic Reflectance Science Product. The auxiliary data includes the meteorological data of National Centers for Environmental Prediction (NCEP), ozone data from the Total Ozone Mapping Spectrometer (TOMS) (1978 - 2004) or Aura Ozone Monitoring Instrument (OMI) (2004 - present), and sea ice extent data from the National Snow and Ice Data Center (NSIDC). Auxiliary data for Aquatic Reflectance processing are retrieved from the Ocean Color web page (<https://oceandata.sci.gsfc.nasa.gov/>). The latency of the auxiliary data for Aquatic Reflectance processing of the new Landsat acquisitions is two days.

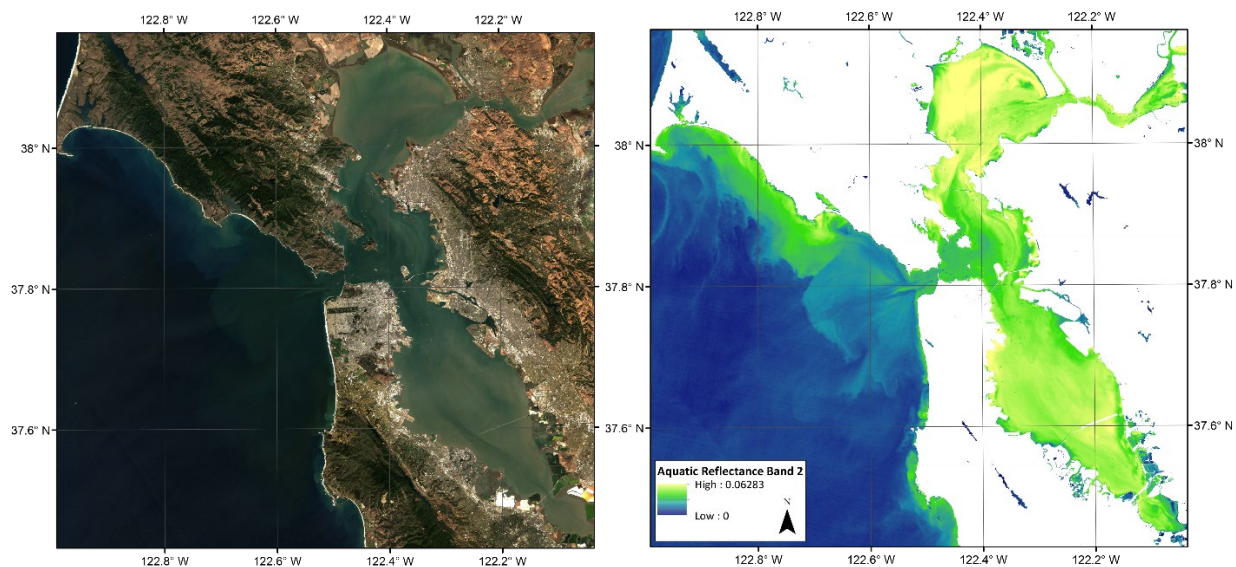


Figure 1-1. Example of Landsat Provisional Aquatic Reflectance: Left, Natural Color Surface Reflectance Image; Right: Aquatic Reflectance Band 2 Image

Figure 1-1 shows a comparison of Surface Reflectance natural color composite image (bands 4,3,2), and the Provisional Aquatic Reflectance Band 2 (Blue band) image of San Francisco Bay, using data acquired by Landsat 8 (Path 44 Row 33) on October 7, 2018.

The Landsat Provisional Aquatic Reflectance Science Product is currently available only for Landsat 8 Operational Land Imager (OLI) data. Thermal data is not required to successfully process Aquatic Reflectance (i.e., both LC08 and LO08 data products can be processed).

The Landsat Provisional Aquatic Reflectance product is processed for visible bands only (Bands 1-4 of the Landsat 8 OLI). The Near Infrared (NIR) and Short-Wave Infrared (SWIR) bands are consumed by the atmospheric compensation and hence are not delivered in the final product. The processing flags (I2_flags) and metadata are also delivered with the product file package. Section 4 details the specifications of the Landsat Aquatic Reflectance product.

1.2 Purpose and Scope

The primary purpose of this document is to provide a detailed description of the Landsat Provisional Aquatic Reflectance Science Product, its characteristics, product packaging, and download accessibility.

The scope of this document is the Provisional Aquatic Reflectance Science Products generated by the USGS Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA).

1.3 Document Organization

This document contains the following sections:

- Section 1 provides an introduction
- Section 2 provides caveats and constraints
- Section 3 provides information about product packaging
- Section 4 provides product characteristics
- Section 5 provides information about product access
- Section 6 provides citation information
- Section 7 provides acknowledgment
- Section 8 provides the contact information of the user services
- Appendix A provides default file characteristics
- Appendix B provides sample metadata fields
- Appendix C contains a list of acronyms
- The References section contains a list of reference documents

Section 2 Caveats and Constraints

1. The current Landsat Aquatic Reflectance Science Product is considered provisional. The atmospheric correction algorithm and subsequent output products have not been completely validated. Most preliminary validation efforts are conducted using the Ocean Color component data of the Aerosol Robotic Network (AERONET) Pahlevan et al., 2017; Ilori et al., 2019, representing moderately coastal waters. The performance of the algorithm over highly turbid and eutrophic inland water bodies requires further verification and/or improvement. For additional information about the preliminary validation details, see the References section.
2. The Landsat Aquatic Reflectance product is currently available only for Landsat 8 Operational Land Imager (OLI) data; the capability to process Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 4-5 Thematic Mapper (TM), and Sentinel-2 Multispectral Instrument (MSI) data likely will be added in the future.
3. An across-track non-uniformity artifact may be visible in the Landsat 8 Aquatic Reflectance Science Product. This non-uniformity is mainly due to slight differences in the viewing geometries of odd and even Focal Plane Modules (FPM) of OLI in along-track direction (Morfitt et al., 2015). In effect, one set of detectors are forward-looking (looking toward the sun) and the others backward-looking (looking away from the sun) as satellite travels in its orbit. This difference in viewing angles results in collecting different reflected radiances from the water surface and ambient aerosols (Pahlevan et al., 2017). The effect is more pronounced toward the eastern portion of the OLI images a) when the solar elevation angle is higher and/or b) under hazy conditions.
4. The Landsat Aquatic Reflectance algorithm assesses the pixels for the presence of water. This procedure may result in omission and commission classification errors. The commission error will trigger Aquatic Reflectance processing for land pixels. Using the Aquatic Reflectance product should be restricted to water pixels.
5. The Landsat Aquatic Reflectance product often includes NoData values over the water pixels. The NoData pixels are usually due to atmospheric correction failure. The processing flags (l2_flags) band provides useful information about the status of Aquatic Reflectance processing. More details about the processing flags band is provided in Section 4.2.1.

Section 3 Product Packaging

3.1 Package Filename

Landsat Provisional Aquatic Reflectance products are supplied in a compressed gzip file (.tar.gz). The package filenames are structured similar to the standard Landsat products. The following is an example of a typical Collection 1 Landsat Aquatic Reflectance package filename.

LXSSPPRRRRYYYYMMDDCCTX-SCyyyymmddhhmmss.tar.gz
(e.g., LC080010892019050601T1-SC20190719150513.tar.gz)

L	Landsat
X	Sensor (“O” = OLI; “C” = OLI/TIRS)
SS	Satellite (“08” = Landsat 8)
PPP	Path
RRR	Row
YYYY	Year of acquisition
MM	Acquisition month
DD	Acquisition day
CC	Landsat Collection number (“01” for Collection 1)
TX	Tier (“01” for Tier 1; “02” for Tier 2; “RT” for Real-Time)
SC	Science dataset
yyyy	Year of ESPA processing
mm	Month of ESPA processing
dd	Day of ESPA processing
hh	Hour of ESPA processing
ss	Seconds of ESPA processing

Additional information about product packaging of the science products processed in ESPA is provided in the [ESPA On-Demand Interface User Guide](#).

3.2 Product Filename

Unzipping the Landsat Provisional Aquatic Reflectance gzip package produces a tarball (.tar), which will “untar” into 5 individual raster files, and an Extensible Markup Language (XML) (.xml) metadata file. The 5 raster files include four Aquatic Reflectance bands and a processing flags band. The filenames are based on the Landsat Collection 1 Product Identifier (ProductID). The Aquatic Reflectance band filenames are appended with the suffix “_ar_” followed by a band designation to denote the Aquatic Reflectance transformation. Section 4 describes the product in more detail. The following is an example of a Landsat Provisional Aquatic Reflectance product filename:

LXSS_LLLL_PPPRRR_YYYYMMDD_yyyymmdd_CX_TX_prod_band.ext
(e.g., LO08_L1TP_024040_20130406_20170310_01_T1_ar_band1.tif)

L Landsat
X Sensor (“O” = OLI; “C” = OLI/TIRS)
SS Satellite (“08” = Landsat 8)
LLLL Processing correction level (“L1TP” = Precision Terrain; “L1GT” = Systematic Terrain; “L1GS” = Systematic)
PPP Path
RRR Row
YYYY Year of acquisition
MM Month of acquisition
DD Day of acquisition
yyyy Year of Level 1 processing
mm Month of Level 1 processing
dd Day of Level 1 processing
CX Collection number (“01”, “02”, etc.)
TX Collection category (“RT” = Real-Time; “T1” = Tier 1; “T2” = Tier 2)
prod Product (“ar”)
band Band, such as “band<1-4>” or “l2_flags”
ext File format extension, such as “tif”, “img”, “hdr”, “hdf”, “nc”, “xml”, or “txt”

Section 4 Product Characteristics

Landsat Provisional Aquatic Reflectance products are generated at 30-meter spatial resolution. The default projection system for Landsat science products is Universal Transverse Mercator (UTM), but other projection systems such as Albers Equal Area (AEA), Sinusoidal, Geographic, and Polar Stereographic (PS) are available through the ESPA on-demand interface. The default file format is Georeferenced Tagged Image File Format (GeoTIFF), but options for delivery in Hierarchical Data Format – Earth Observing System – 2 (HDF-EOS2; .hdf), NetCDF (.nc), or Exelis Visual Information Solutions (ENVI) binary (.img) are available. More information on Landsat output formats supported by ESPA is available in the [ESPA On-Demand Interface User Guide](#).

4.1 Available Products

Available Aquatic Reflectance products for Landsat 8 are listed below:

1. Aquatic Reflectance (AR) – Represents the nondimensional normalized remote-sensing reflectance, assuming a perfectly Lambertian surface
2. Processing Flags (l2_flags) – A bit-packed band that provides per-pixel information about success or failure of processing and validity of sun glint, view angle, solar angle, polarization, chlorophyll-a, etc.
3. Pixel Quality Assessment (pixel_qa) – The bit combinations that define certain quality conditions. More information about Pixel Quality Assessment can be found in the [Landsat 8 Surface Reflectance Code \(LaSRC\) Product Guide](#).
4. Metadata – Includes Landsat scene information in XML and MTL formats.

4.2 Product Specifications

Table 4-1 lists the specifications for each band included in the Landsat Aquatic Reflectance product.

Description	Band Name	Range	Valid Range	Scale Factor	Unit	Fill Value	Data Type
Aquatic Reflectance band 1 (Coastal aerosol)	ProductID_ar_band1	-4,720 to 31,420	0 to 31,420	0.00001	Unitless	-9999	INT16
Aquatic Reflectance band 2 (Blue)	ProductID_ar_band2	-4,720 to 31,420	0 to 31,420	0.00001	Unitless	-9999	INT16
Aquatic Reflectance band 3 (Green)	ProductID_ar_band3	-4,720 to 31,420	0 to 31,420	0.00001	Unitless	-9999	INT16

Description	Band Name	Range	Valid Range	Scale Factor	Unit	Fill Value	Data Type
Aquatic Reflectance band 4 (Red)	ProductID_ar_band4	-4,720 to 31,420	0 to 31,420	0.00001	Unitless	-9999	INT16
Processing Flags	ProductID_l2_flags	0 to $2^{31}-1$	0 to $2^{31}-1$	NA	NA	-9999	INT32
Level 2 Pixel Quality Assessment	ProductID_pixel_qa	0 to 65535	1 to 2047	NA	Bit Index	1 (bit 0)	UINT16
Level 2 XML Metadata file	ProductID.xml	NA	NA	NA	NA	NA	NA

Table 4-1. Landsat Provisional Aquatic Reflectance Product Specifications

4.2.1 Processing Flags

The processing flags (l2_flags) band provides additional per-pixel information about the success or failure of atmospheric correction, as well additional information about high sun glint, water turbidity, coccolithophore blooms, etc. Table 4-2 provides the interpretation of possible pixel values expected in the processing flags band.

Bit	Bit Value	Cumulative Sum	Attribute	Description
0	1	1	ATMFAIL	Atmospheric correction failed
1	2	3	LAND	Designated by the input land file (off for Landsat 8 processing)
2*	4	7	PRODWARN	Intermediate product value falls outside the min/max range
3	8	15	HIGLINT	If glint coefficient > glint threshold (0.005). This is not checked for land or night pixels.
4*	16	31	HILT	Flags high total radiance (Lt) measured by sensor (not used)
5	32	63	HISATZEN	View angle > threshold (60 deg)
6	64	127	COASTZ	Controlled via the bathymetry file, based on the latitude/longitude of the current pixel
7	128	255	SEADAS_CLOUD	Cloud based on SeaDAS algorithm
8	256	511	CLOUD_SHADOW	Cloud shadow based on the cloud mask algorithm
9	512	1023	CLOUD	Cloud based on the cloud mask algorithm
10	1024	2047	COCCOLITH	Flagged based on the coccolithophore algorithm coefficients, detects coccolithophore blooms. (Coccolithophores are a group of phytoplanktons that inhabit a wide variety of marine environments and are distinctive by their production of small calcium plates or coccoliths which are organized around each living cell as an outer covering.)
11	2048	4095	TURBIDW	Flags turbid water. If LwB4 / FonomB4 > 0.0012 Where LwB4: water-leaving radiance band 4 value FonomB4: nominal F0 value for band 4

Bit	Bit Value	Cumulative Sum	Attribute	Description
				F0: the mean solar flux
12	4096	8191	HISOLZEN	Solar angle > threshold (70 deg)
13	8192	16383	Unused	NA
14	16384	32767	LOWLW	If water-leaving radiance band 3 (LwB3) value < 0.15 (nlwmin)
15	32768	65535	CHLFAIL	Flags a failure in the chlorophyll-a calculation
16	65536	131071	NAVWARN	Mainly used for fill pixels
17	131072	262143	Unused	NA
18	262144	524287	RRSWARN	$R_{rs} < \text{min_valid}$ or $R_{rs} > \text{max_valid}$
19	524288	1048575	MAXAERITER	Number of iterations for the aerosol corrections exceeds the maximum threshold (10)
20	1048576	2097151	MODGLINT	glint coefficient > minimum glint threshold (0.0001)
21	2097152	4194303	CHLWARN	Chlorophyll-a < min_valid or chlorophyll-a > max_valid
22	4194304	8388607	ATMWARN	If the value is invalid, then set ATMWARN; also set if MAXAERITER is set. Based on ancillary QC flags (ozone, water vapor, RH, wind speed, surface pressure)
23	8388608	16777215	Unused	NA
24	16777216	33554431	SEAICE	Controlled via the ice file, based on the latitude/longitude of the current pixel
25	33554432	67108863	NAVFAIL	If there is an invalid latitude/longitude value
26	67108864	134217727	FILTER	Pixel is masked if there are not enough valid pixels in the filter to compute the average
27	134217728	268435455	Unused	NA
28	268435456	536870911	Unused	NA
29*	536870912	1073741823	HIPOL	If degree of polarization for any band is > hipol (0.5)
30*	1073741824	2147483647	PRODFAIL	Processing failure (chlorophyll-a retrieval for this pixel failed, data values are outside the valid range, too many bands, etc.)
31	2147483648	4294967295	Unused	NA
*These bits are not used in Landsat implementation of SeaDAS				
NA = Not Applicable				

Table 4-2. Landsat Provisional Aquatic Reflectance Processing Flags (I2_flags) Bit Index

4.2.2 Metadata

Each Landsat Provisional Aquatic Reflectance product will be accompanied by an XML-based metadata file. The metadata fields included in the XML are listed in Appendix B.

Section 5 Product Access

The USGS EROS Center Science Processing Architecture (ESPA) On-demand Interface (<https://espa.cr.usgs.gov/>) offers Landsat Provisional Aquatic Reflectance. Additional customization services such as reprojection, spatial subsetting, and pixel resizing are also available to users.

Further information about ESPA's processing options can be found in the [ESPA On-Demand Interface User Guide](#).

Section 6 Citation Information

There are no restrictions on the use of Landsat Science Products. It is not a requirement of data use, but the following citation may be used in publication or presentation materials to acknowledge the USGS as a data source and to credit the original research.

Landsat Provisional Aquatic Reflectance Science Product courtesy of the U.S. Geological Survey.

Franz, B.A., Bailey, S.W., Kuring, N., & Werdell, P.J. (2015). Ocean color measurements with the Operational Land Imager on Landsat-8: implementation and evaluation in SeaDAS. *Journal of Applied Remote Sensing*, 9(1), 096070. <https://doi.org/10.1117/1.JRS.9.096070>

Pahlevan, N., Schott, J.R., Franz, B.A., Zibordi, G., Markham, B., Bailey, S., Schaaf, C.B., Ondrusek, M., Greb, S. & Strait, C.M. (2017). Landsat 8 remote sensing reflectance (R_{rs}) products: Evaluations, intercomparisons, and enhancements. *Remote sensing of environment*, 190, 289-301. <https://doi.org/10.1016/j.rse.2016.12.030>

Reprints or citations of papers or oral presentations based on USGS data are welcome to help the USGS stay informed of how data are being used. These can be sent to the contact information provided in Section 8.

Section 7 Acknowledgment

The Provisional Aquatic Reflectance algorithm is based on the SeaDAS system that was developed at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) by the Ocean Biology Processing Group (OBPG).

Section 8 User Services

Landsat Science Products and associated interfaces are supported by USGS User Services staff at the USGS Earth Resources Observation and Science (EROS) Center. Questions or comments regarding Landsat Science Products or interfaces are welcome through the Landsat “Contact Us” online correspondence form. Email can also be sent to the USGS User Services address with the same indication of the topic.

USGS User Services

Email: custserv@usgs.gov

Phone: [800-252-4547](tel:800-252-4547)

USGS Landsat Missions Website (LMWS)

<https://www.usgs.gov/land-resources/nli/landsat/connect>

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

Appendix A Default File Characteristics

A typical Landsat Provisional Aquatic Reflectance file size and product naming convention are illustrated below.

Description	Example File Size (Kbytes)	Example File Name
Aquatic Reflectance Bands (4)	113,041	LC08_L1TP_161042_20171008_20180525_01_T1_ar_band*.tif
Processing Flags	226,021	LC08_L1TP_161042_20171008_20180525_01_T1_l2_flags.tif
Level 2 Pixel Quality Assessment (QA)	113,041	LC08_L1TP_161042_20171008_20180525_01_T1_pixel_qa.tif
Metadata	12	LC08_L1TP_161042_20171008_20180525_01_T1.xml

Table A-1. Example Landsat Provisional Aquatic Reflectance Files

Appendix B Metadata Fields

Example of global XML metadata:

```
<global_metadata>
  <data_provider>USGS/EROS</data_provider>
  <satellite>LANDSAT_8</satellite>
  <instrument>OLI_TIRS</instrument>
  <acquisition_date>2015-07-27</acquisition_date>
  <scene_center_time>17:06:24.2632280Z</scene_center_time>
  <level1_production_date>2017-02-26T05:08:56Z</level1_production_date>
  <solar_angles zenith="27.396973" azimuth="129.815964" units="degrees"/>
  <earth_sun_distance>1.015516</earth_sun_distance>
  <wrs system="2" path="28" row="33"/>
  <product_id>LC08_L1TP_028033_20150727_20170226_01_T1</product_id>
</global_metadata_file>LC08_L1TP_028033_20150727_20170226_01_T1_MTL.txt</lpgs_metadata_file>
  <corner location="UL" latitude="39.961950" longitude="-98.254160"/>
  <corner location="LR" latitude="37.822230" longitude="-95.675800"/>
  <bounding_coordinates>
    <west>-98.275949</west>
    <east>-95.576636</east>
    <north>39.962083</north>
    <south>37.822093</south>
  </bounding_coordinates>
  <projection_information projection="UTM" datum="WGS84" units="meters">
    <corner_point location="UL" x="563700.000000" y="4423800.000000"/>
    <corner_point location="LR" x="792600.000000" y="4191300.000000"/>
    <grid_origin>CENTER</grid_origin>
    <utm_proj_params>
      <zone_code>14</zone_code>
    </utm_proj_params>
  </projection_information>
  <orientation_angle>0.000000</orientation_angle>
</global_metadata>
```

Example of Aquatic Reflectance band XML metadata:

```
<band product="aq_refl" source="level1" name="ar_band1" category="image" data_type="INT16"
  nlines="7751" nsamps="7631" fill_value="-9999" scale_factor="0.000010">
  <short_name>LC08AR</short_name>
  <long_name>band 1 aquatic reflectance</long_name>
  <file_name>LC08_L1TP_028033_20150727_20170226_01_T1_ar_band1.img</file_name>
  <pixel_size x="30" y="30" units="meters"/>
  <resample_method>none</resample_method>
  <data_units>reflectance</data_units>
  <valid_range min="-4720.000000" max="31420.000000"/>
  <app_version>ESPA_AQ_REFL_1.1.0</app_version>
  <production_date>2019-10-21T20:52:07Z</production_date>
</band>
```

Example of Processing Flags metadata

```
<band product="aq_refl" source="level1" name="l2_flags" category="qa" data_type="INT32"
  nlines="7751" nsamps="7631" fill_value="-9999">
  <short_name>LC08ARFLAG</short_name>
  <long_name>Aquatic reflectance processing flags</long_name>
  <file_name>LC08_L1TP_028033_20150727_20170226_01_T1_l2_flags.img</file_name>
  <pixel_size x="30" y="30" units="meters"/>
  <resample_method>none</resample_method>
  <data_units>quality/feature classification</data_units>
  <valid_range min="0.000000" max="2147483647.000000"/>
  <bitmap_description>
    <bit num="0">ATMFAIL</bit>
    <bit num="1">LAND</bit>
    <bit num="2">PRODWARN</bit>
    <bit num="3">HIGLINT</bit>
    <bit num="4">HILT</bit>
    <bit num="5">HISATZEN</bit>
    <bit num="6">COASTZ</bit>
    <bit num="7">SEADAS_CLOUD</bit>
    <bit num="8">CLOUD_SHADOW</bit>
    <bit num="9">CLOUD</bit>
    <bit num="10">COCCOLITH</bit>
    <bit num="11">TURBIDW</bit>
    <bit num="12">HISOLZEN</bit>
    <bit num="13">SPARE</bit>
    <bit num="14">LOWLW</bit>
    <bit num="15">CHLFAIL</bit>
    <bit num="16">NAVWARN</bit>
    <bit num="17">SPARE</bit>
    <bit num="18">RRSWARN</bit>
    <bit num="19">MAXAERITER</bit>
    <bit num="20">MODGLINT</bit>
    <bit num="21">CHLWARN</bit>
    <bit num="22">ATMWARN</bit>
    <bit num="23">SPARE</bit>
    <bit num="24">SEAICE</bit>
    <bit num="25">NAVFAIL</bit>
    <bit num="26">FILTER</bit>
    <bit num="27">SPARE</bit>
    <bit num="28">SPARE</bit>
    <bit num="29">HIPOL</bit>
    <bit num="30">PRODFAIL</bit>
  </bitmap_description>
  <app_version>ESPA_AQ_REFL_1.1.0</app_version>
  <production_date>2019-10-21T20:52:07Z</production_date>
</band>
```

Appendix C Acronyms

AEA	Albers Equal Area
AERONET	Aerosol Robotic Network
ANG	Angle band coefficients file extension
AR	Aquatic Reflectance
BA	Burned Area
BRDF	Bidirectional Reflectance Distribution Function
CCB	Configuration Control Board
CR	Change Request
DSWE	Dynamic Surface Water Extent
ENVI	Exelis Visual Information Solutions
EROS	Earth Resources Observation and Science
ESPA	EROS Science Processing Architecture
ETM+	Enhanced Thematic Mapper Plus
FPM	Focal Plane Modules
fSCA	Fractional Snow Covered Area
GeoTIFF	Georeferenced Tagged Image File Format
GSFC	Goddard Space Flight Center
HDF-EOS2	Hierarchical Data Format – Earth Observing System (version 2)
HDR	Header
INT	Integer
INT16	16-bit signed integer
L1	Level 1
L1GS	Level 1 Geometric Systematic
L1GT	Level 1 Systematic Terrain
L1TP	Level 1 Terrain Precision
LMWS	Landsat Missions Website
LSDS	Land Satellites Data System
m	meter
MSI	Multispectral Instrument
MTL	Metadata text file extension
NA	Not Applicable
NASA	National Aeronautics and Space Administration
NC	NetCDF File Format
NCEP	National Centers for Environmental Prediction
NIR	Near Infrared
NSIDC	National Snow and Ice Data Center
OBPG	Ocean Biology Processing Group
OLI	Operational Land Imager
OMI	Aura Ozone Monitoring Instrument
pixel_qa	Pixel Quality Assessment
PS	Polar Stereographic

QA	Quality Assessment
R _{rs}	Remote-Sensing Reflectance
RT	Real-Time
SeaDAS	SeaWiFS Data Analysis System
SeaWiFS	Sea-viewing Wide Field-of-View Sensor
SR	Surface Reflectance
ST	Surface Temperature
SWIR	Shortwave Infrared
T1	Tier 1
T2	Tier 2
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
TOA	Top of Atmosphere
TOMS	Total Ozone Mapping Spectrometer
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
XML	Extensible Markup Language

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Please see <https://www.usgs.gov/land-resources/nli/landsat/glossary-and-acronyms> for a list of acronyms.

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