Schedule "A"

Nova Scotia Scanning Specifications

Province of Nova Scotia
Service Nova Scotia & Municipal Relations
Nova Scotia Geomatics Centre
160 Willow Street
Amherst, N.S.
B4H 3W5

Date: Sept 2006

Version 1.7

Version - Update information

This specification was developed in March 2005 as part of a SNSMR project to finalize its scanning requirements, develop a comprehensive specification and associated *quality control* workflows and inspection processes.

Updates to this specification will be issued periodically as information is modified. Each time a revision is issued, the Revision # will be increased by one and the date will be changed on the bottom of the page(s) affected.

The table below provides a summary of the updates of the specifications:

SUMMARY OF UPDATES

Version	Description	Date
1.6	Final Version for Release	13 June 2005
1.7	Updated metadata specifications	14 Sept 2006

Table of Contents

LTables

List of Figures

List of Appendices

1.0 INTRODUCTION

The Province of Nova Scotia, as represented by Service Nova Scotia and Municipal Relations (SNSMR), the Nova Scotia Geomatics Centre (NSGC) has created the Nova Scotia Scanning Specification (NSSS). This document describes the requirements for scanning aerial photography.

This specification has been developed to ensure the specific quality and overall usability of the scanned aerial photography delivered to SNSMR for applications such as digital photogrammetry, orthophoto map production and for creating the digital aerial photography database.

This specification includes the general requirements for all scanning projects as well as sub-sections that provide specific requirements related to scanning roll-film, diapositives and contact prints.

1.1 Roles and Responsibilities

Table 1 - Roles and Responsibilities describes each participant's roles and responsibilities:

Table 1 - Roles and Responsibilities

Participants	Description	General Responsibilities
Client	The Province of Nova Scotia, as represented by SNSMR, the NSGC	Provides source materials, NSSS and overall project management.
Inspection Group	Third Party Contractor or SNSMR Representative	Responsible for *Quality Assurance (QA)* of deliverables and final delivery to the Client.
Production Group	Third Party Contractor or SNSMR Representative	Responsible for production and *Quality Control (QC)* of deliverables.

The Client reserves the right to determine the interaction between the Production Group and the Inspection Group.

1.2 Technical Authority

Additional information regarding this specification can be obtained from:

Service Nova Scotia and Municipal Relations
Nova Scotia Geomatics Centre
160 Willow Street
Amherst NS B4H 3W5

Tel: 902 667 7231
Fax: 902 667 6008
Email: info@nsgc.gov.ns.ca

2.0 WORKFLOW

2.1 Participant Responsibilities

2.1.1 Client

The Client will be responsible for:

- Provision, handling, storage and shipping of outgoing source materials
- Maintenance and support for NSSS
- Providing approval of Production Group equipment, processes and methodology
- Provision of approval, cancellation and / or termination of any projects
- Approval of any changes to a project scope
- Final approval of project deliverables and project completion.

2.1.2 Production Group

The Production Group will be responsible for ensuring the following items meet the NSSS:

- Handling, storage and shipping of source materials
- Review and inspect source material
- Work environment
- Production equipment
- Scanning & Metadata
- Quality Control
- Submission of deliverables.

Deliverables that do not meet the specification set forth in the NSSS will be rejected and returned to the Production Group for correction.

Methodologies and equipment, which differ from those described in the NSSS, must be submitted to the Client and approved in writing before being implemented.

Failure to adhere to the NSSS may result in termination of the project.

2.1.3 Inspection Group

The Inspection Group will be responsible for ensuring the following items meet the NSSS:

- Handling, storage and shipping of source and production materials
- Quality assurance of the Production Group's delivered materials
- Preparation and submission of quality assurance reports to Production Group and Client
- Return or notification of rejected / unaccepted deliverables to Production Group
- Managing and maintaining the final sets of all accepted files during the course of the project
- Submission of the final accepted (i.e., passed QA) materials to the Client.

3.0 SCANNING REQUIREMENTS

For all scanning projects the detailed manufacturer's specification of each scanner proposed for the project must be sent to the Client. The following scanner specifications are required:

Photogrammetric scanning projects:

- Photogrammetric grade scanner
- Geometric precision of 5 *microns* (μm) or better
- *Resolution* of optics and electronics of 10 μms or better
- *Dynamic range* (of scanner) of 2.5 D or better
- *Bit depth* of at least 8 bits per channel but preferably 11 or 12 bits per channel.

Non-Photogrammetric scanning projects:

- Professional Grade scanner
- Optical resolution of a minimum of 600 *pixels* per inch (ppi) in both x and y, but preferred as 1200 ppi or better
- Dynamic range (of scanner) of 2.4 D or better
- Minimum scan area of 10 inches by 10 inches
- Bit depth of at least 8 bits per channel, but preferably 10 bits or better per channel.

3.1 Calibration Tests

A photogrammetric grade scanner to be used for *Photogrammetric Scanning* projects must be calibrated at least annually. Scanners for non-photogrammetric scanning projects do not need to be calibrated. The Production Group must provide to the Client, a calibration report signed by the manufacturer's technician prior to completing any work on the project.

Evidence of the following calibration test parameters is required:

- Calibration performed by scanning a precision *Reseau Platen* for which calibrated grid coordinates are available with an accuracy of less than 1 μms
- A minimum of 20 well distributed scanned grid intersections should be measured in a precision digital workstation

- The discrepancy between the measured grid coordinates and the calibrated values should be specified as follows:
  - Root Mean Square Error (RMSE) of discrepancies in x and y
  - Mean value of discrepancies in x and y
  - Maximum absolute value of discrepancies in x and y
  - A plot of error vectors.

The report must show the scanner maintains an overall geometric accuracy of not more than 5 μms RMSE at the scanner plate scale[1] and a maximum absolute value of discrepancies in x and y of 1 pixel.

3.2 Calibration Report Requirements

The calibration report must be included in the response to the RFP and have been done by the manufacturer's technician. It also must have been completed within 12 months prior to the scheduled scanning start data and must be valid during the entire project. The following information must be provided in the calibration report sent to the Inspection Group:

- Name of technician
- Contact information for technician
- Signature of technician
- Date of calibration
- Make, model and serial number of scanner
- Individual readings of each grid point
- Calculated RMSE value for the instrument as noted in Section 3.1.

The Inspection Group will review the calibration report and compare the contents to the requirements listed in Appendix C - Production Process Monitoring. If the report is acceptable, the Inspection Group will notify the Client and then the Client will notify the Production Group in writing to proceed with the *Benchmark* (see Appendix C - Production Process Monitoring).

If the report is unacceptable, the Inspection Group will notify the Client who will notify the Production Group and request a new calibration report. If the Production Group is unable to deal with providing a new report immediately, the Client reserves the right to cancel the project and / or any related contracts.

If there is a malfunction with the scanner or routine maintenance is required, which resulted in recalibration of the scanner, the Client must approve the new Calibration Report and another Benchmark will have to be resubmitted.

[1] At the scale of the original "Reseau platen" – glass plate

3.3 Source Materials

Source materials may include:

- Aerial photography roll film
- Aerial photography diapositives
- Aerial photography contact prints
- Flight reports and other related documentation
- Benchmark materials
- Control Frames
- Other related materials.

3.3.1 Source Materials - Roll Film

When scanning from the first generation film, the scanned images must be processed using autododging software. The scanner must not come into physical contact with the film while the film is in motion.

3.3.2 Source Materials - Diapositives

The diapositives will be supplied by the Client and will meet the colour / tonal requirements of the project. No autododging process should be applied to the scans.

3.3.3 Source Materials - Contact Prints

The contact prints will be supplied by the Client and will meet the colour / tonal requirements of the project. No autododging process should be applied to the scans.

3.3.4 Flight Reports - Rejected Frames

The rolls of film (and sets of diapositives or contact prints) for any specific project may include frames that were recorded as rejected on the flight report and / or the photo inspection report. Scans of rejected frames must not be delivered to the Client.

3.4 Operator

Production Group scanner operators shall be trained and experienced in the use of the scanner and its operating software as appropriate and in the selection of scanner operating parameters applicable to the relevant aerial photographic imagery.

3.5 Work Environment

All Client source materials must be handled and maintained with extreme care within the required work environment.

The introduction of dust, debris or scratches to the original materials during the handling, inspection or scanning is unacceptable and cause for the rejection of the scans. Damage to the original material caused by the Production Group or Inspection Group may result in cancellation of the responsible Participants' involvement, and financial penalties being applied.

Handling, inspection, scanning and storage of the Client original roll films, diapositives and contact prints must be completed within a clean and dust free work environment[2]. Handling of all materials must be completed with lint free cotton gloves.

All scanning should occur in a thermostatically controlled, dust free environment with a stable power source. Temperature, relative humidity and fluctuations of temperature in the location in which the scanner is operated shall be maintained at values as required by the operating instructions provided by the scanner manufacturer and as required by *best practices* in the handling of imagery.

If no such operating instructions are provided, room temperature shall be maintained in the range 18 to 24 degrees Celsius, relative humidity in the range 40% to 55%. Temperature fluctuations shall not exceed 2 degrees Celsius per hour.

All materials must be packed in a safe and secure manner to ensure that no damage occurs to materials during shipping.

3.6 Inspection prior to Scanning

Prior to scanning, each frame / print shall be inspected to ensure that it is free of the following:

- Damage
- Scratches, marks or flaws
- Chemical stains or marks
- Fingerprints
- Dust or debris
- Temporary identification or coding marks.

[2] A dust free work environment is a closed-work environment that utilizes climate control and air circulation / filtering equipment and is cleaned to remove dust particles on a regular basis. The work environment should be maintained following industry best practices.

Prior to scanning, the Production Group must submit to the Client their methodology for removing dust and debris. Only cleaning methods approved by the Client shall be used.

Any defects on the original imagery frame that hinder scanning quality must also be itemized and reported to the Client and the scanning should be halted until further instructions from the Client[3].

The scanner shall be cleaned prior to scanning and shall be routinely checked for cleanliness according to manufacturer's instructions.

3.7 Data Resampling

The scanner output may include geometric and / or radiometric corrections that are inherent in the scanner design and which have been approved for use by the Client, providing that:

- There is no resampling to a larger pixel size of the scanner output
- There is no resampling to a smaller pixel size of the scanner output.

3.8 File Format

The scanned and delivered file format is specified as Tagged Image File Format (TIFF):

- Version 6.x with no extensions, as defined in TIFF specification at *http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf*
- Intel byte order
- Uncompressed.

Note: All required fields in the TIFF header for *Greyscale* and *RGB* images, as described in the above TIFF specification, must be populated.

3.9 Spatial Resolution

The spatial resolution must meet the following requirements for the specific type of project being undertaken:

Photogrammetric Scanning:

- 14 μms or 1800 ppi to 10 μm or 2500 ppi.

[3] The Client inspects original imagery prior to it leaving the NSGC.

The Client prefers a scan resolution of 14 μm. However, the Client will accept a scan pixel size in the range of 14 μm to 10 μm recognizing the influence of three factors:

- Object recognition, resolution
- Map accuracy
- Orthophoto resolution both in hard copy and in soft copy.

The scan pixel size range of 10 μm to 14 μm for greyscale scans was selected to enable the Production Group to select a scan pixel size appropriate to their specific scanning equipment without the need to post process the scan data to meet a single specified scan pixel size which may be unavailable as an original scan on any particular scanner.

Non-Photogrammetric Scanning:

- 42 μm or 600 ppi.

Additional information comparing microns and pixels per inch spatial resolution measurements is provided in Appendix B - Resolution Comparison.

3.10 Scan Geometry

For Photogrammetric scanning, an evaluation of the scan geometry will be performed on each scan by using software to measure and evaluate the fiducial marks. The RMSE of the observations on the scan fiducial marks must be no larger than 0.5 pixels. Any RMSE greater than 0.5 pixels (i.e., greater than half the scanning resolution) infers systematic, geometry and / or observation errors. If any of these errors are present and cannot be resolved by re-scanning, the Client must be notified immediately to determine further action.

This must form part of the Production Group's QC process. It will also be performed by the Inspection Group at the benchmark stage and for all subsequent deliveries (See Appendix B - Resolution Comparison).

3.11 Colour Mode / Bit Depth

The *colour mode* / bit depth of the delivered scans will meet the following *minimum* requirements:

- Greyscale scans - one 8 bit channel (i.e., 8 bit greyscale, 256 values)
- Colour scans - three 8 bit channels (i.e., 24 bit colour, 16,777,216 values).

3.12 Scanning Orientation

3.12.1 Photogrammetric Scanning

Whether scanning an original aerial photographic negative or a diapositive, the resulting scan shall be oriented such that the annotation block will be correct reading, whenever possible.

For Photogrammetric scanners with a fixed stage design for the mounting of the photographic image, a traversing *Charged Coupled Device (CCD)* camera must move across the photographic image in the Y direction. When photographic images are loaded correctly, this will minimize the amount of parallax introduced in the stereo model by mechanical scanner errors. Photographic images must be loaded onto the scanner stage such that the arm of the CCD camera is aligned parallel to and moves perpendicular to the direction of the flight line.

When working with individual detached images such as diapositives, the photographic image would normally be loaded onto the scanner stage such that the annotation of the non-rotated scan appears in the bottom left hand corner. Images derived from film roll scanning must be rotated (post processing) such that the annotation appears in the bottom left hand corner of the scan.

3.12.2 Non-Photogrammetric Scanning

When working with film, diapositives or contact prints the photographic image would normally be loaded onto the scanner stage such that the annotation appears *Right-Reading*.

3.13 Scanning Extent

Scanning extent must adhere to the specifications provided in the following sub-sections.

3.13.1 Roll Film and Diapositives

For scans from ‘ten inch’ aerial negative films and diapositives, the area of the image frame to be scanned shall be a rectangle defined on all four sides by the boundary lines which are located 3 mm outside the maximum exposed area of the image frame. The fourth side shall include the instrumentation.

3.13.2 Contact Prints

For scans from contact prints, the area to be scanned shall be the rectangular image frame defined on all four sides by the inside limit of the white border. No portions of the white border shall be included in the scan.

It should be noted that the white border around the contact prints usually varies slightly in both width and length. Care must be taken with each scan to ensure that the entire white border is excluded.

Some contact prints may have a white border that is not exactly square to the image frame, i.e. the interior image frame is slightly rotated as compared to the white border. Contact prints must be scanned and / or processed to ensure that the interior image frame is free from any rotation or skew, i.e., to correct for any rotation or skew in the original.

3.13.3 Fiducial Marks

The scanned area will include all fiducial marks. Fiducial Marks will be clearly visible on all scans.

3.14 Artifacts

3.14.1 Source Material Artifacts

All image frames must be free from any dust, debris or other foreign materials. No scratches or other physical flaws can be introduced to the source materials during the production scanning process.

3.14.2 Scanning Artifacts

Scans must be free from any scanning *artifacts* (i.e., *banding*, dropped, or missing scan lines, dropped out pixels, Newton rings / *moiré patterns*, etc).

3.15 Additional Scanning Activities

The status of the Production Group's scanning will be monitored throughout the course of the project. The Production Group and the Inspection Group will utilize two project components to complete this monitoring:

- Benchmark
- *Control Scans*.

Scanning the Benchmark and inspecting the resultant scans will allow the Client to confirm that the Production Group can produce scans, which meet these specifications. To ensure that the Production Group maintains quality throughout the project, a series of Control Scans will be repeated at a regular interval. The resultant scans will be inspected and monitored by both the Production Group and the Inspection Group. Additional details on the Benchmark and control scan requirements are provided in Appendix C - Production Process Monitoring.

4.0 RADIOMETRIC QUALITY

The Client requires high quality scans with radiometric - tonal / colour composition that is consistent and faithful to the original materials.

The following radiometric characteristics are expected for all scans, except for image frames with skewed tonal representations resulting from subject matter with predominant snow, sand, water, extreme sun glare or shadow areas:

- The minimum and maximum densities of the source material shall be captured without clipping and without leaving unused *bins* on the ends of the histogram
- Scans will typically display a Gaussian distribution of *pixel values* with the mean centered on pixel value 127
- There should be no unusual spikes of data, or gaps in individual pixel bins. The scan must provide effective use of the radiometric resolution (e.g., no empty pixel bins)
- For each scan, the saturation must not exceed 0.5% at each tail of the histogram (e.g., the resulting 0 and 255 *Digital Number (DN)* values for each 8 bit *image band)*
- Scan Contrast (tonal range) is defined as the 'European Commission (EC) *Coefficient of Variation*'[4] of the scanned DN values:

$$\text{EC Coefficient of Variation is the \% of } \frac{\text{Standard Deviation of DN Values}}{\text{Available grey values}}$$

The EC Coefficient of Variation must be in the range of 10-20% (only exceptions will be sun glint on snow or water features)

- For every roll, the DN values and histograms of the Control Scans must agree with the DN values and histograms of the accepted Benchmark Scans (Appendix C - Production Process Monitoring).

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[4] This definition of coefficient of variation is taken from the European Commission-Guidelines for Best Practice and Quality Checking of Ortho Imagery version 2.3, March 2004.

5.0 METADATA REQUIREMENTS

5.1 Metadata File Format

Each Metadata file will be an ASCII text file.

Metadata for each scan will be provided as a separate file that contains fields as outlined in the Aerial Photography Metadata Specification found at the 'Image Scanning' link of the following web-address:

http://www.nsgc.gov.ns.ca/mappingspecs/Specifications/Scanned-Aerial-Meta.pdf

5.2 Metadata File Naming Convention

The metadata file name is the same as the image file name, except with a .txt extension.

6.0 SCAN FILE NAMING

All delivered scans and related metadata files will adhere to the standardized naming convention:

RRRRRRRR_FFFL.xxx

where:

RRRRRRRR	Roll number (8 digits i.e. 001, 002...)
FFF	Frame number (3 digits i.e. 001, 002...)
L	Frame letter (1 character i.e. “A” for 003A)
xxx	For images use tif and for metadata files use txt
“_”	Underscore be used as separator.

The Control Scans will adhere to the standardized naming convention:

RRRRRRRR_FFF_Target.tif (for the *Radiometric Reference Target*)
RRRRRRRR_FFF_Frame.tif (for the Non-Project Specific Air Photo).

7.0 MEDIA

All project data including scans and metadata shall be supplied on two (2) sets of new high speed hard drives (a working set and a backup set) or on other media defined by the Client (for details see Appendix F - Acceptable Delivery Media). All hard drive(s) will be packaged in original shipping containers suitable for safe courier transport.

Each hard drive shall have a digital directory of contents (in text format) in a "Readme" file folder. Each hard drive also shall have a physical label with the following information: the NS roll number, flight line numbers, and frame number ranges.

Each hard drive will be delivered with the following hardcopy documentation: a directory tree identifying the complete contents of the hard drive (all tif and txt files) and a copy of "Scan Log" (see Section 7.1).

On each hard drive, a directory will be created for each roll in the delivery. The scans and metadata files for each frame for the roll will be placed in the directory. The Control Scans will also be included in every roll directory.

7.1 Virus Scanning Requirements

All hard drives will be scanned and delivered virus free. Each delivery will include a "Scan Log" verifying a virus free hard drive.

7.2 Shipping and Packaging

Scans and original roll film source material must not be in transit at the same time, to ensure that in the event of a shipping accident, a copy of the data is preserved. Only a *Bonded Courier* can be used.

Shipping and packaging of the source materials and deliverables is the responsibility of the each project group. For each delivery / shipment, each group involved will provide:

- Prepaid delivery
- Packing that will ensure arrival in a good and safe condition of all materials.

The cycle of shipping is as follows:

- The Client is responsible for shipping to the Production Group
- The Production Group is responsible for shipping to the Inspection Group
- The Inspection Group is responsible for shipping back to the Production Group or the Client, as appropriate.

All materials not meeting the NSSS will be rejected and returned to the Production Group at the Production Group's expense.

The Client reserves the right to request that an individual shipment, when urgently needed, be shipped by the most expedient means available.

Unless otherwise specified all deliveries shall be addressed to:

Service Nova Scotia and Municipal Relations
NOVA SCOTIA GEOMATICS CENTRE
160 Willow St.
Amherst, NS B4H 3W5

ATT: Name of contact person[5]
Phone number of contact person

[5] This information will be provided at the project initiation meeting.

8.0 PRODUCTION QC RESPONSIBILITIES

The Production Group is responsible to implement its own detailed quality control procedures and monitor its work throughout the project. Quality control checks should verify all aspects of the NSSS.

8.1 Status Reports

The Production Group must provide weekly status reports to the Inspection Group.

9.0 DELIVERABLES

9.1 Production Group Deliverables

Project deliverables from the Production Group shall include the five (5) items listed below. Items 9.1.1, 9.1.2, and 9.1.5 will be sent directly to the Client, while items 9.1.3 and 9.1.4 will be sent to the Inspection Group.

9.1.1 Production Scanning Information (only if modified since RFP response)

- Manufacturer's specification on each make and model of scanner proposed
- Detailed description / photographs / video of the production facility outlining:
  - Storage area
  - Scanning area
  - Environmental controls
  - Standard handling procedures
  - Detailed description of the Production Group's own quality control procedures.

9.1.2 Scanner Calibration Report (only if modified since RFP response)

- Only for photogrammetric scanning projects
- Format / content of report as described in Section 3.2
- For each scanner to be used on the project.

9.1.3 Benchmark

- Benchmark scans and all related information (See Appendix C - Production Process Monitoring).

9.1.4 Scans

- All deliveries will typically be based on complete rolls of film
- Each delivery will include the following:
  - Control Scans for each roll in the delivery
  - Scan of each frame
  - Metadata file of each scan
  - Original diapositive, or contact prints[6]
- For each delivery of scans, one set of files (scans, metadata, etc.) will be created by the Production Group and delivered to the Inspection Group

[6] Original roll film will not be delivered as part of the delivery submissions to the Inspection Group.

- Each set of files will be provided on the required delivery media (See Section 7.0)
- Each set of files will be submitted to the Inspection Group according to the project schedule, for quality assurance checks
- The Production Group will maintain its own backup copy of each set until notified by the Client at the end of the project
- Files not meeting the NSSS will be rejected and source materials returned to the Production Group (at their expense), if requested
- The Production Group will scan any files that are rejected and resubmit them to the Inspection Group.

9.1.5 Source Materials

- Any materials sent to the Production Group and not returned throughout the project, will be returned at the end of the project
- For roll film scanning projects, the Client will provide specific time frames to return original roll films throughout the project[7]. Roll film will be shipped according to directions provided in Section 7.2.

9.2 Inspection Group Deliverables

Project deliverables from the Inspection Group include Quality Assurance (QA) reports on the Benchmark and each delivery of scans. QA reports will be sent to both the Production Group and the Client.

The Inspection Group will be responsible for managing and maintaining the final sets of all accepted files from the Production Group over the course of the project. This includes final sets of both the working files and the backup files.

At the end of the project, the Inspection Group will submit the two sets of the final accepted files to the Client, organized and delivered as per Section 7.0.

The working set of files will be shipped to the Client and the backup kept at the Inspection Group. The Inspection Group will confirm that the working set of files has been received in good working order by the Client, prior to shipping the backup set of files.

[7] The delivery schedule for original roll film will be provided by the Client at the project initiation meeting

Appendix A - Specification Terminology

For the purposes of this specification, the following terms and definitions apply:

Term	Definition
Artifact	An object or structure which is introduced into the digital image as a result of the scanning process and which did not exist in the original photographic image.
Banding	An effect also known as posterizing in which smooth gradations of tone are reduced to a set number of solid colours. The result is a set of striped bands rather than smooth tone.
Benchmark	A series of selected frames that will be scanned by the Production Group, then reviewed and approved by the Inspection Group and / or Client before any production work begins. These Benchmark frames and the resulting scans, once accepted, will be used to compare and monitor the quality of the ongoing scanning work.
Best practices	Procedures and guidelines that are widely accepted in industrial practice because experience and research have demonstrated that they are optimal and efficient means to produce a desired result.
Bin	A given pixel intensity. It is usually used to refer to the number of occurrences of a given intensity.
Bit Depth	The number of bits used to describe the colour of each pixel. Greater bit depth allows more colours to be used in the colour palette for the imaging. E.g., 8-bits per pixel will allow 256 colours; 8-bits per colour component in a RGB image will allow 16,777,216 colours (256 X 256 X 256). Sometimes referred to as *colour mode and radiometric resolution.*
Bonded Courier	A courier service that is insured as needed to guarantee the safe handling and shipping of the project materials shipped between the Production Group, Inspection Group and / or Client.
Channel Registration	The process of aligning or the measurement of the spatial alignment of the different image channels / image bands that compose a scan.

Term	Definition
Charged Coupled Device (CCD)	A light capturing element that converts the light reflected or transmitted during a scan to an electrical charge. The strength of the charge is in direct proportion to the intensity of the light. The electrical signal is then converted to a digital signal using an analog-to-digital converter.
Coefficient of variation	Represented as the Standard Deviation of the DN values as a percentage of the available grey levels.
Colour Mode	See Bit Depth.
Contract Number	The number assigned by the Client for a contract resulting from an RFP or DPO.
Control Frames	A set of frames (either on film or hard copy, depending on the type of scanning project) used to provide baseline information for comparison to production scans. The first frame is a Radiometric Reference Target and the second frame is a Non-Project Specific Air Photo.
Control Scans	Scans of the Control Frames. See Control Frames.
Correct-Reading	Correctly oriented and Right-Reading. *Also referred to as Right Reading.*
DPO	Departmental Purchase Order
Density (D)	The photographic density of the transparency as measured by a densitometer. Density is equivalent to D = 1/logT Where T = *Transitivity* of the media.
Density Range (D)	A measure of a device's ability to capture a range of tonal values. Range of density that the scanner can capture defined as: $D_{range}=D_{max}-D_{min}$ *Also referred to as Dynamic Range.*

Term	Definition
Digital Number (DN)	A representation of a scan brightness value. A number representing a discrete grey level in a scan. Normally within the range of 0 to 255 as stored in a single byte (8 bits). *Also known as Pixel Value.*
Dynamic Range	See Density Range.
Greyscale	An image consisting solely of shades of grey and not any other colour. An image with purely luminance data and no chroma information. A number of greys ranging from black to white. An eight bit greyscale image could have 254 greys between black and white.
Image Band	In the context of scanning, a range of measured wavelengths of energy, or portion of a frequency spectrum. Commonly related to a specific colour range. For example, all red data might be stored in a red band. RGB images contain three bands – red, green and blue. *Also referred to as Image Channel.*
Image Channel	See image band.
Inspection Group	Third Party Contractor or SNSMR Representative, who is Responsible for Quality Assurance of deliverables for a project.
LAB	Colour model that defines colours along two polar axes for colour (a and b) and a third for lightness or luminosity (L). LAB allows the specification of colour perceptions in terms of a three-dimensional space. The L*-axis is known as the lightness and extends from 0 (black) to 100 (white). The other two coordinates a* and b* represent redness-greenness and yellowness-blueness respectively.

Term	Definition
Luminosity Histogram	A 2 dimensional graph of the luminance (the brightness of the color) values of a scan. Luminance is defined by the LAB colour model, and is different that the typical RGB colour model. Luminance can be calculated from RGB values. Histograms plot brightness along the horizontal axis and number of pixels at that brightness level along the vertical.
Micron (μm)	The unit of length defined to be 0.000001 metre.
Moiré Pattern	When the matching transparencies or image bands are placed on top of one another so that the patterns do not precisely line up, areas of light and dark patterns are formed. These patterns are called "moiré". *Also see "Newton Rings."*
Newton's Rings	Concentric coloured rings, which appear when two pieces of glass or clear plastic are pressed together. A problem with glass negative carriers and a phenomenon discovered by English physicist Sir Isaac Newton (1643-1727). The rings appear when there is a tiny air gap between two pieces of clear material. Light rays encounter destructive interference if the gap is of a certain size relative to the wavelength, resulting in the effect. It is most pronounced if a convex lens is pressed up against a perfectly flat glass surface. *Also see Moiré Pattern.*
Optical Resolution	Maximum spatial resolution without recourse to interpolation. Resolution imaged by optical system in a capture device – without subsequent software interpolated pixels.

Term	Definition
Photographic Step Wedge	A standard photographic tool showing steps of increasing density. A typical wedge has steps at increments of 0.15 Density units within the range of 0 to 1.5 D.
Pixel	A picture element, the smallest captured unit within the image.
Production Group	Third Party Contractor or SNSMR Representative, who is responsible for production and Quality Control of deliverables for a project.
Photogrammetric Scanning	Scanning using equipment designed to accommodate aerial photographs, roll film and diapositives. It addresses the high geometric (5 – 10 μms), and radiometric (D_{min} 0.2 – D_{max} 4.0) demands of photogrammetry.
Quality Assurance (QA)	The policy, procedures, and systematic actions established in an enterprise for the purpose of providing and maintaining a specified degree of confidence in data integrity and accuracy throughout the life cycle of the data, which includes input, update, manipulation, and output.
Quality Control (QC)	A management function whereby control of the quality of materials, services and processes is exercised for the purpose of preventing undetected production of defective material or the rendering of faulty services.
Radiometric Accuracy	The degree to which the statistical analysis of pixels within a scan adheres to the values specified in the NSSS.
Radiometric Reference Target	A film / paper target containing colour blocks and shades of grey, etc. used to test a scanner's ability to capture and maintain consistency of information over a period of time. The NSSS defines a specific Radiometric Reference Target for contact print scanning and diapositive / roll film scanning projects.
Resolution	The physical size of pixels within a scan. Spatial resolution is normally expressed as the number of pixels

Term	Definition
	per linear unit, e.g., 300ppi (pixels per inch), sometimes dpi (dots per inch). For radiometric resolution see Bit Depth.
Reseau Platen	A grid system of a standard size in the image plane of a photographic system used for measurement purposes. A calibrated glass plate with known grid values.
RFP	Request For Proposal
RGB	Red-green-blue. The three primary colours in additive colour theory. When the three colours are combined (added together) the result is pure white light. RGB is a common colour model used on computer systems – each of the three colours are assigned their own colour channel which can be manipulated independently.
Right-Reading	An image that appears in the normal reading position and not laterally reversed.
Step Wedge	See photographic step wedge.
Transitivity	Percent of light transmitted by a transparent media.
XYZ	Colour model that defines colour as x, y, z coordinates in CIE XYZ colour space.

Appendix B - Resolution Comparison
Pixel Per Inch vs. Microns

Table 2 - Resolution Comparison

Pixels per inch (ppi)	Pixels per cm (ppcm)	Microns (µm)
200	78.740	127.000
300	118.110	84.667
400	157.480	63.500
500	196.850	50.800
600	236.220	42.333
700	275.591	36.286
800	314.961	31.750
900	354.331	28.222
1000	393.701	25.400
1100	433.071	23.091
1200	472.441	21.167
1300	511.811	19.539
1400	551.181	18.143
1500	590.551	16.933
1600	629.921	15.875
1700	669.291	14.941
1800	708.661	14.111
1900	748.031	13.368
2000	787.402	12.700
2100	826.772	12.095
2200	866.142	11.545
2300	905.512	11.044
2400	944.882	10.583
2500	984.252	10.160
2600	1023.622	9.769
2700	1062.992	9.407
2800	1102.362	9.071

This table is provided to allow users to compare common pixel per inch (ppi), pixel per centimetre (ppcm) and micron values.

Conversion Factors for Scanning Resolutions:

1 inch equals 0.00003937 microns
1 cm equals 0.0001 microns.

Formulas to convert between various Scanning resolution units are shown in **Table 3 - Formulas for Conversion**.

Table 3 - Formulas for Conversion

To convert ppi to microns	1/(ppi*0.00003937)
To convert ppcm to microns	1/(ppcm*0.0001)
To convert microns to ppi	1/(µm* 0.00003937)
To convert microns to ppcm	1/(µm* 0.0001)

Appendix C - Production Process Monitoring

Monitoring the Production Process

The quality of the Production Process will be monitored throughout the course of the project using two project components:

- Benchmark
- *Control Frames.*

The Production Group will adhere to the NSSS and create scans with related files from a predetermined set of Project Specific Frames. This portion of the Benchmark will allow the Client to confirm that the Production Group is capable of producing acceptable scans prior to the commencement of the project.

Scanning the Control Frames at a regular interval by the Production Group will ensure that their equipment continues to perform at the same level of quality throughout the project.

During this monitoring process the *Control Scans* will be compared to the originally accepted Benchmark scans to ensure the radiometric (i.e., greyscale and colour) values agree. These checks will be performed by the Production Group and then by the Inspection Group.

If a change in the output scan is observed, the scanning will be stopped and the equipment and / or process adjusted until the original values are reproduced. When acceptable values are reproduced, the scanning can restart. This regular monitoring of a known set of accepted colour values will reduce the number of frames scanned with unacceptable greyscale / colour values.

Benchmark

Every scanning project will include a Benchmark. The Benchmark must be completed and the resulting scans approved by the Inspection Group before any production work can begin. The following source material will be scanned during the Benchmark:

- Project Specific Frames
- Control Frames (non-project specific).

This source material will be scanned on the production equipment which adheres to the proposed production process. Only equipment and processes proposed for the project will be used.

The Benchmark scans and all associated files (metadata, etc) will be produced according to all requirements within the specification (NSSS). Prior to submission to the Inspection Group, the Benchmark materials will be quality controlled by the Production Group to ensure that they meet all requirements in the NSSS.

If there is a malfunction with the scanner or routine maintenance is required which results in recalibration of the scanner, the Client must approve the new Calibration Report and another Benchmark will have to be submitted.

Project Specific Frames

Project Specific Frames include a representative sample[8] of the types of frames in the project. As part of the Benchmark, these frames will be sent to the Production Group to scan according to their proposed production process and using their proposed equipment.

Control Frames

Control Frames will also be scanned by the Production Group during the Benchmark. For the remainder of the project, the Control Frames will be scanned at the beginning of every roll. The Control Frames include:

- A documented Radiometric Reference Target which will have expected colour or greyscale values
- A Non-Project Specific Air Photo.

Film Roll Scanning Projects:

For film roll scanning projects, the Control Frames will exist on film. The Client has created a unique roll of film which consists of only two frames. The first frame will be a Radiometric Reference Target and the second frame will be a Non-Project Specific Air Photo.

The Radiometric Reference Target and tests for roll film and diapositive scanning will use a standard *photographic step wedge*. The Client will provide the Production Group with a control frame comprised of five photographic *step wedge*s arrayed on a 230 mm square film produced from the same material or certified to be an identical copy within the limits required for the purposes of this test. Details on the photographic step wedge and the test parameters SNSMR will use to verify the resulting scans are described in Appendix E - Roll Film / Diapositive Reference Target / Test Requirements.

Contact Print Scanning Projects:

For contact print scanning projects, the Control Frames will exist as hard copy. The first control frame will be the Radiometric Reference Target and the second frame will be a Non-Project Specific Air Photo print. The Radiometric Reference Target to be used to evaluate the production equipment's radiometric range will be the KODAK Q-60 Colour Input Target or equivalent. Details on the KODAK Q60 and the test parameters the Inspection Group will use to verify the resulting scans are described in Appendix D - Contact Print Reference Target and Test Requirements.

[8] The exact number of frames in the Benchmark will be determined on a Project by Project basis by the Client. Exact numbers of frames will be provided in the Project Description / RFP documents.

Submitting the Benchmark

The Benchmark delivery to the Inspection Group will include the scans of the Control Frames, the series of Project Specific Scans and the related metadata for each of the frames sent to the Production Group.

The submitted Benchmark scans will be thoroughly inspected and run through Quality Assurance checks by the Inspection Group. They will be checked for both file integrity and radiometric (tonal / colour) composition. The Radiometric Reference Target will be evaluated according to the test described in Appendix D - Contact Print Reference Target and Test Requirements and Appendix E - Roll Film / Diapositive Reference Target / Test Requirements.

If the Benchmark scans are accepted by the Inspection Group as meeting the NSSS, the Production Group will be advised in writing to begin production scanning.

If the Benchmark scans are rejected, the Production Group will be advised and will be required to redo and submit the Benchmark again.[9]

The Benchmark delivery will be provided as per the file naming conventions, delivery media, packaging and shipping requirements as outlined in Sections 6 and 7 of the NSSS.

Control Frame Scanning During Production

When scanning production commences, the Production Group will scan the Control Frames at the start of each new roll. The resulting scans will be submitted with each roll in the delivery. The Production Group will verify its scanner parameters with these scans to ensure no changes to the scanner quality have occurred prior to scanning any additional frames.

As each delivery of scans is received by the Inspection Group, radiometric values for each of these delivered Control Scans will be first compared to those in the Benchmark delivery. The Inspection Group will review each set of these Control Scans for each roll and will inspect these scans against established values in the Radiometric Reference Target and Control Frames for pixel values and histograms. If these are different, the Inspection Group will notify the Client and will stop any further QA activities and reject the entire roll in that delivery. It will be returned to Production Group for rescanning and resubmission at their expense.

In each delivery and for each roll in the delivery, the Production Group will include new Control Scans.

[9] The Client reserves the right to cancel the project and/or any related contracts should the Benchmark materials be rejected more than twice.

Comparisons of Control Scans

The Inspection Group will utilize the Control Frames scanned at the start of each roll as an initial verification that scans were produced with the correct greyscale / colour composition.

Prior to reviewing any other scans within a delivery the Inspection Group will generate histograms and statistics of the Control Scans. These will then be compared to the histogram and statistics from the original supplied and accepted Benchmark scans.

If the delivery histograms and statistics differ from the original Benchmark scans in values greater than those shown in **Table 4 - Control Scans Comparison Values**, the scans will be rejected and the entire delivery returned to the Production Group for rescanning.

Table 4 - Control Scans Comparison Values

Radiometric Parameter	Maximum Acceptable Differences Between Benchmark and Delivery
Mean Value	5 DN
Saturation	0.25 %
Contrast	2 %
Standard Deviation	5 DN
Number of empty bins	0

Appendix D - Contact Print Reference Target and Test Requirements

Contact Print Radiometric Reference Target

The Client will have a Radiometric Reference Target for contact print scanner evaluation. This target will allow the Inspection Group to evaluate the Production Contractor's equipment for radiometric precision, dynamic range and consistency throughout each scanning project.

The Client will provide the Kodak Q-60 Colour Input Target to the Production Group.

This scanner colour characterization target is produced in accordance with ANSI IT8.7/2 (reflection) Standards (or ISO 12641) are manufactured by Eastman Kodak Company. The Kodak Professional Q-60 Target is provided on Kodak Professional Ektachrome paper in a 4" x 5" format.

The target is designed for use in the commercial and desktop arenas, as a comparative control tool to help customers calibrate their input product to the final output. This target maps the gamut of colour space that Ektachrome Film and colour paper can reproduce. For each target, Kodak provides a digital file documenting the expected colour spaces and greyscale values for the various swatches. These values are provided from KODAK in *XYZ* and *LAB* formats. The Client will provide converted RGB values for specific aim points to the Production Group, if needed.

A sample image of the target is provided in **Figure 1 - Kodak Professional Q-60 Target.**

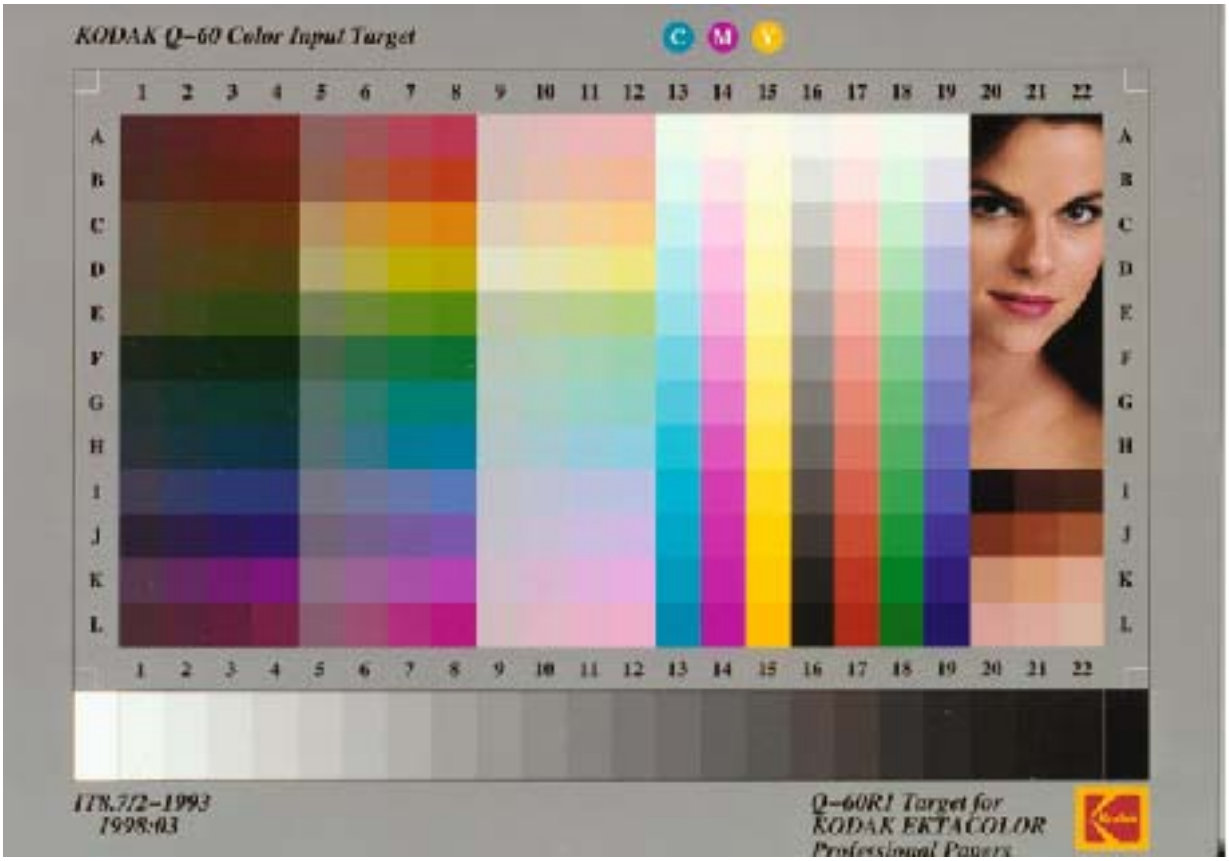

Figure 1 - Kodak Professional Q-60 Target

Contact Print Radiometric Reference Target Control Requirements

The Kodak Q-60 target shall be scanned with scanning parameters selected and recorded, and reported to the Client in accordance with those outlined in the proposed Production process.

Scan Pixel Size

The contact print Radiometric Reference Target shall be scanned at a scan pixel size of 600 pixels per inch.

Number of Scans

The Contact Print Radiometric Reference Target shall initially be scanned in each project as part of the Benchmark tests. It will then be scanned prior to the start of each new roll of prints at the standard settings to be used during the production of the scans for the project as determined by the Production Group.

Control Scan Evaluation

The scans shall be evaluated with standard image analysis software. Pixel values for the grey scale steps 1, 5, 10, 15 and 20 will be measured. Pixel values for colour swatches will be measured (D8, F13, I14, H19). Also, a histogram, standard deviation and mean DN values for the scan will be generated.

Performance Acceptance Levels

Each scan shall meet each of the following acceptance levels:

- For the Benchmark scan, each greyscale and colour swatch measured pixel values shall be within 5 DN values of the anticipated values of the target
- For all deliveries, roll specific scan values will be within 3 DN values of the Benchmark values. In addition the delivery specific scan histogram overall shape must be identical to the Benchmark histogram values. The mean value must be within 5 DN values to the Benchmark value.

If the scans fail to meet these acceptance levels, the Production Group will adjust the scanning equipment and rescan the target. No further scanning will take place until acceptable results have been obtained.

The accepted scan will be saved and then forwarded with the other scans from that roll in the delivery to the Inspection Group.

Should the Production Group be unable to produce an acceptable scan, no further scans will be completed and the Client shall be advised immediately. Remedial action will be planned in consultation with the Production Group.

Appendix E - Roll Film / Diapositive Reference Target / Test Requirements

Roll Film – Diapositive Reference Targets

For roll film and diapositive scanning projects, the Client will employ a Photographic Step Wedge as the Radiometric Reference Target to verify and monitor the scanners' radiometric precision, dynamic range and consistency throughout each scanning project.

The Client shall provide the Production Group with a control frame comprised of five photographic step wedges arrayed on a 230 mm square film produced from the same master or certified to be an identical copy within the limits required for the purposes of this test and typically as shown in **Figure 2 - Photographic Step Wedge.**

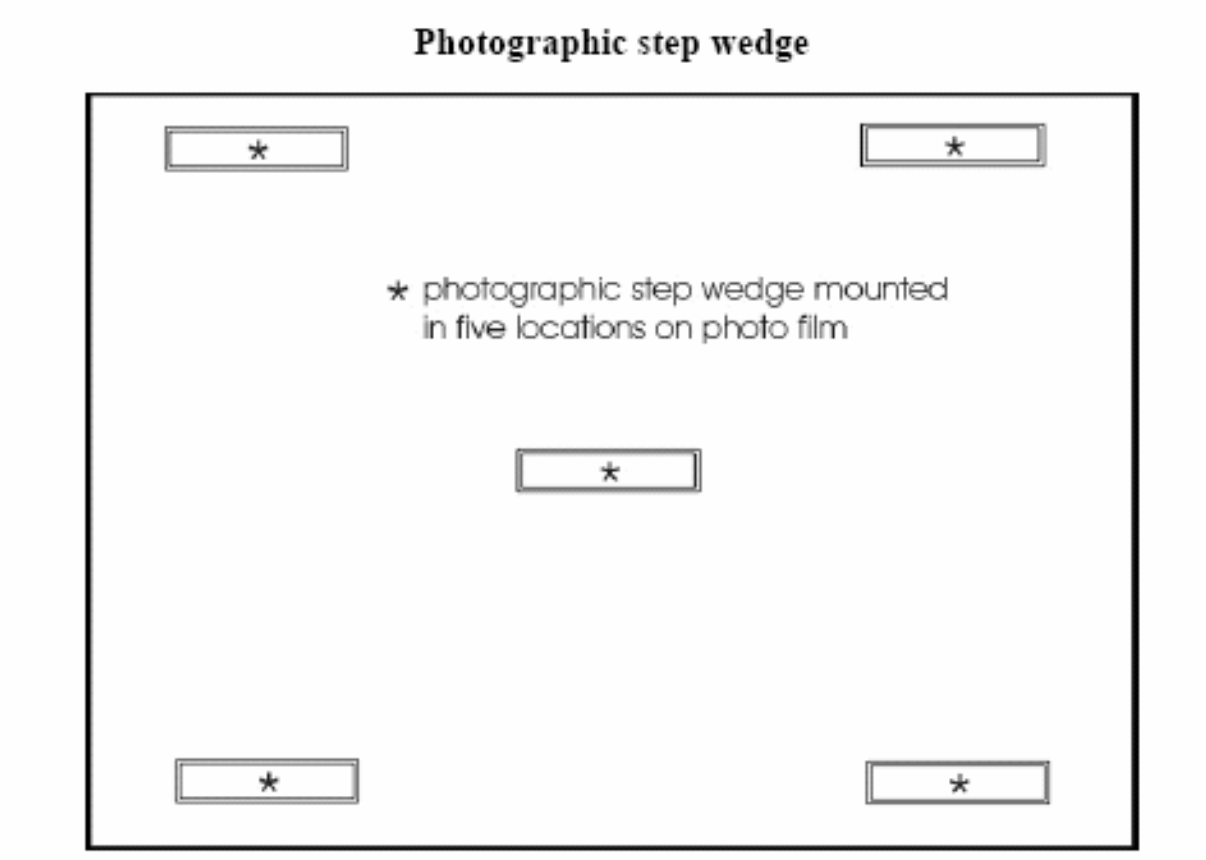

Figure 2 - Photographic Step Wedge

Roll Film – Diapositive Reference Targets Control Procedure

This Radiometric Reference Target shall be scanned with scanning parameters selected and recorded, and reported to the Inspection Group in accordance with the following criteria:

- Density of 0.2 D shall be registered with a pixel value of 255
- Density of 1.5 D shall be registered with a pixel value of 0.

Pixel values for film density values in the range 0.2 D to 1.5 D shall be calculated pro rata to 0 and 255 typically as in **Figure 3 - Photographic Density vs Radiometric Pixel Values.**

Scan Pixel Size

The photographic step wedge film shall be scanned at a scan pixel size of 100 μms +/- 25%.

Control Scan Evaluation

The scanned data file shall be evaluated in standard image analysis software. Pixel values for each density step of each of the five step wedges shall be determined. For each scan, the pixel value for each density step shall be averaged for each of the five step wedges. This average pixel value for each density step shall be plotted against density for each scan.

Performance Acceptance Levels

The scan shall meet each of the following acceptance levels:

- For each scan, the pixel values for each density step shall be within +3% and –3% of the calibrated density values for the photographic step wedge, typically as in **Figure 3 - Photographic Density vs Radiometric Pixel Values**
- For each density step, the maximum positive or negative deviation of any individual pixel value shall not be greater than 10% of the average for the step.

If the scan fails to meet these acceptance levels, the Production Group will adjust the scanning equipment and rescan the target. No further scanning will take place until acceptable results have been obtained.

The accepted scan will be saved and then forwarded with the other scans from the delivery to the Inspection Group.

Should the Production Group be unable to produce an acceptable scan, no further scans will be completed and the Client shall be advised immediately and remedial action will be planned in consultation with the Production Group.

The photographic density vs the radiometric pixel values are shown in **Figure 3 - Photographic Density vs Radiometric Pixel Values**.

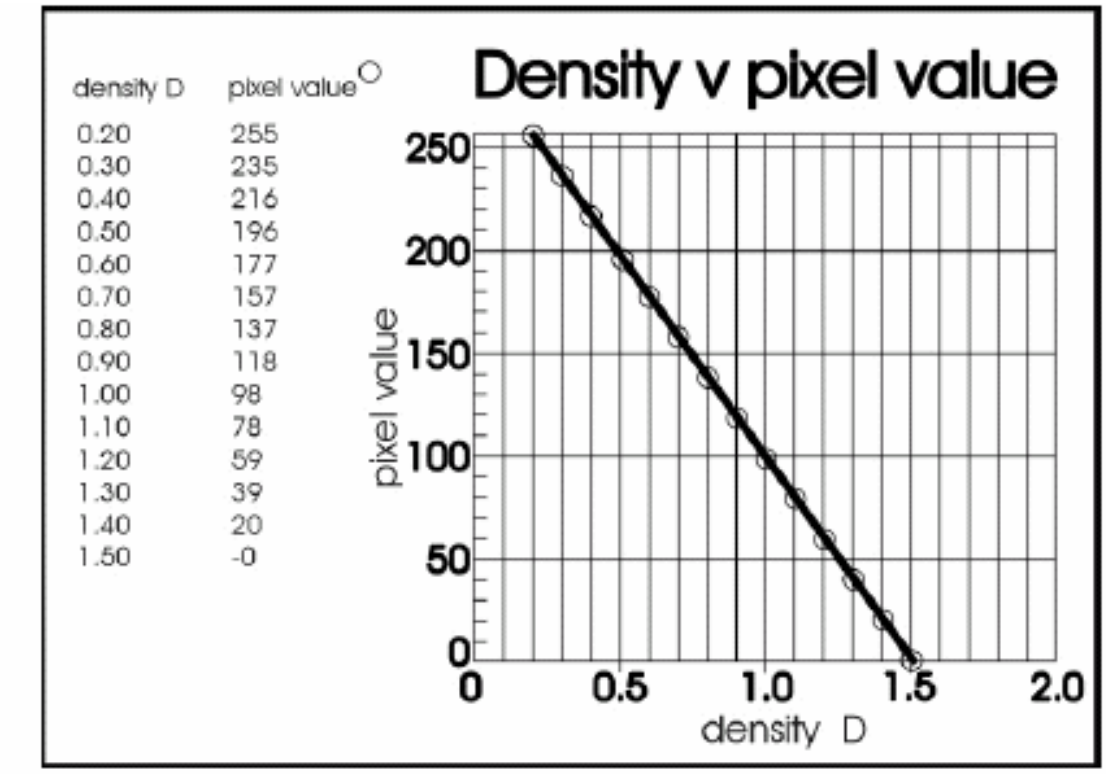

Figure 3 - Photographic Density vs Radiometric Pixel Values

Appendix F - Acceptable Delivery Media

Acceptable Delivery Media

The Client will accept delivery of scans and related metadata on hard drives. The hard drives will conform to the following:

- Hard drive with factory installed enclosures
- 7200 rpm
- USB 2.x or Firewire connection
- 500 GB capacity
- Minimum 3 year manufacturer's warranty.

All external hard drives must be shipped in their original boxes and include all necessary cabling.