Quality Guidance for the Great Lakes Observing System Data Management Activities

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Great Lakes Observing System (GLOS)
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A1. Management and Organization

The Great Lakes Observing System (GLOS) is recognized by the U.S. Integrated Ocean Observing System (IOOS) as the IOOS Regional Association responsible for developing the framework for a coordinated observing system for the Great Lakes as part of the U.S. contribution to the Global Ocean Observing System (GOOS). GLOS is intended to enhance and improve existing observing activities by leading the integration and development of interoperable, easy to access data, products, and related services. As such, it is charged with coordinating and integrating scientific observation data, model outputs and other information related to the Great Lakes basin. Specifically, the mission of GLOS is to *advance the coordination of the extensive Great Lakes regional observing network of people, processes and technology that work together to maximize access to critical, real-time and historical information for use in managing, safeguarding and understanding the Great Lakes and St. Lawrence River system*.

The data integration and data access functions assigned to GLOS are carried out primarily by the GLOS Data Management and Communications (DMAC) subsystem. GLOS DMAC consists of the personnel, information technology infrastructure and data processing systems operated by GLOS that are focused on the transfer, storage and delivery of scientific data about the region. Its purpose is to ingest, store and distribute data produced by GLOS partners, integrate those data with the IOOS national backbone data system, and develop and host data services and derived products of value to researchers, regulators and other user communities throughout the region.

Guided in part by the Data Integration Framework (DIF) adopted by IOOS and in part by the policies and practices of other agencies and scientific institutions, GLOS DMAC accepts and distributes a broad array of data, model outputs and information, allowing scientists, resource managers, decision-makers and other data creators and users to develop a more complete characterization of the Great Lakes. Meeting the needs of these groups may involve data discovery and extraction tools, data transfer and storage services, web-based data mapping services, or other data visualization tools. The goal of DMAC activities is to maximize the utility of GLOS data services, whatever they may be, ensuring they are reliable, efficient and informative.

The following document comprises the Quality Assurance Project Plan (QAPP) for the GLOS DMAC subsystem. It outlines the process GLOS uses for determining quality parameters to be applied to regional data and information services and the quality assurance practices used to ensure that the requirements specified in those parameters are met. This document is a component of the broader GLOS Quality Management Plan. Further information about the overall structure and function of GLOS and the GLOS strategy for quality management can be found there.

A2. Quality Assurance Policy Statement

GLOS considers quality assurance (QA) and quality control (QC) key to the organization’s success and credibility, particularly in its role as a data coordinator for the Great Lakes region. The quality system described in this QAPP is intended to ensure that DMAC standards, practices and procedures result in high quality outputs from GLOS DMAC that accurately reflect the broader quality management goals and standards of the GLOS Regional Association.

This QAPP presents the management policies, roles, responsibilities, and procedures to be followed by GLOS DMAC to ensure that all work performed under GLOS DMAC includes:

- Identification and understanding of project needs and expectations in terms of strategic, technical and quality goals;
- Translation of needs into documented specifications and performance measures to produce the desired products or results; and
- Adequate planning, regular management assessments and effective implementation of adaptive actions

This QAPP pertains to products GLOS DMAC directly implements, including datasets, online data services, archiving services and data exploration and visualization tools, and to DMAC-related projects GLOS contracts to have implemented. Other components of the Great Lakes Observing System may be implemented by partners utilizing the same or different funding sources, but without a contract through GLOS. In these instances, partners will be responsible for fulfilling any quality systems requirements directly.

The GLOS QMP is provided to all staff, contractors, grantees, and other project partners. Resources, guidelines, SOPs and/or documentation requirements for project adherence to the QMP are included in any/all contracts, cooperative agreements, MOUs, etc., as applicable, including the GLOS DMAC QAPP. Relevant project quality documentation is reviewed by GLOS QA Manager, the Executive Director and the GLOS DMAC Coordinator prior to project implementation and evaluated during reviews of project status reports. The GLOS DMAC Coordinator is responsible for ensuring all project partners are familiar with the GLOS DMAC QAPP and have adequate support for adhering to it. GLOS DMAC staff are supported by the GLOS QA Manager, the GLOS Executive Director, the GLOS Board of Directors and the GLOS Technical Advisory Panel as necessary in the development, implementation and revision of the GLOS DMAC QAPP. Because DMAC quality practices are an integrated part of GLOS program management, additional resources for GLOS DMAC quality assurance are not needed.

A3. Organizational Chart

GLOS is a small organization, consisting of the Executive Director, two full-time staff positions (Program Coordinator and Technical Coordinator), and one part-time Business Manager. The QA reporting and communication structure follows directly from the GLOS organizational structure, under which GLOS solicits and manages most projects as a distributed consortium through contracted services. Project partners are independently responsible for project scoping, developing performance metrics, adopting required standards and protocols, independently verifying or validating data quality, and documenting QA/QC procedures as part of contracting/service agreement process with GLOS. GLOS staff and team leads for Observations and Data Management are responsible for the management of these projects and partners, including evaluation and assurance that they are meeting contract requirements. Due to a very small staff size, it is not possible for GLOS to create one position fully dedicated to QA management. GLOS has designated its Technical Coordinator to serve as the QA Manager in an effort to ensure appropriate independent review. It is also important to emphasize that contracted projects are implemented independently of GLOS and undergo various levels of review by team leads, GLOS staff, an independent Technical Advisory Panel, and the GLOS Board of Directors.

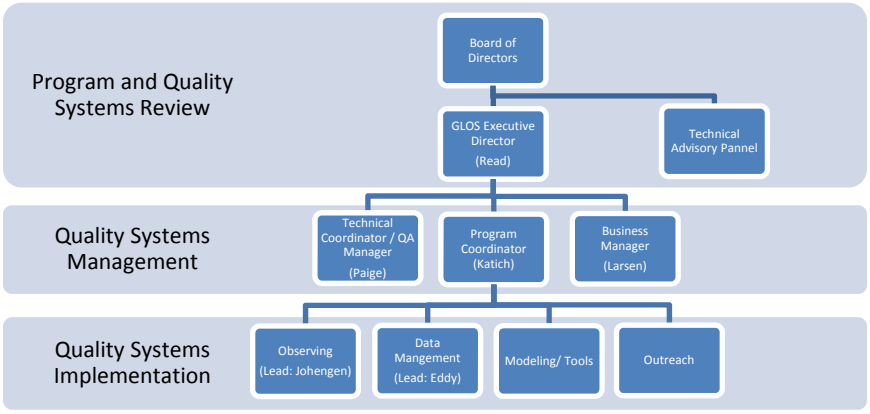

Figure 1: GLOS Organizational Chart

Program Team Leads and other project partners or contractors report to GLOS through the Program Coordinator. The Technical Coordinator serves as an independent QA Manger to provide review and evaluation of quality systems in addition to the other levels of project review provided by the team leads, GLOS staff, Technical Advisory Panel and Board of Directors.

Responsibility for quality assurance of GLOS DMAC internal operations rests with the GLOS DMAC Coordinator, whose duties and activities in this area are overseen by the GLOS Technical Coordinator in her role as QA Manager. In cases where GLOS DMAC undertakes tasks as part of a separately funded GLOS project, GLOS DMAC personnel and practices are subject to the same QA requirements as traditional GLOS project partners.

A4. QA Manager/QA Staff Authorities

Kelli Paige, GLOS staff, serves as the GLOS QA Manager. As GLOS staff, the GLOS QA Manager works independently from those who generate, compile, or evaluate environmental data, because those activities are done through partner organizations or through contract with GLOS. Tom Johengen, Cooperative Institute for Limnology and Ecosystem Research, is responsible for coordinating observing projects quality systems. Stuart Eddy, Great Lakes Commission, is responsible for coordinating data management and communications quality systems. Other project leads will be responsible for coordinating and documenting project-specific quality plans. The Program Coordinator, Sara Katich, is responsible for managing and reviewing project documentation and reporting and works with the Business Manager, Elyse Larsen, who is responsible for coordinating project contracting. Jennifer Read, GLOS Executive Director, is responsible for coordinating review of project plans by the Board of Directors or Technical Advisory Panel. The QA Manager will work with the Executive Director, Technical Advisory Panel and Board of Directors to plan, assess, and improve the organization's quality system.

A5. Technical Activities/Programs

As recognized in the GLOS QMP, any observations, data management, modeling or tool development project undertaken by GLOS is subject to compliance with GLOS protocols and processes for quality assurance and quality control. The vast majority of these projects are implemented through contracts, MOUs, or cooperative agreements with members, partners, or private contractors. GLOS uses this contract process as a mechanism for enforcing, overseeing and evaluating data quality assurance. The GLOS QA Manager works with individual project leads as well as the GLOS Project Coordinator, Business Manager, Observations and Data Management Coordinators to ensure that projects meet applicable quality systems requirements by reviewing project proposals and scope according to a QA/QC Reporting checklist that is incorporated into the GLOS contracting process.

The Data Management Coordinator is responsible for ensuring that DMAC activities and the data components of all GLOS projects meet quality requirements for inclusion in the IOOS Data Integration

Framework (DIF) and/or subsequent use in GLOS-sponsored data analysis or visualization tools or other applications. The QA duties for this position include:

- Review relevant QA/QC Reports and work with project leads to ensure projects meets data management QA/QC requirements;
- Evaluate project compliance and identify any corrective actions needed;
- Assist in the resolution of data format and delivery issues as appropriate;
- Report to the QA Manager about issues regarding the status of project compliance;
- Implement or manage DMAC activities in accordance with the IOOS DIF and other related protocols.

Others directly responsible for portions of any project-related GLOS DMAC QAPP include the Principle Investigator (PI) and the GLOS QA Manager. Their duties include the following:

The PI is defined as the individual who serves as the primary point of contact on a contract, sub-award, MOU, cooperative agreement, etc., entered into with GLOS. This individual is responsible for documenting and directing all technical work performed in a manner that meets the requirements of the QAPP for that project. PIs directing projects with observing, data analysis, modeling or other DMAC-related activities are responsible for developing a QA/QC Report with assistance from the Data Management and/or Observing Coordinator(s) as appropriate. The PI is expected to:

- Determine the need for QA/QC for particular project tasks;
- Complete the QA/QC Report as required by the project contract, cooperative agreement, MOU or other arrangement, and develop other project-specific documents;
- Implement project-specific quality requirements;
- Ensure completion of all project objectives;
- Report results, monitor work quality, and identify, implement and document corrective actions.

The QA Manager is responsible for establishing and documenting guidelines, policies and protocols at all levels to ensure that data quality objectives are met and are consistent with the GLOS QMP. In this capacity, the QA Manager must:

- Evaluate and review project QA/QC Reports, contracts, standard operating procedures and other related documentation for compliance with relevant reference methods or other requirements;
- Assign all QA related tasks to appropriate team members to ensure that the QMP is followed and related project contract due dates are met;
- Ensure that personnel are familiar with the QMP and related system policies and processes;
- Inform the appropriate personnel of QC failures and problems with data quality and assist in developing and implementing corrective actions for QC failures and other QA related problems;
- Ensure that all required documentation for the QA/QC assessment and review process are completed and delivered in a timely manner.

B1. Quality System

The GLOS DMAC QA system is based on the quality management processes set forth in the GLOS QMP, protocols adopted under IOOS DIF and DMAC, the GLOS QAPP review process for individual projects, the GLOS contracting process, and staff and project partner training.

Data development activities that originate with GLOS are carried out primarily as contracted projects. The development and implementation of QA/QC protocols and processes related directly to data development, e.g., retrieval and processing of sensor data, generation of model outputs, etc., are the responsibility of the contracted parties engaged with GLOS. These parties are provided with guidance about the requirements of the GLOS quality management system, including its DMAC components, during the GLOS project planning and contracting process.

Data, model outputs and derived products must meet project-specific QAPP requirements before they may be submitted to GLOS. They must then comply with the GLOS DMAC QAPP before they are fully integrated into the GLOS DMAC system for storage, retrieval, analysis, and use in tools and applications. The GLOS DMAC QA system ensures that contributions of data from projects can be effectively integrated into GLOS itself and, by extension, into the broader IOOS program. In addition, to the extent that the GLOS DMAC QA system evaluates the quality parameters of incoming data, GLOS DMAC provides an added level of oversight and QC beyond that of the project-specific QAPP.

B2. Quality System – Principal Components

GLOS DMAC is charged with oversight of data quality in four major areas. Three of these deal with external data and overlap heavily: data handling, derived products such as data visualization tools, and metadata management. The fourth, systems administration, deals with data processing and telecommunications operations related to DMAC functions.

Data Handling – Data handling is approached from one of three perspectives depending on the data source and the role GLOS plays in the overall process.

(1) Ingestion of GLOS sensor data, model outputs and other data products

Sensor data developed using GLOS platforms and for which GLOS serves as the initial reporting and distribution point must be produced under the guidance of a relevant QAPP developed and implemented by the data provider and reviewed by the GLOS QA Manager and DMAC Coordinator. Once produced, data may be transferred to DMAC at any of several stages.

Most commonly, raw data are assembled by the data provider and then transferred to GLOS as near-real-time datasets. These datasets undergo quality control checks at the time of assembly, then GLOS DMAC monitors data transmission characteristics to screen for transfer errors or service interruption. GLOS DMAC may develop additional quality control procedures in conjunction with the data partner to assist in the detection of sensor anomalies. These may include monitoring of parameter values to confirm that they are within acceptable ranges or tracking of trends over time to help identify inconsistencies. Such additional procedures are reviewed and implemented on a case-by-case basis.

GLOS data partners may also process and store data, then later transfer it to GLOS as part of archival services and/or to improve availability of the data to the broader user community. These datasets undergo appropriate quality control processing for content at the time of creation and in compliance with the QAPP for that project. DMAC quality control for these datasets is carried out by GLOS DMAC staff and consists primarily of ensuring that the file is received intact and includes all required metadata. GLOS staff are currently developing formal service agreement templates to formally document these processes for each data provider as a way of preparing for the future need and growth of this service.

(2) Integration of data from non-GLOS sources

GLOS exists to improve the gathering, discovery and distribution of data related to the waters of the Great Lakes, including data developed by agencies, institutions and organizations other than GLOS. These data may be integrated into GLOS data exploration and visualization tools and may also, in some instances, be stored and distributed by GLOS on behalf of the originating entity.

Production data services operated by federal agencies comply with the quality assurance policies and procedures of that agency. GLOS DMAC monitors data transmission characteristics to screen for transfer errors or service interruption but does not perform quality checks on the actual data.

Experimental data services and products from external sources may be and frequently are incorporated into GLOS data visualization and exploration tools, particularly for use as reference data. The source and status of these data resources are noted in the map legend or associated descriptions. While these products may be incorporated into GLOS, quality procedures for them are presumed not to be fully tested and implemented until the product is declared operational. These elements are monitored in conjunction with staff reviews of services and tools. If GLOS DMAC notices inconsistencies or errors in the service, its use is discontinued.

Commercial online data services may also be incorporated into GLOS products, in particular as sources of geospatial reference used for data visualization. When used for general reference purposes, such services are required to have an adequate quality assurance program in place and document them as part of the contracting process. Hyperlinks are maintained to vendor information pages as a means of allowing GLOS users to examine these datasets further. Note, however, that any commercial service incorporated into GLOS under a contract arrangement is subject to GLOS-approved QAPP requirements appropriate to the data type.

(3) Data archiving, discovery and delivery services

GLOS data services include long-term archiving of some data types. Archiving and retrieval services may be offered as an enhancement to services available from other agencies such as the National Ocean Data Center, or they may provide an official repository for data not handled by other agencies. Data archiving and recovery is considered a file handling service disconnected from the quality of the contents of the files. Therefore, GLOS DMAC quality parameters for individual files handled under this service are based on the detection and repair of corrupted files and are derived from the data checking programs built into file compression software and operating system disk maintenance programs.

Overall quality of data archiving and retrieval as a service is gauged in part by archiving capacity and backup procedures. Data archiving capacity refers to total server storage space and matching backup services. This may be expanded through the acquisition of additional hardware and is therefore considered during proposal development and infrastructure status reviews. Status and needs are reviewed annually at a minimum.

Quality of service is also assessed based on data retrieval capacity and the availability of storage and retrieval services. These are heavily influenced by file type and size and by the age of the data being requested. To the extent possible, recent data is made available online. However, large data files and older data files may be moved to storage servers not accessible via the internet. These files are distributed on request, with the delivery format based primarily on file size. Where possible, a DVD will be created and mailed. However, in many cases the data request is large enough that it is necessary to transfer the files to an external hard drive or other data storage device provided by the data user. QA for data files retrieved

and distributed in this manner is accomplished by testing to confirm that the copying process took place successfully. QA for the process as a whole is accomplished by tracking requests, the steps taken and the time to accomplish, then reviewing these logs with the GLOS QA Manager.

Data Visualization Tools – GLOS data exploration and visualization tools are designed to provide accurate and useful representations of data. Quality measures considered by GLOS DMAC include ease of operation as perceived by the user, clear information about data (metadata management), and consistent availability of services.

Ease of operation is a subjective characteristic and is generally evaluated through user surveys or other third party input during the design process, at implementation and during ongoing operation of the tool. It may be a product of GLOS or IOOS design choices, current web practices in general, or a combination of both. General web trends in particular have led to the use of commercially operated or otherwise un-contracted mapping services. These are selected based on their fit within the design of the GLOS product, but remain clearly identified in the map interface or legend. As stated above, external services such as these are incorporated as is but with appropriate disclaimers and links to additional information unless acquired under contract to GLOS or IOOS, in which case they are subject to GLOS-approved QAPP requirements.

Metadata Management – Cataloging of data for discovery and retrieval is a central GLOS DMAC function. Metadata is a critical component of GLOS data cataloging functions because it allows the sorting and retrieval of data based on described characteristics rather than strictly based on the values stored in individual files or records. This aids in both data storage activities by GLOS DMAC staff and data searches by GLOS users. At the same time, metadata is a significant challenge because of the wide variety of data formats, themes and sources which must be taken into account.

Because of metadata's importance, datasets accepted for distribution or archiving through GLOS must be accompanied by standards-compliant metadata. Standards vary depending on the type of data, but in all cases, IOOS standards are required if available, followed by those issued by the International Standards Organization and the Federal Geographic Data Committee.

System Administration Functions – GLOS DMAC IT services affect overall GLOS data service quality in two areas. The first is data handling, which depends primarily on data storage and data transfer capacity. Data storage resources are evaluated annually and during preparation of all proposals and project plans that may result in increased volumes of data. Data transfer capacity is monitored as part of DMAC operations, including during daily checks of server status and monthly reviews of bandwidth usage from internet service providers.

In addition to appropriate data handling capacity, GLOS DMAC quality of service is dependent on a reliable computing infrastructure. Responsibilities fall into two broad categories, hardware and software maintenance and facility operations. GLOS DMAC personnel oversee hardware and software maintenance, ensuring that servers are tested and updated according to manufacturer recommended schedules and that data backups are performed routinely. GLOS DMAC servers are housed at a remote commercial hosting facility, however, and facility operations are therefore carried out by the hosting firm. These include maintenance of a climate-controlled operating environment, redundant power system to ensure continuity of operations, physical site security and firewall services.

GLOS DMAC hardware and software maintenance schedules are posted and maintained by GLOS DMAC staff. Hosting facility service and maintenance logs can be requested as needed.

B3. Quality System – Tools for Implementation

GLOS DMAC QA practices are facilitated by the standards and policies of the broader GLOS organization, IOOS and other partner organizations. Several sets of tools exist that can be applied to the DMAC quality areas listed above.

Data Quality Guidance – Data quality guidance for GLOS DMAC includes all relevant IOOS standards and recommendations as well as standards set out by any data repository agency to whom GLOS reports or from whom GLOS retrieves data. Specific standards and guidance documents currently referenced include the following:

- IOOS DIF (http://ioos.gov/library/difdmacdocs.html)
- IOOS Quality Assurance of Real-Time Oceanographic Data (QARTOD) reports (http://nautilus.baruch.sc.edu/twiki/bin/view)
- EPA Guidance for Geospatial Data Quality Assurance Project Plans (http://www.epa.gov/quality/qs-docs/g5g-final.pdf)
- NDBC data quality control procedures (http://www.ndbc.noaa.gov/qc.shtml)
- FGDC and ISO Metadata standards (http://www.fgdc.gov/metadata/geospatial-metadata-standards).

Other standards and guidance will be adopted as approved by IOOS, identified for specific projects or called for by other agencies.

GLOS DMAC provides data quality guidance to GLOS project partners during its mandatory review of project QAPPs. QA/QC Project Reports required as part of regular (quarterly) project reporting ensure that QA/QC procedures are followed and further input can be provided once the project is under way.

Operational Guidance – Operational guidance for GLOS DMAC QA activities is derived primarily from the GLOS QMP. Additional guidance may be drawn from service requirements for specific products or DMAC functions, from individual GLOS project specifications, or from partner agency mandates.

Documentation of Activities – GLOS DMAC activities are documented and progress is tracked as part of regular reporting requirements. As a component of the GLOS DMAC QA system, this aids in the identification of problems, development of solutions, assignment of tasks, and verification of the success of any measures taken. It serves as a valuable resource for GLOS DMAC personnel, who are required to consider QA policies and procedures in their activities and may encounter a given problem in conjunction with several projects or project partners.

Performance Evaluations – The GLOS QA Manager is responsible for project evaluations and, with support from the Executive Director and other QA personnel, conducts an evaluation of each project on an annual basis as part of regular work plan development. Evaluations include ratings for various aspects of project work, including implementation of the quality management system and accomplishment of tasks described within the system.

C. Personnel Qualification & Training

GLOS DMAC personnel must perform QA/QC in conjunction with many of the tasks and functions to which they are assigned. Knowledge of quality requirements as documented in adopted standards and/or

project specifications is required. Initial orientation of new staff includes familiarization with GLOS quality policies and practices. Further training and refreshers are provided through online or in-person workshops, in-house briefings or other means. Professional development, training, and refreshers are provided, at minimum, when DMAC staff attend the annual IOOS DMAC Workshop.

The GLOS DMAC Coordinator or other DMAC personnel as appropriate are responsible for attending any training provided on developments in the IOOS DIF or other adopted SOPs, protocols and standards. Relevant information from these training sessions are shared with all other GLOS DMAC personnel by the attendee. GLOS DMAC personnel may attend other training courses related to quality management as feasible and appropriate.

D1. Procurement of Items & Services
All purchases of goods and services by GLOS DMAC must comply with GLOS procurement policies as set forth by the GLOS Board of Directors. In accordance with this, the GLOS Executive Director and Business Manager are the agents authorized to make commitments against GLOS funds and are charged with maintaining an open and competitive process for procurement of goods and services. Bids and proposals for goods and services to be used by GLOS DMAC are assembled from competing vendors by the GLOS DMAC Coordinator. These bids and any relevant assessments by GLOS DMAC personnel are evaluated by the GLOS Executive Director and Business Manager, who then award the contract.

D2. Procurement Document Approval
The GLOS system of internal financial controls requires that different individuals perform the various functions of the procurement process. GLOS DMAC purchases are, therefore, authorized by the GLOS DMAC Coordinator but must be approved by the GLOS Executive Director and Business Manager.

Prior to purchase of any good or service, the GLOS DMAC Coordinator must prepare a purchase authorization detailing the item or service needed and all associated technical and quality requirements. Potential sources must be identified, including price and product characteristics. These may take the form of catalog listings, open quotes or sealed bids to be submitted to the GLOS Executive Director and Business Manager, as appropriate.

D3. Solicitation Response Approval
The GLOS Executive Director maintains signature authority for all procurement contracts and agreements. Contracts and agreements requiring a GLOS signature are forwarded to the Business Manager for processing. All information pertaining to the contract or agreement must be included. Note that license agreements and maintenance contracts are specifically included with other types of contracts. These contracts or agreements are then forwarded to the Executive Director for approval and may also require approval from the GLOS Treasurer. Only those with specifically delegated authority may sign contracts on GLOS behalf; therefore the GLOS DMAC Coordinator has no signature authority for any contracts or agreements.

E. Documents and Records
Maintenance of operational documents within GLOS DMAC is carried out by all GLOS DMAC personnel. The GLOS DMAC Coordinator ensures that records and documents accurately reflect completed work through continual communication with GLOS DMAC staff and all relevant project partners.

Data provided to GLOS are treated as public and distributed without restriction unless specified in project documents. If access is designated as restricted, permissions will be documented and appropriate data protection measures and approval processes will be implemented.

Quotes, purchase orders, invoices and other documents related to the purchase of hardware, software and services are provided by the GLOS DMAC Coordinator to the GLOS Business Manager as necessary.

F. Computer Hardware and Software

Assessments of GLOS DMAC equipment performance take place on a monthly basis. System components and services (bandwidth, domain addresses, etc.) are purchased as needed based on the requirements of specific projects and/or GLOS DMAC level-of-service obligations. Recommendations for new purchases, upgrades or other changes are subject to GLOS DMAC Coordinator approval and authorization by the Executive Director.

Installation, configuration and testing of GLOS DMAC components may be carried out by the vendor, a contracted service and/or GLOS DMAC personnel as appropriate. Depending upon the intended use of the component, testing may also involve project partners. However, in most cases GLOS DMAC is not responsible for the installation and maintenance of software or hardware operated by project partners.

GLOS DMAC backup procedures follow standard data center practices. Incremental backup of data takes place on a daily or weekly basis and can be used to restore lost or corrupted files on the data servers. Routine backups of server operating systems and configurations are made as part of server maintenance. A complete backup of all data is maintained off site and replaced on a biweekly schedule to ensure minimal loss in the event of a catastrophic failure of any equipment.

Documentation of equipment, software, licenses and standard operating procedures is maintained by GLOS DMAC personnel and updated as necessary.

The IT resources being considered within this QAPP do not include personal computers, accessories or office productivity software. These items are not handled as part of GLOS DMAC but rather as part of general GLOS business operations.

G. Planning

GLOS DMAC operations are overseen by the GLOS DMAC Coordinator. Final responsibility for GLOS DMAC operations and products rests with the GLOS DMAC Coordinator, but this role is assumed to require active engagement with project partners and stakeholders, including to resolve any quality issues that may arise. Depending on the area of activity, individual tasks may be carried out by GLOS staff, operations staff at the commercial hosting facility housing the GLOS DMAC servers, or project partners. Solutions must be implemented with the support and approval of the GLOS QA Manager and Executive Director.

Day-to-day GLOS DMAC operations are carried out in accordance with the internal quality requirements and procedures described in Part B above. Planning, scheduling and resource requirements are generally addressed in the GLOS Annual Work Plan. In the event that the overall GLOS quality management process identifies a need for change, resolution of the issue will take place in compliance with the GLOS QMP.

Any projects involving external partners will include quality-related roles for the project PI and any other project personnel. In general, the PI oversees all operations of a project that originate outside the DMAC,

which includes data collection or generation, relevant QA/QC, compilation and analysis, and packaging and transmission of deliverables. Project personnel perform these tasks, guided by the project's own QAPP.

Specific project goals, objectives and issues addressed may vary considerably. To the extent that the quality criteria for a given project vary from the ones for the GLOS DMAC components described above, the project team may formulate appropriate project-specific goals and objectives. In most instances, however, GLOS projects are expected to adopt IOOS-approved data quality standards.

Project schedules will be specified in individual project work plans, as will resource requirements related to GLOS DMAC. This includes the type and quantity of data to be handled, processing needs, timelines, data permissions, etc. The GLOS DMAC Coordinator carries out a review of the QAPP for any DMAC-related aspect of the project to ensure that any project outputs to be handled by GLOS DMAC meet appropriate quality standards.

H. Implementation of Work Processes

DMAC staff follow a variety of practices to ensure the quality of data, processes and services. The specific approach depends on the data parameter being checked. Quality assurance practices related to data streams may include automated monitoring of the data stream itself to identify transmission anomalies and/or manual checking of server log files. The range of values reported for specific parameters in a dataset may be monitored to support or confirm the quality assurance activities of data providers. Internal DMAC data handling processes and data delivery services are monitored both by server administration software and by DMAC personnel during routine status checks.

The following specific quality assurance responsibilities are carried out by GLOS DMAC systems and personnel:

Implementation of IOOS and RA standards – DMAC staff participate with other RAs in IOOS DMAC standards coordination efforts. These include regular conference calls, review of documents, proposals and other materials, and a minimum of one in-person meeting per year. This helps ensure that DMAC staff is aware of and can contribute to ongoing activities related to standards development and adoption.

IOOS standards have been identified or developed for a variety of data services and metadata. Once finalized, they are adopted by GLOS DMAC unless not appropriate or inapplicable (e.g., salinity measurement parameters). Where IOOS standards have not yet been developed, relevant US Federal standards or ISO standards are used in their place.

Automated quality checking of datasets ingested by GLOS data holdings – Data received from GLOS partners are checked first for overt errors based on file structure and header metadata. Files determined to be corrupt are flagged for review by DMAC staff and the sensor or model operator is contacted to resolve problems.

Individual files are checked using ranges of individual parameters. Where data are delivered using NDBC protocols, NDBC quality tests are applied. For parameters not covered by NDBC guidelines, a similar model is used but the acceptable data ranges are developed in cooperation with the data partner.

To the extent that GLOS DMAC has both observation and model data available for a given parameter, these may be used for verification purposes. Output from nowcast and hindcast models, for example, may

be compared with processed sensor observations to confirm that they are operating as expected. Sensor data may also be checked against model output to identify possible equipment failure or other anomalies.

Testing of GLOS data retrieval services – Prior to implementation of any GLOS data retrieval scripts and other software utilities, the retrieval service is tested using actual data. Specific tests are selected based on the data format and data volume, and on the delivery method. Data provided on physical media is tested prior to delivery using software utilities and, where appropriate, manual examination of the data.

Following implementation of a data retrieval service, the processes are checked periodically. In addition, technical support is provided in the event that a file received by a user is corrupted. DMAC staff are assigned to troubleshoot the problem and make any changes necessary. They may also provide the user with additional guidance in the data retrieval process, extract the data themselves and transfer it to the user, or both.

Routine review of web service status and activity logs – DMAC staff manually review web-based services a minimum of once a day to confirm availability.

Web traffic statistics for each server are reviewed monthly using in-house software as well as usage statistics provided by the hosting facility. This is done primarily to monitor bandwidth usage both overall and by server in order to ensure that data transfer capacity meets needs over time. It also allows DMAC staff to identify service anomalies, which may indicate hardware failure, software issues or security threats, and to assess demand for particular services.

Backup services for data archives and systems – As described above, GLOS DMAC backup procedures follow standard data center practices. Incremental backup of data takes place on a daily or weekly basis depending on data type and can be used to restore lost or corrupted files on the data servers. Routine backups of server operating systems and configurations are made as part of server maintenance. A complete backup of all data is maintained off site and replaced on a biweekly schedule to ensure minimal loss in the event of a catastrophic failure of any equipment.

Appropriate use of federal and international agency data sources – GLOS makes extensive use of data from a variety of federal agencies. These are particularly important for data exploration and visualization services that attempt to provide complete and in-depth views of the region. All non-GLOS data services used in GLOS products are reviewed for the presence of quality assurance practices. To the extent possible, only services operating under such practices are incorporated into final versions of GLOS products.

GLOS experimental services and services under development may incorporate less rigidly controlled services provided by other agencies. These are identified as such within the GLOS project and replaced with quality-assured production services if these become available.

Selective use of commercial online data sources – Commercial online data sources are frequently incorporated into GLOS products as sources of reference data. Their use for this purpose is permitted only as appropriate based on several criteria. First, any use by GLOS must comply with published license/use agreements for the data service. Second, the data are used for visualization and general reference purposes only. Finally, the data source is clearly credited.

In cases where commercial data are incorporated into a GLOS project through a project-specific contract with the vendor, the data services are subject to GLOS quality assurance requirements. These include

GLOS DMAC data availability requirements appropriate to the project as well as any data quality requirements defined in QAPPs approved by GLOS observation and remote sensing programs.

Review of QAPPs for GLOS data production projects – The DMAC Coordinator must review all QAPPs submitted by GLOS data partners. This review focuses on data quality and data transfer requirements. The review ensures that data created by the project will meet GLOS data formatting standards as described in section 3.1, that data delivery methods will allow quality checking of data upon ingestion into the GLOS DMAC system as described in section 3.2, and that metadata compliant with GLOS/IOOS requirements will be assembled and submitted with all data.

Protection of data and IT infrastructure from external threats – Sensitive GLOS data and the GLOS IT infrastructure are protected in large part by the selection of a commercial hosting facility to house the GLOS DMAC servers and backup system. The facility maintains a physical security system (electronic ID badges issued to specific individuals and required for entry into the facility), industry standard climate control and redundant power systems, and network traffic monitoring system designed to provide intrusion detection.

The servers themselves are also protected through firewalls and standard systems administration practices, including a limited number of user accounts and control of read and write permissions.

Data quality training for GLOS project partners – GLOS/IOOS DMAC standards provide guidelines for data acquisition, processing and delivery. These vary depending on the nature of the data but may be important to quality assurance within DMAC as well as for the individual project. In addition, DMAC quality assurance processes require that project partners follow certain data submission procedures. DMAC staff recognizes that the list of requirements and the compliance process can be confusing. In an effort to make the process as effective as possible, GLOS DMAC staff are developing quality assurance user guides and other training materials for GLOS project partners and maintain a library of relevant IOOS guides and manuals. Training resources include documents provided to project partners as reference materials, presentations at meetings or via web conference, and workshops held in conjunction with other events.

Establishment of Service Level Agreements – In order to ensure continuity of DMAC operations, data and services provided by outside agents may be subject to service level agreements as follows:

Service level minimums are incorporated into all contracts with commercial service providers. This includes server hosting facilities, internet service providers and contracted technical support services.

Data services operated by GLOS partners and other external resource providers are usually a significant component of GLOS data exploration and theme-based products. In such cases, development work may take place without the implementation of service level agreements. However, service level agreements are required with these resource providers before a final product is released and becomes available to the GLOS community.

In cases where DMAC services are instrumental in operations carried out by GLOS partners, DMAC establishes a service level agreement with that partner. The SLA defines the products and services that the DMAC provides to the partner, which will in turn guide the DMAC staff in configuring DMAC tools to support that partner.

I. Assessment and Response

Individual GLOS DMAC QA procedures may be assessed at any time in response to new issues. At a minimum, they are assessed annually in conjunction development of the GLOS Annual Work Plan.

Annual Assessment – Systematic annual review of the GLOS DMAC QA system takes place during annual work plan development (described further in the GLOS Business Plan). In addition, the GLOS QMP is reviewed by every 5 years or as needed, in coordination with the GLOS strategic planning cycle.

Assessors of quality performance include the GLOS QA Manager and GLOS DMAC Coordinator, and may include project PIs, other project personnel and/or stakeholders to the project. Assessments of process and work performance ultimately reside with the GLOS Executive Director and the Technical Advisory Panel or Board of Directors. Assessments or evaluations are made using a variety of applications as appropriate and may include:

- Surveys of partners and stakeholders
- Technical reviews of performance metrics (usage statistics, service interruptions, etc.)
- Data quality assessments from individual projects
- Reviews of support logs and other service records

Corrective Actions – Corrective actions will take place in response to individual incidents as necessary and as a result of any annual assessment. Corrective action will be made promptly so as not to cause further impairment to service or delay to the project's progress. Where the corrective action taken relates directly to an external project, project PIs are required to provide review and updates after the corrective action has taken place to determine whether the situation has been rectified and to assess whether further action needs to take place. The QA Manager is responsible for documenting any such action.

Disputes – Should there be a dispute after corrective measures have been taken for any external project, GLOS will confer with the PI on steps to ensure project integrity.

J. Quality Improvement

The person most responsible for identifying, planning, implementing, and evaluating the effectiveness of GLOS DMAC quality improvement activities is the GLOS DMAC Coordinator. However, the GLOS DMAC Coordinator requires the engagement of all other GLOS DMAC personnel in quality monitoring and improvement because of the breadth of expertise required to operate the DMAC system. Working together with the GLOS QA Manager, these individuals respond to problems identified within any project and work to identify solutions and implement them. All actions are documented and issues are tracked through to an acceptable level of completion.

General oversight – The GLOS QA Manager is responsible for leading the overall effort to identify, plan, implement and evaluate the effectiveness of quality improvement activities within GLOS. The GLOS DMAC Coordinator works directly with the GLOS QA Manager on all quality improvement activities that may involve GLOS DMAC, including both internal operations and projects involving external partners. These activities may include:

QMP
QA/QC Reports (or QAPP)
Checklists
Evaluations
Assessments
Data collection, management, storage and access

Evaluation
Planning procedures
Technical procedures
Training procedures
Documentation and record keeping
Staffing
Related project elements

A checklist for quality improvements including all of the above is circulated by the QA Manager to GLOS staff and relevant project teams on an annual basis.

Detection and prevention – GLOS DMAC staff carry out routine daily monitoring of server operations and monthly review of network activity. To the extent that this helps identify problems during normal operations, it is a component of GLOS DMAC quality improvement. In addition, the standard IT system administration practices followed by GLOS DMAC are considered an element of quality improvement to the extent that software and hardware updates prevent failures and improve performance.

Correction – In the event that a quality issue related to GLOS DMAC is identified, the GLOS DMAC Coordinator, in consultation with the GLOS QA Manager, determines the nature and extent of action to be taken. All occurrences are documented, as are any corrective actions taken. Regular review of GLOS DMAC activities, including incidents related to quality, and incorporation of any enhancements ensure that reoccurrence is kept to a minimum.

Tracking to closure – GLOS conducts bi-weekly staff meetings to ensure that problems encountered are identified early and dealt with immediately. Individual issues and steps taken are noted at these meetings. All issues involving external projects and/or public-facing DMAC services are issued a tracking number and tracked to completion, including filing a memo with the QA Manager.

Communications – All GLOS staff and other project participants communicate and document project activities they are involved in, including supplier reviews, evaluations and other management system elements through regular (quarterly) reporting. Where these inputs identify process improvement opportunities or offer solutions to problems, they are forwarded to the QA Manager.