AUTOMATED MONITORING SYSTEMS FOR COMPLIANCE OF DISPOSAL OPERATIONS AT EPA-DESIGNATED OCEAN DISPOSAL SITES

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1.0 INTRODUCTION

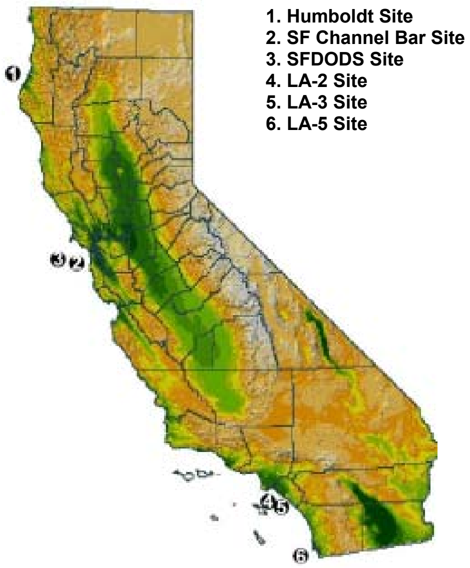
Ocean dredged material disposal sites are designated by EPA to contain the localized impacts of ocean disposal operations within the site boundaries, thereby minimizing cumulative effects of disposal to the area or region in which the site is located. To date, there are six ocean disposal sites in Region IX along the California coast (**Figure 1**) and five ocean disposal sites in the Hawaiian Islands. All of the ocean disposal sites discussed in this report receive dredged material generated from harbor dredging projects. All disposal operations must be conducted in a manner that allows the site to operate without adverse impacts to the marine environment in excess of what is expected under the given site use requirements (written into U.S. Army Corps of Engineers' permits issued for each dredging project. Site use requirements are based on site designation parameters established in the Final Environmental Impact Statement and rulemaking for each ocean disposal site.

Ocean dumping violations investigated by EPA Region IX staff in recent years have often included inadequate utilization of appropriate navigational hardware and software to record the required data to monitor the compliance of disposal operations in accordance with specific site use requirements. The problems have included, but have not been limited to, a lack of accurate scow positioning hardware, and a failure to log the required parameters with software.

A variety of monitoring systems are currently available for offshore, in-bay disposal as well as capping operations. The majority of systems are based on dredge-positioning hardware and/or software, which have been modified to meet the EPA site use and record-keeping requirements. In addition, U.S. Army Corps of Engineers (USACE) regional monitoring practices have encouraged the development of different types of systems. Within the USACE San Francisco District, the Construction Management Office requires bin elevation and draft measurements, as well as scow positions during loading, transit and disposal operations. The recorded sensor information is used to calculate the volume of dredged material placed at the disposal site, and is unique to the San Francisco District within EPA Region IX. One significant problem for the EPA, Region IX has been the variation in the measurement parameters and the variety of data formats. There is an overall need to develop and make available cost-effective, standardized systems that would be "pre-certified" as adequate for compliance with EPA requirements. This could benefit both smaller projects with limited monitoring budgets and larger projects with existing systems.

In recent years, there has been a proliferation of compact, relatively inexpensive commercially-off-the-shelf (COTS) navigation hardware, such as Global Positioning Systems (GPS), equipped with either the Wide Area Augmentation System (WAAS) or Differential GPS receivers for accurate vessel positioning. Other COTS components, such as laptop computers, data loggers, cellular communications, sensors, antennas, power supplies and batteries are available that could be combined to create an unattended "black box" system to adequately monitor disposal operations. Software is available to store and display the data on the Internet that could be utilized by both the permittee and EPA to quickly assess compliance of disposal operations. A standardized database format should be established to provide compatibility with both an Internet viewing program and the existing in-house Geographic Information System (GIS) tool used by the EPA. The display of information should be shared with other monitoring agencies through the Internet on a password-protected web site.

Since the vast majority of ocean dumping nationwide involves dredged material, this report focuses on systems that provide compliance monitoring data for dredged material disposal operations. However, these same systems could be modified to monitor the disposal of other EPA-permitted disposal operations such as fish waste.



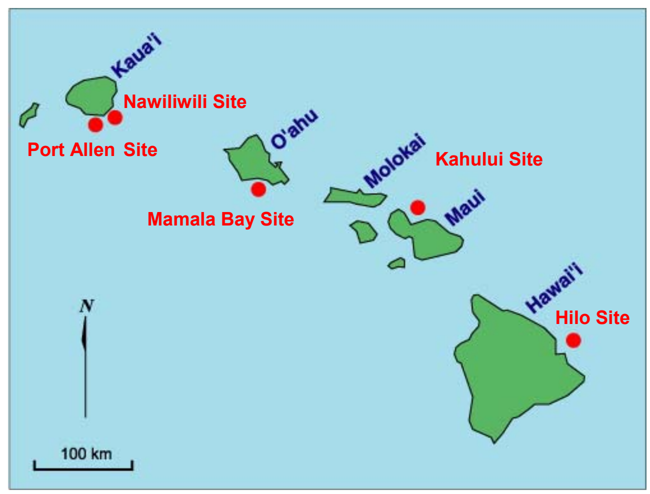


Figure 1. Locations of ocean disposal sites in Region IX offshore California and Hawaii

2.0 SYSTEM DESCRIPTIONS

Several monitoring systems are used throughout the United States, which are classified as either scow-based or tug-based. Systems installed on scows automatically acquire sensor information for position and draft. Some may also record the level of dredged material in the hopper bin, and the status of the doors used to open the bin and drop the load. The scow systems record the data, and some transmit the position information to a helmsman display aboard the tugboat for guidance to the designated site. Alternatively, tug-based systems record the position of the towing tugboat, instead of the scow's position, and do not record scow draft or bin level. Both types of systems generate data for regulatory monitoring, but few provide graphic results to site managers immediately following disposal events. Instead, the agencies either store the data on disks or import them into various in-house GIS programs for display. Regulatory compliance is determined by graphic representation of submitted data often months after project completion.

With advancing technology in the intermodal transportation market, new communication methods will expand the range of tracking capabilities. Several systems transmit vessel data using Low Earth Orbiting (LEO) satellites, meteor-burst transmitters or spread spectrum modems. Though reception is not geographically limited to the near shore with the satellite systems, data transmission must occur while the satellites are overhead, so complete monitoring during all phases of loading, transit, and disposal are not consistently available. Meteor-burst transmitters require large power supplies, and are better suited to tugboats than scows, where power is limited. Spread spectrum modems transmit data through land-based networks, and are used for continuous vessel monitoring. All transmission methods broadcast the information, but do not record it, internally without a logging device. Data logging provides documentation for dredged material disposal monitoring, and proof of regulatory compliance.

2.1 Scow System Descriptions

Monitoring systems installed on scows automatically record position and draft using Commercial-Off-The-Shelf (COTS) components. GPS receivers determine the position of the antenna with an accuracy of 30 feet. The GPS signal is sometimes augmented with either a Differential receiver or a WAAS capability, which increases system accuracy to within 2-5 feet. Pressure sensors placed in the ram wells of the scow measure the draft of the vessel in the water, and acoustic sensors installed above the hopper can be used to measure the height of the material in the bin. The COTS components are interfaced to a computer or logger, which automatically records the data internally.

A computer-based scow system receives sensor information through its serial ports. Sensor power and signal conditioning are provided through separate electrical interfaces. Since the computer is designed to operate continually, a large rechargeable battery is employed to supply power. Most scows do not have the tug's continuous source of power, and must be routinely recharged. Computers also require operating system software, which must be manually reset in the event of failure.

Lyman-Burke, under guidance of the USACE San Francisco District, developed and installed Dredge Data Logging Systems (DDLS) for several dredging contractors operating in the District. The first DDLS systems consisted of a computer that logged data from pressure and bin sensors installed on scows with GPS receivers. This system was modeled after the "Silent Inspector" program developed by the Waterways Experimentation Station (CERC) in the early 1980's. The Silent Inspector was originally developed for and deployed on USACE hopper dredges in the Gulf and Pacific NW Coasts.

Lyman Burke (http://www.winops.com) also offers the Windows Offshore Positioning Software (WINOps™), which is primarily used for positioning of dredges. This system has been adapted for scow tracking use. Manson Construction used the WINOps™ dredge positioning system, which transmitted GPS position information from its scows to the towing tugboat using spread-spectrum radio modems. Western Dock used the software for display of in-bay disposal sites and tug position for helmsman guidance.

Great Lakes Dredge and Dock, Inc., and Bean-Stuyvesant Dredging, Inc., have installed computer-based systems on several of their large split-hull scows. Both systems are powered by large batteries, which are periodically recharged with diesel-powered generators, solar panels and/or wind machines. These installations are not modular by design, rather permanently mounted on scows and built on an industrial scale. **Figure 2** shows such an installation that houses a computer-based system, battery bank, and diesel generator.

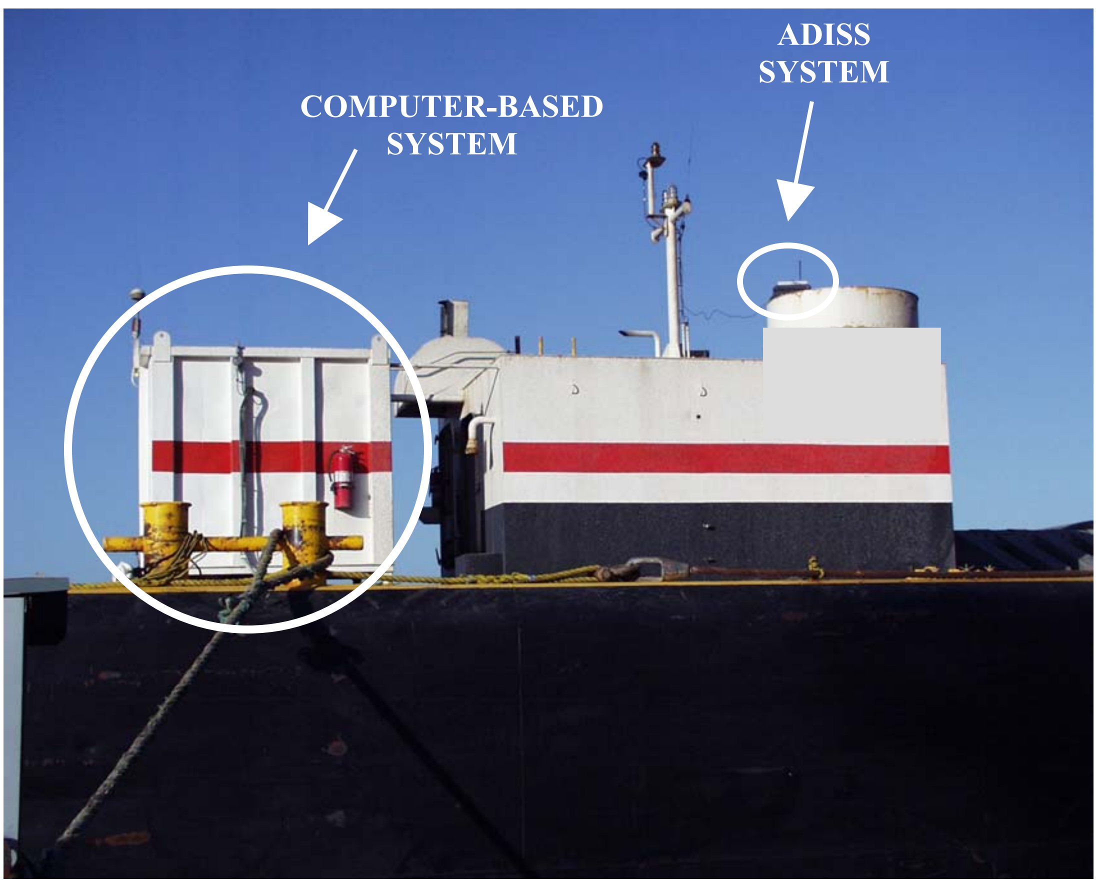


Figure 2. A permanent computer-based installation is housed in the compartment aft (left) of the scow's doghouse, while a portable system (ADISS) rests on top of the air intake to the right.

For these reasons, portable, low-power systems, programmed in assembly language, have been desirable. One system developed by Weeks Marine, Inc., used a palmtop computer to log position and draft data from a COTS GPS receiver and pressure sensor. The palmtop was programmed in the C+ language to record both inputs, and automatically transmit data files via VHF radio modem to the dredge (D. Nelson, pers. comm.). The battery was periodically recharged from a generator installed on the tug.

Lyman-Burk modified its DDLS approach and replaced the computer-based logger with an automated logger, which proved more reliable under the limited power conditions present aboard dredge scows. The "Zeno" logger has been interfaced with an analog cellular telephone to offer remote data downloads to the USACE offices if required. This system made data available for download remotely, however early cellular networks made frequent use impractical due to slow data transfer rates and sparse coverage for marine-based applications.

A portable system has been developed by Science Applications International Corporation (SAIC), which uses an embedded device programmed in assembly language (Tx Basic). Since the device is more stable than the computer-based system, and can be automatically reset, its use eliminates system crashes. The Automated Disposal Surveillance System (ADISS) is programmed to stand by in a "sleep" mode, drawing only milliamps of power, and to re-energize the sensors and record data at pre-set position and draft thresholds (SAIC 1999). Data are continually transmitted to the helmsman display aboard the tug, and telemetered for posting on the Internet. A small solar unit attached to the portable waterproof housing recharges the battery of the ADISS unit on the scow. The portability of the system facilitates its rapid installation and service rotation. **Figure 2** shows the compact ADISS system installed on a scow employed during a dredging project in New York Harbor.

A system is currently under development by SAIC for the USACE, which integrates two draft and two bin sensors with a data logger and an updated spread-spectrum radio modem. The system will include a larger data logging capacity, options for future sensor inputs and increased wireless networking capabilities. It is expected to be introduced for the 2003 dredging season. The new system will be integrated with a revised ADISSWeb system for data display on the Internet.

2.2 Tug System Descriptions

Tug-based systems are less complex than scow-based systems, because they lack sensor input and do not rely on modems to transmit position data. Tug systems generally are composed of the ship's GPS receiver interfaced to a computer. The computer is equipped with a logging program to acquire and store vessel position from the GPS. The program may have provisions for entering the offset distance between the tug's antenna position and the scow, and the bearing of the scow from the tug. Both entries can be used to estimate the position of the scow.

Because scow position is estimated from the tug's GPS, it is less accurate than the scow-based system. A comparison of accuracy shows the tug-based system varies between 50 – 250 feet (SAIC 1997), and depends on the quality of the offset and bearing information.

Since scow draft is not recorded with the tug-based system, the location of placement is usually noted with a computer flag entry. The system relies on the helmsman to enter an event mark using the keyboard. Both the initiation and completion of disposal are noted to provide a flag in the time/position database for each placement location.

Weeks Marine, Inc. has combined a tug-based system with a remote control operating system, which notes the position of the tug at the time of opening and closing the scow doors. This system provides the location of placement by the remote activation of the scow hydraulic system, alone. No change in draft is recorded, so placement location cannot be precisely determined.

This remote control system does not provide helmsman guidance to the disposal area. The operator does not have confirmation the scow is in position before activating the opening device. Graphical positioning indicators displayed in real-time are critical to accurate placements within a small target.

SAIC has modified its ADISSPlay software to record tug position from the ship's GPS receiver. The helmsman display shows both the tug position and the scow's estimated location to the target once the offset has been entered. The revised software, ADISSLite, can be installed on an existing ship's computer to display tug and estimated scow position over electronic NOS charts. The program records position and offset information in the ADISSPlay format, so the trackline data can be displayed later on the Internet for both the dredging contractor and the site managers. The data are plotted over the target cell, eliminating any question of interpretation.

SAIC has also produced a palmtop computer program to accomplish similar ends: ADISSPalm provides helmsman guidance to the disposal site, records GPS position data, and logs the information for viewing purposes. The system includes GPS input and mapping from a portable unit. Once the data are recovered, they can be quickly plotted and viewed through the Internet by the contractor and manager, alike.

The WINOps™ software by Lyman-Burke Associates offers a similar logging mode for towboats and scows. The program can be set to plot inputs from a GPS antenna located aboard the towing vessel overlaid on a CAD-generated drawing. Estimated scow position can be plotted based on the length of towline. The on-site survey engineer typically programs this distance at the start of the project. The helmsman sets a flag in the program to indicate when the scow doors open and close during disposal. Alternatively, GPS data from a scow can be transmitted to the tug using a wireless modem for display of vessel position relative to the disposal target. Guidance to the disposal site is provided without NOS chart backgrounds. Results of each trip are plotted aboard the towing vessel after disposal. The vessel operator assigns trip numbers during disposal.

2.3 Graphic Display Descriptions

A variety of graphic displays are in regional use to demonstrate compliance with disposal regulations. Within Region IX, a Geographic Information System (GIS) program is used by the EPA to plot data submitted from the dredging contractors via USACE in ASCII format. The program is used to determine regulatory compliance by plotting scow positions for each transit over the boundaries of the Farallon Islands Marine Sanctuary and the U.S. Coast Guard traffic control lanes to San Francisco Bay. The GIS program is also used to determine if all of the dredged material is deposited within the boundaries of the SF-DODS, or if leakage has occurred during transit to the site, potentially compromising the water quality. During previous efforts to determine compliance, the program has been modified to accept a variety of data formats with limited success. Electronic data submitted by dredging contractors did not include unique trip numbers and was frequently corrupted due to the use 3.5" media. The effort has been additionally confounded by several undocumented coordinate transformations, output formats and metric/US units within the DDLS data format. Modifications were required to correct the deficiencies of the submitted data. This process took months to produce accurate plots. The non-uniformity of the input data has compromised the EPA's ability to effectively monitor projects, and to correct contractor actions during project operations. As a result, the agency has been limited to levying fines for permit infractions months after project completion.

The contractor's on-site engineers typically generate graphical displays of tracking data. Manual downloads of data via floppy disk are imported to Microsoft Excel, AutoDesk's AutoCAD or Coastal Ocean Oceanographic's HYPACK software. Recently, dedicated software tools have been developed, which allow dredging contractors nationwide to display the data with either a simple viewing application, such as ADISSView, or over the Internet with ADISSWeb. Plots from these utilities have been used to illustrate transit and disposal positions, and have been made available along with the raw data to USACE and the EPA.

The incorporation of the utilities has eliminated uncertainties in the data display. Previously, contractors used a Computer Aided Drafting (CAD) program to plot transit and disposal events. At times, the lack of State Plane Coordinate zone documentation submitted with the data had resulted in projection uncertainties within the EPA's GIS plots, confounding confirmation of the CAD plots. Since the ADISSView and ADISSWeb plots are produced in the same coordinates used by the EPA's GIS program (Latitude and Longitude instead of Eastings and Northings), the projection problems have been eliminated, and the data are readily plotted for verification.

Presently, at the San Francisco, Galveston, New York, New England, Wilmington, Jacksonville, Charleston, and Honolulu USACE Districts, ADISSWeb is utilized by the District managers and the dredging contractors to view scow position and draft. Data are automatically processed as received and posted on the Internet for display. Daily QA procedures at SAIC insure the reliability of the information. The data can be downloaded in comma-separated ASCII format to the District managers for further in-depth analysis. **Figure 3** shows an ADISSWeb display of processed data. When used with its automated e-mail alarm features, ADISSWeb has fostered communication between the dredging contractor and the monitoring agency, resulting in the timely management of disposal operations at the designated offshore disposal sites. Prevention of deleterious activities has decreased the potential for enforcement actions, and the risks to contractors.

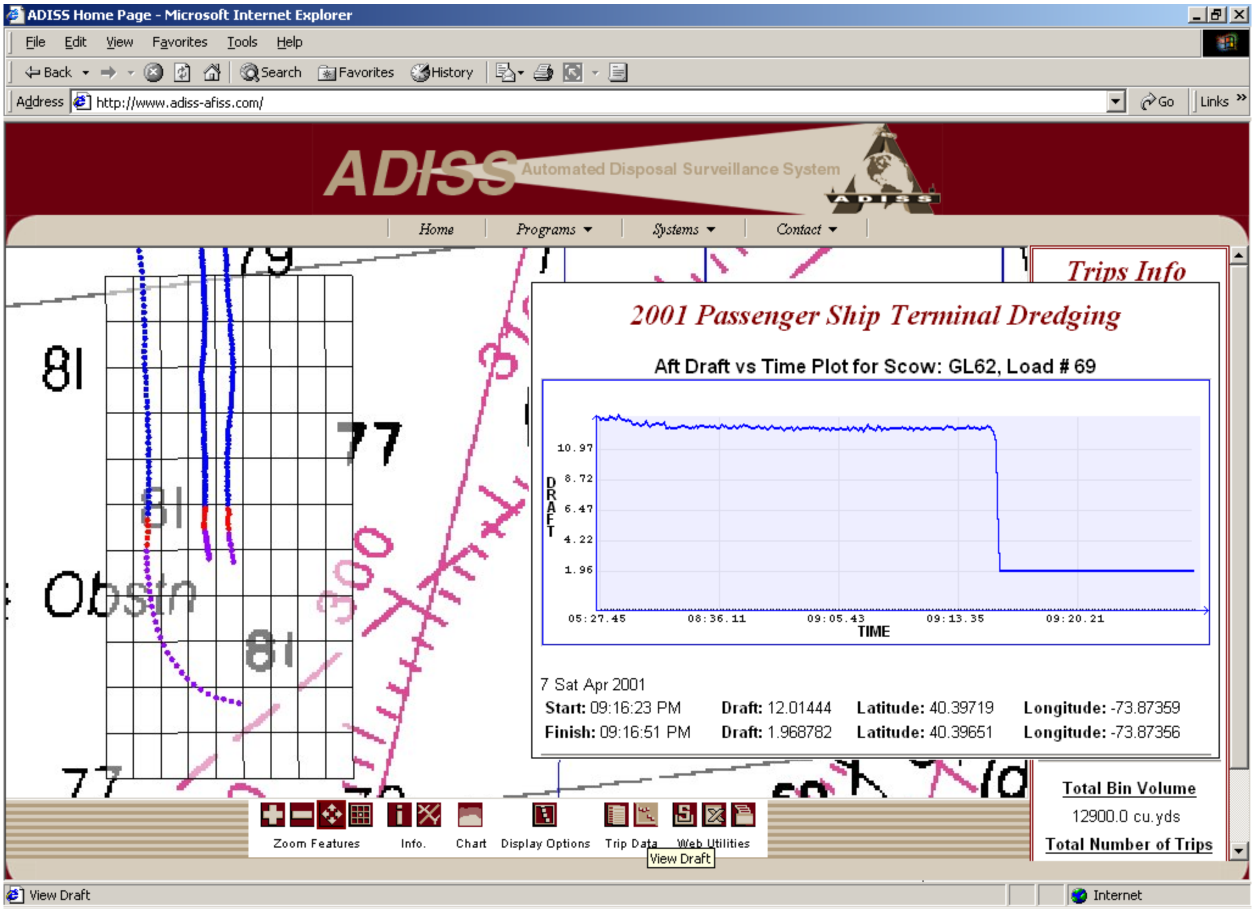


Figure 3. ADISSWeb shows the position of dredged material placement (red dots on left) and the transit record of scow draft (on right) in the USACE New York District at the Historic Area Remediation Site (HARS). Note the rapid decrease in draft indicative of a complete disposal of material.

3.0 COMPARISON OF MONITORING SYSTEMS

EPA Region IX disposal site requirements are described in site management and monitoring plans (SMMPs) developed for each designated ocean disposal site. The SMMPs generally require that basic information be recorded for disposal operations, such as location of disposals within the designated site. The San Francisco Deep Ocean Disposal Site (SFDODS), located seaward and in the vicinity of three major federal marine sanctuaries, has the most stringent SMMP requirements implemented among all of the ocean disposal sites in Region IX. In particular, there are more specific mandatory conditions that include, but are not limited to:

- Sea state restrictions for transit to disposal site,
- Bin volume limit for dredged material in the scow such that there would be no expected leaking,
- Inspector certification for proper loading,
- No leaking during transit to disposal site,
- Maintaining 3-mile distance from Farallon Islands,
- Discharge of dredged material within the target only, and
- Maintain daily records of volume of dredged material disposed at site.

Specific types of hardware, software, and inspector and operator procedures are necessary to fulfill the detailed record-keeping requirements for SFDODS disposal operations. By comparison, the SMMPs for the other Region IX sites have more generally described record-keeping performance standards. Applicants and their contractors can meet the record-keeping requirement with at any of the Region IX sites with their choice of hardware, software, and record-keeping procedures.

Present requirements for the application of GIS tools should include position information in the NAD-83 datum. (For practical purposes, NAD83 can be considered the same as WGS84). Since GPS data are always output in the NAD-83 datum, this requirement will be met by projects using this data source for vessel position. EPA Region IX imports the submitted data into its GIS ArcAvenue™ program, and converts it to the ALBERS 9 projection for graphic display and hard copy output (C. Henley, pers. comm.). Several ArcAvenue™ scripts have been written with varying degrees of success to import data formats submitted by past projects.

Previous format problems experienced by EPA Region IX include:

- Data corruption
- File loss
- Different formats within a project
- The lack of flags signifying load
- Transit and placement activities
- The lack of project, transit and vessel identifiers

All of these problems have cost the agency hundreds of hours in labor to verify compliance with permit regulations. During one major project in San Francisco Bay, 70% of the submitted data files were corrupted, and undocumented changes included feet-to-meter switches, X-to-Y swaps, and several State Plane Coordinate system changes (M. Grenninger, pers. comm.).

Comparison criteria for aspects critical to disposal operations have been applied to both the scow-based and tug-based systems. The criteria are:

- Vessel positions recorded by time, date and geographic location
- Standardized database of monitoring information compatible with EPA and USACE GIS systems
- Real-time helmsman display of position and draft during transit to the disposal area
- Track line plots of each vessel transit to the disposal area
- Data, time and position of disposal initiation and completion recorded in database
- Volume of dredged material load recorded in the database
- Vessel and project identifications recorded in the database
- Draft measurements recorded in the database to assess vessel leakage
- Availability of data to facilitate effective management in near real-time

3.1 Scow-based System Comparisons

<u>Vessel positions recorded by time, date and geographic location:</u>
All of the scow monitoring systems record position information with time, date, and position data, as transmitted by GPS satellites. The COTS receivers decode the signal and provide the data in the most common protocol, GGA (Global Positioning System Fix Data). Some of the systems convert the Latitude-Longitude North American Datum-1983 (NAD-83) position information received from the GPS unit to the Easting-Northing values (Feet) of the State Plane Coordinate system. These values need to be re-converted to Latitude and Longitude for use by the EPA GIS program to confirm regulatory compliance. Other systems record the Latitude and Longitude data in its original form, which is readily plotted by the GIS program without risk of projection error.

<u>Standardized database of monitoring information compatible with GIS:</u>
Dredging permits issued by the USACE San Francisco District had historically specified data to be submitted in the DDLS format. Originally described in WES (1996), the intent has been to codify the acquisition and submittal of information. All data were to be submitted in ASCII format to USACE San Francisco District on 3.5” 1.44 MB disks or CD. Time, date, position, draft, and bin data are assigned fields in a space-delimited, floating-point format with record fields of a prescribed size. Latitude-Longitude NAD-83 position data from a GPS receiver are converted to an unspecified zone of the State Plane (Lambert) Coordinate format. The DDLS format lacks trip identifiers and does not specify loading, transit or disposal modes of operation, which are necessary to accurately assess permit compliance.

The WINOPS ™ system provides data logging and output in the DDLS format as a binary-encoded file. The software provides a utility which allows export to an ASCII format for further analysis. Graphical viewing or playback of the data requires the purchase of a WINOPS™ software license.

Proprietary systems such as those developed by Great Lakes Dredge and Dock, allow custom configuration of ASCII file output from within the software. A field engineer is able to configure the output at the start of a project, taking into account the requirements of a particular USACE District or EPA region.

SAIC has employed a uniform, pre-established data structure for submittal of electronic information to the regulatory agencies, and includes a minimum level of information. Time, date, position and draft information are integrated to facilitate the retrieval and organization within large datasets. The solution to these problems is the requirement of a standardized database format and/or contractor-provided visualization in a standardized format. **Figure 4** shows the display of ADISSWeb, provided to the EPA, Region IX and to USACE San Francisco District to verify permit compliance in near real-time.

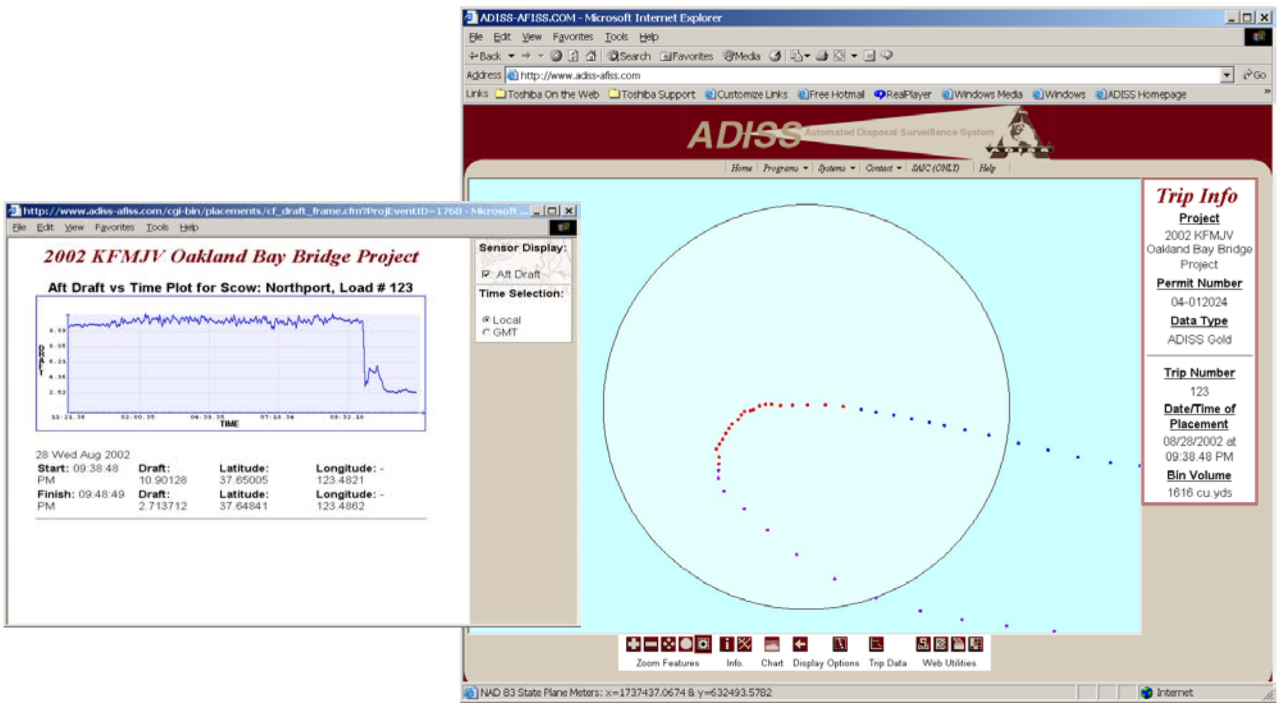


Figure 4. ADISSWeb shows a scow-based position of dredged material placement (red dots in right panel) and the transit record of scow draft (left panel) at the SFDODS.

SAIC has built an MSACCESS97™ database structure using a model of "events" and "points". The database structure is established by creating two tables: "event" and "point". The "events" contain identifiers needed for each transit, while the "points" have information for each position fix acquired from the GPS receiver during the transit. The two sets of information are linked using the "Project Identification" and the "Event Identification" fields. Tables 1 and 2 depict examples of typical data fields and their Names, Data Types and Sizes. The linked identifier fields are color-coded in red and green.

Table 1. "Event" Information

Name	Type	Size
Project Name	Text	255
Project Identification	Number (Long)	4
Event Identification	Number (Long)	4
Trip Number	Number (Long)	4
Tug Name	Text	255
Computer Name	Text	255
Target Cell	Text	50
Scow Name	Text	255
Offset	Number (Long)	4
Aft Draft	Number (Long)	4
Forward Draft	Number (Long)	4
Volume of Material	Number (Long)	4
Start Recording	Date/Time	8
Doors Open	Date/Time	8
Doors Open Latitude	Number (Double)	8
Doors Open Longitude	Number (Double)	8
Doors Open Heading	Number (Single)	4
End Disposal	Date/Time	8
Disposal End Latitude	Number (Double)	8
Disposal End Longitude	Number (Double)	8
Disposal End Heading	Number (Single)	4
Doors Close	Date/Time	8
Doors Close Latitude	Number (Double)	8
Doors Close Longitude	Number (Double)	8
Doors Close Heading	Number (Single)	4

Table 2. "Point" Information

Name	Type	Size
Point Identification	Number (Long)	4
Project Identification	Number (Long)	4
Event Identification	Number (Long)	4
DGPS Latitude	Number (Double)	8
DGPS Longitude	Number (Double)	8
Latitude	Number (Double)	8
Longitude	Number (Double)	8
GMT Date Time	Date/Time	8
Helmsman Phase	Text	255

The following is an example of the first six entries of an "Event" table:

Project_Name	Proj_ID	Event_ID	Trip_No	Comp_Name	Tug_Name
	78	1	1	ADISSPlay19	Richard

The following is an example of the first six entries of a "Point" table:

Point_ID	Proj_ID	Event_ID	DGPSLat	DGPSLong	Lat	Long	GMTDate_Time
1	78	93	37.81887	-122.31595	37.81887	-122.31595	10/31/2002 2:52:11 AM

In the Point table, "DGPS Latitude" and "DGPS Longitude" refer to the GPS receiver input for the scow's position, while "Latitude" and "Longitude" contain the calculated position information for the center of the scow's bin. Project requirements may dictate use of only certain elements of the prescribed database format. Values not used should assume a pre-determined default value (e.g. "N/A").

Real-time helmsman display of position and draft during transit to the disposal area:
Real-time helmsman displays are available only on certain scow-based systems. Generally, the position information is transmitted via radio modem to a receiver aboard the tug, where it is plotted and displayed on a computer. The helmsman uses the display to guide the tug and scow to the designated disposal area, ensuring the entire load is placed within the boundaries of the site. Commercial software, such as Visual Basic™ and Geo View™, has been used to program the routines, and display and log the data on the tug.

Previous DDLS system specifications for disposal at the SFDODS and in-bay disposal sites did not include scow-based real-time helmsman display. Consequently, the helmsman may not have known the exact location of the scow following the tug when exiting the disposal site. This resulted in several missed placements during disposal projects, which could have been avoided with a wheelhouse display of scow position. Current system specifications include a requirement for scow position display, which can be satisfied with the WINOps ™ or the ADISSPlay systems.

One of the helmsman display systems, ADISSPlay, also shows vessel draft information, and is used to determine scow leakage during transit (**Figure 4**). SAIC added this feature to ADISSPlay at the request of one of its commercial clients, who wished to proactively decide whether to rotate its equipment into dry dock for repair. The ability to receive the information in near real-time, and plot the draft data with a viewing program allows the regulatory agency to determine leakage before requesting a dredging company to repair faulty scow seals.

Track line plots of each vessel transit to the disposal area:
Track line plots of vessel transits to the disposal areas are generally constructed and submitted by the dredging companies to the USACE District office after the position information has been retrieved and plotted using either a CAD program or Internet viewing software. For the SFDODS, the SMMP requires that track line records be displayed to show that scows containing dredged material did not transgress either the Farallon Island 3-mile limit or the USCG traffic lanes, while enroute to the SFDODS. For all disposal sites in Region IX, track line plots would

also demonstrate that all of the dredged material was deposited within the disposal site boundaries.

The WINOPS system provides tools for the tug operator to print a hard-copy of disposal time and position (as determined visually by the tug operator and translated by key-presses) for submittal when returning to the dredge. Track-line data can also be viewed as an animation for review. Proprietary systems developed by larger dredging contractors require manual download via floppy diskette and manual import to a CAD or spreadsheet application for plotting. The ADISSPlay system provides automated color-coded track-line plots for the tug operator to print and/or transmit wirelessly to the ADISSWeb system for immediate internet-based display.

Date, time and position of disposal initiation and completion recorded in database:
Date, time, and positions of disposal initiation and completion are generally recorded in the database of most scow-based systems. The recorded draft and bin data require interpretation to determine the initial and final placement positions for each transit. Once the data have been downloaded, dredging engineers determine the position of placement by the sudden changes in draft and bin information, and plot this placement information using CAD program or viewing software. The recorded information and plots are submitted to the USACE District office and to the regional EPA office to determine compliance with the federally mandated statutes for offshore disposal.

Since data interpretation is vulnerable to misrepresentation by dredging companies to avoid financial penalties and corrective actions for the misplacement of dredged material, some of the monitoring agencies have resorted to constructing placement plots using GIS tools. Submitted data are imported into GIS systems to validate the track lines plots submitted by the dredging companies. Specifically, the EPA Region IX and USACE New York District (NYD) both plot the track line data using ArcAvenue™ scripts written for the purpose of validation. The USACE San Francisco District sometimes plots data using the DREDGEMON program.

Where statute enforcement and public oversight is critical to the management of dredge disposal operations, a third-party is necessary to process the placement data. Since 1997, the NYD has employed SAIC to manage the data from the dredging improvement and maintenance projects in New York Harbor (SAIC 2001). Recently, USACE San Francisco District has also employed SAIC for similar purposes. In this capacity, SAIC automatically collects the information using cellular technology, processes and displays it on the Internet for the agency's evaluation. Should a load be misplaced, the data are downloaded to the in-house GIS programs for further analysis and corrective actions.

The WINOPS system has built-in functionality for date/time stamping of material disposal based on a tug operator's visual observations. The tug operator presses keys to mark two positions during the disposal cycle for date/time stamps. The tug operator is asked for an identifier upon pressing the first key at which point a trip number can be entered. The positions logged are not fixed in the software to be defined as "start of disposal" or "end of disposal", though tug operators are typically trained by the contractor's field engineer to mark them in this manner. A hard-copy of the two positions in relation to the disposal area is automatically generated by a printer on board the tug after disposal. Proprietary systems from GLDD rely on similar sequences of key-presses to tag date/time of disposal. The ADISSPlay helmsman system incorporates three large icons for the tug operator to click as the disposal sequence progresses. As the tug operator is often busy with multiple tasks during disposal hence icons marked as “Start of disposal”, “End of Disposal” and “Close Doors” are shown as large pictures and are “grayed-out” as they are clicked to avoid confusion. The date/time stamps from each button press are recorded automatically and used as preliminary color-coding of disposal points until the data is QA/QC’ed and disposal can be determined by draft sensor data.

Volume of dredged material load recorded in the database:
If the volume of material loaded in each scow has been established as a database entry, the information can be utilized by the regulating agencies to track disposal site capacity. A cumulative spreadsheet of volumes helps agencies manage site activities by showing a running summary for the total yearly maximum. ADISSWeb may be used to determine the total project volume from bin and draft data, when distributed for the real-time management of in-bay disposal projects. Other systems rely on a dredging contractors’ paper log of volumes or electronic spreadsheet of tallied volumes submitted via a fax or e-mail.

Vessel and project identifications recorded in the database:
Other needed database entries include the identifiers for each project, trip, and vessel. Without them, data retrieval and display from a master database containing position and draft data is problematic. During several previous dredging projects in San Francisco Bay, no project or vessel identifiers were recorded in the datasets provided to the USACE San Francisco District and EPA Region IX. As a result, disposal site managers were not able to validate project compliance with permit requirements at the SFDODS without investigating other sources of information. Trip identification information is also an asset, because it can be used to link disposal operations with dredging records. Vessel identification is critical to the detection of scow leakage.

WINOPS and the proprietary systems developed by the dredging contractors use file-naming conventions introduced with the Silent Inspector system in the 1980’s. The WINOPS system, for example, records a file named “Sc100503.LOG” which may pertain to a vessel named “scow 1” containing data collected on the 5th day of 2003. In contrast, the ADISS system is set up at the start of each project with entries for permit number, project name, year and contractor name. Each unique disposal trip is tagged with the proper vessel name (scow and tug) in the database. The ADISS system allows trip information to span multiple days without the need for a split at midnight required by the 24-hour file structure and Julian date stamp.

Draft measurements recorded in the database to assess vessel leakage:
Draft information stored in the database have been retrieved and plotted to show scow leakage for each transit. If vessel identifiers have been used, then a pattern of leakage can be established for a particular scow. Corrective action to repair a faulty seal or hydraulic system can be taken quickly to prevent further water quality degradation over the transit route (**Figure 5**).

In addition to showing leakage in scows, draft records in the database also reveal how successful the placement operations are within the boundaries of the designated site. The sudden decrease displayed from a draft record indicates a complete disposal within a short time over a limited area. But a gradual change in the draft record means the load left the scow slowly, and was dispersed over a larger area outside site boundaries.

The timely submittal of the draft information is critical to correct leakage problems. If data are transmitted to the regulatory agency on a monthly basis, then a potential problem may not be addressed until the contents of many loads have been dispersed along the transit route. However, if the data are automatically submitted, and examined for potential leakage in near real-time, then a decision to repair a faulty scow can be reached quickly, preventing an enforcement action after the project has ended.

Display and dissemination of data is dependent on hardware and software incorporated in each system. WINOPS and the proprietary systems developed by dredging contractors rely on manual download to diskette for generation of draft plots. Later versions of the DDLS system incorporated an analog cellular telephone for direct downloading of 24-hour records from the scow to a remote PC. Solar panels and battery banks were added to accommodate the added power consumption of the analog phone. USACE technical staff were able to initiate a call to the system and download draft data for manipulation and import to CAD software

The ADISS system provides a real-time display of draft to the tug operator. At the start of each trip, the tug operator is shown a graphic of the starting draft of the vessel. As the vessel transits to the disposal site, the graphic is updated in real-time. If draft decreases while underway, the data gives an indication that the scow may be leaking. If draft is increasing, the scow may be taking on water and sinking. If the tug operator is monitoring the display during transit, he is able to immediately alert a project manager of a potential problem. If the operator is unable to monitor the draft while underway and a draft change occurs, the ADISS data is transmitted wirelessly to an off-site processing station and automatically checked for draft changes. An automated application scans incoming draft data for possible leakage. If the leakage threshold is exceeded for a given trip, the automated system sends e-mail alarms to regulators and/or dredging contractors to advise them to view the data on the ADISSWeb system for further analysis. The e-mail alert system is a requirement in New York and San Francisco USACE districts.

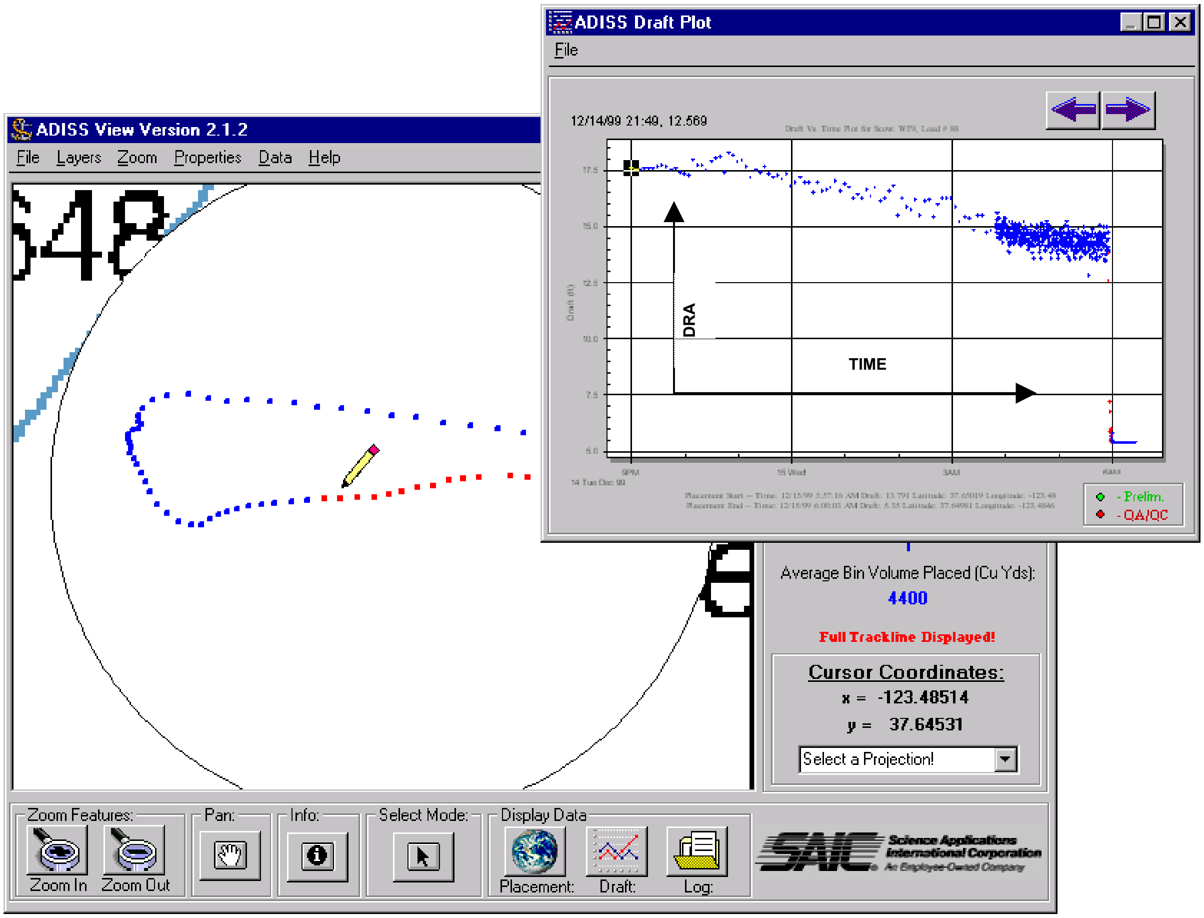


Figure 5. ADISSView plots the draft data illustrating a leaking scow in transit. Notice the draft plot gradually decreases several feet as the material leaks from the scow. Programmed for a sudden change in draft, the disposal occurred within the site.

<u>Availability of data to facilitate effective management in near real-time:</u>
Systems that provide immediate data transmission to both the dredging contractor and the monitoring agency should also provide a means of graphing the draft information, and plotting the scow position to facilitate monitoring scow operations in near real-time. The display must be clear and unequivocal, so that both the dredging contractor and the monitoring agency can reach a common understanding of the situation without delay.

As previously mentioned, the WINOPS and proprietary systems developed by dredging contractors rely on manual download to diskette for generation of draft plots. The later versions of the DDLS system which incorporated an analog cellular telephone enabled USACE technical staff to initiate a call to the system and download draft data for manipulation and import to CAD software. These methods often require extensive labor resources.

SAIC has instituted a near real-time reporting system for the EPA, Region IX and the SFD, that use a combination of cellular phone technology and spread spectrum modems. The systems, which provide immediate data transmission to both the dredging contractors and the monitoring agencies, provide a means of graphing the draft information, and plotting the scow position to facilitate this process. The ADISS system acquires both draft and position information for each transit immediately following placement at the target site, and posts it for viewing on a web site. Both the contractor and agencies view the data with ADISSWeb. The systems serve multiple dredging projects, and provide a means to submit Inspector Logs automatically, with the draft and position information forwarded to both the agencies and the contractors.

3.2 Tug System Comparisons

The same evaluation criteria, which were applied to the scow-based systems for aspects critical to disposal operations, have been applied to tug-based systems.

Vessel positions recorded by time, date and geographic location:
Like the scow monitoring systems, the tug-based systems record position information with time, date, and position data, as transmitted by the GPS satellites. The GPS receivers decode the signal and provide the data in the most common protocol, GGA (Global Positioning System Fix Data). Systems such as WINOPS and the proprietary versions developed by dredging contractors convert the Latitude-Longitude North American Datum-1983 (NAD-83) position information received from the GPS unit to the Easting-Northing values (Feet or Meters) of the State Plane Coordinate system. These values need to be re-converted to Latitude and Longitude for use by the EPA GIS program to confirm regulatory compliance. Systems such as ADISSLite record the Latitude and Longitude data in its original form, which is readily plotted by the GIS program without risk of projection error.

Standardized database of monitoring information compatible with GIS:
Although tug-based systems do not meet the requirements for monitoring of disposal operations at SFDODS, they could be used at other locations within EPA, Region IX.

To date, the only standardized database format for the tug-based systems is that used by ADISSLite. The basic requirements include time, date and position data, as well as flags for the beginning and the completion of each disposal. The format also includes identifiers for the dredging project, the tug, the scow, and the trip number. The offset distance and bearing between the tug and scow are entered in the database along with the loaded vessel draft and volume information. WINOps™ provides this information as well in the Northings and Eastings format. Identifiers can be supplied by the vessel operator for trip number. Scow and tug identities are logged manually and not embedded in the dataset.

As previously described for the scow-based systems, requirements for the application of GIS tools to the data submitted by dredging projects to EPA Region IX include position information in the NAD-83 datum. Since GPS data is output in the NAD-83 datum, this requirement will always be met by projects using this data source. ADISS data are displayed on the Internet and available for downloading in a standard comma-separated ASCII format. This format is viewable with most commercially available text editors and spreadsheet programs. EPA Region IX uses the ADISSWeb system to download the raw data for closer review if the graphical plots are in question. Previously, several ArcAvenue™ scripts have been written to import a variety data formats presented by past projects. The standardized format eliminates this time consuming exercise.

Real-time helmsman display of vessel position during transit to the disposal area:
Real-time helmsman displays form the guidance portion of some of the tug-based systems. The Weeks Marine tug-based system only records position, and does not display it for guidance to the disposal site. Only the ADISSLite and the WINOps™ programs plot the position information. ADISSLite plots both the tug position and the estimated location of the scow using the GGA input from the ship's GPS receiver. Both positions are plotted over the appropriate NOS chart with an overlay of the target boundaries. After the helmsman inputs the offset distance and bearing from the tug to the scow, the display is used to guide the tow to the designated disposal area, ensuring the load is placed within the boundaries of the site. As with the scow-based display systems, commercial software (Visual Basic™ and Geo View™) has been used to script the ADISSLite program routines, and display and log the position data on the tug (**Figure 6**).

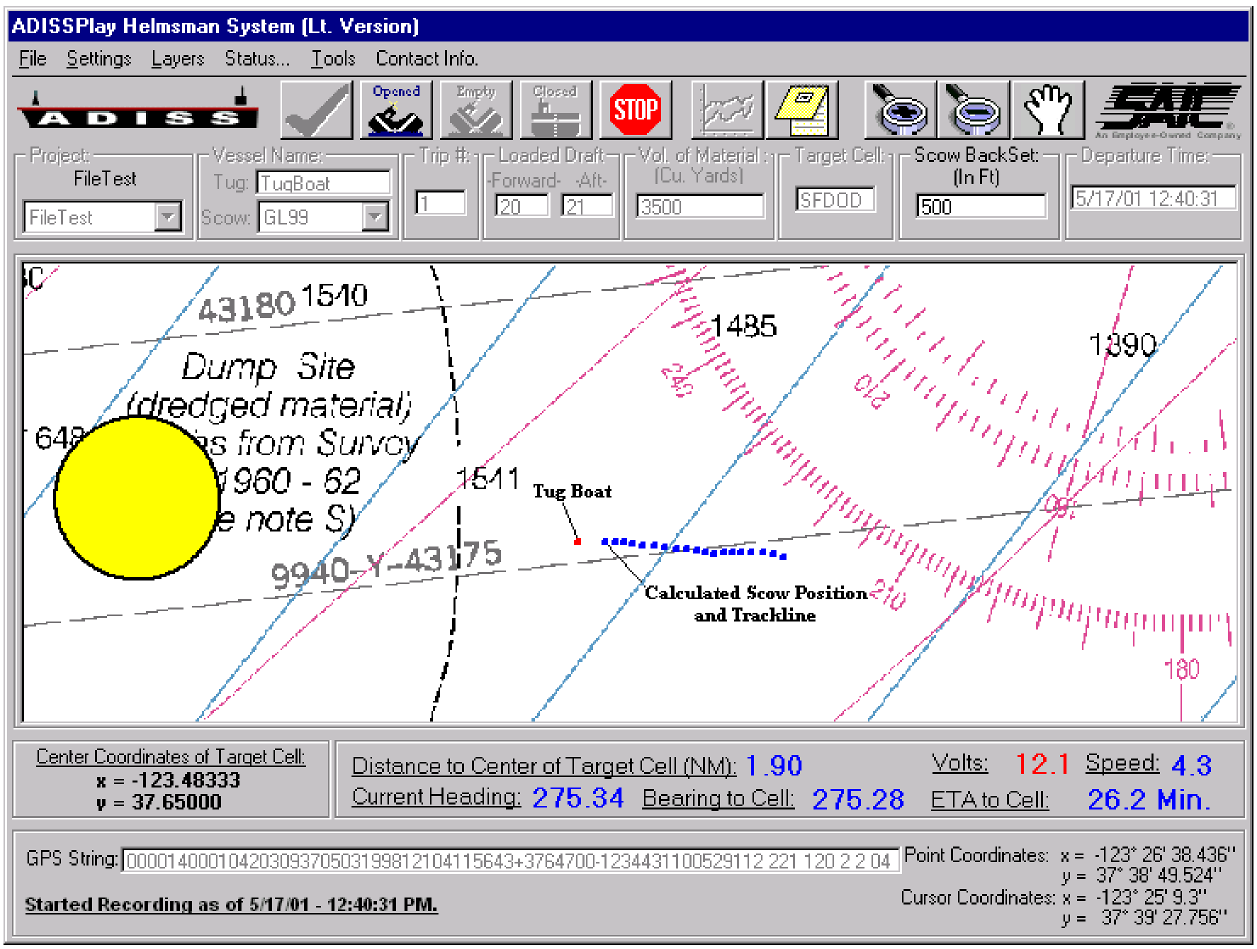


Figure 6. Tug-based ADISSLite screen display plots the tugs GPS positions (red) and a trackline of the scow's estimated position (blue) over an NOS chart to the target area.

Great Lakes Dredge and Dock (GLDD), Inc, has modified a similar system typically used on hopper dredges for load placements of split-hull scows in Boston Harbor. The modified system was installed on a tug to guide placement of loads to Confined Aquatic Disposal (CAD) cells. The estimated GPS position of the scow secured to the 'hip' of the tug was plotted over the CAD cell boundaries during placement using the tug's GPS position. GLDD does not use this tug-based system for offshore placements. Instead, GLDD employs either the ADISS/ADISSPlay system or an in-house scow-based system for disposals made by scows towed "on the wire."

Track line plots of each vessel transit to the disposal area:
Track line plots of transits to the disposal areas can be illustrated by the dredging companies and provided to USACE after the data have been manually retrieved and plotted using a CAD program (e.g. WINOPS, proprietary dredging contractor-developed systems). Alternately, ADISSLite files are transmitted via cellular technology, and viewed by the dredging contractor and the monitoring agency using the Internet or ADISSView. Track line plots can be printed or imported for report presentation. All of these viewing methods can be used to evaluate the potential for encroachment across marine sanctuary boundaries.

Date, time and position of disposal initiation and completion recorded in database:
Date, time, and position of disposal initiation and completion are sometimes recorded in the database of tug-based systems. When disposal points have not been recorded, the risk of violating permit conditions has been significant. The tug-based system used for a Southern California dredging project did not record the disposal points electronically for hundreds of placements at LA-3. Subsequently, the locations were estimated from the changes in track line direction, which indicated most of the loads were misplaced outside site boundaries (B. Ross, pers. comm.). In fact, the dredging contractor had utilized an erroneous location for the disposal site from the outset of the project. Had the disposal points been recorded and viewed by both the dredging contractor and the regulatory agency in a timely manner, this error could have been quickly corrected, and a large fine avoided.

When the disposal points are recorded, and transmitted for viewing by tug-based systems, project engineers and agency regulators can effectively manage operations and confirm permit compliance. Weeks Marine's tug-based system records the disposal points along with the date and time, but does not transmit or display the information for review. The purpose of this system is to record the position of scow door activation from its remote controller. In practice, once the data had been recovered from the tug, it was submitted in raw form to the regulatory agency. In contrast, the ADISSLite tug-based system records and transmits the disposal points to the Internet for viewing by dredging engineers and agency managers. The initiation and completion of disposal operations depend on the tug operator's input to flag the beginning and end of each event from visual queues. If the operator's view is obstructed or diminished by darkness, the opening and closing of scow doors and the change in draft may be difficult to detect.

In general, precise determination of load placement is subject to more errors with tug-based systems. In a comparison of methods between systems, the tug-based estimations of scow position were usually within 50-250 feet of the actual location (SAIC, 1997). Therefore, where accurate positioning is required on a capping project, the scow-based system offers the accuracy needed to ensure the even distribution of material within a designated disposal site. The accuracy offered by the tug-based system would be sufficient for disposal in large target areas, where precise positioning is not a requirement.

Volume of dredged material load recorded in the database:
The volume of material loaded in each scow can be entered into ADISSLite during the beginning of each transit, and later utilized by the regulating agencies to track disposal site capacity. A cumulative spreadsheet of volumes can help regulatory agencies manage site activities by keeping a running summary for the total yearly maximum at each site. ADISSWeb may be used to determine the total project volume from bin and draft data, when distributed for the real-time management of in-bay disposal projects. Other systems rely on dredging contractors logging volumes on paper or with a spreadsheet and submittal of tallied volumes via a faxed hard-copy or e-mail.

Vessel and project identifications recorded in the database:
All databases should include identifiers for the project, trip, and vessel. Tug-based systems that do not record identifiers provide data of limited value for validation. Without project identifiers, data retrieval and display from a master database containing other project data is problematic.

WINOPS and the proprietary systems from dredging contractors use file-naming conventions introduced with the Silent Inspector system in the 1980's. The WINOPS system, for example, records a file named "Sc100503.LOG" which may pertain to a vessel named "scow 1" containing data collected on the 5th day of 2003. In contrast, the ADISS system is set up at the start of each project with entries for permit number, project name, year and contractor name. Each unique disposal trip is tagged with the proper vessel name (scow and tug) in the database. The ADISS system allows trip information to span multiple days without the need for a split at midnight required by the 24-hour file structure / Julian date stamp.

Draft measurements recorded in the database to assess vessel leakage:
No draft information is provided in tug-based systems where sensor input is absent. Determination of scow leakage is not possible without sensor input to the tug-based systems.

A development for tug-based systems includes recovering data from draft and bin sensor loggers. The data logged from the sensors are appended to the tug position information during operation to produce a complete picture of transit and placement activities. SAIC has produced bin sensors for Dutra Dredging, Inc. during the 2001 Richmond dredging project which have been deployed successfully on several projects during the 2002 dredging season. The systems consist of a low-power acoustic sensor housed in a waterproof case with a logger. The logger records the distance from the sensor to the surface of the material in the hopper bin at five-minute intervals, and the data are manually downloaded on a weekly basis and appended to the independently collected ADISS data from the scow.

Though the system is designed to work with a scow-based system, its data can also be appended to a tug-based database by using an ADISSView menu option. The option makes use of the time stamps in the data strings of both sources of information to append the two into a single database. Bin and draft information can then be plotted and viewed to determine leakage. Position of placement typically cannot be determined accurately due to the long fix interval (e.g. 5-minute) limitation. The data can be plotted on the Internet with ADISSWeb for viewing.

Availability of data to facilitate effective management in near real-time:

Tug-based systems that provide immediate data transmission to the Internet for plotting the scow position, and monitoring scow operations in near real-time. WINOPS and proprietary dredging contractor-developed systems rely on manual download via floppy disk for data retrieval. SAIC has instituted two reporting systems for the EPA, Region IX, using cellular phone technology. The systems, which provide immediate data transmission to the Internet, provide a means of plotting the scow position to facilitate this process. One of the systems, ADISSLite transmits position information for each transit immediately following placement at the in-bay disposal site, and posts it for viewing on a password-protected web site (http://www.adiss-afiss.com). The ADISSPalm system was tested during the San Rafael 2001 dredging project. The vessel operator downloaded the data manually and e-mailed the files for processing on the web during the project. Recent upgrades to wireless technology now allow wireless downloads from the towing vessel following each disposal event. Both systems are scaleable, and can serve multiple dredging projects simultaneously without confusing projects or events.

4.0 SYSTEM COSTS

A permit applicant typically considers costs to maintain an electronic monitoring system based on individual project requirements when preparing the bid to perform the dredging work. Depending on an applicant's in-house abilities and resources, costs are optimized by either of the following alternatives:

- The applicant purchases and maintains the equipment and processes data.
- The applicant hires a third party to supply and maintain equipment and process the data.

The following chart depicts a qualitative evaluation of cost, complexity, labor and reliability associated with Scow-based (above red line) and Tug-based (below the red line) systems.

Monitoring Systems Available

System Name	System Type	Cost	Complexity	Labor	Reliability
Computer-Based System (1st DDLS, GLDD, …)	Black-box, Contractor-serviced	$$$	***	***	*
DDLS V2 System	Black-box, Contractor serviced	$$$	***	***	**
ADISS	Black box, wireless, remote third-party serviced and automatic download.	$$	**	*	***
ADISSLite	"Trust-Me" system. Vessel-captain operated.	$$	*	**	***
ADISSPalm	"Trust-Me" system. Vessel-captain operated.	$	*	**	***

It is important to note that costs are largely dependent on labor required to maintain the systems. Initial costs of hardware for each system are insignificant compared to the labor and travel costs required for on-site technical maintenance. Labor and travel costs are reduced by reliable wireless data retrieval and trouble-shooting capabilities. System obsolescence and ability to meet varying contract specifications must also be considered in evaluating cost effectiveness.

4.1 Scow System Costs

4.1.1 Applicant Develops and Maintains the Equipment and Processes Data

The most costly method of deploying and maintaining a scow monitoring system relies on the dredging contractor to carry out the design, installation and maintenance. Contractors have typically designed systems using combinations of dredging survey equipment and industrial components as a permanent installation to a scow. A permanent system equipped with a computer, draft and bin sensors, a GPS receiver, radio modem and a power regeneration system costs tens of thousands of dollars per installation. Only the large dredging companies have the funds necessary to engineer such systems. Electronic equipment must be protected to function reliably during the rugged conditions in the marine environment, and components are sealed and connections are potted to prevent corrosion. Chasses are insulated from vibration, and sensitive electronics are shielded from radio frequency interference. The cost of the components is usually less than half of the cost of the installation and maintenance.

Because the system cannot be removed, maintenance of sensors and electronics is often required following long offshore transits between project sites along the coast. In practice, however, electronic scow monitoring systems are often maintained only if scow becomes unfit for departure to the disposal site due to system malfunction. This scenario leads to costly delays that can result in tens of thousands of dollars due to lost production time. The associated costs of emergency site-visits by an experienced electrical engineer include last-minute air-travel, car rental, housing and meals.

On a day-to-day basis, an on-site field or survey engineer typically conducts data processing. This person is assigned to physically download the electronic data from each vessel to floppy disk on a daily basis. The data are then downloaded to a computer system in a field office, processed and plotted. On-site personnel, lodging and transportation costs outweigh the cost of hardware and installation on projects continuing longer than one month.

The dredging contractor considers cost implications of hardware and software obsolescence when choosing a monitoring system. During recent years, the rapid rate of improvements made by the electronics industry have exponentially decreased the cost and increased the capabilities of COTS components. USACE and EPA monitoring requirements have been updated accordingly to leverage this trend. Requirements for larger data storage, wireless networks, real-time web-based tracking and even internet-based camera systems have become standard in certain USACE Districts and EPA regions. While costs of these technologies have decreased rapidly, the new requirements have rendered previously- purchased or developed systems obsolete. A contractor's cost to develop, test and install new systems on a fleet of scows for a given project can lead to an outlay of funds greater than $100,000.

4.1.2 Applicant Hires a Third Party to Develop and Maintain the Equipment and Process the Data

A third-party entity, which combines in-house development, production, and service of vessel tracking systems with existing working relationships with USACE Districts and EPA regions within the country, is an option available to reduce costs to dredging contractors. SAIC has integrated such abilities and employs a rental fleet of its portable ADISS systems. By charging a daily rental fee, SAIC is able to maintain standardized, bench-tested, portable units that are continually updated to replace worn and obsolete equipment. The objective of this approach is to eliminate costly lost production time with reliable equipment and software.

The compact format of the system allows inexpensive shipping via commercial carrier. The self-contained nature of the system facilitates rapid installation with minimal welding. On-site installation aboard multiple scows is often reduced to several hours instead of several days. Contractor field or survey engineers already on site can be trained to demobilize the equipment for return shipment at the completion of the project reducing the requirement for travel costs of a specialized technician.

The implementation of wireless hardware in the systems allows remote troubleshooting and training via the Internet. This feature increases response time to correct system problems and reduces costly dredging plant delays due to system problems. Labor and travel costs associated with emergency technician visits to the project site are allayed if the problem can be remotely solved. System repairs requiring hardware replacement are often handled remotely through cellular communications with on-site personnel such as vessel operators and survey engineers and shipping of a pre-configured and bench-tested replacement system to the project site.

Data processing costs are reduced through use of COTS wireless data networks and a centralized, automated processing system. Combined with the automated internet-based mapping display via the Internet, manual processing labor costs associated with an on-site engineer are drastically reduced. Daily Quality Control of data is handled by the third-party firm in a fraction of the time required for a contractor's on-site engineer to manually collect data and produce the plots.

4.2 Tug System Costs

4.2.1 Applicant Develops and Maintains the Equipment and Processes Data

A helmsman display system for plotting the tug and estimated scow position information may be developed or purchased by the contractor and can be installed on a contractor's existing towing vessel computer or installed in parallel as a stand-alone system. If a GPS receiver has been previously interfaced to the existing towing vessel computer, then the helmsman software can be configured to run as a background process to the primary tug navigation software on the same system. In this case, the cost of the computer and GPS would have been previously absorbed. This method is seldom practiced. Possible conflicts with a ship's main navigation computer and specialized scow positioning software could compromise the safety of the vessel and its crew. Most all dredging contractors opt to invest in the proportionally minimal cost of a parallel computer system for scow positioning to prevent system failure and possibility of an ensuing accident.

Data are typically manually downloaded, plotted and submitted on a daily or weekly basis by an on-site survey or field engineer. COTS software such as WINOPS™, HYPACK™ and MSExcel™ are used to manually plot the electronic data. A contractor may hire or use in-house resources to develop routines to meet specialized plotting and data format requirements.

A cellular telephone equipped with Internet capabilities can be added and interfaced to the helmsman computer to provide a means of remote data transfer. Cellular phones and services are available at a cost of less than $300 and $99 per month for unlimited Internet access. COTS data transfer software such as PCAnywhere™ can be purchased and installed. This method seldom taken by a contractor due to the complexities, costs and logistics in setting up a host computer with a dedicated internet connection to act as a PCAnywhere host for the towing vessel's computer. Setup and administration of a 1-year service contract for local cellular service (a requirement of most all cellular providers) can be prohibitive if a project spans only a brief two-month period.

A dredging contractor, seeking to find ways of reducing costs, typically employs software and hardware for scow monitoring which is already owned or has been previously developed for the purposes of dredge positioning. These software packages are typically installed on large-format desktop computer systems and interfaced with survey-quality DGPS receivers. An on-site field engineer installs this setup in the wheelhouse of the towing vessel.

4.2.2 The Applicant Hires a Third Party to Supply and Maintain Equipment and Process the Data

Labor and travel for an on-site engineer contribute to the majority of costs when employing a manually serviced system aboard a towing vessel. Troubleshooting, and maintenance costs contribute as well. Wireless communications hardware and services are rapidly cycled by service providers requiring purchase of new hardware and software and for an experienced technician to update the system and check that no conflicts occur with other applications running on the system.

In practice, the installation of wireless data hardware and software with helmsman system helmsman display software on an existing tug computer requires more labor to troubleshoot and maintain than the rental of a portable stand-alone system. A separate system pre-configured for each project with a uniform set of limited navigation tools has proven a much more cost-effective method of equipment deployment. Before deployment on each project, the system software and hardware are upgraded to ensure proper compatibility with cost-effective server-based automated processing software.

By configuring all systems with a uniform operating system and hardware components, SAIC is able to deploy pre-configured and bench-tested systems for rapid installation on board towing vessels. Rental funds are used to replace equipment stocks that become outdated and worn during deployments. Each system's software is updated and tested in the lab or remotely via Internet link before the start of each project. Cellular telephone costs are distributed across multiple clients to save expensive account administration and on-going service costs. Rental costs for the laptop and software, GPS receiver, serial interface hardware, data-enabled cellular telephone, printer and radio modem(s) amount to appx $40 per day.

As a very low-cost alternative with a reduced feature set, installation of a palmtop computer integrated with a GPS receiver will be less expensive than rental of a personal computer. Cost for hardware is less than $800. **Figure 7** shows the elements of a Palmtop system.

Figure 7. ADISSPalm hardware consists of a Palmtop Visor™ interfaced to a portable GPS receiver.

5.0 SAIC/EPA DEMONSTRATION PROJECTS

Under contract by EPA Region IX from 2000 through 2002, SAIC performed demonstrations of monitoring systems on several projects. Data were also collected prior to the EPA demonstration under contract by EPA Region IX, USACE San Francisco and dredging contractors. In total, SAIC has deployed its ADISS systems on the following ten projects in California and Hawaii:

- Palos Verdes Pilot Capping Project, Los Angeles and Long Beach
- Dutra Dredging: San Diego, San Rafael, Oakland and Richmond
- Manson Construction: San Francisco Bay Bridge retrofit dredging
- Western Dock: Vallejo and San Rafael (Marin Keys and Marin Yacht Club)
- EAI: Larkspur Ferry Terminal Dredging
- American Marine: Ala Wai Canal – Honolulu, HI

SAIC installed and serviced the ADISS system aboard a trailing suction hopper dredge during a five-week pilot study program. The purpose of the study was to determine the efficacy of deep-water capping off the California coast. 108 loads of dredge material were tracked by the ADISS system as it was placed within the pre-determined cells. During each event, several aspects of the material spreading were monitored using non-ADISS oceanographic sensors (e.g. Optical Backscatter, Underwater video, Acoustic Doppler Current Measurements, Temperature, Side-scan Sonar and Single-beam bathymetry, etc). The ADISS system was used to correlate position of the material disposal with information recovered from the oceanographic sensors for post-processing and analysis.

ADISS was installed on two towing vessels and three scows for the 2001 Richmond Dredging Project. The system recorded 134 of 141 trips to the SFDODS. This translates to a data return percentage of 92%. Following the Richmond project, the ADISS system was installed on two tugs and two scows to collect 80 of the 86 trips during the 2001 Oakland Dredging Project. System reliability for the Oakland project was 93%.

The ADISSPalm system was deployed for 67 trips during the Marin Yacht Club Project. The tug captain operated the system successfully, recording a total of 64 trips for a reliability of 96%. Missed trips occurred due to battery drain on the palmtop computer during constant use. The problem was corrected by supplying an adapter to power the system from the vessel's battery source and using the internal batteries to supply backup power.

ADISSLite was deployed for 67 trips on the Marin Keys project and 41 trips on the Vallejo yacht club project. The tug captain was successful in logging 96% of the Marin Keys trips. During the Vallejo project 100% reliability was achieved after ironing out problems with the towing vessel's generator system. The vessel operators reported that the system was intuitive and easy to use.

The ADISS system was deployed on three scows in Honolulu, HI for dredging in the Ala Wai Canal and disposal at the South Oahu Disposal Site. The project began in August 2002 with an expected completion date in the summer of 2003. Following the installation and training visit at the start of the project, SAIC has supported the project remotely from San Francisco and

Newport, RI. To date, the ADISS Helmsman system has guided the tug operator to the disposal site and the GPS and draft data displayed on the ADISSWeb system for approximately 99.7% of the 600 trips. Placement of material within the disposal site boundary, based on drop in draft of the scow during the disposal phase, shows to have been conducted correctly for 100% of the trips.

The Bay Bridge Dredging Project performed by KFM Joint Venture during the summer of 2002 employed the ADISS system as well. During the three-month project, three tugs and three split-hull scows were used to transport a total of 170 loads of dredged material from the project site in Oakland, through two marine sanctuaries, to the SFDODS disposal site. The ADISS system yielded a 100% data return. SAIC was employed as a third party to install and maintain the rental ADISS equipment, wirelessly download the data for automated processing, and host the data using the ADISSWeb system. Using the ADISS data plots, EPA determined that leakage did not occur during any of the scow transits and that each load was properly placed within the disposal site.

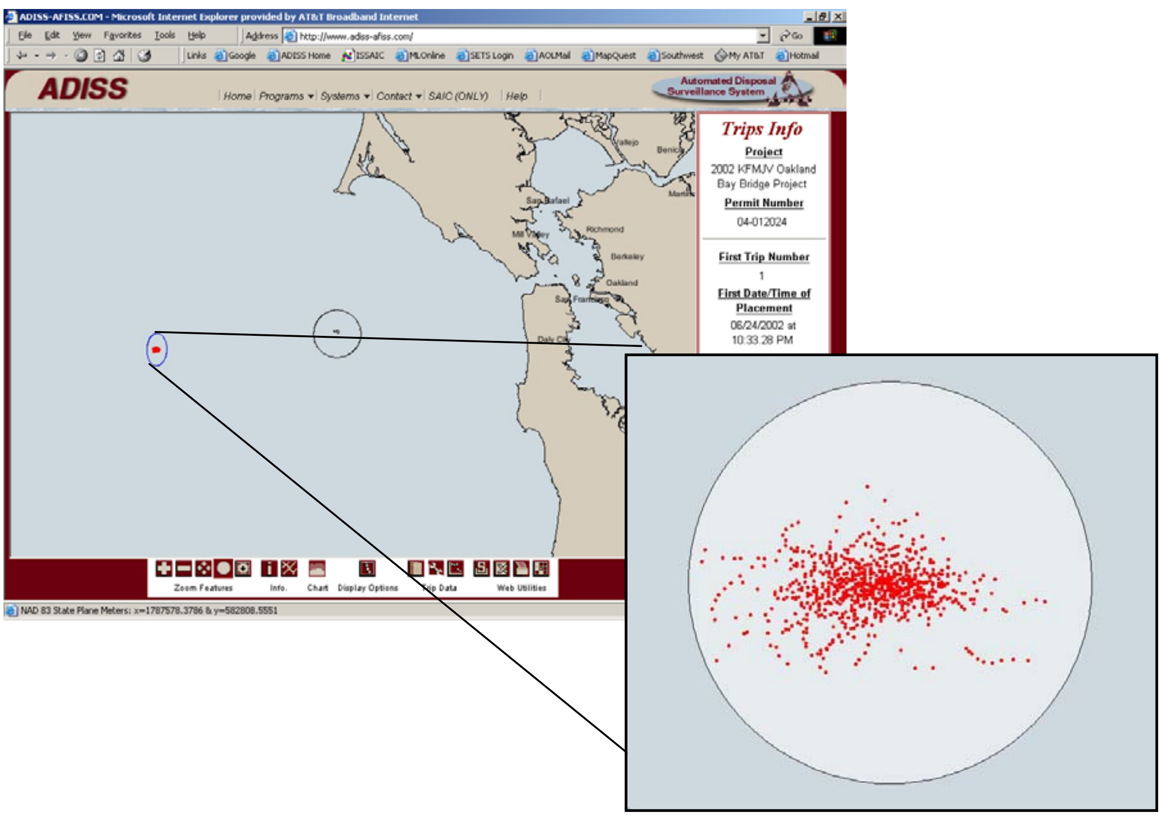


Figure 8. Disposal points for all 170 trips as displayed by the ADISSWeb system for the 2002 KFMJV Oakland Bay Bridge Dredging Project.

6.0 DISCUSSION

Since the monitoring system must satisfy the requirements for permit verification, the following questions are key to a successful project:

1. What types of data should be collected ? (e.g. position, draft, bin level)

   Projects involving transportation of dredged materials through environmentally sensitive areas, such as marine sanctuaries, should require a scow-based monitoring system with at least one draft sensor, located preferably aft. If draft and bin measurements are recorded and transmitted with a scow-based system, then leakage and placements can be determined and compliance can be verified.

   A scow-based system should also be utilized where the non-random placement of dredged material is needed to remediate a previously contaminated disposal site or disperse the material evenly over the sea floor. Scow-based systems have been demonstrated as effective tools for deep water capping operations.

   Conversely, a tug-based system does not include draft-sensing equipment on the scow, and leakage cannot be reliably determined. A tug-based system may be suitable for a short-duration project involving transportation of small amounts (less than 250 cubic yards per load) of suitable dredged material to a large in-bay disposal site, where random placement is acceptable.

2. Does the system record accurate scow position and draft ?

   Systems should record GPS positions and differential correction for SFDODS and other offshore disposal operations with an accuracy of 10 feet. For other projects with less restrictive requirements, such as for large, in-bay disposal sites, the EPA could specify GPS positional accuracy within 30 feet.

   Draft sensors should be accurate within 2-3 inches for the system to be capable of leak detection during transit. The monitoring system should average multiple sensor signal outputs, and eliminate the display of vessel heave in the detection of potential leakage.

3. Is the system capable of recording information in the required standardized format for the project ?

   Scow-based systems should acquire data in the standard format approved in the permit. No system should be used unless the database conforms to the standard, otherwise it will remain as difficult as previous databases have been to plot and verify compliance. The goal of adopting a standardized database should be to eliminate problems, and create a seamless flow of data from the vessels to the viewing program.

4. Is there a need for a helmsman display to avoid transits across areas of concern (e.g. marine sanctuaries) ?

A helmsman system should be employed for the accurate placement of dredged material within sites located offshore. Project disposal sites adjoining environmentally sensitive areas should require a helmsman display to avoid trespassing. The system should include wireless transmission and automated processing of track line data to display vessel course to and from the disposal site.

5. Is there a need for information to be transmitted quickly for review by the dredging contractor, site manager or regulatory agencies?

   Systems that transmit position and draft information to the Internet for visual confirmation of regulatory compliance should be utilized when verification of leakage and proper placement are required on a near real-time basis. One system has been demonstrated in San Francisco Bay during 2002, which has produced displays of misplacements and leaking scows to both the site managers and the dredging contractors. The early detection and quick correction of operator errors and scow equipment malfunctions can potentially eliminate or reduce post-project enforcement actions, and reduce the financial risks to contractors.

6. Can monitoring system malfunctions be quickly discovered and corrected ? (e.g. erroneous disposal site coordinates and component failures.)

   Wireless communications and automated alarms can be used to monitor system performance, and correct some problems remotely. A faulty monitoring system can be quickly detected through wireless communications, and reported via automated alarms to service technicians. Correction of many problems can be effected through wireless communications without expensive service visits to the dredge site. Like wise, a required monitoring system can be programmed to self-check proper function prior to each transit, and would reduce the risk of plant production shut down to replace inoperable components. A system, which is portable, wireless and supported by automated alarms, provides a cost-effective solution to many existing project requirements.

   Manually serviced systems without wireless data transfer rely on visual indicators of system performance, which are often ignored by distracted tug operators or dredge personnel. If data is downloaded on a weekly or daily basis and not plotted, indications of a failed battery or sensor may appear only after several trips have been made with the inoperable system. These cases will lead to infractions of permit and contract conditions, and fines. An engineer assigned to manually check and operate the system is more expensive than the installation of a helmsman system, equipped with wireless communications and automated alarms.

7. What is the reliability of the system to provide information for compliance verification ?

   The reliability of different electronic monitoring systems should be determined for approval prior to implementation on a project. Systems with low dependability and high maintenance should be avoided. Initial cost savings for an inexpensive system, which has not been tested and proven can result in higher maintenance and troubleshooting costs along with the possibility of fines and production delays due to system failure. System reliability is key to approval for monitoring, and should be withheld until the technical problems have been solved, and system reliability has been demonstrated.

8. How important is the cost of the monitoring system ?

   The cost of monitoring has shown to be consistently less than that of fines levied for non-compliance. When possible, certain requirements may be waived by EPA on a project-by-project basis. After consideration of environment sensitivity of the project, cost considerations will be taken into account. Non revenue-generating municipal entities with small dredging needs will be considered on a different basis than the large revenue-generating entities such as major ports and marinas.

In summary, advancements in technology, improvements in wireless communications, and the availability of third-party services have recently enabled effective solutions for monitoring of dredge material disposal performance. The monitoring systems deployed during the 2000-2002 dredging demonstrations for the EPA and the Corps, have proven to be reliable and cost-effective monitoring solutions. The various configurations of software and hardware available from vendors can be successfully tailored to meet the EPA and the Corps project requirements for electronic monitoring.

7.0 REFERENCES

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