RETAINING WALL INVENTORY AND CONDITION ASSESSMENT PROGRAM (WIP)

National Park Service Procedures Manual

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Federal Highway Administration

Federal Lands Highway

Commitment to Excellence

Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

FOREWORD

The National Park Service (NPS) is responsible for the management and maintenance of nearly 5,500 miles of paved roads and parkways across more than 250 park properties nationwide. In addition to the primary pavement asset, the NPS is also responsible for appraising and managing deferred maintenance needs of numerous subsidiary roadway features, including bridges, retaining walls, culverts and traffic barriers. Referred to as "equipment" in asset management parlance, these features are major contributors to the safety and accessibility of the NPS roads system and represent substantial roadway infrastructure investments. Given the wide range of geographic settings and public usage comprising the NPS network of roads, defining the backlog of roadway equipment is a major challenge to the park program.

The Federal Lands Highway (FLH) of the Federal Highway Administration (FHWA), in partnership with the National Park Service (NPS), has undertaken the development of a comprehensive retaining wall asset inventory and condition assessment procedure as part of the NPS Retaining Wall Inventory and Condition Assessment Program (WIP). The purpose of this program is to define, quantify, and assess wall assets associated with park roadways in terms of their location, geometry, construction attributes, geotechnical and structural condition, failure consequence, cultural aspects, apparent design criteria, and cost of structure maintenance, repair or replacement. In support of the WIP, this Procedures Manual documents the data collection and management processes, wall attribute and element definitions, and team member responsibilities for conducting retaining wall inventories and condition assessments based on nearly 3,500 wall assessments conducted to date within 32 national parks across the country. Although primarily intended to serve the WIP as it moves forward, this manual should find application within a broader national audience as federal, state and local agencies tackle retaining wall asset issues tied to transportation infrastructure.

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Notice

Quality Assurance Statement

Cover Photos: Complex stone masonry earth retaining structures at Glacier National Park (top) and Ranier National Park (bottom).

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16. Abstract

The Federal Lands Highway (FLH) of the Federal Highway Administration (FHWA), in partnership with the National Park Service (NPS), has undertaken the development of a comprehensive retaining wall asset inventory and condition assessment procedure as part of the NPS Wall Inventory Program (WIP). The purpose of this program is to define, quantify, and assess wall assets associated with park roadways in terms of their location, geometry, construction attributes, geotechnical and structural condition, failure consequence, cultural aspects, apparent design criteria, and cost of structure maintenance, repair or replacement. In support of the WIP, this Procedures Manual documents the data collection and management processes, wall attribute and element definitions, and team member responsibilities for conducting retaining wall inventories and condition assessments based on nearly 3,500 wall assessments conducted to date within 32 national parks across the country. The WIP is supported by several key developments described in this manual, including a comprehensive training program for field inspectors, an MS Access-based database, unique data collection forms, a supporting field guide, and a wall repair/replace cost estimation guide. Although primarily intended to serve the WIP as it moves forward, this manual should find application within a broader national audience as federal, state and local agencies tackle retaining wall asset issues tied to transportation infrastructure.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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ACRONYMS

Acronym	Definition	Acronym	Definition
AASHTO	American Association of State Highway Transportation Officials	HALE	Haleakala National Park
ACAD	Acadia National Park	HOSP	Hot Springs National Park
ADT	Average Daily Traffic	IMR	Intermountain Region
AKR	Alaska Region	LCS	List of Classified Structures
BAWA	Baltimore Washington Parkway	MEVE	Mesa Verde National Park
BIP	NPS Bridge Inspection Program	MORA	Mount Rainier National Park
BISO	Big South Fork National River and Recreation Area	MSE	Mechanically Stabilized Earth
BLRI	Blue Ridge Parkway	MWR	Midwest Region
BRCA	Bryce Canyon National Park	NATR	Natchez Trace National Park
CAVO	Capulin Volcano National Monument	NBIS	National Bridge Inventory System
CFLHD	Central Federal Lands Highway Division	NCR	National Capital Region
CMU	Concrete Masonry Unit	NER	North East Region
COLM	Colorado National Monument	NPS	National Park Service
CRLA	Crater Lake National Park	OLYM	Olympic National Park
CRV	Cost-to-Replace Value	PWR	Pacific West Region
DEWA	Delaware Water Gap National Recreation Area	QA	Quality assurance
DOT	Department of Transportation	QC	Quality control
EFLHD	Eastern Federal Lands Highway Division	RIP	NPS Road Inventory Program
ERFO	Emergency Relief for Federally Owned Roads	ROMO	Rocky Mountain National Park
FCI	Facility Condition Index	SEKI	Sequoia and Kings Canyon National Parks
FHWA	Federal Highway Administration	SER	Southeast Region
FLHD	Federal Lands Highway Division	SHEN	Shenandoah National Park
FMSS	Facility Management Software System	UV	Ultraviolet Radiation
FTP	File Transfer Protocol	WASO	Washington Administrative Support Office
FW	Fill Wall	WFLHD	Western Federal Lands Highway Division
GLAC	Glacier National Park	WICA	Wind Cave National Park
GOGA	Golden Gate National Recreation Area	WIP	Wall Inventory Program
GPS	Global Positioning System	YELL	Yellowstone National Park
GRSM	Great Smoky Mountains National Park	YOSE	Yosemite National Park
GWMP	George Washington Memorial Parkway	ZION	Zion National Park

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The NPS Retaining Wall Inventory and Assessment Team would like to thank Mr. Butch Wlaschin, Director, Federal Highway Administration Office of Asset Management, and Mr. Mark Hartsoe, Chief, National Park Service Park Roads and Parkways Program, for their support and guidance throughout the development and implementation of this valuable program. In addition, we would especially like to thank the numerous Park Superintendents, Facility Managers, Resource and Maintenance staff throughout the inventory parks for their enthusiastic participation, support and safe implementation of the WIP. Finally, we would also like to thank the FHWA Resource Center and Federal Lands Highway Division technical and management staffs for their efforts to merge cross-functional skills across division offices for the successful delivery of the first-ever earth retaining structure inventory and condition assessment in our nation's national parks.

CHAPTER 1 – INTRODUCTION

This Procedures Manual documents the data collection and management processes, wall attribute and element definitions, and team member responsibilities for conducting retaining wall inventories and condition assessments as part of the National Park Service (NPS) Retaining Wall Inventory Program (WIP). The procedures described herein are based on a multi-phase development effort involving:

- Reviews of similar programs undertaken by state transportation departments and municipalities;
- Development of a customized retaining wall inventory and assessment program aligned with specific NPS asset management requirements;
- Piloting of the proposed data collection methodology at several parks nationwide; and
- Completion of inventories within 32 National Parks, Monuments, Recreation Areas, Parkways and Seashores accounting for nearly 3,500 retaining walls within the WIP database.

Although primarily intended to serve the Wall Inventory Program as it moves forward, this Procedures Manual should find application within a broader national audience as federal, state and local agencies tackle retaining wall asset issues tied to transportation infrastructure.

Figure 1. Photo. Two-man inventory team measures and assesses the condition of a mortared stone masonry gravity fill wall, with integral guardwall parapet, at Mount Rainier National Park.

1.1 PURPOSE AND NEED FOR A WALL INVENTORY PROGRAM

The National Park Service (NPS) is responsible for the management and maintenance of nearly 5,500 miles of paved roads and parkways across more than 250 park properties nationwide. In addition to the primary pavement asset, the NPS is also responsible for appraising and managing deferred maintenance needs of numerous subsidiary roadway features, including bridges, retaining walls, culverts, traffic barriers, signage, lighting facilities, etc. Referred to as "equipment" in asset management parlance, these features are major contributors to the safety and accessibility of the NPS roads system and represent substantial roadway infrastructure investments. Given the wide range of geographic settings and public usage comprising the NPS network of roads, defining the backlog of roadway equipment is a major challenge to the park program.

The purpose of the Wall Inventory Program is to define, quantify, and assess retaining wall assets associated with park roadways in terms of their location, geometry, construction attributes, condition assessment, failure consequence, cultural aspects, apparent design criteria, and cost of structure maintenance, repair or replacement. The main intent of this effort is to determine the backlog of needs associated with retaining wall assets – equipment features ascribed to the "parent" roadway asset, which is defined and evaluated under the NPS Road Inventory Program (RIP). Prior to development of the WIP, the vast majority of retaining walls were not accounted for in the park asset management program. Based on WIP inventory work to date, NPS wall assets are valued at well over $400M.

Ultimately, condition assessments for retaining wall structures are expressed as deferred maintenance costs, which are then divided by current year replacement costs to arrive at a "Facility Condition Index" (FCI). Coupling this condition prioritization index with an "Asset Priority Index" (API), which measures the feature's importance to the mission of the park, capital asset investments are made more efficiently. This approach appropriately focuses maintenance and construction priorities on value, rather than solely on cost. Wall inventory condition and cost data are readily transferred from the WIP database to the NPS Facility Management Software System (FMSS), the primary asset documentation, management and planning platform maintained at each park. In addition, wall data are also provided to the Road Inventory Program to update equipment assets associated with the parent roadway asset. Bridge, culvert and traffic barrier data are also provided to FMSS and RIP via other inventory programs.

This asset inventory program has been commissioned at the request of the NPS Washington Office (WASO), Park Facility Management Division. The program is supported by both NPS WASO personnel and staff from the Federal Lands Highway Division (FLH) of the Federal Highway Administration (FHWA). NPS personnel are primarily responsible for integration of WIP wall data within the FMSS asset management system, while FLH personnel have taken the lead for delivery of field inventories. Similar to the RIP, it is the intent of the wall program to periodically reassess retaining wall resources at program parks to ensure timely, accurate information is available to support NPS asset management initiatives and park resource planning and maintenance activities. Thus, the WIP is ultimately for the purpose of asset management.

1.2 BACKGROUND OF PROGRAM DEVELOPMENT

The Wall Inventory Program has been developed and initially delivered under three well-defined phases of work. Phase 1 investigated the feasibility of developing and conducting retaining wall inventories for the NPS, ultimately providing specific recommendations for inventory methods and practices supporting the needs of the FMSS asset program. This initial phase concentrated on the following key program subjects:

- *State-of-the Practice Literature Review*: Summary of current efforts by federal, state, and local agencies to develop retaining wall inventory programs. Aside from the current NPS road and bridge inventory programs, variations of wall inventories were evaluated from seven state departments of transportation and one municipality.
- *Wall Types, Definitions and Associated Costs*: Identification of the range of wall types and components to be encountered on park roads; development of wall and adjacent feature definitions; preliminary estimation of costs for wall rehabilitation, repair and replacement.
- *Inventory Scope*: Determination of inventory size and breadth to reliably characterize the NPS retaining wall asset base.
- *Information Tracking*: Development of a wall data collection scheme that is consistent with existing bridge and road inventory programs and supports the long-term needs of FMSS.
- *Risks Associated with Poor Wall Performance*: Development of an assessment methodology that defines wall component distresses and describes modes of failure and poor performance.
- *Cultural Resource Considerations*: Development of procedures to determine when a wall should be considered a cultural resource, and how cultural considerations should be incorporated in wall assessments and repair/replace recommendations.

Figure 2. Photo. Assessment of a culturally significant culvert headwall at Acadia National Park.

Phase 1 resulted in an interim report published by FLH in April 2005, entitled "National Park Service Retaining Wall Inventory and Assessment – Phase 1 Report." This document is available from the Geotechnical Group, Central Federal Lands Highway Division, FHWA, Lakewood, CO.

Following Phase 1 review and concurrence by contributing agencies in early 2006, work was initiated under Phase 2 to develop, refine, and test data collection methods and processes. Program efforts focused on the refinement and definition of approximately 65 wall attributes; development of field data collection procedures, field forms, field guides and general cost information; advancement of FMSS data management and transfer processes; and the development of a fully searchable database using Microsoft Access and Oracle platforms. Several developmental pilot studies were conducted during Phase 2, beginning with Sequoia and Crater Lake National Parks during the summer of 2006. Full-scale production pilots were conducted in late-2006 at Wind Caves, Zion and Mesa Verde National Parks, Capulin Volcano National Monument, and Delaware Water Gap National Recreation Area.

Data collection, storage, and transfer methods and processes were finalized in March 2007 prior to initiating full-scale park inventories under Phase 3. Program training was also provided at that time to approximately 25 inventory participants, including multi-disciplinary engineers and support staff from the NPS and the three FLH division offices. Phase 3 fieldwork began in April 2007 and concluded in November 2008, with inventory teams completing assessments on nearly 3,500 retaining walls in 32 NPS properties across the U.S. This initial inventory effort, believed to encompass the majority of retaining wall structures within the parks system, serves as the basis for updated program developments included in this Procedures Manual.

1.3 A PROGRAM PERSPECTIVE ON DEFERRED MAINTENANCE

"Deferred maintenance" is the practice of allowing infrastructure to deteriorate by postponing prudent but non-essential repairs to save cost, labor and/or material. Although a policy of continued deferred maintenance will generally result in higher repair costs or structure replacement due to failure than if normal maintenance had occurred, deferring maintenance until structure deterioration begins to accelerate can be cost-beneficial to an organization seeking to optimally divert maintenance funds to other priorities or projects. Competition between annual maintenance and project funds drives the need for quantitative asset management to identify these priorities, and underlies the justification for periodically assessing and monitoring structure condition and performance over its service life.

> The ultimate goal of the asset management program is to determine at what point in time maintenance dollars are best spent to sustain structure performance, extend service life, and avoid extensive repairs and/or replacement of structure elements.

In the Wall Inventory Program a measure of deferred maintenance prioritization is not determined until the wall condition assessments are uploaded to the NPS FMSS asset management system – when the aforementioned Facility Condition Index is calculated based on required maintenance/repair/replace costs versus the structure replacement cost. As a result, the FLH inventory field team acquires only a limited knowledge of the park's scheduled maintenance activities before assessing wall condition and performance. Therefore, *the focus of the WIP inventory is less on park-scheduled preventive maintenance activities and more on re-establishing and/or maintaining required wall performance through non-routine maintenance, wall repair, and wall replacement.* Although this approach may not follow the strict definition or intent of a deferred maintenance program, retaining walls are typically long-life structures where deterioration and loss of performance occurs gradually over many years. Within an approximate10-year inspection cycle, for example, it can be expected that significant wall deficiencies – those requiring action prior to the next inspection – will be appropriately expedited within annual maintenance budgets.

In some cases, it can be a challenge for the inventory team to discern whether the deterioration of a wall element warrants some type of action, particularly when the element condition history is not known. Limiting the term of consideration to the next inspection, rather than requiring the inspecting engineer to evaluate wall elements based on the life expectancy of the structure, helps to focus non-routine maintenance and repair activities on near-term performance issues. This approach allocates limited dollars where they can do the most good, and avoids high routine maintenance costs when wall performance may be only marginally improved.

Repointing of mortared stone masonry walls illustrates how the inspecting engineer should approach the issue of what constitutes a needed and justified wall repair within the Wall Inventory Program. To date, the WIP has evaluated nearly 3,500 retaining walls, with ~75% representing historic stone masonry and placed stone structures. Of that 75%, nearly a third are mortared structures, accounting for over 800 walls in the inventory. Most of these structures were built 60+ years ago, and although virtually all of the walls are showing signs of gradual deterioration, the vast majority is performing well. Over the service life of these structures it is common for mortared joints to show signs of shrinkage cracking and debonding from the rock, along with associated seepage throughout the height of the wall. Although the cracking may be extensive, the wall may show no additional signs of significant distress, such as bulging, rotation, toppling, settlement, etc., suggesting that the mortar is providing sufficient interlock to maintain wall stability (perhaps performing as a well-chinked, dry-laid stone wall). Without the benefit of several decades of wall performance experience, the inspecting engineer might be tempted to characterize shrinkage cracking following wall construction as a substantial deficiency potentially impacting service life and, thereby, warranting repointing of the entire structure (replacement of the outer 1-2 inches of mortar). However, the longer-term performance history of walls currently in the WIP database clearly shows that such cracking/debonding is, by itself, neither a performance issue nor a regularly occurring maintenance item, but rather an occasional repair item when coupled with other developing distresses. In this case, attempting to bring the wall back to its original, as-constructed mortared condition would have been an unnecessary maintenance expense since wall performance was not being affected – and an expense that could have been realized several times over the service life of the wall.

Since the Wall Inventory Program has only just begun, development of performance histories for the many wall elements captured by the inventory is still in its infancy. As the program moves forward, the distinction between regular minor maintenance and performance-related non-routine maintenance and wall repair will become more evident. In the meantime, the inspecting engineer needs to identify those deficiencies and distresses to wall performance that must be addressed in the near-term (before the next inspection) to mitigate more costly repair/replace measures.

1.4 RECOMMENDED INVENTORY AND ASSESSMENT CYCLE

The efficient management of retaining wall assets over their expected life cycle requires on-going, systematic performance assessment of all or a portion of the total asset inspected in the initial inventory. The period, breadth and depth of recurring wall assessments and manner in which future assessments may be undertaken (e.g., NPS and/or FLHD personnel) are a function of several considerations, including:

- **Reinspection Cycle Based on Total Asset Performance**: Of the approximate 3,500 walls inventoried in the Cycle 1 assessment, only about 1% required replacement and 3% required significant to substantial repair. Despite the 60+ year age of a majority of the total asset inventoried, the overall performance of retaining walls in the 32 parks inspected was very good, with a relatively low Facility Condition Index (FCI) as compared to other park assets.
- **Reinspection Cycle Based on Wall Type**: The total asset inventory is comprised of numerous wall types with different performance attributes and life-cycles. For example, a high percentage of the stone masonry walls built in the 30's and 40's are performing well today with little to no signs of significant deterioration, whereas a significant percentage of corrugated metal bin walls built in the 60's and 70's are indicating rapidly deteriorating metal facing elements. The inspection cycles for metal- and wire-faced walls may need to be shorter than for stone masonry walls to optimize life-cycle maintenance.
- **Reinspection Cycle Based on Wall Location**: Environmental factors can greatly impact wall performance. For example, some of the worst examples of wall deterioration in the Cycle 1 inventory were seen in concrete and metal-faced walls subject to coastal marine environments. Parks subject to high annual precipitation, extreme freeze-thaw cycles, and/or heavy, rapid vegetation growth are also highly susceptible to accelerated wall deterioration.
- **Reinspection Due to External Event/Park Request**: Qualifying emergency relief (ERFO) events, global geotechnical events (e.g., landslides), rapidly developing wall failures, recent wall construction in the park, etc. may also trigger the need for updated inspections.

In general, if the reinspection cycle is too short, the cost of the program quickly outweighs the benefits; too long, timely maintenance activities may be missed, seriously impacting effective life-cycle asset management. Based on the results of Cycle 1 inspections, indicating good overall health of the retaining wall asset within the 32 parks inspected, WIP reinspection should be based on the following recommendations:

(1) The total wall asset should be reinspected, per the following guidelines, on a maximum 10-year cycle;

(2) Reinspection of the total asset should include full assessment of walls with condition ratings less than 70 and/or walls with prior recommendations and associated work orders to replace wall elements or replace the entire wall;

(3) Spot checks should be done on walls with prior recommendations for Maintenance or Minor Repair;

(4) Walls previously identified as requiring Further Investigation should be fully reassessed, with investigation results reviewed and incorporated within the updated assessment (if available);

(5) Walls constructed since the previous inspection should be fully assessed and added to the park database; and

(6) Walls potentially impacted by qualifying ERFO events should be fully reassessed shortly following the event.

To the extent practical, FLH geotechnical and structural engineering personnel should conduct reassessments of at-risk walls, including walls rated in poor condition, walls with element(s) repair and/or replace work orders, and/or walls requiring additional investigation. Spot-checking can be most efficiently accomplished by park maintenance staff, and should be done on a more regular cycle (e.g., every 2-3 years) to identify developing problems.

1.5 TRAINING REQUIREMENTS

Retaining wall assessments are most commonly conducted by teams of two to three individuals knowledgeable in wall components and construction, and skilled in recognizing a wide range of element distresses and failure modes. Teams are generally led by a Geotechnical, Geological or Structural Engineer, and are supported by additional engineering or technical staff from the survey, design and/or construction disciplines. The primary goals of the team are to readily identify and consistently document the many factors contributing to a wall's overall condition and performance, and to then determine the appropriate course of distress remediation required, if any. Upon completion of the field inventory, team members are also responsible for entering wall data into the WIP Database and reporting FMSS information to park management.

To prepare for field evaluations, teams should be fully trained on the various components of the wall inventory program documented within this Procedures Manual, including:

- Park communication process and information gathering requirements prior to site work;
- Pre-field preparation, including acquisition of RIP roadway and Visidata information, BIP bridge information, and necessary field equipment, forms, etc.;
- Proper means for filling out inventory field forms, including a complete knowledge of the definition, intent, and application of each attribute and element within the form;
- Proper use and interpretation of the information contained within the WIP Field Guide;
- Proper use and interpretation of the information contained within the WIP Cost Guide;
- Use of the WIP database for entering/extracting field data and archiving wall photos;
- Park communication process and information delivery requirements following site work; and
- Management of key documents, including park communications, field forms, photos, etc.;
- Safety training.

The remaining chapters in this Procedures Manual contain detailed information regarding the various processes and procedures to be followed throughout a retaining wall inventory effort, including definitions for each of the inventoried wall attributes and elements. *Poor quality field assessments, including incomplete forms, minimal or non-descriptive element condition narratives, or similar deficiencies, are directly attributable to a lack of training on program requirements.* Therefore, it is imperative that all team members are well-versed on the contents of this Procedures Manual before undertaking field inventories. It is further required that team members practice, as a group, logging assessments on standard field forms for several different wall types prior to full-scale park inventory work. A full day of hands-on training will greatly expedite field work, assist team members in learning how to best work together, and ensure complete, consistent wall assessments from the onset. Refresher training should also be a part of every field inventory, with multiple inventory teams working together the first day in the park to ensure data collection and reporting consistency.

Figure 3. Photo. Safely accessing walls requires not only awareness of wall hazards but also specialized skills to mitigate risks encountered when conducting field inventories.

In addition to the aforementioned process and procedures training, teams should also participate in formal safety training. Retaining walls, by their very nature and often located in steep settings, are extremely hazardous structures to investigate. Safely locating and accessing walls begins with roadway safety precautions (e.g., proper signage, flagging, vehicle pull-offs, etc.), and further includes proper personal safety gear and the use of personal protective equipment when evaluating the wall structure (e.g., ropes and harnesses). Communicating safety concerns and needs with park personnel is also an imperative component of the inventory process – including not only wall access issues, but also awareness of potentially dangerous encounters with wildlife, insects and poisonous plants. The Team Leader is responsible for coordinating safety requirements with the team and park personnel, and for ensuring that team members know and understand their roles and responsibilities in practicing the highest standards of safety at all times during field work.

It cannot be overstated… ***Comprehensive team training is essential for safely conducting wall inventories and providing consistent, high-quality assessments of wall performance.***

1.6 PROCEDURES MANUAL ORGANIZATION

The remainder of this Procedures Manual focuses on the processes, methods and definitions supporting the NPS Wall Inventory Program. Chapter 2 describes pre-field, field, and post-field data collection, storage and transfer procedures, as well as the responsibilities of team members in carrying out effective, high-quality field assessments. In addition, Chapter 2 includes a brief overview of current data management practices – recognizing that information technology systems are ever-changing. Requirements for both wall assessment and field safety training are also described in Chapter 2. Chapter 3 presents wall acceptance criteria for determining whether a wall should be included in the inventory. In general, the criteria attempt to qualify walls for the WIP inventory program based on association with park roadways, contribution to roadway stability and safety, and wall geometry. Finally, Chapter 4 defines the many wall attributes and elements that are logged, measured, calculated or assessed during field inventories. Recognizing that there exists a vast range of wall settings and conditions in the field, this section offers guidance and examples for evaluating each wall attribute and element. Program letter templates, blank data forms, and detailed user and cost guides are provided in the appendices.

CHAPTER 2 – DATA COLLECTION PROCESS AND PROCEDURES

As previously mentioned, the Wall Inventory Program has aspects resident within both the FHWA Federal Lands Highway program and the National Park Service. FLH is responsible for collecting, documenting, storing and transmitting wall assessment data to the NPS who, in turn, is responsible for incorporating the information within the FMSS asset management system. With that in mind, this chapter is devoted to describing FLH data management processes and procedures; NPS FMSS processes and procedures are beyond the scope of this Procedures Manual, and are documented elsewhere. The following subsections outline the standards for performing wall inventory tasks, and are broken into four primary categories: **(1)** pre-field activities, **(2)** field assessment activities, **(3)** post-field activities, and **(4)** data management activities.

2.1 GENERAL INVENTORY AND ASSESSMENT PROCESS

Figure 4 identifies the four primary categories of activities comprising the Wall Inventory Program, and lists specific activities under each.

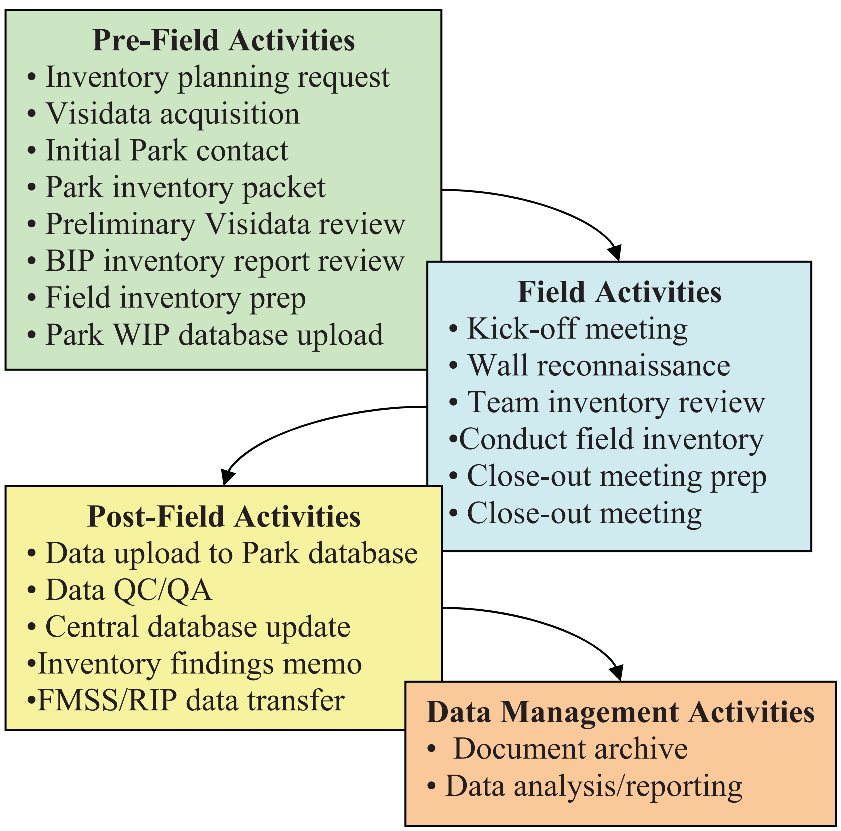


Figure 4. Graphic. Key activities within the four basic activities categories comprising the FLH Wall Inventory Program.

Pre-field activities generally include coordinating park inventory planning and information gathering, acquisition and review of Road Inventory Program (RIP) and Visidata information, assembling/checking required field equipment and inventory forms, and uploading the Park WIP Database from the Database Administrator. Field activities include holding a kick-off meeting with park facility, maintenance and/or FMSS staff; performing as-needed wall reconnaissance with knowledgeable park maintenance staff; conducting initial "calibration" wall inventories with team members to ensure consistency amongst the teams; conducting the remainder of the wall inventory (and interim database uploads); conducting a team review meeting to prepare for the park close-out meeting; and, finally, holding a close-out meeting with park facilities management. Post-field activities include uploading field data to the Park WIP Database (if not already completed in the field), updating the Central WIP Database, and submitting general findings to the park. Finally, data management activities include transferring FMSS data to and requesting data from the park FMSS coordinator, transferring final wall feature data to the RIP system, managing data archives, and responding to requests for database queries and reports.

Responsibilities for managing, completing and communicating each of these tasks falls to the FLH WIP Program Manager, Database Administrator, and/or Team Lead, as described in the following subsections. Providing consistent, high-quality field inventories, and ensuring the long-term security and accessibility of park wall data requires *all* contributors be fully trained on inventory procedures and program delivery expectations.

2.2 PRE-FIELD ACTIVITIES AND PROCEDURES

Several planning and coordination tasks need to be completed prior to arriving at the park. The success and expediency of field efforts hinges on the timely completion of each task, follow-up with inventory team and park personnel, and overall attention to detail. Pre-field activities goals include:

- Determining the early scope and schedule of the on-site wall inventory effort;
- Establishing roles and responsibilities of both inventory team and park personnel, generally pertaining to pre-site wall information collection, on-site reconnaissance support, and field inspection safety requirements; and
- Developing early site data to be included in the inventory, including route names and locations, estimated number of walls and their approximate locations and ages, general wall types and conditions, and cultural resource information.

The following subsections describe pre-field activities, identify responsible parties for task management and completion, and provide approximate task start times and durations prior to arriving at the park. Associated documents and forms referenced within the following subsections are available in Appendices A and B. Definitions of wall attributes, elements and location descriptors associated with the field forms referenced in this section are provided in subsequent chapters.

2.2.1 Inventory Planning Request

All park inventory work is requested by the NPS WIP Program Manager, with field inventory scheduling and staffing coordinated through the FLH WIP Program Manager. The FLH WIP

Program Manager is responsible for efficiently managing the WIP field program and scheduling inventories and resources to take best advantage of seasonal park access, personnel availability, and potential inventory economies, such as combining trips to nearby parks.

One to two months prior to site work, the FLH WIP Program Manager assigns a Team Lead and support staff to the inventory, and directs the Team Lead to initiate inventory planning with the park Superintendent and Facilities Manager. At the same time, the Program Manager notifies the Database Administrator of the tentatively scheduled inventory. From this point forward, the Team Lead is the primary party responsible for organizing and directing field teams, conducting the wall inventory/assessment, providing compiled field data to the Database Administrator, and delivering findings to park management

2.2.2 Visidata Acquisition

At the request of the Team Lead, and at least one month prior to site work, the Database Administrator requests the FLH Road Inventory Program Administrator to provide for each field team an external hard-drive loaded with the complete Visidata files for the park to be inventoried, as well as .pdf versions of the full RIP Route Inventory Report and associated Route Identification and Intersections listings (RIP Route listing example is provided in Appendix A). The Database Administrator quality checks the hard-drive files to ensure all reports are uploaded and all routes are available and viewing-operational in Visidata. The Team Lead further checks that each team has laptop resources loaded with the Visidata software, the hard-drives and park Visidata files are fully functional on each laptop, and team members are skilled in the use of Visidata and the identification/interpretation of WIP-required data.

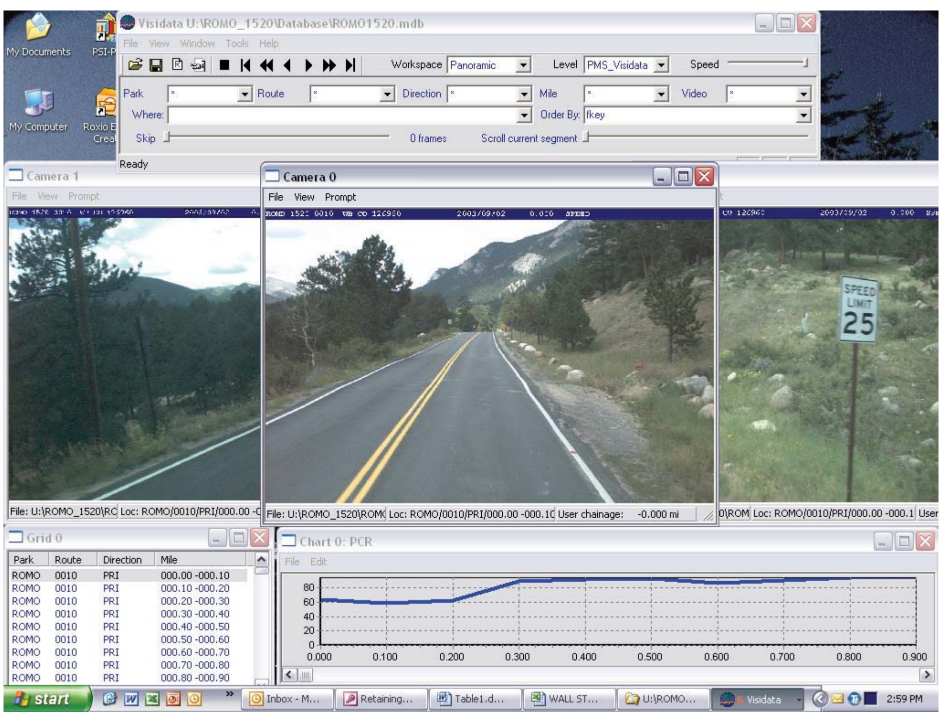


Figure 5. Graphic. Typical Visidata screen showing roadway video, milepoints, features, etc.

It should be noted that virtually all of the initial 32 parks inventoried in Phase 3 employed Visidata Cycle 3 road survey data. Future inventories will employ Cycle 4 roadway surveys. Cycle 4 will have milepoint reference changes to many, if not all, routes to eliminate rolling starts captured in Cycle 3. This survey change will result in variances to previously recorded wall start milepoints. The RIP version being used should be noted in all inventory documentation and the Park WIP Database, and wall milepoint locations should be updated during all future inspections (crosswalk of WIP data to Cycle 4 is underway now).

2.2.3 Initial Park Contact

One month prior to site work, the Team Lead contacts the park Superintendent and Facilities Manager to discuss the following:

- Authority, scope, processes, deliverables and general roles and responsibilities;
- Specific criteria defining park retaining wall structures to be inventoried;
- Tentative park inventory scheduling – respective of park commitments – including date, time and location of the park kick-off meeting (, anticipated duration of the field inventory, approximate date of the close-out meeting;
- Request for park personnel assistance, including pre-site questionnaire response, kick-off meeting attendance, wall reconnaissance support, traffic control support, and close-out meeting attendance;
- Listing of FLH and park personnel to conduct/support the wall inventory, including inventory team members, park FMSS and maintenance personnel knowledgeable in the park road construction history, etc.;
- Safety issues pertaining to safety planning and coordination, traffic control requirements, time-of-year traffic issues, wall access requirements, and potential wall/slope hazards;
- General listing of RIP and non-RIP routes and parking areas with retaining walls;
- Estimated number of walls in the park, and approximate locations;
- General types, sizes and ages of walls present, if known;
- General condition of walls, particularly noting recent or pending wall failures, substantive/recurring maintenance/repair, etc.;
- Acquisition of existing FMSS wall data, including wall locations, wall geometrics, equipment numbers and maintenance-repair-replace recommendations/costs;
- Cultural and environmental resource aspects of retaining walls and associated roadway corridors, including availability of supporting documentation and recommended park personnel contacts; and
- Availability of wall documentation, including as-builts, repair histories, cost data, and park-developed wall inventories.

Fully documenting each of these items is critical to a well-planned and successful field inventory. To assist the Team Lead in collecting this vital information during the interview, a “Pre-Inventory Phone Interview Checklist” is provided in Appendix A. Before closing the interview, the Team Lead should notify park management that an information request packet will be sent to them, including a cover letter recapping the scope and scheduling of the wall inventory, a draft kick-off meeting agenda, and a brief questionnaire regarding wall resources within the park (all of which is described under the next subsection).

Before wall assessments can be conducted, the inventory team needs to first locate qualifying earth retaining structures (as defined in Chapter 3 – Wall Inventory Criteria and Guidelines). The initial phone interview, and subsequent discussions with park personnel prior to arriving on site, is the first stage of a four-stage process to locate wall assets within the park. Phone interviews are followed by more detailed requests for wall counts and locations in the park wall inventory packet. Concurrent with the park request for information, an office review is conducted, including RIP route reports, Visidata video files, FLH Bridge Inventory Program (BIP) data, and available FLH as-builts. Finally, a pre-inventory park reconnaissance is undertaken following the kick-off meeting. Each stage helps to further identify and refine wall locations and draws on the several resources available to the program, including **(1)** park management, maintenance, and cultural staff experience; **(2)** existing park cultural resource and construction reports; **(3)** "home-grown" wall resource inventories; **(4)** previously compiled FMSS information; and **(5)** historic as-builts. Communicating this wall location process to park management during the initial phone interview is critical to engaging appropriate park personnel in the inventory planning process and, ultimately, developing a comprehensive wall inventory.

> Although wall location information is requested prior to the site visit, it is not uncommon for park staff to provide this information for the first time at the kick-off meeting.

2.2.4 Park Wall Inventory Packet

Immediately following the initial phone interview with park management, the Team Lead submits the following information packet and data request to the park Superintendent and Facilities Manager:

Cover Letter: As a formal follow-up to the phone interview, the authorization, purpose, scope, and proposed schedule for park inventory work are covered in a brief notification letter. In addition, park support is also solicited in compiling available wall information, completing the enclosed wall resources questionnaire, participating in on-site kick-off and close-out meetings, providing knowledgeable staff for wall reconnaissance, and assisting with traffic control and related wall access safety requirements. An example cover letter is provided in Appendix A.

Kick-Off Meeting Agenda: A draft kick-off meeting agenda is enclosed in the packet to ensure appropriate park staff are invited to the meeting and engaged at the onset of the field inventory. An example of the meeting agenda is provided in Appendix A, and is fully discussed in Subsection 2.3.1.

WIP Retaining Wall Questionnaire Form: Also enclosed in the packet is a brief retaining wall resource questionnaire to be circulated amongst knowledgeable park staff. The intent of the questionnaire, discussed during the initial phone interview, is to provide general wall information based on available knowledge; it is *not* a request for park personnel to formally recon, locate and/or describe walls prior to inventory team arrival. The information should be transmitted to the Team Lead prior to inventory team arrival at the park. At a minimum, the park should be prepared to discuss the requested information at the time of the kick-off meeting. An example of an appropriately completed questionnaire is provided in Appendix A. The questionnaire requests the following general information:

(1) What is the estimated number of walls in the park, and their approximate age?
(2) What specific routes/parking areas have retaining walls, and approximately where are they located along the route?
(3) Have any repairs been done to retaining walls, and is cost/repair data available?
(4) Do any cultural resource issues exist pertaining to walls, and is related information available?
(5) Does the park maintain any type of wall inventory or structures database?
(6) Are there any walls with serious problems, and where are they approximately located?

Figure 6. Photo. Multi-tiered soil nail wall under construction with decorative modular block facing. Without input from knowledgeable park staff, the wall inventory might overlook the soil nail reinforcing elements when evaluating the completed structure.

2.2.5 Preliminary RIP and Visidata Review

Following delivery of the full RIP Route Inventory Report and Visidata roadway video files, and prior to the site visit, the Team Lead (and other key team members, as appropriate) should review the available route/parking area information to further identify known and suspected wall locations. Numbered/named routes included in RIP and Visidata should be cross-checked with those noted during the phone interview and/or provided in the subsequent questionnaire sent to the park to identify routes and parking areas not covered by the RIP survey. Walls listed in the RIP Route Inventory Report roadway/parking area features tables and those located during a review of the Visidata video files should be logged on the Visidata Retaining Wall Location Form for quick reference once on site. An example of the Visidata form is provided in Appendix A. Wall information to be collected on this form includes:

- RIP route/parking area name and/or number, or park-designated route/parking area name if not in RIP;
- Side of road in which the wall is located when traveling in the direction of increasing RIP milepoints (or approximate location within the parking area);
- Approximate Visidata wall start and end milepoints (if available);

- Apparent wall function (e.g., fill wall, cut wall, etc.);
- Apparent wall type (e.g., MSE, crib, bin, soldier pile, etc.); and
- Comments regarding wall accessibility, general wall condition, etc.

Definitions for wall attributes, elements, and location descriptors are provided in subsequent chapters of this Procedures Manual. A copy of the Visidata Quick Start Guide, included in the required field documents list, but useful when conducting in-office Visidata reviews, is provided in Appendix B.

2.2.6 Field Inventory Prep

To ensure the inventory team is fully prepared, the Team Lead should hold a planning meeting 1-2 weeks prior to site work to review the wall information collected to date, plan for efficient route inventory scheduling, and discuss personal safety issues unique to the park environment (terrain, weather, insects, poisonous plants/animals, tourist traffic, etc.). The team should also review the following WIP information/equipment checklist (provided in Appendix A) to ensure *each team* is fully equipped for field inventory work:

Electronic Files

- WIP team and park contacts
- Park-provided wall inventory information and reports
- Visidata software uploaded to laptops (and tested)
- Park Visidata video files loaded to external hard drives (and tested)
- Visidata Retaining Wall Location Form (preliminary wall location information)
- Visidata Quick Start Guide
- Park WIP Database (Microsoft Access and supplemental programs loaded onto laptops and tested)
- WIP Field Inspection Forms
- WIP Field Guide
- WIP Cost Guide
- WIP Procedures Manual
- RIP Route Inventory Report (complete report – electronic file is backup to hard copy)
- RIP Route Identification Report (summary route listing)
- RIP Intersection Report

Hard Documents

- WIP Procedures Manual
- WIP Pre-Inventory Interview Checklist (phone interview notes)
- Park-provided wall inventory information and reports
- Park notification letter
- WIP Kick-Off Meeting Agenda (several copies for the meeting)
- WIP Retaining Wall Questionnaire (several copies, blank or what the park provided)
- Visidata Retaining Wall Location Form (preliminary wall location information)
- WIP Retaining Wall Reconnaissance Forms (several blank for field recon)
- WIP FMSS Data – Manual Input Procedure and Test Guide (copies for the park)
- FMSS Specification Data Template spreadsheet (several copies for meeting)
- Visidata Quick Start Guide

- RIP Route Inventory Report (complete report)
- RIP Route Identification Report (summary route listing)
- RIP Intersection Report
- BIP bridge inventory listing (with bridge numbers/names)
- WIP Field Inspection Forms (2x the anticipated number of walls, "Rite-in-the-Rain" paper)
- WIP Field Guide
- WIP Cost Guide (current year version)
- Park maps (from park website)

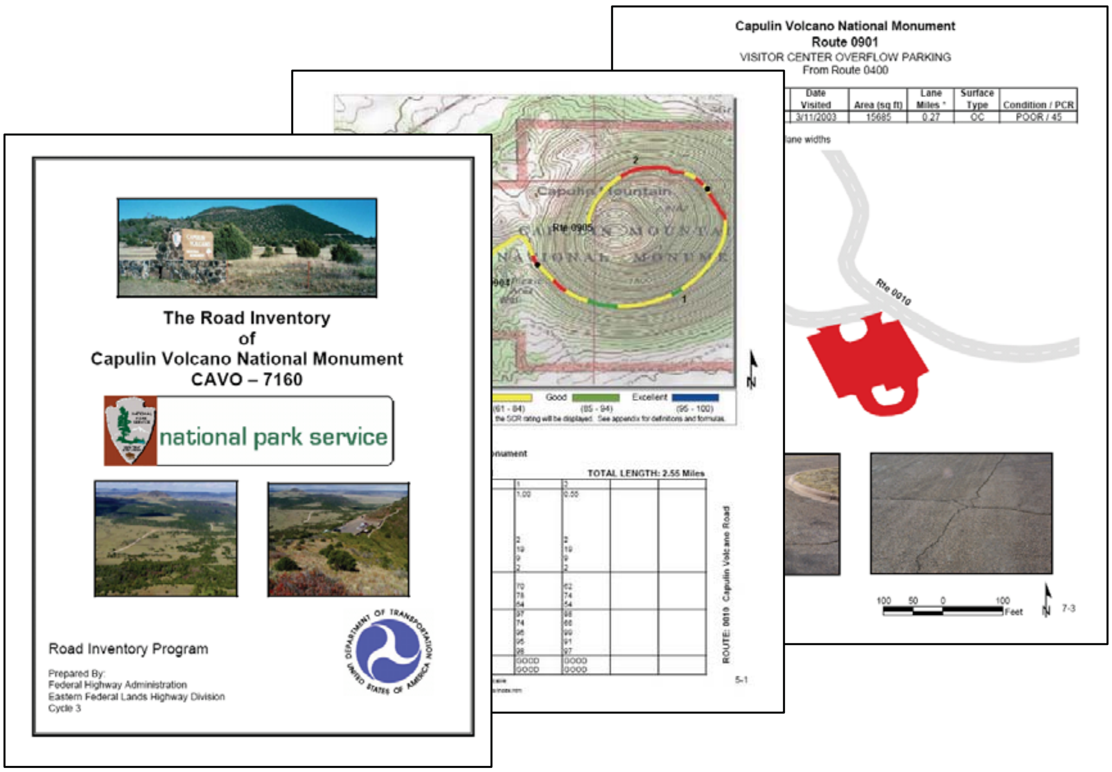


Figure 7. Graphic. Example of a RIP Route Inventory Report. This document is essential for all field inventory work as it contains complete route and parking area listings and locations, detailed route and parking area maps, and features tables providing useful Visidata milepoints for such things as visible retaining walls, guardwalls/guardrails, signs, etc.

Field Equipment

- Personal safety equipment (vest, hard hat, gloves, waterproof boots, first-aid, sunscreen, insect repellant, etc.)
- Climbing gear (safety harness, ropes, anchors, belay/ascension hardware)
- Laptop with writeable CD and ports for thumb drives, mouse, and external drives (two per team desirable)
- Thumb drive with backup electronic files
- External hard drives with Visidata and RIP Route Inventory Report files (tested)

- DC-to-AC power converter with two AC outlets for laptop and external hard drive
- Wall measuring tools (tapes – 25’, 100’, 300’, clinometers, distance meter, etc.)
- Enclosed metal clipboard (with Field Form, Field Guide and Cost Guide storage capacity)
- Calculator (two per team)
- Camera (two per team, with spare storage card)
- Misc. supplies (batteries, survey flagging, flashlight, toilet paper, etc.)

The Team Lead is also responsible for scheduling and coordinating transportation, lodging, and meeting times and locations for the inventory team. This is particularly important when multiple teams are working together in large, expansive parks.

2.2.7 Park WIP Database Upload

Although teams generally complete field form data uploads to the WIP database upon return to the office, it is recommended to upload data in the field whenever possible to improve day-to-day accuracy and consistency in recording wall condition and performance, and to provide data redundancy in the event field forms are misplaced or lost (field data management procedures are described in detail in subsection 2.3.3). The Database Administrator will provide the park-specific database to team members via an FLH FTP site, along with supplemental database programming, documentation and training. Team members must ensure that current versions of Microsoft Access are loaded on field laptops, and that the provided version of the Park WIP Database is functioning properly before traveling to the field. Additional information on database access and use is provided in Appendix D.

2.3 FIELD ACTIVITIES AND PROCEDURES

Upon arrival at the park, the inventory team is responsible for four basic tasks:

(1) Holding a kick-off meeting with park facilities, resource, maintenance and FMSS staff;
(2) Conducting a reconnaissance of wall resources with park maintenance staff;
(3) Conducting the wall field inventory and assessment for all park routes and parking areas; and
(4) Holding a close-out meeting with park facilities, resource and maintenance management.

All team members, to the extent practical, should participate in each of the four tasks to ensure walls are fully located and inventoried, and that inventory needs and findings are fully communicated to interested park personnel. Field inventory and assessment activities goals include:

- Engaging park facilities, resource and maintenance staff in generally scoping wall locations and conditions prior to wall inventory and assessment (final step in pre-locating walls prior to the inventory);
- Collecting required inventory data to accurately locate walls, describe wall types and geometrics, characterize wall elements and their condition, and determine if and what maintenance-repair-replace measures are needed; and

- Communicating wall condition and performance findings to park staff following the field inventory and assessment – particularly poorly performing walls that may represent a safety hazard to the traveling public.

The following subsections describe field inventory/assessment activities, and identify responsible parties for task management and completion. Supporting forms and documents are provided in Appendix B.

2.3.1 Kick-Off Meeting
A kick-off meeting is held with key park personnel before commencing wall inventory field work. Although park management may attend, kick-off meeting participation is generally limited to facilities, maintenance, resource, and/or FMSS staff directly responsible for managing the structural and cultural aspects of park retaining wall resources. Key meeting subjects include preliminary wall locations within the park, WIP wall assessment procedures, roadway traffic control, wall access safety requirements, reconnaissance planning, and reporting. More specifically, the meeting should include the following (an example meeting agenda is provided in Appendix A):

Overview of the NPS Retaining Wall Inventory Program
- Intent of the Wall Inventory Program:
  - To provide parks with information regarding roadway and parking area retaining walls for FMSS asset management.
  - To also provide FHWA with baseline retaining wall condition information to assist with future project analyses and development.
- General Site Inventory Procedures: Overview wall location, description, measurement, condition assessment, cultural resource, consequence of failure, required action, and work order considerations contained within the Inventory Field Form.
- Integrating Cultural Resource Needs: Review cultural/historic wall resource and roadway corridor issues, as well as wall maintenance-repair-replace considerations.
- Data Access and Management (FMSS): Overview FMSS Specification Data Template, park transmittal of equipment numbers to FLH, and data transmittal process and responsibilities.

Inventory Safety Practices
- Wall Data Collection Practices: Review wall measurement and assessment procedures, noting roadway and wall access requirements.
- Roadside Safety Practices: Review number of participating personnel, parking restrictions/practices, wall access issues, personal safety gear, designated traffic spotters, etc.
- Traffic Control: Discuss final traffic control plan, including signage, traffic cones, FLH/NPS flaggers/spotters, and identification of congested, high-traffic areas.
- General Fall Protection/Hazard Management: Discuss FLH wall access procedures (limited to top and toe of walls), recognition of rock fall hazards during wall access, and park-specific safety requirements.
- Communication Planning: Review emergency contacts/procedures and acquire park-provided radios.
- Park Entrance Passes: Arrange for park entrance passes (as needed), vehicle identification placards, and alerts to park security of inventory team activities.

Figure 8. Photo. Although signage is a key element of a minimum roadway safety plan, best practices require pulling vehicles well off the road at high-visibility locations, maintaining ample sight distance, using cones to delineate vehicles, and using flashers or roof-mounted safety lights.

Inventory Activities and Schedule Review

- Pre-Site Questionnaire Review: Kick-off meeting review of pre-site questionnaire results regarding general location of park retaining walls, location/condition of problem walls, and prep for wall reconnaissance with park staff.
- Wall Location Reconnaissance: Conduct maintenance staff interview (or other facilities knowledgeable park personnel) and perform park-wide wall reconnaissance.
- Wall Inventory/Assessment: Discuss general strategy for systematically conducting the inventory (including safety/traffic considerations), and refine wall inventory completion schedule.
- Close-Out Meeting: Arrange tentative close-out meeting schedule and required attendance.

During the kick-off meeting, the Team Lead should provide park staff with copies of the WIP Field Inspection Form, FMSS Specification Data Template spreadsheet, and the WIP FMSS Data – Manual Input Procedure and Test Guide (provided in Appendices B and C).

*****IMPORTANT*****
It cannot be overstated that ***conducting retaining wall assessments is hazardous work***. The kick-off meeting and subsequent wall reconnaissance with park staff are the best opportunities to identify potential safety hazards (e.g., steep slopes, rockfall onto lower roadways during wall inspections), establish park-specific safety practices and emergency procedures, and communicate and reinforce required safety measures with team members.

2.3.2 Wall Reconnaissance

Following the kick-off meeting, inventory teams should conduct a wall reconnaissance along assigned park routes and parking areas. Knowledgeable park maintenance or resource staff should accompany the teams to identify wall locations not readily visible from the roadway or parking area. Often, retaining walls, and particularly qualifying culvert headwalls, are obscured by vegetation, located well out of sight below road grade, exist in areas where earth retention requirements may not appear to be required (generally includes historic structures preserved by subsequent roadway construction), or blend in with the surrounding environment so well as to be potentially missed by the inventory team. Park staff can significantly increase the chances for capturing these hidden structures in the wall inventory. Park staff also greatly assist by interpreting available documents describing historic wall location/construction, translating past structure inventories (which are often not clearly associated with roadway features or mile markers), and relating wall performance observations over time.

When conducting the reconnaissance, teams should have at their disposal **(1)** the Visidata Retaining Wall Location Form listing previously identified wall features, **(2)** the RIP Route Inventory Report, **(3)** several Retaining Wall Reconnaissance Forms for logging identified walls (provided in Appendix B), and **(4)** supplemental maps of the park (though the route maps within the RIP Inventory Report may suffice). The reconnaissance is conducted as a drive-by "windshield survey" – rarely stopping to examine walls in order to expedite the review of what is typically many routes and parking areas. In some instances, it may be advantageous to flag wall starts with surveyors tape to assist in locating the walls during the inventory. Labeling the flagging with wall information also helps to distinguish it from other flagging used by the park. This is particularly useful when walls are located in areas of dense vegetation.

Information collected on the Reconnaissance Form includes:

- RIP route/parking area name and/or number, or park-designated route/parking area name if not in RIP;
- Side of road in which the wall is located when traveling in the direction of increasing RIP milepoints (or approximate location within the parking area);
- Approximate Visidata wall start milepoint (if available), or route milepost;
- Approximate wall length;
- Apparent wall function (e.g., fill wall, cut wall, etc.);
- Apparent wall type (e.g., MSE, crib, bin, soldier pile, etc.);
- Approximate year the wall was built; and
- Comments regarding wall accessibility, general wall condition, etc.

Wall reconnaissance can be very time consuming, so teams should plan accordingly when scheduling site inventory work. Team Leads should clearly communicate the intentions of the reconnaissance effort(s) to park staff well ahead of time to ensure staff resources are available, particularly in large parks where multiple, concurrent reconnaissance efforts may be required. When park resources are limited, the size of the park calls for multiple inventory teams, or remote wall locations require excessive drive times, the Team Lead may opt to conduct the reconnaissance concurrent with wall assessments to expedite the inventory schedule.

Once the reconnaissance is completed, the Team Lead should hold a team meeting to **(1)** cross-check and update wall locations with previously compiled RIP/Visidata locations, and **(2)** develop strategies for efficiently conducting the park wall inventory, focusing on wall types and conditions to be encountered and the development of appropriate work orders.

When conducting future wall inventories in parks with prior wall assessments, be careful to note the RIP cycle used to locate walls during the previous inspection. For Cycle 1 WIP, RIP Cycle 3 milepoint data was used. RIP Cycle 4 surveys were underway nationwide at the conclusion of the initial WIP inventory, requiring migration of Cycle 3 milepoints into the new Cycle 4 measurement system.

2.3.3 Wall Inventory and Assessment

Following the wall reconnaissance, inventory teams undertake a systematic process of inventorying and assessing wall conditions along RIP and non-RIP routes and parking areas per the qualification criteria and condition assessment guidelines presented later in this Procedures Manual. The inventory is further guided by the findings from the staff interviews, RIP/Visidata review, and park reconnaissance; however, additional walls will undoubtedly be located as teams systematically work their way along park roads. Teams should anticipate inflation of preliminary wall counts, particularly if numerous qualifying culvert inlet and outlet headwalls may be encountered (culvert headwall qualifications are described in Chapter 3).

Teams are generally comprised of two individuals, typically led by a Geotechnical, Geological or Structural Engineer and supported by engineering or technical staff from the survey, design and/or construction disciplines. Team members should be knowledgeable in wall components and construction, and skilled in recognizing a wide range of element distresses and failure modes. Team members should also be fully trained in WIP processes and procedures, and proficient in the use of the RIP Route Inventory Report, Visidata, and supporting field documentation.

Efficiently conducting wall assessments requires one person to assume the lead on locating walls with respect to Visidata features and milepoints/mileposts, measuring wall dimensions, and acquiring representative wall photos, while the other team member assumes the responsibility for recording static wall data, condition assessments, and recommended actions on the Field Inspection Forms. More specifically, teams are responsible for the following:

- Accurately locate the wall (park, route number/name, milepoint, etc.);
- Describe wall dimensions and features;
- Acquire descriptive photos;
- Rate the condition of the wall and its key elements, as well as the reliability of the data supporting the wall rating;
- Assess if further investigations are required;
- Determine the design criteria used to construct the wall (if any);
- Determine the consequences of wall failure;
- Determine whether the wall is a cultural resource or not;

- Determine the appropriate repair/replace actions (no action/monitor, maintenance, repair element, replace element, replace wall, and/or investigate);
- Develop an appropriate work order, as needed, estimating investigation, maintenance, repair, replacement costs; and
- ***Conduct all aspects of the inspection in a manner promoting safety amongst the team and traveling public***.

Figure 9. Photo. Inventory team members must work together to measure wall attributes, accurately describe and rate wall elements, and watch for unsafe conditions.

Wall inventory and condition assessment information is captured within the approximate 65 wall attributes and elements documented on the Field Inspection Form, examples of which are provided in Appendix B. Developing this information in the field is further supplemented by two companion documents: the WIP Field Guide – a quick reference guide for wall codes and condition assessment definitions, and the WIP Cost Guide – a compilation of general wall repair and replacement costs. Both of these documents are provided in Appendix B and further described in Chapter 4.

Although responsible for different aspects of the wall assessment, ***team members do not work independent from one another***. The team as a whole is responsible for producing a complete, accurate and quantitatively descriptive assessment of each wall inventoried. This requires that team members discuss and agree on wall conditions and recommended actions, and check each other's work products, ensuring all relevant elements of the Field Inspection Form are addressed. ***Inventory teams should not leave a wall site until the assessment is complete to the satisfaction of both team members*** and is ready for upload to the Park WIP Database – the first level of program quality control (QC). At no time should teams forego completion of Field Inspection

Forms or simply copy prior forms for similar wall types. This practice, although inviting when regularly encountering nearly identical structures (e.g., repetitive headwall features), leads to errors and inaccuracies, and diminishes the value and substance of the inventory.

To optimize inventory team efficiency and the quality of wall assessments, teams should implement the following quality control/quality assurance (QC/QA) practices at every park:

(1) *Post-Recon Inventory Practice*: Immediately following wall reconnaissance, and prior to initiating full-scale wall inventories, teams should assess several different wall types/functions as a group to ensure wall assessment methods and expectations are well understood, that consistent, highly descriptive condition narratives are being produced, and that appropriate work orders are being developed. **This effort is especially critical when multiple teams are inventorying a wide array of wall types in diverse settings throughout a large park.**

(2) *Daily Progress Reporting*: Teams should meet each evening to report daily progress, discuss wall findings and issues, and refine route inventory planning.

(3) *Regular Database Upload*: Teams should regularly upload wall data to the park WIP database to improve day-to-day accuracy and consistency in recording wall condition and performance, to expedite yet-to-be-completed wall assessments, and to provide data redundancy in case field forms are misplaced or lost. Teams commonly inventory between 15 to 25 walls per day, depending on drive times, weather, wall access, wall sizes, vegetation, etc. Over the course of a day, and throughout the course of the park inventory, teams will naturally refine wall descriptions and condition evaluations. Teams should strive for consistency in conducting and reporting wall assessments, requiring regular review and "fine tuning" of their work product as the inventory progresses. Uploading at least a portion of the wall data to the database every couple of days will help to achieve these goals (it simply may not be practical to load all of the data in the field). In addition, completing data uploads in the field avoids the potential for data entry to languish weeks after the field work was completed.

*****IMPORTANT*****
Providing high-quality, consistent wall assessments requires team members adhere to the data collection and reporting processes and standards presented in this Procedures Manual. Bear in mind that not only will the collected inventory information support current NPS FMSS asset management initiatives, but it also serves as the foundation for future park wall inventories.

2.3.4 Close-Out Meeting

At the conclusion of the wall inventory, the Team Lead, and preferably the entire inventory team, meets with park facilities, maintenance and resource staff to review preliminary findings, reiterate FMSS specification data table and equipment number transmittal requirements, and briefly discuss the contents of the forthcoming findings memorandum to be submitted to the park Superintendent and Facilities Manager (discussed in subsection 2.4.3). In addition, and most importantly, ***park staff is informed of any walls exhibiting severe distress, that are actively failing, or that represent significant short-term capital expenditures or risks to public safety***. If

park staff are not available to meet at the end of the field inventory, the Team Lead should teleconference with interested park staff as soon as possible following return to the office.
To make the most of the close-out meeting, team members should meet before the meeting to compare notes and list specific issues to be transmitted to park staff. This is also a good time to double-check that all roads and parking areas were covered by the inventory.

Before leaving the park, the Team Lead should ensure that all traffic control signage and cones, park radios, vehicle placards, etc., are returned to the park in working order.

2.4 POST-FIELD ACTIVITIES AND PROCEDURES

Post-field activities include uploading field data to the Park WIP Database (if not already completed in the field), updating the Central WIP Database, submitting general findings to park management, transferring FMSS data to the park FMSS coordinator, transferring final wall feature data to the Road Inventory Program (RIP), and managing data archives and requests for database queries and reports. Post-field activities goals include:

- Capturing, maintaining and reporting wall data in an efficient, safe, quality-assured manner that allows flexible interfacing with FMSS and RIP databases; and
- Supporting FMSS and RIP program needs and inventory reporting.

Supporting forms and documents are provided in Appendix C. The WIP Database Users Manual is provided in Appendix D.

2.4.1 Field Data Upload to Park WIP Database

Although it is recommended to complete wall data uploads to the Park WIP Database in the field (or at least a large portion of the wall data), teams often opt to perform this task upon return to the office. In either event, a system of quality checks (QC) and quality assurance (QA) needs to be followed to ensure the final database presents a complete and consistent representation of wall features, conditions, and recommended actions. Although the WIP database automatically employs a system of basic quality checks, including missing, invalid or conflicting data fields/formats, the database cannot discern between correct/incorrect measurements or complete/incomplete condition narratives. It is the responsibility of the team member to ensure measurements are accurate, wall descriptors are correct, and narratives are concise and informative. Additional guidance on documenting wall data is provided in Chapter 4.

In general, the following QC/QA approach is recommended:

- Team members are responsible for uploading the Field Inspection Forms they recorded. This allows the team member a final opportunity to make corrections and refinements for accuracy and consistency (and avoids obvious problems with reading others handwriting).
- Wall data should be uploaded to the WIP database as soon as possible. Opportunities for quality improvements diminish with the passage of time, so every effort should be made to upload the wall data immediately upon return to the office (preferably already completed in the field).
- If the responsible team member is assisted by others in uploading the field forms, the responsible team member performs a final quality check, comparing each field form to the

uploaded database, before submitting to the Database Administrator (this method of data upload is the least desirable, and commonly results in errors and inconsistencies).

- Each Field Inspection Form is initialed and dated by the individual responsible for adding the data to the WIP database and archiving the hard copy. This ensures that all walls are included in the database, and allows quality discrepancies to be quickly resolved.
- The Database Administrator compiles the Park WIP Database and conducts a second quality check to ensure **(1)** that recorded wall measurements appear reasonable, and **(2)** that condition narratives are well-composed, descriptive, and reasonably consistent from one team member to the next.
- The Database Administrator then provides wall summary reports to the Team Lead for a final quality check. The Team Lead spot checks database condition narratives and thoroughly reviews all work orders for completeness and accuracy.
- The Team Lead formally assures database quality by preparing the Inventory Findings Memorandum.

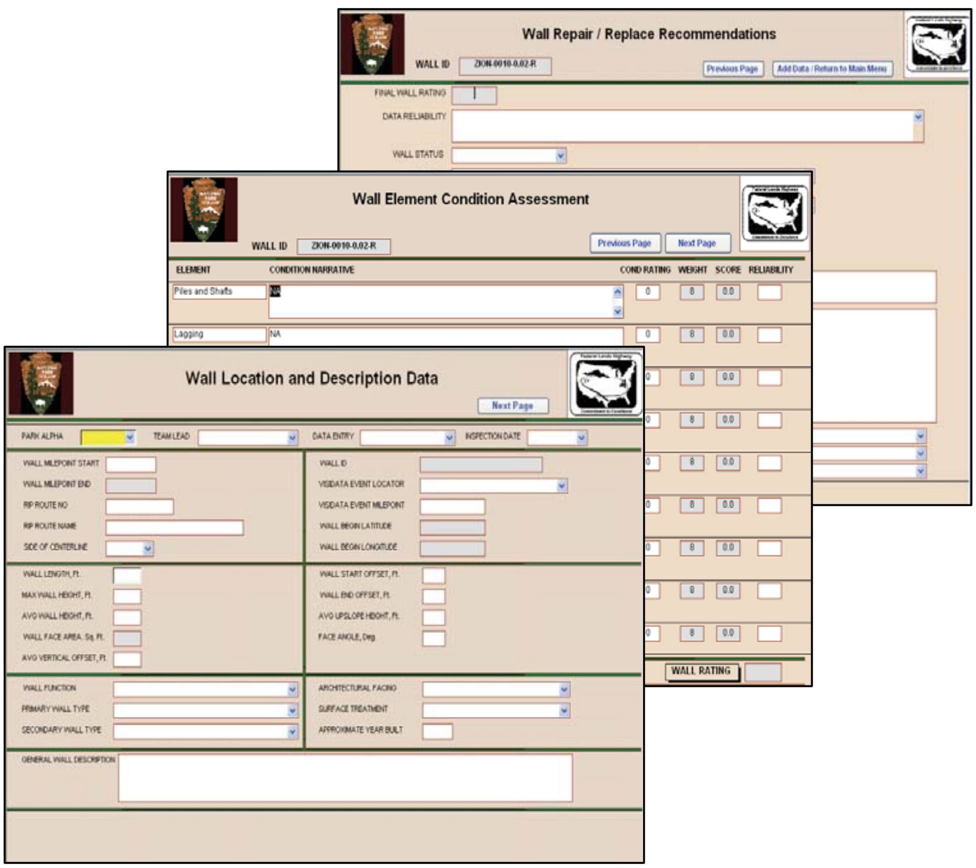


Figure 10. Graphic. The WIP database 3-page architecture follows the general flow of wall attribute and element documentation on the Field Inspection Form.

As previously noted, the Database Administrator is responsible for providing the Park WIP Database to the team, as well as supporting its use and update. Specific information on database access and use is provided in Appendix D.

*****IMPORTANT*****
Field data has a "shelf-life". The quality of field inventories is directly proportional to the effort made in the field to write concise and descriptive condition assessments, assure that assessments are consistent throughout the field inspection, and expeditiously upload the data to the Park WIP Database. Every effort should be made to complete as much of the work in the field as possible to avoid data refinement and database uploading from languishing once in the office.

2.4.2 Central WIP Database Update

Once the Park WIP Database is completed, the Database Administrator merges the information into the Central WIP Database, along with photo files updated to reflect park wall ID numbers and archive documents. Once uploaded to the Central WIP Database, changes or edits should be provided to the Database Administrator as written and initialed changes to the original Field Inspection Forms. Electronic edits/changes within the database should not be made in lieu of documenting changes/edits on the Field Forms.

The Central WIP Database is resident at the Central Federal Lands Highway Division (CFLHD) office in Lakewood, CO, and is supported by the CFLHD Information Technologies group. The Database Administrator is responsible for managing all system upgrades or changes to the database architecture or platform, and is currently the main point of contact for all ad hoc database queries and reporting. A web-based interface for conducting user-defined database queries may soon be available allowing team members easy access to the Central WIP Database without having to submit requests through the Database Administrator. Additional information on the structure of the database system and management protocols is provided in the WIP Database Users Manual, located in Appendix D.

2.4.3 Inventory Findings Memorandum

Once the Park WIP Database is uploaded and all QC/QA checks have been completed, and preferably within a month of completing the field inventory, the Team Lead is responsible for preparing a brief memorandum to the park Superintendent summarizing inventory findings. Copies, with attachments, are also sent to the park Facilities Manager, NPS WASO WIP Coordinator, and the FLH Program Manager, as well as the Central WIP Database document archive. The memorandum, an example of which is included in Appendix C, should include the following basic information:

- Dates and duration of the park inventory;
- NPS and FLH participants involved in planning and conducting the work;
- Tabulation of the general survey findings, including route name/number, number of walls surveyed per route, types and functions of walls surveyed per route, range of conditions encountered, breakdown of recommended actions, work order costs per specific wall location, etc.;
- Location and description of at-risk walls in the park requiring immediate attention;
- Overview of the pending FMSS data exchange process between the park and the FLH Database Administrator, and
- Contact information for the NPS WASO WIP Coordinator, FLH Program Manager and Database Administrator.

In addition, four attachments are included with the memorandum:

(1) Retaining Wall Summary Data Tables – listing of pertinent information on each of the walls inventoried and/or requiring work orders (example provided in Appendix C);

(2) FMSS Work Order File – final specification data template file for data transfer directly to FMSS (example provided in Appendix C);

(3) FMSS Data Input Procedures and Test Guide – brief reference manual describing the FMSS upload process (example provided in Appendix C); and

(4) Wall Photos – CD containing all wall photos listed by wall identification number.

These items are transmitted with the Findings Memorandum in order to remain under the strict control and responsibility of the Team Lead. The Database Administrator assumes the responsibility for assisting with park FMSS data uploads, uploading final FMSS wall equipment numbers to the Central WIP Database, and sending final wall feature location data to RIP.

2.4.4 FMSS and RIP Data Transmittals

Once the Findings Memorandum has been sent to the park, the Database Administrator archives a copy of the FMSS Work Order File in the Central WIP Database and contacts the park Facilities Manager and/or FMSS Coordinator to request that they submit FMSS-generated wall equipment numbers to FLH for WIP database completion. The Database Administrator is available to support the process, but the park is ultimately responsible for uploading and forwarding requested FMSS information.

Upon receipt of the FMSS wall equipment numbers from the park, the Database Administrator updates the Central WIP Database and forwards a RIP Wall Features Update File to the FLH RIP Coordinator. An example of the wall features file is provided in Appendix C.

2.5 DATA MANAGEMENT ACTIVITIES

Once the FMSS wall equipment numbers have been added to the Central WIP Database, and RIP wall features have been forward to the RIP program, the park inventory process is complete. From this point forward the Database Administrator is responsible for managing and updating the Central WIP Database, generating ad hoc reports, and supporting new and recurrent wall inventories.

The current WIP Database was developed as a Microsoft Access application to mirror similar inventory developments in the FLH Road Inventory Program and the Bridge Inventory Program, while ultimately allowing migration to an Oracle platform for database management, rapid queries, and future developments (e.g., incorporation within an FLH Geographical Information System). The park-specific version of the database is very user-friendly and is structured to enter data in the same systematic manner in which the Field Inspection Forms are recorded. Wall files can also be easily edited, following the same page-to-page format as data entry. Data quality is enhanced by automated checks for missing data, invalid characters or data formats, and conflicting data fields or formats. The database also provides the user with a number of quick-access “canned” reports summarizing wall functions, types, required actions, route numbers and repair costs, as well as the option to request ad hoc reports from the Database Administrator regarding any of the 60+ data fields logged per inventoried wall. Web-access developments are also currently underway that will allow remote users to interface with the Central WIP Database and generate user-defined queries and reports, as needed.

Specific information on the structure and functionality of the WIP Database are included in the WIP Database Users Manual, located in Appendix D.

CHAPTER 3 – WALL ACCEPTANCE CRITERIA AND GUIDELINES

This chapter presents WIP retaining wall acceptance criteria, answering the fundamental question: "What constitutes a qualifying retaining wall?" Although seemingly straightforward, the apparent simplicity of describing, measuring and evaluating earth retaining structures can be deceiving. As evidenced by the numerous acceptance criteria presented in this chapter, there is more to a qualifying earth retaining structure than meets the eye.

Figure 11. Photo. This culturally sensitive, mortared stone masonry cut wall at Capulin Volcano National Monument falls under the height requirement over the majority of its ~300 ft length, with only a short section extending above the minimum 4 ft acceptance criterion. Should the entire wall be included in the inventory? (Yes, per the discussion provided later in this section.)

Clearly, opinions will vary from time-to-time as to how the criteria and definitions presented in this Procedures Manual should be interpreted and applied to field conditions. During the development of this program, inventory teams were often challenged to best describe unique wall conditions, and were occasionally required to exercise judgment beyond the guidance provided in this manual. Regardless of the situation, inventory teams should always bear in mind that *the ultimate goal of the program is to identify qualifying retaining structures in need of non-routine maintenance, element repair, or total replacement*. This inventory and assessment effort only represents an initial screening of wall asset needs for a given park. More detailed wall assessments will be required prior to programming wall repairs or complete structure replacements.

3.1 WALL ACCEPTANCE CRITERIA

The following wall acceptance criteria assist inventory teams in determining what constitutes a qualifying earth retaining structure and whether or not it should be included in the inventory:

(1) **Qualifying Roads**: The inventory includes retaining walls, together with qualifying culvert headwalls, located on all classes of paved park roadways and parking areas as described in the RIP Route Inventory Report or identified by park facilities, maintenance, or resource staff.

(2) **Relation to the Roadway Asset**: Retaining walls and culvert headwalls, that meet the minimum height requirements, must reside within the known or assumed construction limits of the existing roadway or parking area <u>and</u> must support or protect the roadway or parking area.

(3) **Wall Height**: The maximum wall height, measuring only that portion of the wall structure intended to actively retain soil and/or rock, must be greater than or equal to 4 ft. For culvert headwalls/wingwalls, maximum wall heights must be greater than or equal to 6 ft (example shown in Figure 11).

(4) **Wall Embedment**: Fully- or partially-buried retaining wall structures are included in the inventory that are known to meet the minimum wall height requirements, and when wall locations are known or verifiable.

(5) **Wall Face Angle**: Individual walls are further defined by an internal wall face angle, measured at the wall face, greater than or equal to 45^{o} (≥1H:1V face slope ratio). This criterion also applies to the internal angle of tiered wall systems (when considered as a single wall system), measured along the top edges of each wall tier.

(6) **General Acceptance**: When wall acceptance based on the above criteria is marginal or difficult to discern, include the wall in the inventory, particularly where the intent is to support and/or protect the roadway or parking area <u>and</u> where failure would significantly impact the roadway or parking area and/or require replacement with a similar structure.

3.2 APPLYING WALL ACCEPTANCE CRITERIA

In general, the above criteria attempt to qualify walls for the WIP inventory program based on association with park roads, contribution to roadway stability and safety, and wall geometrics. Each criterion is certainly open to interpretation; however, the following guidance, coupled with the wall element definitions presented later in Chapter 4, should help to clarify the intent and application of the criteria.

3.2.1 Qualifying Roads

It is the intent of the program to restrict inventoried walls to NPS-managed paved roads and parking areas surveyed under the Road Inventory Program (RIP). All paved park travelways are generally covered by the RIP survey, though occasionally inventory teams may encounter new roadwork in a park not captured by the latest RIP survey cycle. Walls associated with these roadways and parking areas should be included in the WIP inventory, and should follow the naming conventions described in subsections 4.1.3 and 4.1.4. Gravel roads are generally excluded from the program; these roadway assets are not included in the park RIP survey, and may not exist within the park FMSS system. However, as it is the intent of the inventory program to assess retaining wall assets associated with park roads, qualifying walls along gravel roads should be included in the inventory when such assets are identified by park staff.

3.2.2 Relationship to the Roadway Asset

Retaining walls are those structures intended to actively resist earth loads and include fill walls, cut walls and a subclass of specialty walls – culvert headwalls, bridge walls, switchback walls flood walls, and slope protection, as defined in Subsection 4.2.1. The inventory program further defines walls as residing within roadway construction limits and contributing to the safety and/or stability of the roadway asset. In general, it is rare that a retaining wall meeting the minimum geometrics requirements spelled out in the acceptance criteria would not contribute to the performance of the parent roadway asset. However, on occasion walls will be encountered with no apparent structural value or consequence to the adjacent roadway or parking area and, therefore, are not considered functioning park roadway assets. Such walls may have been built during original roadway construction and are no longer contributing to the current road alignment or, perhaps, were built for adjacent walking paths, carriage roads, or historic rail lines not associated with the constructed limits of the current roadway. These walls may certainly be of cultural value to the park, and appropriately inventoried by cultural surveys, but would not be included in the WIP inventory as a roadway asset.

3.2.3 Wall Function

Among the various wall functions described later in this manual, the inclusion of culvert headwalls is worth noting as it pertains to the application of the acceptance criteria. It was recognized early in the development of the program that **(1)** culvert headwalls not only protect culvert inlets and outlets, but also often provide critical support to overlying roadways, **(2)** at times it is difficult to discern whether the inlet/outlet structure is serving as a culvert headwall or a retaining wall containing a culvert, and **(3)** park-conducted culvert surveys might evaluate the condition of the headwall/wingwalls, but would not necessarily tie wall performance to the ultimate performance of the adjacent roadway asset. Although these are all good reasons to include culvert headwalls in the inventory, it was also recognized that by including all culvert structures meeting the aforementioned retaining wall criteria the program could quickly escalate into an overwhelming culvert inventory. To stem the number of headwalls inventoried, while ensuring the vast majority truly affecting roadway performance were assessed, the wall height requirement for culverts was raised to greater than or equal to six feet. Furthermore, it was determined that failure of the headwall/wingwall structure would have to result in adverse impacts to the roadway. This additional level of screening eliminates minor headwall structures possessing only localized failure potential, greatly reducing the impact of culverts on the inventory. It also eliminates those inlet/outlet structures located well beyond the influence of the road, For example, culverts outletting at the toe of long, well-vegetated, stable fill slopes would not be included.

On occasion, a retaining wall may be part of an asset appraised under another inventory program. A good example would be a retaining wall surrounding the abutment of a bridge structure. In this case, the wall would be evaluated as a key component of the bridge under the Bridge Inspection Program (BIP), and would not be included in the WIP inventory. This particular case is described in detail in Subsection 4.2.1.

3.2.4 Wall Height

In addition to the aforementioned height distinction between culvert headwalls and all other wall functions (e.g., cut walls, fill walls); three other aspects of wall height are worth noting. First, the maximum wall height should be measured from the toe of the wall to the *intended* height of earth retention. This height measurement accounts for soil/rock materials that may have been removed from behind the original wall (e.g., excavated or removed by erosion). Secondly, parapets or integral guardwall structures extending above the intended retained earth height of the wall are not to be included in the maximum height determination. These features are evaluated as contributing "secondary wall elements" in the condition assessment, and will be further evaluated as traffic barriers under a separate inventory program currently in development. Finally, if any portion of the wall meets the height criterion, the entire wall length is included in the inventory – not just the segment meeting the criterion. This avoids only a portion of a culturally sensitive wall asset being accounted for in the inventory, a case where the cultural context of the entire wall will need to be considered if any actions are required.

Figure 12. Photo. This outlet headwall and adjacent wingwalls clearly meets the culvert height criterion and directly supports the overlying roadway.

3.2.5 Wall Embedment

During wall condition assessment, only that portion of the wall that can actually be seen is evaluated and measured. However, when determining whether a wall qualifies for assessment, the inventory team should include fully- or partially-buried walls when locations and embedment are ***known or verifiable***. This allows the team some latitude in accepting walls potentially important to roadway stability that might otherwise not qualify on exposed height alone, or walls with deeply embedded foundations in serious disrepair that need to be brought to the attention of park management. Although not lending themselves to primary wall element assessment, buried structures may represent substantial park investments which need to be inventoried nonetheless.

Examples include patterned ground anchor walls used to restrain landslides and buried portions of tieback soldier pile walls.

3.2.6 Wall Face Angle

Although typically constructed at internal face angles much greater than 45^{o} (FHWA defines a retaining wall as having an internal face angle greater than or equal to 70^{o}), occasionally some earth retaining structures may be built at or near this low-end criterion (e.g., rockeries, tiered gabion walls, tiered stone masonry walls). Additionally, during WIP development it was determined that low-face-angle, placed rock inlays and/or buttresses, termed "slope protection" and used as either erosion control or earth retention structures, should also qualify under the WIP inventory. These "walls" are often major structures protecting and/or supporting park roadways, and represent substantial assets to the park.

Figure 13. Photo. This placed stone retaining structure, with a 50+^{o} face angle, retains the fill slope supporting the roadway at Haleakala National Park and could be included in the WIP.

Occasionally, tiered wall systems may be comprised of different wall types, possibly constructed at different times, and/or may have vertical or horizontal offsets between walls such that it may be more appropriate to consider the walls individually rather than as an integrated earth retention system. The team has the latitude to discern between tiered wall systems and individual walls, but should always employ sound engineering principles regarding tiered wall analyses when differentiating between the two. The inventory guidelines presented in Chapter 4 allow for capturing the necessary wall geometrics and performance data regardless of whether the tiered walls are considered a single wall system or series of separate walls.

3.2.7 Qualifying Wall Examples

Aside from the more obvious retaining wall structures that meet the above criteria, the following examples illustrate wall occurrences where it may be more difficult to discern whether they belong in the inventory. The intent of these examples is not to cover all occurrences of marginal walls, but to illustrate the intent of the acceptance criteria.

(1) An approximate 3.5-ft tall rockery (visible portion above ground), with an estimated 2-ft-deep embedment, based on partially exposed placed boulders along the base of the wall, runs approximately 100 ft along the outboard edge of a sidewalk surrounding a parking area. The downslope is very gentle, graded at less than a 6H:1V slope ratio. The inspecting engineer determines that although the wall may marginally meet the intent of the height requirement, and has aesthetic value, failure of the wall would neither impact the parking area nor require replacement of the wall (fill could be used instead). This wall *should not* be included in the inventory (though it may be included in a park cultural inventory).

(2) A culturally sensitive mortared stone masonry cut wall extends for nearly 300 ft along the inboard edge of a roadway. Although a majority of the wall length is less than 3-ft tall, a short 20-ft-long section extends to over 6 ft in height. The inspecting engineer determines that this taller section is providing roadway protection and is integral to the entire length of the structure such that any substantial repair would have to consider the cultural aspects of the entire wall. The entire length of this wall *should* be included in the inventory.

(3) A 5.5-ft-tall concrete headwall, suspected to be embedded another 1-2 ft (but not verifiable), protects a culvert outlet at the bottom of a large, well-vegetated fill with a constructed slope ratio of 2H:1V. The headwall is offset nearly 80 ft from the roadway. The inspecting engineer determines that although the headwall resides within the roadway construction limits and may marginally meet the intent of the 6-ft height criterion for culvert walls, failure or removal of the headwall altogether *would not impact the roadway*. This wall does not assuredly meet the height criterion and represents no failure risk to the roadway; therefore, it *should not* be included in the inventory.

(4) An historic mortared stone masonry guardwall runs for hundreds of feet along the outboard edge of a narrow roadway. Supporting the above-grade portion of the guardwall is a mortared stone masonry foundation, varying in exposed height from 1-3 ft, and known to be embedded another 1-2 ft based on localized foundation exposures resulting from toe slope erosion. The earth retaining portion of the wall meets the minimum inventory height requirement in numerous locations, and the inspecting engineer determines that although the primary intent of the retaining wall/foundation is to support and reinforce the guardwall, the wall also directly supports the roadway. This structure *should* be included in the wall inventory. The inspecting engineer will need to further determine the appropriate length of wall to include in the inventory (discussed in subsection 4.2.8). [Were the wall to not meet the height criterion, including observable embedment, this structure would be more appropriately inventoried under the forthcoming traffic barrier inventory program.]

(5) An MSE wall is located mid-slope on a sparsely vegetated outboard fill, with an upslope ratio of 1.5H:1V. The maximum exposed height of the wall is 3 ft, though the majority is less than 2-ft tall. The inspecting engineer determines the wall to be at least two baskets tall (each basket is 2-ft tall), noting that at least a portion of the lower basket is partially embedded in foundation soils. Although the exposed height of the wall is less than the 4-ft height criterion, and the very short apparent height might suggest that no impact to the roadway would occur should the wall fail, the inspecting engineer determines that the wall may nonetheless be a significant roadway supporting structure due to known embedded wall height. Although difficult to definitively determine the contribution of the wall to roadway stability, this wall *should* be included in the inventory per the intent of the General Acceptance criterion.

Figure 14. Photo. A mid-slope wire-faced MSE wall at Mesa Verde National Park that just meets the height criterion based on known embedment of partially-exposed lower baskets.

(6) A relatively new concrete cantilever wall with form-lined concrete facing runs above grade along the edge of a parking area. The wall is nearly 7-ft tall; however, upon further examination the wall protects a stairway leading up to a sidewalk running along the back of the wall – with the top portion of the wall serving as a protective parapet. Less than 4 ft of the wall height is actually retaining soil/rock. The inspecting engineer determines that this wall *should not* be included in the inventory.

(7) A 5-tiered, dry-laid, stone masonry wall system resides within the interior section of a roadway switchback curve. Individual walls comprising the tiered wall system range in exposed maximum height from 3 ft to 5.5 ft, with tier offsets of approximately 3 ft. Although some wall sections within the system do not meet the 4-ft wall height criterion, the overall wall system face angle, measured between 45^{o} and 55^{o}, indicates the walls are functioning as a composite earth retaining system. The inspecting engineer appropriately determines that the entire wall system *should* be included in the inventory, with the reported maximum wall height inclusive of all five tiers.

Clearly, a wide range of retaining wall applications may be encountered throughout the course of an inventory program spanning the construction period and environments represented within the National Park System. Nonetheless, by following the standards and guidelines presented herein, well-trained inventory teams, armed with sound engineering judgment, should be able to prepare accurate, representative wall condition and performance assessments meeting the goals of the Wall Inventory Program.

CHAPTER 4 – WALL DATA COLLECTION GUIDELINES

As stated in Chapter 1, the purpose of the Wall Inventory Program is to define, quantify, and assess wall assets in terms of their location, geometrics, construction attributes, condition, failure consequence, cultural concerns, apparent design criteria, and cost of structure maintenance, repair or replacement. To this end, various wall attributes and elements are measured, calculated, assessed and rated within the following five data categories, and documented on the **Field Inspection Form provided in Appendix B**:

- **Wall Location Data**: Walls are located by park name, route number/name, side of roadway, RIP wall start and end milepoint, and calculated RIP wall start latitude/longitude.

- **Wall Description Data**: Walls are described by function, type, year built, architectural facings and surface treatments. Measurements are recorded pertaining to wall length, maximum height, face area, face angle, and vertical and horizontal offsets from the roadway. Photos are also logged for each wall, noting location relative to the roadway, major wall features, and overall element conditions.

- **Wall Condition Assessment**: Primary and secondary wall element conditions are described relative to extent, severity and urgency of observable distresses, and then numerically rated, giving due consideration to data reliability. The overall performance of the wall system is also evaluated and rated, with all ratings weighted and combined to arrive at an overall wall condition rating – the “Final Wall Rating”.

- **Wall Action Assessment**: Objective consideration is given to **(1)** the Final Wall Rating, **(2)** any identified requirements for further site investigations, **(3)** the apparent design criteria employed at the time of construction, **(4)** any cultural concerns, and **(5)** the consequence(s) of failure to determine a recommended action. Actions include no action; monitor the wall; conduct maintenance-level work; repair wall elements; replace wall elements; replace the entire wall.

- **Work Order Development**: Brief, yet descriptive work orders are prepared when maintenance, repair or replace actions are required. Unit costs for major work items are generated from the WIP Cost Guide, park cost data, etc., to arrive at order-of-magnitude costs (not inclusive of cultural assessment, engineering design or construction management costs).

These major wall data categories are located within the Field Inspection Form, are further defined in the following Chapter 4 subsections, and are quick-referenced in the WIP Field Guide. As previously noted, wall attributes and elements are defined to the extent practicable – and are generally easy to discern in the field. The inspecting engineer will nonetheless need to rely on their knowledge of wall systems and use good judgment when interpreting the intent of each wall attribute and element over the wide variety of wall settings and applications to be encountered.

The requirement for sound engineering judgment in the WIP is most apparent in the manner in which recommended wall actions are determined. Whereas similar condition-based inventory systems may directly correlate a numerical rating to a specific action, the WIP assessment methodology develops a numerical condition rating for applicable wall elements which is then objectively considered relative to other influencing factors to arrive at a recommended action. Other factors include such things as the consequences of wall failure, the cultural/historic significance of the structure – a very important aspect of the park program – and the reliability of the condition assessment data. The result is the selection of an appropriate action founded on a well-documented element condition and wall performance assessment, suitable for development of repair/replace work orders and associated cost estimates. The current wall assessment methodology meets the more comprehensive WIP goals of identifying walls in need of non-routine maintenance, repair or replacement, allowing statistical assessments of wall elements throughout the entire WIP database, and providing the baseline for all future wall assessments.

Figure 15. Photo. Retaining walls are found in a wide array of settings. Wall performance is impacted by factors other than constructed components, including foundation materials, top and side slopes, vegetation, drainage, etc.

Although emphasized earlier in this manual, it bears repeating that all team members must be fully trained and skilled at interpreting and applying the criteria and wall element definitions contained in this manual. ***Collected wall data must be accurate, concise and descriptive***. For example, park and route naming conventions must be followed to ensure proper wall location. Wall type and treatment codes must be properly recorded to accurately classify walls and their components. To ensure continuity of condition assessments throughout the WIP, condition narratives must closely follow the descriptive vocabulary found in the WIP Field Guide for characterizing the extent, severity and urgency of wall distresses. And although briefly stated, work orders need to thoroughly account for major work items to arrive at order-of-magnitude repair/replace cost estimates. By following the data collection and documentation standards and guidance presented in this chapter, each team will be able to produce high-quality wall assessments directly supporting the NPS FMSS asset management program.

4.1 WALL LOCATION DATA

The first step of the inventory is to locate the retaining wall relative to the park RIP road survey. The RIP Cycle 3 program (currently being replaced by Cycle 4 surveys) provides milepoints to approximate 5-ft accuracy (0.001 miles), as well as GPS latitude and longitude points every 106 ft (0.02 miles), along the centerlane in the direction of the survey. These redundant measurement systems provide a good basis from which to locate retaining walls associated with the roadway for years to come, allowing future WIP inventories to be incorporated easily within RIP.

4.1.1 Park Name

"Park Name" is the NPS four-letter "Park Alpha" abbreviation, available from the park or the RIP Route Inventory Report; for example, Golden Gate National Recreation Area – GOGA; Yosemite National Park – YOSE; Capulin Volcano National Monument – CAVO. It is important to check the current Park Alpha with the most recent cycle version of RIP to ensure naming conventions have not changed since prior surveys.

The three-letter abbreviation of the "NPS Region" associated with the park name is automatically loaded in the WIP database. The seven NPS regions include: [AKR] Alaska Region; [IMR] Intermountain Region; [MWR] Midwest Region; [NCR] National Capital Region; [NER] Northeast Region; [PWR] Pacific West Region; [SER] Southeast Region.

4.1.2 Inspected By/Date

The individual responsible for filling out the Field Form for a given wall lists their name in the "Inspected By" box. This person may be the Team Lead or a Team Member, but must always be an individual properly trained in wall data collection within the WIP – particularly in the manner in which wall element condition narratives are to be composed. The inspection date refers to the date the inspection is completed.

4.1.3 Route/Parking No.

"Route/Parking Number" is the complete four-to-seven-digit RIP route/parking area number, as specified in the RIP Route Inventory Report (e.g., 0010, 0915). For roadways not in RIP, use the park-supplied route number or the convention RRR#, designating the roadway "#" as 1, 2, 3, etc., as new roads are encountered (e.g., RRR1 for the first non-RIP road encountered). For parking areas not in RIP, use the park-supplied parking area number or the convention PPP#, designating the parking area "#" as 1, 2, 3, etc., as new parking areas are encountered. These unique alpha-numeric designations, unlike the all-numeric designations in RIP, will allow future WIP users to quickly determine which roads and parking areas were in the RIP database and which were not. Therefore, it is important to correctly log this information in the required format as this route number designation is then used to develop consistent, descriptive and comparable Wall Identification Numbers within the Park WIP Database.

NOTE: Non-RIP route and parking area numbers must be at least four characters long when entered into the Park WIP Database.

4.1.4 Route/Parking Name

"Route/Parking Name" is logged exactly as specified in the RIP Route Inventory Report. For roads and parking areas not in RIP, use either the park-designated name or an appropriate descriptor. For example, "South Falls Overflow Parking" or "Amphitheater Access Road" would be good descriptors identifying both the type of travelway and general location within the park. Route names such as "Parking Lot" or "Unnamed Access Road" are not acceptable. For non-RIP routes, describe the start and end termini in the General Wall Description notes to more clearly locate the roadway in the park.

4.1.5 Side of Centerline

"Side of Centerline" designates where the wall is located relative to the roadway; right (R) or left (L), when traveling in the direction of increasing RIP milepoints or increasing park mileposts when RIP data are not available. "Mileposts" are either physical mile markers or odometer mileage starting from a referenced intersection, logged in the General Wall Description Notes.

For parking areas, where no RIP milepoint or park-designated milepost information is available, walls are to be numbered in ascending order as they are encountered when traveling counterclockwise around the parking area (most common direction of traffic flow). Designate parking area walls as P1, P2, P3, etc., as new walls are encountered.

4.1.6 Visidata Event Milepoint

For park routes included in the RIP Route Inventory Report, Visidata is used to calculate equivalent RIP milepoints to the nearest 0.001 mile for wall locations. When wall milepoints are not already available in the Visidata features table (which is commonly the case), the milepoint of a nearby Visidata-listed feature, such as a guardrail end, culvert inlet, park sign, etc., is selected from the Visidata features table and recorded on the Field Inspection Form. Although the Visidata Event Milepoint is not uploaded to the WIP database, it is included on the Field Form for convenience in calculating the Wall Start Milepoint.

NOTE: RIP milepoint data does not exist for non-RIP roads, or for any parking areas (RIP and non-RIP), so no Visidata Event Milepoints are recorded.

4.1.7 Wall Start/End Milepoint

For RIP roads, the "Wall Start Milepoint" is either the available wall milepoint provided in the Visidata features table for the route or is calculated to the nearest 0.001 mile based on the distance measured from a nearby "Visidata Event Milepoint" to the start of the wall, as it is projected to the edge of the roadway. Since wall locations will be updated to RIP following completion of the inventory, existing RIP wall start locations should always be used to avoid recording duplicate walls in the RIP features tables (generally the milepoints will be slightly different, resulting in a double entry at the same approximate location).

For calculated wall start locations, the distance along the roadway from the Visidata feature to the start of the wall is converted to thousandths of a mile and then added/subtracted from the Visidata Event Milepoint to arrive at the equivalent RIP milepoint for the wall start. When the Visidata event feature is within 50 ft of the wall start, simply divide the distance by 5 to estimate thousandths of a mile (i.e., the estimated and actual distances round to the same thousandth). When the Visidata event feature is beyond 50 ft, a more accurate calculation is required.

For roadways without RIP Visidata information, log the approximate odometer mileage, corroborated by mileposts (if present), for the wall start. Log odometer values to hundredths of a mile, to the extent practical. For all parking areas (RIP or non-RIP), always log “0.000” for the Wall Start Milepoint, as milepoint data are not available (milepoints/mileposts are always shown to three decimal places).

The “Wall End Milepoint” (for both RIP and non-RIP roads) is calculated based on the “Wall Start Milepoint” and the measured distance along the roadway. The actual wall length is not used for this calculation, as it may be longer or shorter than the projected length along the roadway.

4.1.8 Wall Start Latitude/Longitude

“Wall Start Latitude” and “Wall Start Longitude” are the interpolated centerlane latitude/longitude adjacent to the wall start based on available Visidata centerlane milepoint latitude/longitude data. These values are calculated automatically for RIP routes within the WIP database once a Wall Start Milepoint is given. Latitude and longitude data are unavailable for non-RIP roads and all parking areas (no RIP-generated GPS data available). Due to varying GPS access across the country, the WIP does not currently attempt to acquire GPS data for walls beyond what is currently available in the RIP program.

4.1.9 WIP Wall ID

The “WIP Wall ID” is an identification number automatically generated in the WIP database in lieu of the NPS FMSS equipment number to eventually be assigned by park staff. The format for the Wall ID is “Park Alpha– Route/Parking No.–Wall Start Milepoint–Side of Centerline”. Because there are several possible formats for the Route/Parking No. (RIP or non-RIP roads) and the Wall Start Milepoint (Visidata vs. odometer), there are several distinctive formats for the Wall ID (examples are given in the next subsection).

The “FMSS Asset Number” is an additional unique wall identifier used by the NPS, and is assigned by park asset management personnel following completion of the wall inventory. This unique FMSS identifier is added to the Central WIP Database upon receipt from the park.

4.1.10 Wall Location Examples

A couple of examples may help to better understand the wall location process for the various roadway and parking area designations to be encountered in the field.

RIP Route Example: A fill wall is located in the Bryce Canyon National Park (BRCA) below the right side of Park Route 0012 – Canyon View Road, a paved roadway surveyed under the RIP program. The wall is not visible from the roadway, and is not included as a feature in Visidata. The wall start, projected upslope to the edge of the roadway, begins 45 ft up-station from a drop inlet structure that is identified as an event feature in Visidata. The Visidata milepoint for the drop inlet is 1.234. The Wall Start Milepoint is 45/5 thousandths, or 0.009 miles, greater than the milepoint for the drop inlet, for a calculated Wall Start Milepoint of 1.243. The projected wall end location is 349 ft further up-station along the roadway. There are no nearby Visidata features to conveniently measure from to acquire the Wall End Milepoint, so the inspecting engineer calculates an additional 0.066 miles (or 349 ft/5,280 ft/mi) must be added to the wall start value to arrive at a Wall End Milepoint of 1.309. Wall start latitude and longitude are automatically calculated within the WIP database from GPS points acquired during the RIP survey. The WIP Wall ID is BRCA-0012-1.243-R.

Non-RIP Route Example: A cut wall, identified by park personnel during the kick-off meeting, is located along the left side of a non-RIP gravel service road in Acadia National Park (ACAD). The park refers to the road as Route 23 – Tower Station Road. There are no mile markers along the road, so the inspecting engineer begins taking odometer mileage from the intersection with Route 0010 – Main Park Road, noting this starting point in the Wall General Description Notes section of the Field Form. It is determined that the projection of the wall start to the edge of the roadway approximately begins at milepoint 1.15 (odometer estimated to nearest 0.05 miles), and is logged on the Field Form and in the WIP database as 1.150. The Wall End Milepoint is determined in the same manner as in the preceding example. Since the route is not in the RIP database, the WIP database cannot calculate latitude and longitude for the wall start. The WIP Wall ID is ACAD-0023-1.150-L.

WIP Wall ID formats vary depending on the availability of route number and milepoint data, and the location of the wall relative to the roadway or parking area. The following further defines the range of possible Wall ID formats:

RIP Route with Visidata: “MEVE-0010-1.204-R” represents a wall in Mesa Verde National Park, located on RIP route 0010 at milepoint 1.204, on the right side of the road when heading in the direction of increasing milepoints.

RIP Parking Area without Visidata: “CAVO-0910-0.000-P3” represents a wall in Capulin Volcano National Monument (Figure 16), located in RIP parking area 0910, with no milepoint data, and is the third wall in the parking area progressing counterclockwise from the entrance.

Non-RIP/Park-Designated Route with Odometer: “WICA-001B-0.250-L” represents a wall in Wind Caves National Monument, located on non-RIP/Park-designated route 1B (minimum of four characters) at odometer milepoint 0.250 (minimum of four characters), on the left side of the road when heading in the direction of increasing roadway mileposts.

Non-RIP/Non-Park-Designated Route with Odometer: “DEWA-RRR3-10.350-L” represents a wall in Delaware Water Gap National Park, located on inventory-designated non-RIP route “3” at odometer milepoint 10.350, on the left side of the road when heading in the direction of increasing roadway mileposts.

Non-RIP Parking Area: “ZION-PPP2-0.000-P1” represents a wall in Zion National Park, located in inventory-designated non-RIP parking area “2”, with no Visidata, representing the first wall in the parking area progressing counterclockwise from the entrance.

Figure 16. Photo. An example of parking area walls at Capulin Volcano National Monument. The wall in the foreground would be designated P1, the wall at the far end would be P2, and the wall partially shown on the left would be P3 per the WIP counterclockwise wall numbering notation for parking areas.

4.2 WALL DESCRIPTION DATA

Once a wall has been located relative to the roadway RIP Visidata survey or odometer mileage, the next step in the inventory is to describe and measure wall attributes. Wall description data include function, type, architectural facings and surface treatments; wall measurements include length, maximum height, face area, face angle, and horizontal and vertical offsets from the adjacent road grade.

4.2.1 Wall Function

“Wall Function” refers to the purpose of the retaining structure (e.g., supporting cut or fill material). In addition to the more conventional applications of fill walls and cut walls, five additional wall functions have also been identified within the WIP inventory: bridge walls, (culvert) head walls, switchback walls, flood walls and slope protection. Although these additional functions may be classified as either fill or cut walls, they are sufficiently unique and important to include separately, allowing their occurrence in parks to be quantified by future database queries. In application, "Wall Function" should be first defined by one of these five specialty functions, if appropriate, rather than the more general options "fill wall" or "cut wall".

Table 1. WIP wall functions and associated field inventory codes.

Wall Function	Code
Fill Wall	FW
Cut Wall	CW
Bridge Wall	BW
Head Wall	HW
Switchback Wall	SW
Flood Wall	FL
Slope Protection	SP

Each category, with Field Form function code given in []'s, is further defined by the following:

Fill Wall [FW]: A "fill wall" (Figure 17) is an earth retaining structure supporting specified soil or aggregate backfill. Fill walls are typically located below roadway grade on the outboard side of the roadway or parking area, but may also exist above travelway grade in locations commonly associated with cut walls. The inspecting engineer should be careful to always characterize the wall by function, and not simply location relative to the roadway or parking area.

Figure 17. Photo. A gabion gravity fill wall under construction below roadway grade.

Cut Wall [CW]: A "cut wall" (Figure 18) is an earth retaining structure directly supporting natural ground; either constructed directly against the excavated soil/rock mass, or against a minor volume of drainage backfill. Cut walls are typically located above roadway grade on the inboard side of the roadway or parking area, but may also exist below travelway grade in locations commonly associated with fill walls. The engineer should be careful to characterize the wall by function, and not simply the location relative to the roadway or parking area.

Figure 18. Photo. A mortared stone masonry cut wall at Rocky Mountain National Park.

Bridge Wall [BW]: A "bridge wall" is an earth retaining structure associated with a bridge (defined as having a ≥20 ft span) that is not directly part of the bridge substructure, and is not already inventoried by the FLH Bridge Inspection Program (BIP). Such walls might include pre-existing walls (e.g., historic retaining walls left in place during bridge construction), cut or fill walls not associated with abutments and wingwalls, or extended cut or fill walls along bridge approaches. The Team Lead should acquire bridge inspection data from the BIP prior to the field inventory to assist in both determining which structures have been evaluated as bridges in the park and what earth retaining bridge elements have already been included in the BIP survey.

The following further defines retaining walls associated with bridge structures:

Bridge Wingwalls: For the purposes of the retaining wall inventory, bridge wingwalls are generally not considered qualifying retaining walls and should not be inventoried in the Wall Inventory Program – they are already inventoried and inspected through the Bridge Inventory Program. Wingwalls are limited in length (generally less than 40 ft), often taper in height, and can be parallel to or at any angle from the abutment face. Their purpose is to contain the roadway embankment at the immediate approach to the bridge. Walls adjacent to bridge abutments are only considered wingwalls in two specific construction conditions:

- When the wingwall is constructed integrally with the bridge abutment; and
- When the wingwall is built at the same time as the bridge, but separated from the abutment by a bond breaker or joint.

If wingwalls, as defined above, continue for more than 40 feet beyond the abutment without a change in construction type, the entire wall beyond the abutment (beginning immediately past the end of the bridge deck) should be considered a retaining wall and evaluated under WIP (Figures 19 and 20). If there is a change in construction type within 40 feet of the abutment, the point where the change occurs should be interpreted as the wingwall/retaining wall juncture (Figure 21). In lieu of these criteria for bridge walls, the inspecting engineer may determine that wingwall structures, despite size or construction method, are integral to the bridge and would be included in the BIP program.

Figure 19. Photo. Example of a highly battered, dry-laid stone masonry wall supporting the bridge approach at Acadia National Park. This wall is not integral to the bridge structure and, therefore, should be assessed as a retaining wall under the Wall Inventory Program.

Secondary Bridge Abutment Walls: Walls that are under a bridge and in front of an abutment are already inventoried and inspected through the bridge inspection program, and should not be inventoried in the retaining wall program. Walls that are not within the vertical projection of the bridge deck, and are not constructed integrally with either wingwalls or abutments, should be considered WIP-inventoried retaining walls. These structures are commonly found in front of or downslope from wingwalls (Figure 22).

Bridge Spanning Pre-Existing Wall: Bridges that are constructed on top of pre-existing or long channel walls are not considered to have wingwalls. In these cases, the portion of the wall within the vertical projection of the bridge deck should be considered the bridge abutment, and the remainder of the wall should be considered a retaining wall, potentially qualifying for inclusion in the wall inventory program.

Figure 20. Photo. Although the approach walls are integral to the bridge abutment, they extend sufficiently from the end of the deck to be considered fill walls primarily supporting the roadway. Approach walls such as these should be included in the WIP inventory if not already evaluated under the BIP program.

Figure 21. Photo. Example of approach walls clearly distinguished from the bridge abutment by a constructive joint, approximately 15 feet from the end of the deck.

Figure 22. Photo. Example of secondary bridge walls (tiered MSE walls extending from the abutment and approach walls) that are not part of the bridge abutment structure and should be included in the WIP inventory.

Large Culverts: Small bridges (more appropriately described as large culverts) that are 20 feet or less in total span along the centerline of the roadway are not typically defined as bridges or included in the Bridge Inspection Program. Therefore, any walls associated with these drainage/passage structures, and meeting the minimum wall acceptance criteria, should be included in the wall inventory as "head walls", if applicable and according to the headwall/wingwall definition given herein. Otherwise, walls associated with these structures (e.g., approach walls, secondary walls) should be defined as either cut or fill walls.

NOTE: Tunnel portals are generally covered under the Bridge Inspection Program. However, portal approach walls and/or secondary walls should be covered under the WIP inventory if the inspecting engineer determines they are not integral to the tunnel portal, following the same guidance for adjacent wall features described under Bridge Walls.

Head Wall [HW]: A "head wall" (Figure 23) is a cut or fill wall located at the inlet and/or outlet end of a drainage or passage structure (e.g., water culvert, animal passage). Head walls (including associated wingwalls) should only be included in the wall inventory if they meet the wall acceptance criteria – particularly the special 6 ft head wall height criterion and the intent to support or protect the roadway. If the head wall is of sufficient size, and would significantly impact the roadway were it to fail, it should be included in the inventory. If the same head wall would not directly or immediately impact the roadway if it failed (e.g., a head wall at the bottom of a long, well-vegetated fill slope), it should not be included in the wall inventory. The entire head wall/wingwall structure at either an inlet or outlet should be considered one continuous wall system, as opposed to evaluating each separately (the length would be measured from the end of one wingwall, across the head wall, to the end of the other wingwall).

Figure 23. Photo. Is it a fill wall with an elaborate culvert structure, or a culvert with an elaborate headwall? In this case, the outlet was considered a large retaining wall with a culvert, whereas the much smaller inlet was considered a culvert headwall.

Switchback Wall [SW]: A "switchback wall" (Figure 24) is a cut or fill wall located on the inside of a switchback curve, simultaneously supporting the upper roadway and protecting the lower roadway. The switchback wall is located and described as it is first encountered along the roadway when traveling in the direction of increasing milepost.

Figure 24. Photo. Example of a mortared stone masonry switchback wall at Sequoia National Park between upper and lower roadway on the inside of a switchback curve.

Flood Wall [FL]: "Flood walls" (Figure 25) encompass earth retaining structures constructed along flood channels, inland surge walls, and seawalls. Although inclusion of these walls in the WIP inventory requires they meet the aforementioned wall acceptance criteria (particularly noting the retained earth height requirements, since many floodwalls are non-earth retaining structures), a special case is worth noting: the flood wall clearly resides outside the road/parking area construction limits, but failure would nonetheless result in roadway/parking area damage. The inspecting engineer will need to use prudent judgment in determining if a flood wall structure sufficiently meets the intent of the program to include it in the inventory.

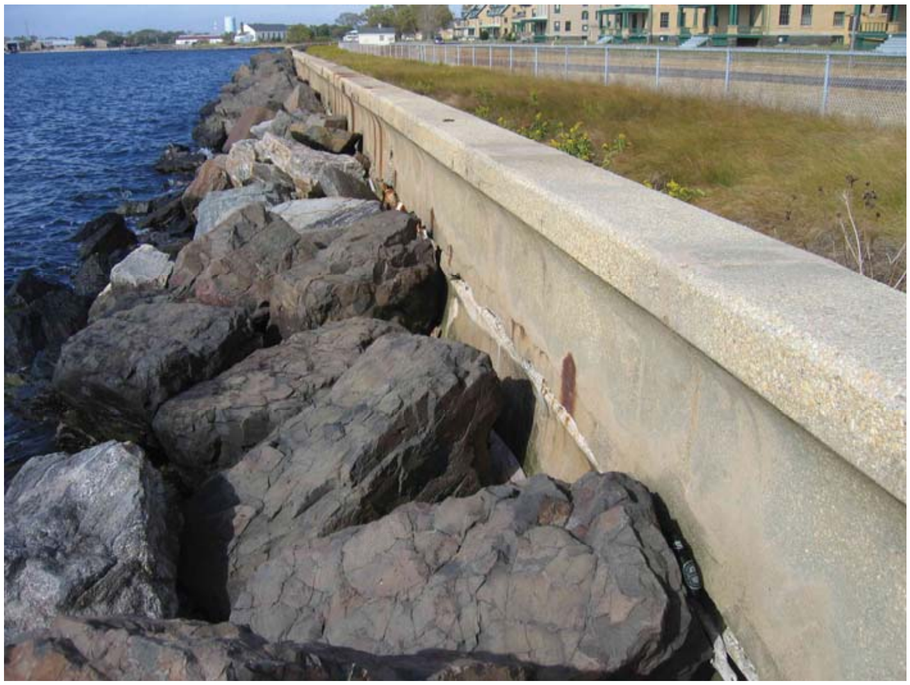


Figure 25. Photo. Although this seawall at the Sandy Hook unit of the Gateway National Recreation Area sits well outside the construction limits of the RIP-surveyed road (back right), failure of this structure would result in rapid and severe shoreline erosion, eventually impacting the roadway.

Slope Protection [SP]: "Slope protection" (Figure 26) includes earth retention and/or erosion control structures meeting the aforementioned general wall acceptance criteria that may not be considered conventional retaining wall structures. Such structures may include rock buttresses, grouted/ungrouted riprap, and stacked or grouted rock inlays constructed at slope ratios ≥ 45^o (1H:1V), and generally not exceeding 70^o (1H:2.5V). These structures are comprised of hand- or machine-placed rock, and should not be confused with over-steepened, end-dumped rock fills. Although not always adhering to the conventional definition or perception of an earth retaining structure, slope protection structures should be included in the inventory as they represent significant park assets supporting and/or protecting roads, and are best evaluated under the WIP inventory. For clarification, rockeries – retaining wall structures far more rigidly designed and specified than rock buttresses, and typically built at face angles ≥ 70^o – would typically be characterized as cut or fill walls, and not slope protection. Riprap rundowns, primarily used for water conveyance and not earth retention, would not be included as Slope Protection.

Figure 26. Photo. Machine- and hand-placed slope protection at Rocky Mountain National Park.

Clearly, conventional perceptions of what might constitute a retaining wall are stretched within the Wall Inventory Program to best accommodate a broadly defined asset base spanning a number of similar inventory efforts (bridge, culvert, and traffic barrier). The inspecting engineer should always lean toward including an earth retention structure when its function, geometrics and/or potential failure impacts to an adjacent travelway are difficult to discern.

4.2.2 Primary Wall Type

"Primary Wall Type" refers to the predominant earth retention structure and/or construction material comprising the retaining wall. When more than one wall type is present, engineering judgment is required to determine which wall type is providing the greatest contribution to earth retention and/or is the predominant support structure. Although, in many cases, the newest constructed portion of a multi-type wall might be considered the Primary Wall Type, older wall segments supporting newer wall construction may actually provide the predominant earth retention mechanism to the composite structure. In any event, composite wall structures should be described under "Wall General Description Notes" to clarify wall characteristics.

In many cases, it can be very difficult to determine the actual wall type. For example, soil nail walls commonly have a structural concrete facing or other decorative facing obscuring the soil nail reinforcement. Mechanically stabilized earth (MSE) walls may also have reinforcing elements obscured by an assortment of facings that may mislead the inventory inspection team. Although it is important to eventually determine the type of wall and its components, it is sufficient for the inventory team to describe the apparent wall type and its visible component performance during this initial inventory and assessment screening.

Wall types and inventory codes are listed in Table 2. General descriptions and examples of the various types of walls that may be encountered during an inventory are also provided below.

Table 2. WIP wall types and associated field inventory codes.

Wall Type Description	Code
Anchor, Tieback H-Pile	AH
Anchor, Micropile	AM
Anchor, Tieback Sheet Pile	AS
Bin, Concrete	BC
Bin, Metal	BM
Cantilever, Concrete	CL
Cantilever, Soldier Pile	CP
Cantilever, Sheet Pile	CS
Crib, Concrete	CC
Crib, Metal	CM
Crib, Timber	CT
Gravity, Concrete Block/Brick	GB
Gravity, Mass Concrete	GC
Gravity, Dry Stone	GD
Gravity, Gabion	GG
Gravity, Mortared Stone	GM
MSE, Geosynthetic Wrapped Face	MG
MSE, Precast Panel	MP
MSE, Segmental Block	MS
MSE, Welded Wire Face	MW
Soil Nail	SN
Tangent/Secant Pile	TP
Other, User Defined	OT

Anchor, Tieback H-Pile [AH]: A tieback H-Pile wall (Figure 27), or soldier pile tieback wall, is commonly comprised of H-piles driven on 6-10 ft centers, lagged with timber planks or concrete panels, and secured through the retained earth mass with tieback cables or bar ground anchors. Variations in pile and tieback configurations are common, ranging from flanged piles allowing tieback passage through the pile to tieback whaler assemblies spanning piles. Although generally a cut wall installation, this wall type can also be used as a fill wall in outboard wall applications.

Anchor, Micropile [AM]: The anchor micropile wall (Figure 28) is a rarely used variant of the H-pile tieback system. This cut wall installation, generally comprised of closely-spaced micropiles (3-6 ft), requires a structural wall facing for permanent applications. Shotcrete facings are most common.

Anchor, Tieback Sheet Pile [AS]: The tieback sheet pile wall (Figure 29) is more commonly used as a temporary excavation support measure than a permanent wall structure. However, this wall type may be commonly found in seawall applications. The piles may be steel or vinyl and a variety of coatings may be applied to the sheeting, whalers and ground anchor assemblies.

Figure 27. Photo. Timber-lagged soldier pile tieback wall at Mesa Verde National Park. A steel box-frame whaler assembly is used in this example as the bearing member for the ground anchors. Surface treatments are commonly applied to the timber lagging (weathering sealants) and exposed steel pile, whaler and ground anchor assemblies (paint).

Figure 28. Photo. Micropile tieback wall prior to shotcrete facing finish (ADSC, 2006).

Figure 29. Photo. Steel sheet piling with bar ground anchors placed through steel whalers. This cut wall is constructed "top-down", with the ground in front of the driven sheet piles excavated in lifts and ground anchor assemblies installed as the excavation proceeds to final grade.

Bin, Concrete [BC]: Concrete bin walls (Figure 30), employing large, steel reinforced concrete box construction are also rarely seen on NPS properties. New products employing hollow cast concrete boxes filled with aggregate and faced with various formliner patterns are becoming popular alternatives to cast-in-place concrete walls or solid block walls.

Bin, Metal [BM]: Metal bin walls (Figure 31) comprised a significant percentage of the walls inspected during the WIP Cycle 1 inventory and assessment. This type of wall was particularly popular within the western U.S. park system in the 60's and early 70's. The steel bins are comprised of individual units generally 8-10 ft wide and of varying depth into the slope, and may be galvanized or sprayed with other corrosion-resistant coatings.

Cantilever, Concrete [CL]: Concrete walls (Figure 32) comprised almost 10% of the total number of walls inspected within the Cycle 1 WIP inventory (most often occurring as culvert head wall/wingwall structures). The cantilever concrete wall, generally a cast-in-place fill wall (though smaller walls maybe precast and transported to the site), likely comprises the majority of the newer concrete wall structures inventoried owing to its cheaper construction. However, unless the stem wall thickness is exposed, it can be very difficult to discern this wall type from a mass gravity concrete structure.

Cantilever, Soldier Pile [CP]: The cantilever soldier pile wall (Figure 33) is of similar construction to the tieback version, less the ground anchors. Whereas the tieback version almost exclusively employs steel piling, the soldier pile wall may employ alternative concrete "piling" supporting both timber and concrete lagging. Generally a cut wall installation, this wall type can also be used as a fill wall in outboard wall applications.

Figure 30. Photo. Precast hollow concrete "bin" blocks, with a formlined architectural facing, are dry-laid at this cut wall installation and then aggregate filled for a rapidly-constructed, low-cost alternative to gravity concrete walls. (Courtesy Stone Strong, LLC)

Figure 31. Photo. Heavily corroded metal bin wall at China Beach, Golden Gate National Recreation Area. Constructed in the 60's, the protective coating on the exposed bin facing elements has long since deteriorated.

Figure 32. Photo. Cast-in-place concrete cantilever walls are commonly found serving as wingwall structures for large box culvert features within the WIP inventory.

Figure 33. Photo. Timber-lagged, soldier pile fill wall employing steel H-piles at Olympic National Park. To limit wall deflection, unanchored soldier pile walls are generally restricted to heights well under 15 ft, depending on the size of piling employed. Both piles and lagging are commonly treated for corrosion and dry rot, respectively.

Figure 34. Photo. Cantilever steel sheet pile cut wall with "deadman" anchors placed at the top of the wall to support the higher wall sections.

Cantilever, Sheet Pile [CS]: As with the anchored version, cantilever sheet pile walls(Figure 34) may be constructed of steel or vinyl, and are more commonly associated with applications near water bodies (e.g., coastal sites, bridges). A variety of coatings may be applied to steel sheet piles and metal fixtures. Occasionally, these structures may employ low-capacity "deadman" anchorage along the upper third of the pile, an element that may be overlooked during inspection.

Crib, Concrete [CC]: An open-faced version of the concrete bin wall, examples of the concrete crib wall (Figure 35) are scattered throughout the park system, coast-to-coast. These wall systems lend themselves to vegetated faces, but also suffer more rapid deterioration due to weathering and vegetation root damage than other wall types.

Crib, Metal [CM]: Metal crib walls (Figure 36) were rarely encountered in the WIP Cycle 1 inventory. Of similar construction to the concrete crib version, the metal crib wall also suffers rapid weathering and damage from unchecked vegetation. Crib walls commonly also employ some fashion of backing mat to retain wall fill, an element that should also be rated on this structure.

Crib, Timber [CT]: A popular wall construction method of urban landscape architects, the timber crib wall (Figure 37) is seldom encountered in the park system. Although some small timber crib walls, built with 4-6 inch square timbers, were inspected during the Cycle 1 inventory, the more common and robust construction involved large diameter, unshaped logs with crushed rock fill.

Figure 35. Photo. Concrete crib wall at Sequoia National Park. This wall is filled with crushed aggregate, though many similar structures may be constructed with planted faces.

Figure 36. Photo. Metal crib wall at Mesa Verde National Park. Large rock fill was used on this wall to avoid the need for facing mats to retain fill aggregate.

Figure 37. Photo. Timber crib wall at Yellowstone National Park employing large-diameter logs set "Lincoln Log" style on a placed rock fill.

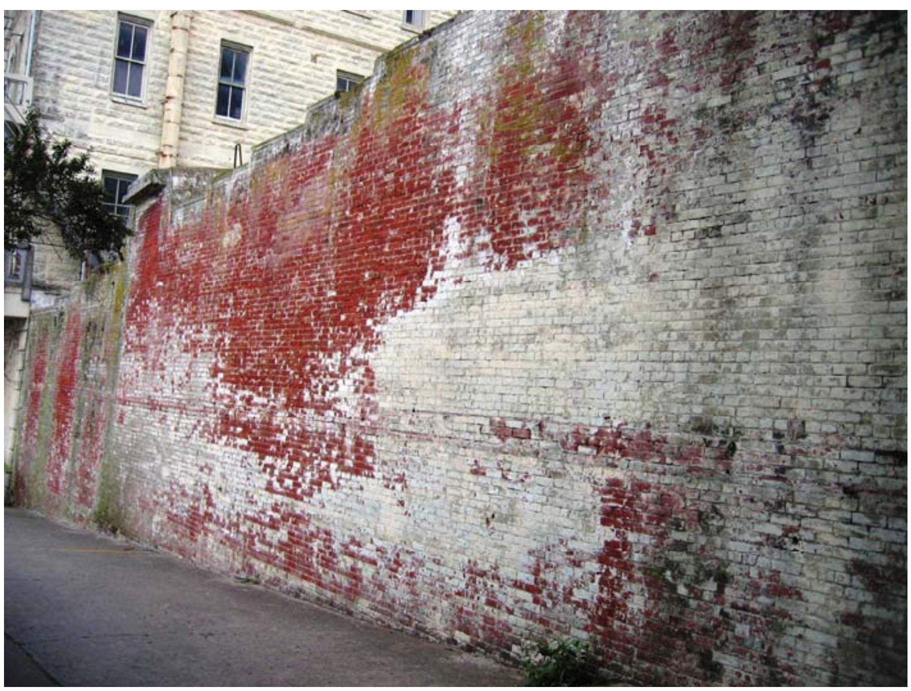


Figure 38. Photo. Tall painted brick wall at the Alcatraz unit of the Golden Gate National Recreation Area. Nearby concrete block walls suggest the interior of this wall may be constructed of larger blocks, with bricks added as a decorative facing.

Figure 39. Photo. Painted mass concrete gravity wall bordering Ft. Mason at the Golden Gate National Recreation Area. Although less aesthetically appealing than other wall types or facings, the inspecting engineer should nonetheless be aware of the cultural sensitivity of these structures.

Gravity, Concrete Block/Brick [GB]: Concrete block/brick walls (Figure 38) were rarely encountered during the Cycle 1 inventory. Many of these were quite tall (>8-10 ft), suggesting a different interior wall construction method (e.g., mass concrete gravity wall) employing a brick facing. Unless the interior of the wall is exposed, the wall should be classified as a brick structure.

Gravity, Mass Concrete [GC]: As noted earlier, concrete walls accounted for nearly 10% of all walls inspected in the Cycle 1 inventory. Mass concrete gravity walls (Figure 39) generally represented structures constructed prior to 1960. These structures may or may not be steel reinforced, and often suffer from chemical weathering and poor aggregate mixes.

Gravity, Dry Stone [GD]: Dry stone gravity walls (Figure 40), constructed as both cut and fill structures, represented nearly 25% of all walls inspected in the Cycle 1 inventory. Most of these walls were constructed in the 30's and 40's, and historic records indicate that dry-laid stone, either uncut or masoned, was generally used throughout the wall. It is common to find varying levels of workmanship within a single wall structure, requiring careful inspection of the entire wall face.

Gravity, Gabion [GG]: Wire-basket gabion gravity walls (Figure 41) were often encountered as outboard fill walls. In most cases, these structures were constructed at face angles flatter than 70 degrees, often approaching 1H:1V slope ratios. Although this wall system is often used as a facing for a reinforced soil mass (MSE design), unless the inspecting engineer knows otherwise the wall should be considered a gabion gravity structure.

Figure 40. Photo. Dry-laid stone masonry wall at Yellowstone National Park built atop lower stone masonry wall (different construction periods?). The dimension, degree rock cutting, and placement quality of stone masonry work can vary greatly – even within a single wall.

Figure 41. Photo. Angular rock fill gabion wall at the toe of a large fill along the Blue Ridge Parkway.

Figure 42. Photo. Mortared stone masonry head wall along the Blue Ridge Parkway. Although the mortar is often highly weathered in these structures, well-masoned and placed rock result in remarkably stable, high-performing, long-life structures.

Gravity, Mortared Stone [GM]: The mortared stone gravity wall (Figure 42) was the most common wall type encountered, accounting for nearly 50% of all walls inspected. This wall type is particular popular for constructing culvert head walls and wingwalls, employing both uncut and masoned stone. Mortared stone masonry is also often used as an architectural treatment for a number of other wall types (e.g., concrete walls, MSE walls, sol nail walls).

MSE, Geosynthetic Wrapped Face [MG]: The geosynthetic wrapped face MSE wall (Figure 43) is most commonly used either as a temporary wall structure or as a permanent wall with an architectural facing, making it difficult for the inspecting engineer to identify this wall type without prior knowledge of wall construction. These fill wall structures may utilize a variety of wall facing types, including sod-wrapped geogrids providing for a vegetated finish.

MSE, Precast Panel [MP]: Precast panel MSE walls (Figure 44) are very popular within urban areas as the architectural facing is integral to the wall structure, thereby expediting construction in congested traffic corridors. Integral panel construction should not be confused with precast architectural facing panels that simply cover the underlying wall face (typically a wire-faced wall). Both metallic and geosynthetic reinforcements are used with this wall type, though determining which has been used may not be possible during the site inspection.

MSE, Segmental Block [MS]: A wide variety of block styles and configurations may be used to build segmental block MSE structures (Figure 45). Reinforcements are generally geosynthetic fabrics or grids, and can often be seen extending beneath blocks along the face. As with the precast panel walls, blocks can also be used solely as architectural facings in front of wire-faced walls.

Figure 43. Photo. Multi-tiered, plantable, geosynthetic wrapped MSE wall. Although UV-resistant materials are available, the inspecting engineer should pay close attention to the degradation of exposed geosynthetics versus the age of the wall. (Courtesy Tensar Corp.)

Figure 44. Photo. Precast panel MSE wall at Great Smoky Mountains National Park. A variety of architectural facing options are available, including formlined concrete and stained or painted treatments.

Figure 45. Photo. Segmental block wall with geogrid reinforcement at Bryce Canyon National Park. Although MSE walls can tolerate substantial settlements, brittle facings such as blocks or precast panels can result in severe cracking with relatively minor differential displacements.

Figure 46. Photo. Wire-faced MSE wall, nearing completion at Colorado National Monument, utilizes a geosynthetic fabric to ensure retention of the metallic-grid reinforced aggregate. Left unprotected, this facing system would be susceptible to UV damage in the years to come.

Figure 47. Photo. Soil nail wall at Yellowstone National Park with a form-lined, cast-in-place simulated stone structural facing. The formliner is subsequently stained or painted to better simulate natural stone.

MSE, Welded Wire Face [MW]: Welded wire face MSE walls (Figure 46) are perhaps the most common MSE applications in the Cycle 1 database. Although standard wire mats are used to retain fill material at the face, supplemental materials such as hardware cloth and geotextiles may be used along with variable sized facing aggregate and face staining options.

Soil Nail [SN]: Soil nail walls (Figure 47) are a cut wall technique employing grouted steel bars (nails) as ground reinforcement. Permanent soil nail walls typically have at least a structural shotcrete facing, though a wide variety of facings can be employed, ranging from stone masonry work to extravagantly sculpted, stained and/or painted shotcrete. Unless the inspecting engineer is aware of the construction method used at the time of the inspection, correctly classifying a cut wall structure as a soil nail wall can be very difficult, particularly when a rock facing is used.

Tangent/Secant Pile [TP]: The tangent/secant pile wall (Figure 48) is a cut wall design typically employed where very small horizontal deflections can be tolerated and tieback systems cannot be used (e.g., urban constructions involving neighboring structures). These walls are typically faced with precast panels upon wall completion, so identifying them in the field would be nearly impossible without prior knowledge of the construction method.

Other, User Defined [OT]: "Other" refers to wall types rarely encountered in park roadway construction, including patterned ground anchors, segmental concrete "T" walls, cantilever "Z" walls, slurry walls, split-tire gravity walls, etc. (Figure 49 and 50).

Figure 48. Photo. Tangent pile cut wall constructed of drilled shafts. This expensive wall system is primarily used where top-down soil nail or ground anchor construction is not feasible due to subsurface obstructions within the retained ground mass.

Figure 49. Photo. "Other" wall type: geosynthetic reinforced earth wall with planted geocell facing. This wall facing method may prove to be a superior means for establishing face vegetation in high growth climates. Note the installation of the concrete leveling pad.

Figure 50. Photo. "Other" wall type: segmental concrete "T" wall at Zion National Park. Each precast "T" panel has concrete ribs extending into the compacted retained fill to serve as ground reinforcement and facing panel anchorage. The Ashlar block formliner was stained to match the surrounding country rock.

> *****IMPORTANT*****
> Depending on the wall type and facing systems used, it can be very difficult to determine the primary wall type. Always seek the expertise of park facilities, resource and maintenance staff to best determine the types of structures being inspected.

4.2.3 Secondary Wall Type(s)

"Secondary Wall Types" refers to one or more smaller walls that may exist in conjunction with the larger primary wall structure. While a secondary wall may not comprise a large percentage of the overall wall structure, it may nonetheless serve as a critical part of the soil/rock retention system. For example, and perhaps the most common occurrence of a secondary wall, an original short earth retaining structure that has been substantially built upon to extend the height of the wall may serve as an important foundation element of the newer wall, but would be considered a secondary wall type owing to its smaller contribution to ground support or overall size within the wall system. The Secondary Wall Type may, in some cases, be the same as the Primary Wall Type, but represent a different construction period.

4.2.4 Approximate Year Built

"Approximate Year Built" refers to the actual or approximate year the *primary* wall was constructed (+/- 5 years) per available construction data, park personnel knowledge, the age of similar structures in the park or region, and/or the year of roadway construction. This is a very important piece of data to query within the WIP database, so every reasonable effort should be made to determine when the wall was built. Default to "unknown" if no wall construction information is available or the approximate year built cannot be reasonably attributed to other known construction in the park. Document the approximate year built for secondary walls in the General Wall Description Notes.

4.2.5 Architectural Facings

"Architectural Facing" refers to any facing element that does not directly contribute to the support capacity of the structure. These would include manufactured block or rock facades/veneers, partial- or full-height precast panels, sculpted shotcrete, formlined concrete, etc. In some cases it will be difficult to discern whether the wall facing is a structural element (e.g., sculpted thick shotcrete finish over a suspected soil nail wall). When the structural contribution of the wall facing cannot be clearly determined, default to evaluating the facing as a contributing structural element.

Architectural facing types and inventory codes are listed in Table 3. General descriptions and selected examples of the various types of facings that may be encountered during an inventory are also provided below.

Table 3. WIP architectural facing types and associated field inventory codes.

Architectural Facing	Code
Brick Veneer	BV
Cementitious Overlay	CO
Fractured Fin Concrete	FF
Formlined Concrete	FL
Plain Concrete (float finish or light texture)	PC
Planted Face	PF
Sculpted Shotcrete	SC
Shotcrete (nozzle finish)	SH
Steel/Metal	SM
Stone	SO
Simulated Stone	SS
Stone Veneer	SV
Timber	TI
Other – User Defined	OT

Brick Veneer [BV]: Retaining walls are seldom constructed solely of brick. Generally, the interior of the wall is constructed of either mass concrete or larger concrete blocks (also referred to as concrete masonry units (CMU's), cement blocks, and cinder blocks). Figure 38 is a good example of a suspected brick veneer facing.

Cementitious Overlay [CO]: A cementitious overlay is a thin application of cement to a wall facing used to enhance the aesthetic appeal of the structure. The overlay may range from a plain, flat finish (possibly stained or painted) to a colored and/or textured application.

Figure 51. Photo. Example of one of the many "Fractured Fin" formliner architectural facing treatments available and commonly used in urban construction. (Courtesy Fitzgerald Formliners)

Figure 52. Photo. Although a seemingly accidental wall finish, a rough wood formliner was actually used in the construction of this concrete cantilever wall at Golden Gate National Recreation Area to simulate historical concrete construction practices throughout the park. This example emphasizes the need to discuss the cultural attributes of retaining walls with park resource staff prior to undertaking site inspections.

Fractured Fin Concrete [FF]: Fractured fin concrete (Figure 51) refers to a specific, yet popular category of formlined architectural treatments employing smooth/rough linear relief (striations, grooves, ridges – “fins”). This family of architectural concrete patterns is commonly seen throughout urban architecture, but is rarely seen within the park system.

Formlined Concrete [FL]: Formlined concrete (Figure 52) refers to a broad category of concrete facing finishes achieved by placing patterned molds within the concrete forms. Examples range from the aforementioned geometrical “Fractured Fin” patterns to simulated stone or brick patterns, to extravagant reliefs involving images of landscapes, animals, unique designs, etc. Figures 47 and 50 are typical examples of formliner applications within the park system. Surface treatments including color additives, stains and paint may be used in conjunction with formliner facings.

Plain Concrete (float finish or light texture) [PC]: As the name implies, plain concrete simply refers to a float finish with minimal texturing applied, if any. As illustrated in Figure 52, the inspecting engineer should be careful to not minimize the potential cultural importance of these facing finishes.

Planted Face [PF]: Planted face architectural treatments (Figure 53) are often found on geosynthetic-wrapped walls, but may also be used in conjunction with wire-faced MSE and gabion walls, as well as a variety of tiered wall types. Planting pockets can be sources for the onset of wall facing failures. The inspecting engineer should also consider that although it may be desirable for a particular wall face to be vegetated, not all forms of vegetation are good for long-term wall stability (e.g., trees growing from the facing).

Sculpted Shotcrete [SC]: Sculpted shotcrete (Figure 54) has been used on a limited basis in the parks, and is generally considered an architectural facing option for soil nail walls (where shotcrete finishes are often used). Color additives, staining and painting treatments are also commonly applied to enhance facing appearance or simulation of natural surfaces. This facing treatment may also be part of a secondary wall remediation effort, where shotcrete is used to quickly repair a failing wall section, and then sculpted for aesthetic purposes.

Shotcrete (nozzle finish) [SH]: Nozzle finished shotcrete is seldom seen in park applications, except where the wall is well hidden from the visiting public. In some circumstances, irregular surfaces, color additives, and/or staining may be used to further assist in camouflaging the structure.

Steel/Metal [SM]: Decorative metal wall facing treatments are very rarely used, and no examples of this treatment were readily apparent in the WIP Cycle 1 inventory. Decorative gabion facings could be interpreted to fall under this category, but would be better classified as “Other” to capture the gabion basket and rock fill architectural system.

Stone [SO]: Stone facings, mortared or dry-laid treatments comprised of one or more courses of stone across the thickness of the facing, are occasionally used in front of soil nail walls and MSE structures (Figure 55). Stonework can range from highly-masoned, “hand-sized” pieces to large machine-placed rockery material.

Figure 53. Photo. A well-vegetated wire-faced MSE wall in Siskiyou National Forest. Grasses, small bushes and other forms of light ground cover are appropriate for vegetated wall faces. Trees growing from the wall face or along the top of the wall, present a wall performance threat.

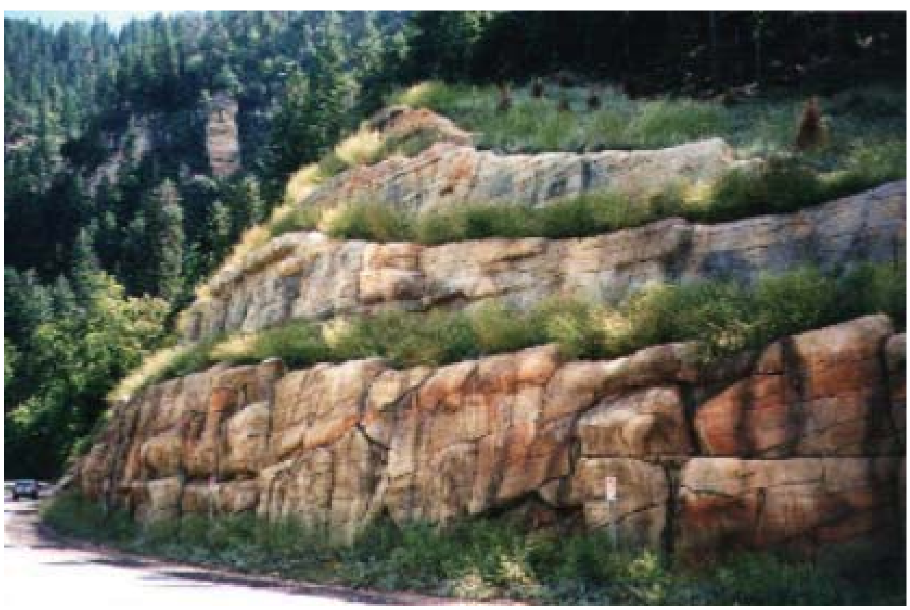


Figure 54. Photo. A dramatic example of the artistic range achievable with sculpted shotcrete. As time passes, the staining may fade along the wall, only to be replaced with natural staining due to annual weathering processes. The inspecting engineer will need to carefully evaluate both the condition of applied surface treatments and current visual quality of the facing when determining if remedial actions are required.

Figure 55. Photo. Single-course, mortared stone facing placed in front of an MSE wall structure. Well-built facings can make it very difficult to discern modern facades from historical structures. (Courtesy Mountain Village Metropolitan District, Telluride, CO)

Simulated Stone [SS]: Simulated stone (Figure 56) is generally considered a type of formliner treatment, but may also include such things as individual artificial stone products mortared on the wall face or precast concrete simulated stone masonry blocks (e.g., Ashlar blocks).

Stone Veneer [SV]: Stone veneer facings are comprised of thin plates of rock mortared to the wall face – commonly on concrete or shotcrete walls. Many of these veneers are historic, and close inspection often reveals the methods used to split the rock facing – an important item to consider when pricing repairs or replacement options.

Timber [TI]: Timber-faced walls (Figure 57) are rarely encountered in the park system, likely due to the maintenance requirements involved. Timber lagging and cribbing should not be confused as an architectural treatment. Lagging and cribbing are primary wall structural elements.

Other – User Defined [OT]: As noted above, a good example of an “Other” wall facing treatment would be the composite architectural aspects of a gabion-faced MSE structure (where the gabions are known to be non-structural). The gabion baskets allow for a wide array of basket geometries, rock fill colors and textures, and staining and planting options.

*****IMPORTANT*****
Depending on the wall type and facing systems used, it can be very difficult to determine whether a facing is structural or purely architectural. Always seek the expertise of park facilities, resource and maintenance staff to best determine the types of facing treatments being inspected.

Figure 56. Photo. Simulated stone using a deep-inset formliner and individually stained rock units. This application attempted to disguise the form joints by matching whole rocks panel-to-panel. (Courtesy Vail Associates)

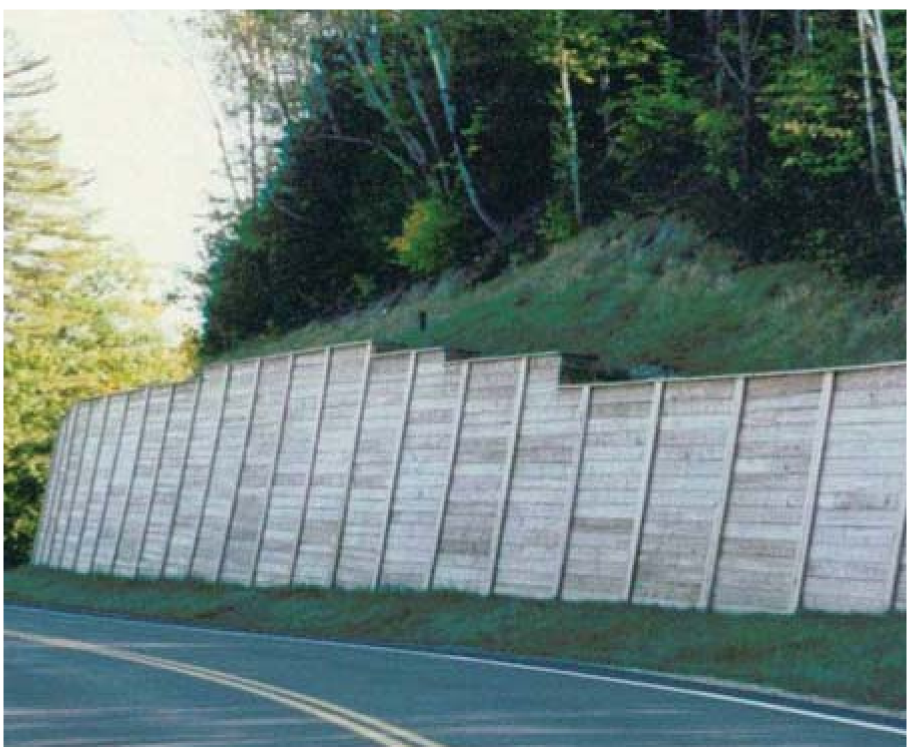


Figure 57. Photo. Timber-faced soil nail wall. (Courtesy New Hampshire DOT)

4.2.6 Surface Treatments

"Surface Treatments" includes all coatings or treatments used to color, preserve or protect wall elements. Surface treatments may include stain, galvanization, paint, tar coatings, wood preservatives, concrete sealers, color additives, or surface texturing (other than formliner applications). The inspecting engineer should note that more than one surface treatment might be present on a wall (e.g., painted piles and preserved wood lagging on a soldier pile wall).

Surface treatment types and inventory codes are listed in Table 4. General descriptions and selected examples of the various types of treatments that may be encountered during an inventory are also provided below.

Table 4. WIP surface treatment types and associated field inventory codes.

Surface Treatments	Code
Bush Hammer (tool-textured concrete)	BG
Color Additive	CA
Galvanized	GL
Painted	PA
Preservative	PS
Silane Sealer	SE
Stain	ST
Tar Coated	TR
Weathering Steel	WS
Other – User Defined	OT

Bush Hammer (tool-textured concrete) [BG]: A bush hammer is a masonry tool used to texturize stone and concrete (Figure 58). As the tool impacts the surface, a rough, pockmarked texture is created that simulates a naturally weathered surface. Tooling of the material may be done on site, in the case of cast-in-place concrete structures, or may be completed on precast wall elements prior to shipping. Although this surface treatment is rarely applied to park concrete structures, it is often seen on concrete panels used as architectural facings for MSE walls.

Color Additive [CA]: Color additives may be added to both cast-in-place and precast concrete wall elements (Figure 59), including modular blocks and architectural facing panels (Figures 44 and 49). Colored shotcrete is used for both sculpted and nozzle finish applications.

Galvanized [GL]: Galvanized metal wall elements are typically limited in park applications to coatings applied to facing and basket wires on MSE and gabion walls. When used on metal bin or crib walls, other forms of surface treatments (e.g., paint) may be used in conjunction with galvanization to minimize the visual impacts to the environment.

Painted [PA]: The most common application of paint-based treatments is corrosion protection of steel piling and non-galvanized steel fixtures (Figure 60). However, paint is also used on concrete, brick and wood surfaces, and ranges from poorly-applied, unprimed coatings to highly crafted applications simulating natural stone.

Figure 58. Photo. Example of concrete blocks textured with a bush hammer prior to placement. A range of textures can be created with this technique, depending on the hammer head size and configuration. (Courtesy Doublewal Corporation)

Figure 59. Photo. Example of float-finished, colored shotcrete applied over an MSE wall facing. (Courtesy Maricopa County, AZ)

Figure 60. Photo. Severe weathering distress is evident on painted steel sheet piling at the Sandy Hook Unit, Gateway National Recreation Area. Less conspicuous weathering of painted surfaces can be difficult to discern without close inspection and knowledge of the most recent paint applications.

Preservative [PS]: A variety of preservatives may be used to inhibit weathering of wood elements, including treatments applied by the manufacturer and subsequent treatments applied by park maintenance staff. Timber lagging on soldier pile walls and the exposed timber elements of crib walls are wood elements often treated several times over the lifetime of the structure.

Silane Sealer [SE]: Silane is a spray-on stone and concrete weathering protectant particularly known for its ability to permeate porous surfaces. A wide range of sealants are available spanning Silane, urethane and epoxy based treatments. Stain can also be introduced with these types of surface sealants.

Stain [ST]: Stains (Figure 61) can be applied to a wide range of wall types and architectural facings, including concrete, shotcrete, metal and wood elements, as well as rock fills in MSE and gabion walls. Although stains are generally applied for aesthetic purposes, many types of stain treatments also serve as wall element preservatives.

Tar Coated [TR]: Tar or bituminous coatings are most commonly seen in park applications as weathering treatments applied to timber crib or timber-faced walls (generally large timbers). These coatings may also be used as corrosion protectants on non-galvanized wall elements.

Figure 61. Photo. Example of sculpted shotcrete stained to match the surrounding landscape. Fading due to seasonal weathering and UV damage may require additional staining to meet aesthetics objectives.

Figure 62. Photo. Weathering steel, sold under the "CORTEN" trademark, can provide a long-life, low-maintenance surface treatment for wall systems in the right environment. (Courtesy Richer Metal, Dodge Center, MN)

Weathering Steel [WS]: Weathering steel (Figure 62), best-known under the trademark CORTEN steel, is a group of steel alloys developed to eliminate the need for corrosion protective coatings and painting, forming a rust-like appearance if exposed to the weather for several years.

Other – User Defined [OT]: "Other" simply refers to surface treatments not covered in Table 4.

> *****IMPORTANT*****
> Surface treatments can be difficult to discern and are *often* overlooked during wall inspection. The inspecting team should discuss with park facilities staff the types and durabilities of surface treatments being periodically applied to wall elements.

4.2.7 Wall General Description Notes

The inspecting engineer should briefly describe attributes of the wall structure not fully described in the wall inventory, including the purpose of the wall, the general setting/terrain in which the wall resides, the type of construction, presence of multiple wall types and/or different construction periods, and the consequence of wall failure. An example of an appropriate wall description might include…"Recently repointed mortared stone masonry fill wall, supporting seasonally high ADT Park entrance road, founded on steep slope with signs of seasonal seepage." In the case of bridge walls, the National Bridge Inventory System (NBIS) bridge number should be logged, if known. If the wall is located on a non-RIP route, additional location descriptors should be added here.

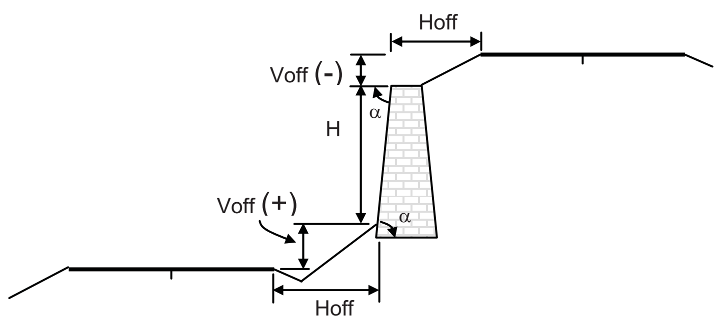
4.2.8 Wall Length

"Wall Length" is defined as the actual measured maximum earth retaining length of the wall, measured to the nearest foot, excluding non-earth retaining wall features such as guardwalls and parapets (Figure 63). Guardwalls, guard rails and other traffic barriers are covered under other inventories. In situations where long sections of guardwall are underlain by shorter, discrete retaining wall structures, the inspecting engineer must discern at what point the guardwall is a feature of the retaining wall supporting the roadway or is constructed atop a foundation structure built primarily to support the guardwall and not the roadway (which may approach the ≥ 4 ft wall height criteria). In situations where the guardwall foundation structure is determined to also serve as a retaining wall for the roadway, and meets the criteria and intent of the wall acceptance criteria, the structure should be included in the wall inventory.

When evaluating an undulating, variable-height wall with one or more intervening short-height sections (< 4 ft), the inspecting engineer needs to discern whether the wall is acting as one retaining structure or if sections are functioning independent of one another requiring separate inventories. Considering the wall type, construction materials, and cultural aspects, the inspecting engineer should determine if wall replacement would involve the entire structure or just the independent segment when determining how to include the wall(s) in the inventory.

4.2.9 Maximum Wall Height

"Maximum Wall Height" refers to the maximum *observable and/or verifiable* height of the wall (Figure 63), measured to the nearest foot. Estimated embedment and/or guardwall/parapet structures are *not* included in the maximum wall height. The maximum height measurement extends from the groundline at the wall toe to the top-of-wall groundline, or to the estimated original designed top-of-wall groundline for the case where retained material has been removed (e.g., surface erosion behind the top of the wall). An estimated maximum height shall be logged for fully buried structures based on available information or estimates provided by park staff.



H	Exposed wall height, ft
Voff	Average vertical distance from pavement to cut wall toe or groundline at top of fill wall (+ above/- below roadway), ft
Hoff	Horizontal distance to wall face from edge of pavement or gravel travelway, ft
Hmax	Maximum exposed or verifiable wall height, ft
α	Wall face angle, degrees
L	Total constructed wall length at top of wall ground line, ft

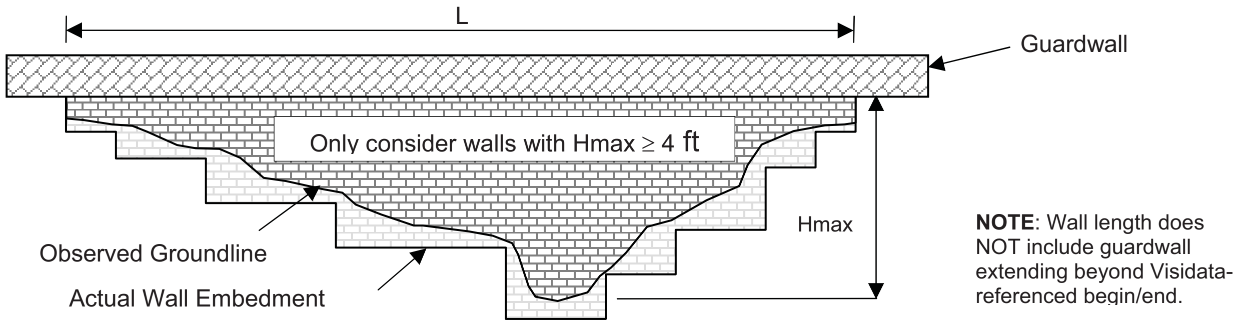


Figure 63. Graphic. Drawing showing required field measurements, including the observed maximum wall height, actual wall length, vertical and horizontal offsets from the edge of road, and wall face angle.

4.2.10 Wall Face Area

"Wall Face Area" is the field-calculated exposed area of the wall face, determined to the nearest 5 sqft, less culvert opening area when this area is estimated to be greater than 25% of the wall face area and guardwall/parapet area(s). The inspecting engineer should note that this value is akin to the "estimated vertical wall face projection area", as used in estimating wall construction. Several methods may be used to estimate the exposed wall face area; however, the preferred method is to divide the wall face into simple polygons, determine the area of each polygon, and sum the individual areas. This method requires multiple wall measurements, but generally results in more accurate estimates of wall face area.

4.2.11 Vertical Offset

"Vertical Offset" (Figure 63) is the average vertical distance, measured to the nearest foot, from edge of travelway to the toe of above-grade walls or groundline at the top of below-grade walls (recorded as + ft above travelway and - ft below travelway). For example, the toe of an inboard cut wall could be either above the nearest edge of road grade (+ vertical measurement) or within the ditchline below the nearest edge of road grade (- vertical measurement). Outboard fill walls are commonly at or below road grade (- vertical measurement).

4.2.12 Wall Start/End Offset

"Wall Start Offset" (Figure 63) is the approximate horizontal distance, measured to the nearest foot, from the edge of pavement to the wall face at the start of the wall. Similarly, "Wall End Offset" is the horizontal distance from the edge of pavement to the wall face at the end of the wall.

4.2.13 Face Angle

"Face Angle" (Figure 63) refers to the internal wall face angle measured from the horizontal to the nearest degree. The corresponding angle, or alternate interior angle to the internal wall angle, is the dip angle of the wall face, measured from the horizontal down the wall face. In most cases, the face angle will fall between the minimum acceptance criterion angle of 45^o and 90^o; however, negatively battered walls may be encountered (overhanging walls with face angles > 90^o).

4.2.14 Photo Description/No.

"Photo Description/No." requires the investigating engineer to photo document the retaining wall, logging the digital photo number taken in the field and a brief descriptor for each photo. In general, the use of photos should be limited. One to two reference photos per wall should be taken from locations that facilitate easy future identification. Additional photos may be taken to document the magnitude and extent of wall distresses or unusual circumstances and to allow tracking of distress progression over time. To avoid excessive file sizes, digital cameras should be set to "low" or "medium" resolutions.

The following types of photos are sufficient for capturing key wall elements (use only as needed):

- Wall Approach – taken from the roadway/parking area looking up-station at the overall wall setting;
- Wall Frontal Elevation – taken from directly in front of the wall or slightly off to one side, and from sufficient distance back from the wall so as to capture the majority or entirety of the structure (when possible);
- Top of Wall/Roadway – taken looking up-station along the top of the wall, and capturing the condition of the roadway/parking area and traffic barriers immediate to the structure;
- Wall Face Alignment – taken from the side of the wall (up- or down-station, as access permits), capturing the cross-sectional view of the wall face;
- Wall Face Detail – taken directly in front of the wall, capturing the details of major wall structural and/or facing elements; and
- Wall Failure/Deficiency Detail – taken at specific wall locations illustrating typical wall deficiencies or element distress.

Most walls may only require 2-3 photos for adequate photo documentation (culvert headwalls often only require a single photo), whereas long complex walls may require additional photos (generally limited to 6-7 photos whenever possible).

Upon returning from the field, all photos shall be renamed to include the unique wall identifier established in the WIP Database (Park Alpha + Route No. + Milepoint + Side of Road) plus a photo number (1, 2, 3…). For example, MEVE-0010-2.134-R-3 would be the third photo taken of a wall in Mesa Verde National Park on the right side of Route 10 at milepoint 2.134. All photos should be backed up to a laptop, thumb drive or CD *each day in the field* to ensure photos for each wall inspected are safely delivered to the Central WIP Database.

4.2.15 Park-Designated Wall ID

In addition to the unique "WIP Wall ID" generated within the database (Park Alpha + Route No. + Milepoint + Side of Road), the park may already have a naming/numbering convention in place for wall structures. Park-generated wall identification systems may use approximate or measured mileposts, may use the milepoint information provided by RIP, or may simply number walls by occurrence from a starting reference point (e.g., beginning of a route). Some parks employ sophisticated bar coding technologies, which may be directly tied to FMSS asset numbers. In some cases, more than one wall identification system may be used within a given park. For example, park maintenance may use a wall identification system developed at the time of roadway construction, park resource staff may uniquely identify wall structures of historical significance, and facilities management may have all or a portion of park retaining walls already posted to FMSS with assigned asset numbers. To the extent practical, when park-designated wall identification numbers exist they should be logged on the Field Inspection Form and added to the database. Previously assigned FMSS asset numbers should take precedence over all other park-designated wall identification numbers (if available).

4.3 WALL CONDITION ASSESSMENT

At this point in the field inspection, the retaining wall has been located relative to the RIP Visidata milepoint reference system, odometer mileage along the route, or parking area nomenclature and the wall attributes have been classified, measured, and photographed. **The next step in the field inspection is to assess the condition of primary and secondary wall elements relative to extent, severity and urgency of observable distresses, and then numerically rate each element, giving due consideration to data reliability.** In addition to the element assessment, the overall performance of the wall system is evaluated and rated considering "global" aspects of wall performance that may not be directly observable. Finally, all element and global ratings are weighted and combined to arrive at a "Final Wall Rating".

Successfully assessing the condition of a retaining wall structure requires **(1)** qualified and trained inspecting engineers, **(2)** a systematic, well-defined, element-based assessment methodology, and **(3)** a commitment to providing complete, consistent and concise element condition narratives and ratings. To this end, this section describes the "Primary" and "Secondary" wall elements to be evaluated and the assessment of overall wall performance, defines the minimum elements to be evaluated per wall type, provides guidance and examples for preparing quality element condition narratives, and defines how element ratings and weighting factors are selected and applied.

4.3.1 Wall Element and Overall Performance Definitions

An elemental condition assessment and rating system is used to evaluate overall wall condition, identify remedial actions that may be required immediately or in the near future, and provide condition measures to track performance changes with subsequent inspections. Primary and secondary wall elements are evaluated, as well as the performance of the overall system of wall elements. Primary elements include structural components; secondary elements include subsidiary features of the wall system and surrounding setting that contribute to wall performance.

"Elements", as used herein, are visible to the inspecting team. There are clearly wall components that are not visible, but are nonetheless important to the performance of the wall (e.g., MSE wall reinforcements). The rating of overall performance is the only way the performance and condition of these wall components are assessed in the WIP.

The following lists the primary and secondary wall elements to be evaluated, describes the overall wall performance features to be evaluated, and provides guidance on the minimum descriptive information required for the condition narrative. (NOTE: Specific types of element distresses to be captured in the assessment per wall element are described later in subsection 4.3.3 Element Condition Narrative Guidance.)

Primary Wall Elements

Piles and Shafts: "Piles and Shafts" include driven piles, micropiles or drilled shafts comprising all or part of the visible wall, as well as supplemental structures such as timber, steel or concrete walers (Figure 27). Identify the specific type of pile or shaft (e.g., timber pile; steel H-pile; pre-stressed concrete pile; vinyl sheet pile; cased micropile; secant drilled shaft) and describe the installation method (e.g., driven; drilled; cast-in-place), if known.

Lagging: "Lagging" refers to structural timber, concrete or steel lagging between piles and walers (Figure 27). Describe lagging according to material type, size, treatment and installation method (e.g., treated 6x6 timber lagging; pre-cast 8-ft-square concrete panels).

Anchor Heads: "Anchor Heads" refers to all visible parts of a tieback ground anchor system, including the pad and bearing assembly, generally observed without removing the anchor cap (Figure 27). Describe the bearing structure and manner in which the ground anchor is affixed within the wall structure (e.g., single row of strand ground anchors placed on 8-ft centers through steel, box-frame whalers).

Wire/Geosynthetic Facing Elements: "Wire/Geosynthetic Facing Elements" refers to the visible facing/basket wire, soil reinforcing elements, hardware cloth, geotextiles/geogrids, and

Figure 64. Photo. Not all MSE wall facing systems are the same. Mats may or may not be galvanized (left) and, depending on the size of facing fill versus the minimum wire mat opening, hardware cloth may or may not be required for fill retention (right).

facing stone that may be readily observable in the wall facing (Figures 46 and 64). Describe the component materials, placement location, special appurtenances (e.g., facing panel struts) and method of construction in the condition narrative (e.g., 4-in-square, galvanized wire mesh gabion baskets with 6-in to 8-in round river rock fill; sod-rolled, geogrid-wrapped, geogrid reinforced face).

Bin or Crib: “Bin or Crib” refers to the visible portion of a cellular gravity wall (Figure 35, 36 and 37). Describe the component materials and method of construction (e.g., 8x8 treated timber crib wall; 10x10 corrugated steel bin wall).

Concrete: “Concrete” refers to visible precast or cast-in-place concrete wall and footing elements (Figure 65). Concrete piles, lagging, crib blocks, manufactured block/brick, and architectural facing elements are not included under this element. Describe the type of concrete (if known), size of aggregate (if visible), and method of construction (pre-cast/cast-in-place) (e.g., non-reinforced, cast-in-place concrete with rounded “river run” aggregate).

Shotcrete: “Shotcrete” refers to visible structural shotcrete at the wall face, and does not include architectural facing (unless the facing is both structural and architectural). Describe the relative strength, thickness, color, and finish and application quality in the condition narrative (e.g., 8-in thick, fiber-reinforced, float-finished, steel-reinforced shotcrete with red color additive).

Figure 65. Photo. Severely weathered reinforced concrete headwall at Delaware Water Gap National Recreation Area.

Figure 66. Photo. Not all mortar applications are the same: (from left-to-right) highly-crafted mortar placement on fairly new wall at Bryce Canyon National Park; poor, inconsistent mortaring at Capulin Volcano National Monument; well-placed, yet highly weathered mortar showing signs of excessive seepage through headwall at Great Smoky Mountains National Park.

Figure 67. Photo. A mortared stone masonry headwall along the Blue Ridge Parkway, subsequently overlain with a dry-laid, placed-stone retaining wall built around trees growing at either end of the headwall.

Mortar: "Mortar" refers to visible mortar used between either uncut, "pitched" (hand-worked) or masoned rock, between manufactured blocks or brick, or used for wall repairs (Figures 66 and 67). Describe the type of mortar used (if known), placement quality, whether or not the mortar was placed at the time of wall construction, if repointing work is evident, and if mortar reinforcement was used (e.g., mortared stone masonry wall with unfinished mortar joints; trowel-finished, mortar set solid cinder blocks; trowel-finished mortar patch with chicken wire reinforcement). [NOTE: Additional discussion on repointing is provided in sections 1.3 A Program Perspective on Deferred Maintenance and 4.4.6 Recommended Action.]

Manufactured Block/Brick: "Manufactured Block/Brick" include concrete masonry units (CMU's), segmental blocks (Figure 45), large gravity blocks (often referred to as "bin blocks"), etc., but does <u>not</u> include concrete lagging or crib wall components. Describe the specific type and size of manufactured block/brick and method of construction (e.g., decorative, dry-laid, 8-in by 18-in Keystone segmental block with tan color additive).

Placed Stone: "Placed Stone" refers to dry-laid, rockery, or mortar-set, rough or lightly worked, uncut rock. Describe the type, size range of rock, and construction method (e.g., dry-laid, rectangular12-in to 24-in long and 4-in to 10-in thick, limestone; mortared 6-in to 10-in diameter rounded, granitic river rock).

Stone Masonry: "Stone Masonry" refers to dry-laid or mortar-set cut or "pitched" (hand-worked) rock. Describe the type, size range of rock, and construction method (e.g., mortared, 8-in to 24-in rectangular, red sandstone "Ashlar" blocks).

Figure 68. Photo. Examples of deteriorating wall foundation conditions: (clockwise from upper left) outlet scour at culvert headwall, Great Smoky National Park; soft soil erosion from under mortared stone masonry walls at Yellowstone and Crater Lake National Parks; deteriorating rock foundation at Acadia National Park.

Wall Foundation Material: "Wall Foundation Material" refers to the visible soil and/or rock immediately adjacent to and supporting the wall, within 2-4 ft of the wall toe or noticeable bench in front of the wall on steep slopes (Figure 68). Describe the type of foundation material present or missing, apparent strength of the foundation material, and construction characteristics of the foundation (e.g., hard, intact bedrock foundation throughout; soft, clayey soil foundation, scoured beneath 50% of the wall). The performance of buried foundation elements such as spread footings or piles is not captured under this condition element but, rather, under the "Performance" element in the "Wall Performance" section of the condition assessment (described later in this section).

Other Primary Wall Element: "Other Primary Wall Element" includes any element providing structural capacity to the wall not listed. Describe the type of element, materials and construction methods, as appropriate.

Figure 69. Photo. Plugged "weephole" drain at bottom of mortared stone masonry wall.

Secondary Wall Elements

Wall Drains: "Wall Drains" refers to the function and capacity of visible drain holes, pipes, slot drains, etc., providing wall *internal or subsurface drainage* (Figure 69). Describe the type and occurrence of wall drain(s), as well as the occurrence and magnitude of seepage through and around the wall (e.g., PVC weephole drains at toe of wall on 50-ft centers). A lack of visible wall drains requires the inspecting engineer to judge the overall drainage capability of the retaining structure, noting the presence of such things as soft and/or wet foundation soils, retained material piping from the wall face, excessive corrosion staining/efflorescence at specific wall locations, distressed elements immediate to seepage locations, etc. In the absence of visible wall drains and potential water-related problem areas, Wall Drains should be judged as functioning as intended.

Architectural Facing: "Architectural Facing" includes any facing that is not relied on for structural capacity, including concrete, shotcrete, stone, timber, geosynthetic/vegetation, etc. (subsection 4.2.5). Describe the type of facing, thickness, and construction method in the condition narrative (e.g., 6-in thick, sculpted, colored shotcrete with staining; 4-in-thick mortared stone masonry veneer; 4x6 precast concrete panel façade hung from wire-faced MSE wall).

Traffic Barrier/Fence: "Traffic Barrier/Fence" (Figure 70) refers to the condition of barriers, guardwalls, parapets and/or fences above, below or within the influence of the wall. Only describe and rate the barrier relative to wall performance, <u>not</u> its performance as a barrier (traffic barrier performance is evaluated under other asset and/or roadway safety programs). Describe the type, size and location of the barrier relative to the wall in the condition narrative (e.g., galvanized "W" guardrail on wood posts; mortared stone masonry parapet serving as constructed guardwall). This element should not be rated when the barrier structure lies outside the known or assumed influence of the wall, including the retained earth volume and adjacent slopes.

Figure 70. Photo. A section of parapet along this mortared stone masonry wall at Glacier National Park has been damaged due to vehicular impact. This portion of the wall would be assessed and rated under the "Traffic Barrier/Fence" secondary element.

Figure 71. Photo. Severe roadway damage due to timber crib wall fill settlement, loss of fill material, foundation bearing failure or global slope instability (or combination thereof).

Road/Sidewalk/Shoulder: "Road/Sidewalk/Shoulder" (Figure 71) includes the road, sidewalk and/or shoulder above or below a wall, and within the influence of the wall. These features should only be described and rated relative to wall performance; for example, pavement performance should not be rated, however, wall fill settlement seen as roadway patches should be described and rated. Describe the type, size, location and construction method(s) for each of these elements (e.g., 20-ft wide asphalt road surface with 5-ft-wide gravel shoulders on 3H:1V outboard slope; 6-ft-wide concrete sidewalk). The shoulder is generally defined as extending no greater than 5 ft horizontally from the roadway/sidewalk, and with less than a -5 ft vertical offset.

Upslope: "Upslope" (Figure 72) refers to the groundslope above a wall affecting wall condition and/or performance. Describe and rate the upslope condition for all walls located above roadway grade, regardless of slope ratio. Rate the upslope condition for all walls located below roadway grade, regardless of slope ratio, when the vertical offset to the wall is greater than 5 ft (otherwise include the condition of the upslope under the "Road/Sidewalk/Shoulder" element). Look for slumps, cracks, seeps, bulges, erosion, etc. that may affect wall performance. Describe the approximate slope ratio, slope height, and slope soil/rock constituents (e.g., lightly vegetated roadway fill extending 15-ft above top of wall at a 1.5H:1V slope ratio).

Downslope: "Downslope" (Figure 73) refers to the groundslope area below a wall, distinct from the Wall Foundation Material element, and possibly affecting wall condition and/or performance. Describe and rate the downslope condition for all walls above or below roadway grade, regardless of slope ratio. In the case of above grade walls (e.g., cut wall above inboard ditchline), describe the downslope below the foundation materials, which may include the ditchline and roadway bench. For walls that toe into the bottom of steep upslopes (e.g., culvert inlet headwall in an inboard ditch), describe the downslope setting (actually grading uphill from the toe of the wall/inlet structure) and the slope conditions. For walls that toe into an inlet/outlet drainage, describe the condition of the drainage. Look for slumps, cracks, seeps, bulges, erosion, etc. that may affect wall performance. Describe the approximate slope ratio, slope height, and constituent soil/rock materials (e.g., 10-ft of highly eroded roadway fill material on a 1H:1V downslope over 100+ ft of highly weathered rock; inboard headwall toes at base of steep (4H:1V) stable rock slope; stream channel below outlet headwall is deeply incised in soil/cobble matrix, with signs of head-cutting to headwall and wingwall foundations).

Lateral Slope: "Lateral Slope" refers to the ground slope laterally adjacent to a wall affecting wall condition and/or performance. Describe and rate the lateral slope conditions for all retaining walls. Look for slumps, cracks, seeps, bulges, erosion, etc. that may affect wall performance. Describe the approximate slope ratio, lateral extent of influence, and constituent soil/rock materials in the condition narrative (e.g., approximate 1.5H:1V lateral soil slope with deep erosion at wall end; durable, intact rock outcrop abutting wall end). Walls laterally terminated within oversteepened slopes commonly experience erosion problems at one or both ends.

Figure 72. Photo. Assuming the head wall height meets the 6-ft criterion, the overlying slope would be evaluated as an "Upslope" secondary element.

Figure 73. Photo. MSE wall at Glacier National Park awaiting final facing. The bench in front of the wall would be evaluated as a "Wall Foundation Material" primary element. The rocky slope below the bench would be evaluated as a secondary element under "Downslope".

Figure 74. Photo. Left unchecked, trees will grow just about anywhere, and can cause severe damage to retaining walls.

Vegetation: "Vegetation" refers to all forms of vegetation near the wall or on the wall face affecting wall performance (Figure 74). Describe the type, size, relative age and extent of vegetation when current growth impacts wall performance, or may potentially impact wall performance in the future. The overall impact of vegetation should also be carefully considered – good or bad – and noted in the condition narrative (e.g., roots from approximate 6-in-diameter trees at top of wall are pushing dry-laid stones from wall face; shrubs growing above, between, and below gabion baskets are mitigating run-off erosion of soft, silty soils).

Culvert: "Culvert" refers to the presence and condition of culverts, inlets and outlets through, below or adjacent to walls. Describe the culvert material, type, size, location, design and construction method (e.g., 18-in-diameter corrugated metal culvert pipe outletting 6-ft above toe of wall; mortared stone masonry arch culvert inletting at toe of wall). As these structures concentrate water flows through walls, the inspecting engineer should be particularly mindful to evaluate the functionality and capacity of the culvert, noting seeps, staining, accumulated soils and debris, and inlet/outlet erosion issues, as well as the internal integrity of the culvert. This level of inspection is only suitable as it pertains to the WIP. Culvert inspections should be carried out by qualified Hydraulics Engineers.

Curb/Berm/Ditch: "Curb/Berm/Ditch" refers to lined or unlined *surface drainage* features above or below the wall. Describe the type, location, capacity, and construction method of each element (e.g., 6-in asphalt curb with overtopping erosion evident 6-ft back from top of wall face).

Other Secondary Wall Element: "Other Secondary Wall Element" includes any element not providing structural capacity to the wall not listed. Describe the type of element, materials and construction methods, as appropriate.

Wall Performance

The final item to be assessed and rated on the Field Inspection Form, "Performance" refers to the overall, composite functionality of the primary wall structure and secondary wall elements, as indicated by a broader view of wall performance not necessarily captured by observed distresses for specific elements. "Performance" includes global wall distresses (rotation, settlement, translation, displacement, etc.) and/or evidence of prior repairs that may indicate component problems. This rating element also allows the composite, relational performance between all wall elements to be evaluated, aside from just evaluating individual element conditions, and may include the impact of combined distresses. The inspecting engineer should also note whether wall repairs are evident, specifically what repairs were made, and whether or not the repairs were successful at returning the wall to its intended function and level of service. Performance may also take into account previous inspection information.

Figures 75 and 76 present examples of wall distress that would be captured in the overall wall "Performance" description.

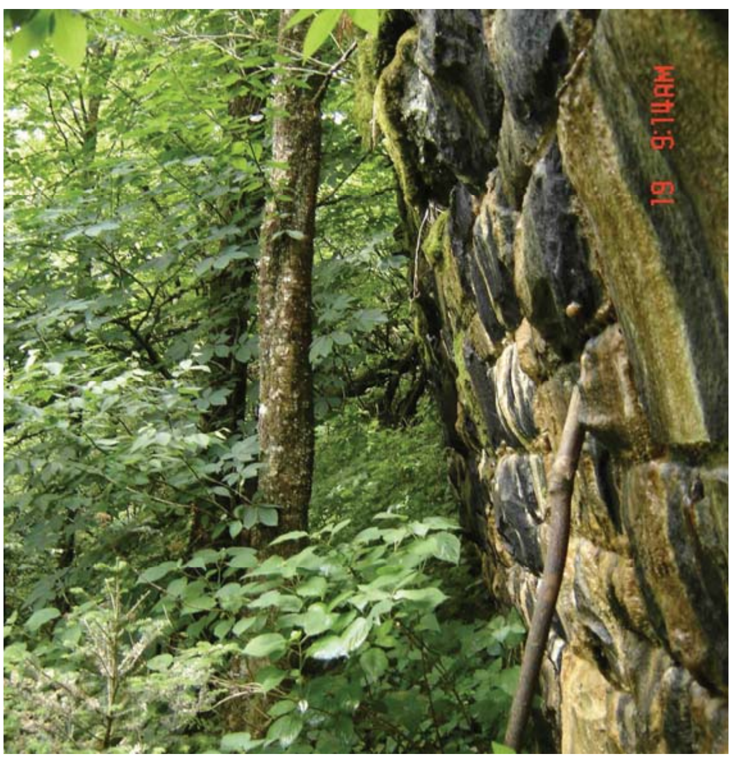


Figure 75. Photo. Overturning mortared stone masonry wall at Great Smoky Mountains National Park (assessment of primary/secondary elements alone would miss this obvious pending failure).

Figure 76. Photo. Developing wall problems at New River Gorge National River evidenced by post-construction remedial actions.

4.3.2 Minimum Element Rating Requirements

Specific primary and secondary wall elements are assessed and rated for each wall type listed in Table 2. For example, for a tieback H-pile wall, the assessment of "Piles", "Lagging" and "Anchor Heads" would be required; "Roadway/Sidewalk/Shoulder", "Upslope" and "Downslope" would be required depending on wall location relative to the roadway; and other primary and secondary elements would be assessed per their occurrence. "Wall Foundation Material" (primary element), "Wall Drains" and "Lateral Slope" (secondary elements), and "Performance" are assessed and rated for *all* walls. The chart in Figure 77 provides guidance on the minimum element assessment and rating priorities for each wall type listed in Table 2 (subsection 4.2.2 Primary Wall Type).

WALL TYPE	PRIMARY ELEMENTS	Piles and Shafts	Lagging	Anchor Heads	Wire/Geosyn. Facing Elements	Bin or Crib	Concrete	Shotcrete	Mortar	Manufactured Block/Brick	Placed Stone	Stone Masonry	Wall Foundation Material	Other Primary Element	SECONDARY ELEMENTS	Wall Drains	Architectural Facing	Traffic Barrier/Fence	Road/Sidewalk/Shoulder	Upslope	Downslope	Lateral Slope	Vegetation	Culvert	Curb/Berm/Ditch	Other Secondary Element	WALL PERFORMANCE	Performance
[AH] Anchor, Tieback H-Pile		●	●	●									●			●			○	○	○	●						●
[AM] Anchor Micropile		●		●									●			●			○	○	○	●						●
[AS] Anchor, Tieback Sheet Pile		●		●									●			●			○	○	○	●						●
[BC] Bin, Concrete						●							●			●			○	○	○	●						●
[BM] Bin, Metal						●							●			●			○	○	○	●						●
[CL] Cantilever, Concrete							●						●			●			○	○	○	●						●
[CP] Cantilever, Soldier Pile		●	●										●			●			○	○	○	●						●
[CS] Cantilever, Sheet Pile		●											●			●			○	○	○	●						●
[CC] Crib, Concrete						●							●			●			○	○	○	●						●
[CM] Crib, Metal						●							●			●			○	○	○	●						●
[CT] Crib, Timber						●							●			●			○	○	○	●						●
[GB] Gravity, Concrete Block/Brick									●	●			●			●			○	○	○	●						●
[GC] Gravity, Mass Concrete							●						●			●			○	○	○	●						●
[GD] Gravity, Dry Stone											○	○	●			●			○	○	○	●						●
[GG] Gravity, Gabion					●								●			●			○	○	○	●						●
[GM] Gravity, Mortared Stone									●		○	○	●			●			○	○	○	●						●
[MG] MSE, Geosyn. Wrapped Face					●								●			●			○	○	○	●						●
[MP] MSE, Precast Panel							●						●			●			○	○	○	●						●
[MS] MSE, Segmental Block										●			●			●			○	○	○	●						●
[MW] MSE, Welded Wire Face					●								●			●			○	○	○	●						●
[SN] Soil Nail								●					●			●			○	○	○	●						●
[TP] Tangent/Secant Pile		●											●			●			○	○	○	●						●
[OT] Other, User Defined													●			●			○	○	○	●						●

● Wall elements that should always be rated for the given wall type (others may also apply).
○ 1 of 2 primary wall elements required depending on material observed.
2 of 3 secondary wall elements required depending on wall location relative to roadway.

Road/Sidewalk/Shoulder: Rate only when these elements lie within the influence of the wall. The shoulder is generally defined as extending no greater than 5 ft horizontally from the roadway/sidewalk, and less than -5 ft vertical offset.

Upslope: Rate the upslope condition for all walls above roadway grade, regardless of slope ratio. Rate the upslope condition for all walls below roadway grade, regardless of slope ratio, when the vertical offset to the wall from the roadway/shoulder is greater than 5 ft (otherwise evaluate the condition of the upslope under the "Road/Sidewalk/Shoulder" element).

Downslope: Rate the downslope condition for all walls above or below roadway grade, regardless of slope ratio.

Figure 77. Graphic. Required wall assessment and rating elements per WIP wall type.

> *****IMPORTANT*****
> Although a wall or system of wall structures may possess a variety of contributing primary and secondary elements, the inspecting engineer must ensure that the wall elements identified in Figure 76 are assessed at a minimum (yellow items are collected for all wall types). Also, wall systems comprised of a primary wall type and one or more secondary wall types are evaluated as one overall retaining wall.

4.3.3 Element Condition Narrative Guidance

Once the pertinent primary and secondary wall elements have been identified for a given wall type, the inspecting engineer documents element condition on the back page of the Field Inspection Form (example provided in Appendix B). The "Condition Narrative", written for each wall element assessed, clearly and concisely describes an element's condition in terms of the ***type(s), severity, extent and urgency*** of observed element distresses. These narratives are then used to support the selection of appropriate element condition ratings, as discussed in the next subsection. The inspecting engineer should use the distress definitions and terminology provided in the "Element Condition Narrative Guidance", presented in Table 5 and in the Wall Inspection Field Guide, when developing descriptive narratives to encourage database consistency.

Table 5. Condition narrative guidance for typical wall element distresses within four general categories: Corrosion/Weathering, Cracking/Breaking, Distortion/Deflection, Lost Bearing/Missing Elements.

WALL ELEMENT CONDITION RATING GUIDANCE
GOOD TO EXCELLENT **(minor to no distress, minimal to no impact, few to no occurrences)**
Corrosion/Weathering • No evidence of corrosion/staining, contamination or cracking/spalling due to weathering or chemical attack. • Compacted, placed or masoned rock, and associated chinking, is dense, angular, fresh, and without post-placement fracturing or chemical degradation. • No significant weathering/weakening of bedrock, softening of soil, or saturated ground conditions evident. • No impacts from vegetation noted within the wall or within adjacent elements. **Cracking/Breaking** • No evidence of element cracking, breaking, or construction/post-construction damage, opening of discontinuities in rock, or cracks or gullies in soils. • Concrete, shotcrete, and mortar is sound, durable, and shows little or no signs of shrinkage cracking or spalling. • Drains are clearly open (flowing), and in full working order. **Distortion/Deflection** • Wall elements are as constructed, and/or show no signs of significant settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. **Lost Bearing/Missing Elements** • No wall elements are missing. • Wall elements are fully bearing against retained soil/rock units. • Foundation soils/rock are more than adequate to support the wall, consistently dense, drained and strong. • No slope failures have occurred either removing or adding materials from the wall area.
FAIR **(moderate distress, significant to substantial impact, multiple occurrences)**
Corrosion/Weathering • Moderate corrosion/staining, contamination or cracking/spalling due to weathering or chemical attack. • Compacted, placed or masoned rock is not fresh or angular, showing significant weathering, post-placement fracturing, chemical degradation, and/or localized loosening. • Significant weathering/weakening of bedrock rock, softening of soil, or saturated ground conditions evident. • Moderate impacts from vegetation are evident within the wall or within adjacent elements. **Cracking/Breaking** • Localized element cracking, breaking, abrasion and/or construction/post-construction damage, opening of discontinuities in rock, or cracks or gullies in soils. • Concrete, shotcrete, and mortar is occasionally soft or drummy, has lost durability, and shows occasional cracking and/or spalling sufficient to intercept reinforcement. • Drains cannot be clearly determined to be fully operational. **Distortion/Deflection** • Wall elements show significant localized settlement, bulging, bending, heaving, misalignment, distortion, deflection, and/or displacement beyond normal prescribed post-construction limits (e.g., wall face rotation, basket bulging, anchor head displacement, bin displacement).

Lost Bearing/Missing Elements • Some wall elements are missing (e.g., chinking, lagging, brick-work) or non-functional. • Wall elements are generally bearing against retained soil/rock units, but localized open voids may exist along the back and top of the wall. • Foundation soils/rock are adequate to support the wall, but susceptible to shrink-swell, erosion, scour, or vegetation impacts. • Isolated slope failures have occurred either removing or adding materials from the wall area.
POOR TO CRITICAL **(severe distress, failure is imminent, pervasive occurrences)**
Corrosion/Weathering • Metallic wall elements are corroded and have lost significant section affecting strength. • Concrete/shotcrete is extensively spalled, cracked, and/or weakened, and may show evidence of widespread aggregate reaction. • Compacted, placed or masoned rock is highly weathered, showing extensive post-placement fracturing, chemical degradation, and/or loosening within the placed volume. • Extensive weathering/weakening of bedrock, softening of soil, or saturated ground conditions evident. • Severe impacts from vegetation are evident within the wall or within adjacent elements. **Cracking/Breaking** • Extensive severe element cracking, breaking, abrasion or construction/post-construction damage, opening of discontinuities in rock, or cracks or gullies in soils. • Concrete, shotcrete, and mortar is consistently soft, drummy, or missing, has lost durability and strength, and shows pervasive cracking and/or spalling intercepting corroding/weathering reinforcement. • Drainage is missing, clearly damaged, and/or obviously clogged and non-functional. **Distortion/Deflection** • Wall elements show extensive settlement, bulging, bending, heaving, distortion, misalignment, deflection, and/or displacement well beyond prescribed post-construction limits, including loss of ground reinforcement and retention. **Lost Bearing/Missing Elements** • Many or key wall elements are missing (e.g., placed wall stone, chinking, lagging) or non-functional. • Many or key wall elements are no longer bearing against retained soil/rock units, with visible open voids evident behind a large portion of the wall. • Foundation soils/rock show signs of failure, excessive settlement, scour, erosion, substantial voids, bench failure, slope over-steepening, and/or may be adversely impacted by vegetation. • Substantial slope failures have occurred either removing or adding materials from the wall area.

In some cases, limited wall access and/or vegetation, snow or water cover may obscure wall elements from direct observation. The inspecting engineer should note accessibility/visibility issues in the condition narrative, rate the element to the extent possible per the guidelines in section 4.3.4, and document the level of data reliability per the guidelines in section 4.3.6.

Examples of descriptive narratives following the aforementioned guidance include:

Lagging: Timber lagging moderately to highly weathered. Splitting/dry rot of 20% of the wall facing. 10-15% of timber lagging broken or missing. Wall backfill migrating through the face at several locations. Minor piping at top of wall where lagging is broken/missing.

Stone Masonry: No cracking; only minor weathering/chemical attack within sandstone masonry blocks. Isolated blocks are missing due to mortar failure, but not immediately affecting wall performance.

Piles and Shafts: Moderate to severe corrosion occurring at waler/H-pile junction welds over approximately 25% of the wall. Three adjacent piles show outward deflection indicating possible tieback anchor failure. No evidence of anchor failure seen in the anchor cap.

Concrete: Regular vertical/transverse cracking on 3-5 ft centers. Moisture seepage through lower wall cracks. Spalled concrete near wall start with exposed reinforcing steel showing substantial corrosion. No additional signs of chemical attack along the wall face.

Wall Drains: 4-in diameter PVC drain pipes exiting base of wall every 50 ft. Several pipes are broken at the face, but appear open and functioning. No signs of seepage through the wall face or wall foundation.

Upslope: 1.5H:1V soil upslope extends 15 vertical feet to roadway grade. No slumping or significant erosion due to good slope vegetation.

*****IMPORTANT***** It is imperative that the inspecting engineer write element condition narratives sufficient to support both the element rating and to justify recommended maintenance, repair, and replace actions. This information serves as the basis for future inspections, requiring an accurate depiction of conditions from which to compare future wall element performance.

4.3.4 Element Condition Rating Definitions

At this point, the inspecting engineer has identified the type of wall being evaluated, determined the primary and secondary wall elements to be assessed (considering the minimum elements to be evaluated as shown in Figure 76), and prepared concise and descriptive condition narratives for each wall element. The next step is to provide a 1-10 numerical "Element Condition Rating" for each wall element per the rating definitions given in Table 6. Although there is some latitude regarding how element ratings may be interpreted, program experience indicates that rating variances among inspecting engineers are generally within ±2 rating points for a given element.

Although the Element Condition Rating does consider the nature and urgency of observed distresses, the inspecting engineer should *not* rate an element based on the anticipated action to be taken to maintain, repair or replace the element. **Only the condition of the element should be rated.** Although actions are closely related to element condition, final recommendations for wall repairs consider a number of factors, described in later section 4.4 Wall Action Assessment. Table 6 condition rating definitions apply to all primary and secondary wall elements, and are provided to consistently define element **severity**, **extent** and **repair/replace urgency**.

To provide a measure of the performance of wall elements that cannot be directly observed, as well as the overall earth retaining system, a "Wall Performance" rating is provided for all walls inventoried as well – commensurate with the requirement to assess the performance condition of each wall as described in the previous subsection. This allows the inspecting engineer to assess the composite performance of all wall elements acting together, including global wall distresses (rotation, settlement, translation, displacement, etc.) and/or evidence of prior repairs that may

Table 6. Primary and secondary wall element numerical condition rating definitions.

Element Condition Rating	Element Rating Definition
9-10 Excellent	No-to-very-low extent of very low distress. Defects are minor, are within the normal range for *newly constructed or fabricated* elements, and may include those resulting from fabrication or construction. In practice, ratings of 9 to 10 are only given to elements with very minor to no distress whatsoever – conditions typically seen only shortly after wall construction or substantial wall repairs.
7-8 Good	Low-to-moderate extent of low severity distress. Distress does not significantly compromise the element function, nor is there significant severe distress to major structural components. In practice, ratings of 7 to 8 indicate highly functioning wall elements that are only beginning to show the first signs of distress or weathering. For example, a ten-year-old soldier pile wall may have moderately extensive minor surface corrosion on piles where protective paint has weathered and peeled, and may have wood lagging beginning to split. Distresses are very low overall, present over a modest amount of the wall, and do not require immediate or near-term attention.
5-6 Fair	High extent of low severity distress and/or low-to-medium extent of medium to high severity distress. Distress present does not compromise element function, but lack of treatment may lead to impaired function and/or elevated risk of element failure in the near term. In practice, ratings of 5 to 6 indicate functioning wall elements with specific distresses that need to be mitigated in the near-term to avoid significant repairs or element replacement in the longer term. For example, numerous anchor struts holding MSE wire facing elements in place are beginning to break due to corrosion and suspected over-stressing of the connections at the time of construction. Although the overall function of the reinforced earth wall is not in jeopardy, failing wall facing baskets are allowing facing fill to spill out. If several overlying baskets experience this isolated element failure, significant wall face sag and deformation may result at the top of wall, eventually impacting the overlying guardrail installation. This element should be inspected carefully along the entire wall and repaired as needed to forestall further facing basket deterioration.
3-4 Poor	Medium-to-high extent of medium-to-high severity distress. Distress present threatens element function, and strength is obviously compromised and/or structural analysis is warranted. The element condition does not pose an immediate threat to wall stability and closure is not necessary. In practice, a rating of 3 to 4 indicates marginally functioning, severely distressed wall elements in jeopardy of failing without element repair or replacement in the near-term. For example, mortar throughout a historic stone masonry wall is cracked, spalling, highly weathered, and often missing. Individual stone blocks are missing from the wall face, and adjacent blocks show signs of outward displacement. Although not an immediate threat to overall wall stability, stone block replacement and repointing throughout the wall in the near term are necessary to forestall rapid wall deterioration.
1-2 Critical	Medium-to-high extent of high severity distress. Element is no longer serving intended function. Element performance is threatening overall stability of the wall at the time of inspection. In practice, a rating of 1 to 2 indicates a wall that is no longer functioning as intended, and is in danger of failing catastrophically at any time. For example, a 15-ft-tall cast-in-place concrete cantilever wall has a large open horizontal crack running the full length of the wall at the base of the stem. Vertical cracks are also beginning to open up in the wall face. Water is seeping from most wall cracks, and is running from the basal horizontal crack at several locations. The wall face has rotated outward, resulting in a negative batter of several degrees. The overlying guardrail is highly distorted above the wall and the adjacent roadway is showing significant settlement above the retained fill. The wall is in imminent danger of failing catastrophically, requiring the overlying roadway be closed to all traffic until the wall can be replaced or retained soil backslope can be stabilized.

further indicate component problems or, conversely, functional improvements. Table 7 provides general guidance on defining overall wall performance and the numerical performance rating. The inspecting engineer should use this guidance in conjunction with the wall element rating guidance provided in Table 6 when determining an appropriate wall performance rating.

Table 7. Wall performance rating definitions.

Performance Rating	Performance Rating Definition
7-10 Good to Excellent	**Good to Excellent** No combinations of element distresses are observed indicating unseen problems or creating significant performance problems. No history of remediation or repair to wall or adjacent elements is observed.
5-6 Fair	**Fair** Some observed global distress is not associated with specific elements. Some element distress combinations are observed that indicate wall component problems. Minor work on primary elements or major work on secondary elements has occurred improving overall wall function.
1-4 Poor to Critical	**Poor to Critical** Global wall rotation, sliding, settlement, and/or overturning is readily apparent. Combined element distresses clearly indicate serious stability problems with components or global wall stability. Major repairs have occurred to wall structural elements, though functionality has not improved significantly. Severe distresses are apparent on adjoining roadways.

For example, an MSE wall with a geogrid-wrapped face shows little sign of specific element distress (geogrid and backing geotextile are largely unweathered, drains are working, etc.). However, the wall is differentially settling at one end, as evidenced by a 3-6 inch vertical sag extending full-height in the wall face. A tension crack has begun to open at the top of the wall just beyond the estimated length of reinforcements, further indicating a global or external wall failure mechanism is actively developing. The inspecting engineer describes the overall wall performance as “low”, providing appropriate narrative describing the state of global distress, and rates the wall performance at a “4” per the rating definitions.

4.3.5 Weighting Factors

“Weighting Factor” simply refers to the weighting of the “Element Condition Rating” to account for various levels of element importance in the final “Wall Condition Rating”. “Primary Wall Elements” and “Wall Performance” apply a standard weighting of 8 to each element condition rating. Secondary wall elements apply a variable weighting scheme (0.5-5) dependent on the element condition rating: 0.5 for an element condition rating of 8-10, 1.0 for a rating of 4-7, and 5.0 for a rating of 1-3.

These element weightings have been determined to sufficiently discern element impacts on wall performance. However, as more wall inventory data are collected, weightings will be re-evaluated for appropriateness, and altered as needed to provide meaningful and consistent wall condition ratings.

4.3.6 Data Reliability Factors

"Data Reliability" is a 1-3 numeric rating describing the level to which the condition of a primary or secondary element could be observed. Although most of the aforementioned wall elements can be readily observed and assessed, there are occasions when elements are obscured by heavy vegetation, snow cover, water or are simply not readily accessible within the constraints of the inventory. This rating documents the relative reliability of the data based on observation access, and helps direct recommendations for future investigations. Table 8 provides simple data reliability factor definitions.

Table 8. Data reliability definitions.

Data Reliability Factor	Data Reliability Factor Definition
1 Poor	**Poor** Conditions cannot be sufficiently observed to rate element(s), warranting additional investigations to better define element performance and/or to determine the cause(s) of poor performance.
2 Good	**Good** Observed conditions are sufficient to rate the condition of wall element(s); however, additional investigations would be useful to better understand element performance.
3 Very Good	**Very Good** Observed conditions clearly describe wall performance. Additional investigations are not needed.

The need for additional investigations may result from several conditions. For example, the wall face may be inaccessible without a crane basket, snow, water or vegetation cover may preclude direct observation of wall elements, or causes of distress are not readily apparent. Following completion of the wall element condition assessment, the inspecting engineer reviews the data reliability for all wall elements and determines if additional investigation is warranted.

4.4 WALL ACTION ASSESSMENT

Once the overall wall performance and pertinent primary/secondary wall elements have been assessed and rated, the inspecting engineer rolls up the weighted element ratings into a "Final Wall Rating". This value ranges from 5-100, and is representative of the overall wall condition per the ratings definitions provided in Table 6.

Arriving at the Final Wall Rating is the first step in determining the appropriate action(s) to take relative to potential structure repairs or wall replacement – but other factors also need to be considered. Aside from the condition-based Final Wall Rating, the WIP action assessment considers four additional items: Are additional investigations required (how reliable is our assessment)?; What design criteria may have been used in planning the structure (was the structure engineered)?; What aspects of the wall structure are historic or contribute to the cultural context of the road asset?; What are the consequences of wall failure? Taken together, these five parameters allow the inspecting engineer to subjectively determine what action is required to sustain or improve wall performance: do nothing (the wall is performing as intended), monitor identified wall problems until the next inspection, perform routine maintenance, repair wall elements, replace wall elements, or replace the entire wall.

This approach is perhaps a departure from more conventional assessment schemes whereby a numeric wall rating is directly related to an action level, and not simply part of a decision process. In the case of the NPS program, the focus is on arriving at appropriate recommendations for sustaining/improving wall performance and developing early cost estimates for recommended actions – not necessarily on fitting a wall rating to an action. Within the WIP it is entirely possible to have walls with poor performance ratings given "No Action" work order assessments and, conversely, to have highly rated walls with high priority maintenance and/or repairs recommended. Although only a contributor to the final wall action assessment, numeric element ratings do allow the overall health of the NPS earth retaining structure asset base to be quickly assessed, point to common element problems within specific wall types, and help the inspecting engineer to arrive at consistent wall condition assessments.

Figure 78. Photo. A sizeable portion of this concrete crib wall is obscured by heavy vegetation. Although observed conditions are sufficient to rate the condition of wall elements, additional investigations might be required or recommended to better understand element performance, particularly if material or structural problems were suspected. (Data Reliability Factor = 2)

Clearly, the requirement to rate different primary wall elements per wall type, coupled with the potential for a range of secondary elements to be rated for any given wall, results in Final Wall Ratings that cannot be directly compared wall-to-wall. However, experience with developing ratings for many wall types indicates the WIP methodology satisfactorily characterizes the relative condition of walls sufficient to develop meaningful action recommendations and allow assessment of the total asset.

4.4.1 Final Wall Condition Rating

As noted above, "Wall Condition Rating" is the weighted average of all condition-rated wall elements and the wall performance, ranging from 5-100. While the rating is generally indicative of the level of action required (e.g., maintenance; repairs; element replacement*), it is directly related to the severity, extent and urgency of wall element distresses.*

4.4.2 Investigation Requirements

"Investigation Required?" (as shown on the front page of the Field Form in Appendix B) refers to whether the observational data are acceptable for characterizing wall distresses and overall performance, or if deficiencies exist, possibly warranting additional investigations *aside from routine geotechnical work involved with wall design/rehabilitation/replacement*. The inspecting engineer determines if additional investigations are warranted based on consideration of the overall element reliability ratings provided during condition assessment and, if so, prepares a work order for the investigation. For example, wall face elements may show little more than normal levels of distress for a structure 10-15 years old, yet the roadway above the retained fill section of the wall is showing substantial annual settlement, requiring regular roadway repair and repaving. A thorough inspection of the wall and adjacent elements does not immediately reveal the cause of the excessive fill settlement, suggesting the need for a preliminary subsurface investigation.

4.4.3 Design Criteria

"Design Criteria" is a measure of how well *current* design criteria are satisfied. The inspecting engineer should be knowledgeable of AASHTO wall design standards and aware of historic construction practices and workmanship sufficient to select from one of the following levels of applied design criteria:

- **None**: Does not meet any known design standards or systematic construction methods commonly used at the time of construction;
- **Non-AASHTO**: Does not meet AASHTO design standards (Figure 79), but is consistent with other structures of its type and period of construction exhibiting established construction workmanship and good performance; or
- **AASHTO:** Appears to meet AASHTO geometric, design, materials, and construction standards in effect at the time of construction.

For example, a newly constructed MSE wall, with proper facing fill, face batter, basket construction, toe and crest grading, apparent embedment, and systematic drainage in all likelihood meets AASHTO design requirements. Although clearly a non-AASHTO structure, intact and highly performing 70-year-old mortared stone masonry walls showing a high degree of craftsmanship and attention to foundation preparation and drainage would be considered a well-designed structure, consistent with other quality retaining structures of its period. In contrast, a rockery built with little consideration of stone size requirements, proper stone placement, or required drainage would be classified in the inventory as meeting no form of design criteria.

Figure 79. Photo. Although built to strict material and construction standards, this new rockery wall along the Guanella Pass Road in Colorado is a non-AASHTO design.

4.4.4 Cultural Concerns

"Cultural Concern?" refers to whether historic and/or cultural aspects of the wall should be considered and incorporated into the repair/replace recommendations. The inspecting engineer is required prior to the site visit, and at the time of the inventory kick-off meeting with park facilities and resource personnel, to determine if any or all park walls are culturally significant or are part of a cultural corridor, requiring special repair or replacement methods, materials, and/or construction standards. The specific types of repairs and processes for repair need to be well understood by the inventory team, with questions pertaining to specific walls directed to the park Cultural Resource Specialist at the time of the inventory. **All stone walls should be assumed culturally significant in the absence of additional information** (Figure 80).

4.4.5 Failure Consequence

The "Consequences of Failure" item provides a relative estimate of the cumulative risk to the public, associated roadway asset, and park facilities/operations were the wall to catastrophically fail. The inspecting engineer should become familiar with the park's alternate routes, daily traffic volumes, and road closure impacts sufficient to select from one of the following levels of failure consequence that most closely fits each situation:

- **Low**: No loss of roadway, no-to-low public risk, no impact to traffic during wall repair/replacement;
- **Moderate**: Hourly to short-term closure of roadway, low-to-moderate public risk, multiple alternate routes available; or
- **High**: Seasonal to long-term loss of roadway, substantial loss-of-life risk, no alternate routes available.

Figure 80. Photo. Although this stone masonry-faced MSE wall at Bryce Canyon National Park is a relatively new structure built to AASHTO standards, it is nonetheless culturally sensitive as it contributes to the cultural context of the roadway corridor.

For the purposes of the NPS wall asset program, a more in-depth assessment of risk is not required. The WIP scope of data delivery is limited to a wall inventory and structure condition assessment. Risks associated with wall failure are best quantified and evaluated during later phases of asset management – those involving life-cycle cost analyses and budget prioritization – which are managed by the NPS within their FMSS program. By grossly assessing relative risk at this stage, attention can be drawn to walls requiring immediate or near-term attention.

NOTE: It should be emphasized to inspection teams that this wall action assessment factor is only related to public and asset risks following wall failure – it is not a measure of the risk potential for failure to occur. Structural (brittle vs. ductile failure), internal (reinforcement or tieback failure), external (sliding, overturning, bearing failure), or global failure modes should be discussed in the condition rating and described in the close-out memorandum to the park, as appropriate.

4.4.6 Recommended Action

The "Action" box on the Field Form (Appendix B) refers to the action to be taken to mitigate wall distresses, if present, and ensure the structure is functioning as intended. The inspecting engineer selects one of the following actions based primarily on the condition of wall elements (severity and extent of observed distresses), the urgency to mitigate distresses, and the consequence of wall failure – and *not* considering whether the work can be done by park facilities staff or must be contracted. Consideration is also given to whether or not additional investigations have been recommended, to what level specific design criteria were used in constructing the wall and may be required, and whether or not the wall is subject to cultural considerations that may direct specific types of repairs, repair methods and/or materials.

- **No Action**: The wall is fully functioning, with no action required at the time of the inspection.
- **Monitor**: The wall requires regular monitoring and/or investigation to determine the nature of observed distresses and what action may be required.
- **Maintenance**: Routine or cyclic maintenance is required to correct minor or low severity recurring deficiencies spanning a single wall element or the entire structure in order to minimize or delay further wall deterioration (Figure 81).
- **Repair Elements**: Minor to extensive repair of wall element(s) is required in the near-term to prevent rapid element deterioration, loss of performance or failure (Figure 82).
- **Replace Elements**: Replacement of specific wall element(s) or an entire section of wall is required in the near-term to preserve wall stability (Figure 83).
- **Replace Wall**: Replacement of the entire wall structure is required to reestablish the intended function of the wall (Figure 84).

For example, a 30-year-old metal bin wall is being evaluated along the main entrance road to a seasonally popular park. Significant corrosion has occurred in the exposed face of the bin wall, allowing the bin to be easily punctured with a geologist's pick. Several areas of the wall face, particularly near the bottom of the wall are beginning to develop open corrosion holes, with some loss of bin fill evident. Although the wall facing steel is highly distressed, the wall appears to be functioning well, with no signs of lost bearing capacity, settlement or displacement apparent in the wall face or along the overlying roadway. The inspecting engineer is concerned that the buried bin elements may also be suffering from significant corrosion, and has recommended additional investigation. The wall was built to well-defined standards at the time of construction and does not qualify as a cultural resource. The engineer, carefully considering all of these factors, determines that only minor maintenance is required at this time. However, due to the high ADT and critical-park-route nature of the roadway, it is recommended, and expensed within the work order, that a subsurface investigation be conducted to determine the integrity of the buried portion of the bin (is it better or worse than the facing steel?).

> Field inspectors often have difficulty discerning "Maintenance" from "Repair" activities. Maintenance activities include items that are of a *cyclic or recurrent* nature: vegetation removal, cleaning wall drains, removing debris from culverts, replacing dislodged chinking, painting soldier piles, cleaning and sealing concrete and wood facings. Repair activities include non-routine fixing and restoring of wall elements to their intended function: resetting dislodged stonework, repointing stone masonry, regrading/reseeding adjacent slopes, patching concrete spalls, mending damaged wire baskets.

Figure 81. Photo. Culvert headwall along the Baltimore-Washington Parkway requiring removal of harmful vegetation along the top of the headwall. Vegetation removal was the most common type of maintenance item recommended throughout the Cycle 1 WIP inventory effort.

Figure 82. Photo. Much needed concrete repair on a cast-in-place gravity wall at Steamtown National Historic Site in Pennsylvania.

Figure 83. Photo. Dry-laid stone masonry elements in need of replacement at Yosemite National Park following minor slope instability.

Figure 84. Photo. Severely corroded metal bin wall in serious need of complete replacement at China Beach within the Golden Gate National Recreation Area.

As discussed in Section 1.3, nearly 25% of the total wall asset inventoried in Cycle 1 includes mortared stone walls (using mortared, pitched or rough stone). These structures generally represent the oldest walls in the WIP database and, therefore, it is common for the mortar to be highly weathered, cracked, spalled, broken or missing altogether. Although assessment of mortar condition is straightforward, following the guidance provided in Table 5, field inspectors were often confused as to whether maintenance or repair level work was required and, if so, which was more appropriate for the potentially large mortared stone wall asset within a given park. Should cracked and spalling mortar be repaired to restore the wall to its original condition, or should the wall be evaluated solely on performance, allowing the cracked mortar to be assessed similar to chinking in a dry-laid stone wall? Should mortar restoration work be simple crack sealing, a more comprehensive repointing effort, or should the wall or sections of the wall be disassembled and reset? Should this work be considered a recurrent maintenance activity or is it more appropriately defined as wall repair?

For consistency amongst inspectors, mortar will be evaluated per the condition assessment guidelines presented in subsection 4.3.1, recommended work will fall under the "Repair" category (non-cyclical/recurrent element restoration), and the need for repair will be based on wall performance, rather than on a requirement to restore the mortar element to its original condition. Giving due consideration to the potential for a 10-year reinspection period, the field inspector will need to exercise engineering judgment when determining whether mortar repairs are required.

4.5 WORK ORDER DEVELOPMENT

At this stage of the inventory/assessment process the wall has been located, the geometrics and functional characteristics described, the condition of specific elements and overall performance assessed, and actionable recommendations developed, as needed. If any action is recommended, including additional investigations or maintenance through full wall replacement, a brief work order description and "order-of-magnitude" (Class D) cost estimate is developed for general work items. The intent of the work order is to briefly characterize the work elements involved (e.g., labor, material, equipment) and provide a *very preliminary* cost suitable for comparison to other work orders within FMSS (excluding costs related to studies, engineering, permitting, procurement, etc., and location cost factors).

Work order costs are developed using the WIP Cost Guide provided in Appendix B, or other appropriate sources of cost information available at the time of the field inspection. The WIP Cost Guide provides costs related to wall and ancillary structure repair/replacement from three sources: **(1)** total wall replacement costs referenced in the 1997 edition of FHWA Geotechnical Engineering Circular No.2 "Earth Retaining Systems", updated to approximate 2007 costs (as available) with recent FLH wall construction bid histories, **(2)** cumulative costs for selected wall repairs based on recent project bid histories, price-indexed to 2007, and **(3)** 2007 price-indexed average costs for selected FLH pay items based on recent CFLHD project bid histories. The WIP Cost Guide, though far from complete and often requiring substantial estimation and interpolation, can serve as a useful reference when developing preliminary work order costs.

Prior to implementing future WIP inspection cycles, the FLH WIP Program Manager must update wall element and replacement costs per current year price indices. Field inspection teams should seek additional cost information from park facilities and maintenance staff to refine work order estimates to the extent practical.

Considerable variance in cost estimates can occur among inventory team members based on their interpretation of Cost Guide pricing, scope of work, and estimating experience of the inspector. Clearly, proper work order pricing is a subject in need of improvement for future inspection cycles. In the meantime, work order scoping and pricing consistency is best addressed through **(1)** standardized unit pricing based on FLHD bid histories, **(2)** training on proper work order development and pricing, **(3)** practical experience with field forms, condition narratives and work orders prior to conducting park inspections, and **(4)** collaboration between team members during wall assessments to get everyone on the same page regarding wall ratings and work order development. Park maintenance staff can oftentimes be invaluable sources for local construction costs, as well nearby material sources, concrete plants, fabricators, etc.

4.5.1 Brief Work Order Description

"Brief Work Order Description" is a very short, succinct description of the recommended work contained in the itemized repair/replace recommendations serving as the FMSS work order. This short description is used by the NPS in their FMSS asset management system in conjunction with the actual work order. For example, "replace broken wall lagging", "remove small trees from wall face", or "replace entire retaining wall" would be examples of suitable brief work order descriptions.

4.5.2 Repair/Replace Recommendations/Cost

"Repair/Replace Recommendations" is an itemized description of wall repairs, methods, estimated quantities, and costs per repair item, including consideration of constructability and cultural issues. Recommendations may also include, or even be limited to, additional site investigations required to fully scope the wall repair project. The inspecting engineer briefly describes the work items required to repair, rehabilitate or reconstruct wall elements, and then expenses each work item for the FMSS Work Order. Materials, equipment, labor and ancillary items (maintenance of traffic, staging area requirements, paving, etc.) should all be included in the cost breakdown. Design costs, construction management costs, and ancillary costs associated with such things as cultural/historic conservation activities are, however, not included. The current year WIP Cost Guide (2007; Appendix B) should be used for unit costs.

The following example illustrates an acceptable level of detail for the typical work order:

Remove trees growing from wall face. Remove damaged/broken masonry rock blocks, cleaning useable blocks and wasting unsuitable blocks. Replace damaged and missing interior wall and facing stones, and mortar in place. Repair/replace damaged and missing mortar around adjacent intact blocks. Reestablish curb drainage, cleaning debris accumulated along the top of wall and adding new curbing.
Labor: 4 man-days @ $550/day = $2,000
Dimensioned masonry, rock face finish: 4 cuyd @ $1,000/cuyd = $4,000

8-in asphalt curbing: 40 ft @ $10/ft = $400
Tree removal: 2 trees @ $100/tree = $200
Miscellaneous tools and equipment: $1,000 lump sum
Traffic control: 2 days (park-provided, gratis)
Total = $7,600

"Repair/Replace Cost", shown in the lower right corner of the Field Form, is the total estimated repair /replace and/or investigation cost based on itemized elements identified in the work order and priced per the current year Cost Guide. The minimum cost for qualified work is $55 – the estimated cost of one hour of labor.

CHAPTER 5 – FUTURE WIP DEVELOPMENT

With the completion of the first retaining wall inspection cycle in late 2008, attention is turning to continued development of the WIP to enhance future inspection cycles, follow through on stakeholder management needs of the current asset database, and provide for long-term program maintenance and data accessibility. A great deal was learned over the course of the WIP development and Cycle 1 implementation which directly impacts current and future NPS asset management efforts, as well as a broader audience within the U.S. transportation industry. The following highlights on-going work and recommendations to ensure program sustainability and incorporation of "lessons learned" from the Cycle 1 inventory.

Data Maintenance and Accessibility

Currently, inventoried wall data reside in several forms: **(1)** archived original hardcopy field forms; **(2)** scanned Adobe .pdf files for each original field form; **(3)** the WIP Microsoft Access-based user-friendly database, currently resident on the CFL project server system; and, **(4)** a secure copy of all data fields within a searchable Oracle platform database. Quality control (QC) checks were integrated within the original Access WIP database to ensure data integrity to the extent possible when transferring field form information to electronic format. An independent quality assurance (QA) sampling of the field forms, Access database and Oracle database has also been completed to identify and correct data transcription errors. The specific data items transmitted to the NPS FMSS asset management system and to the RIP database has also provided an additional opportunity for QC/QA-level data checks. The Cycle 1 WIP data are now securely archived and backed up, the data integrity has been shown to be high via the QC/QA efforts to date, and write accessibility is controlled through the Database Administrator.

Data accessibility is currently provided via canned reports available on the CFLHD web site, read-only database searches via internal user access to the server-based WIP database, or ad hoc requests of the Database Administrator. Efforts are currently underway within CFLHD to develop a division-wide geographical information system (GIS) for the management of project and roadway information. The WIP database information will be directly linked to each park within this developing system. Although user access to the WIP database external to FLH has been developed and can be provided via a firewalled external server system, access to date is cumbersome and yet to be used. New developments in secure information sharing may make future inspection cycles more readily accessible to outside parties. For now, the avenues for accessing the data appear to be suitable for the needs of the NPS and internal FLH users – though this will certainly change as structure and geotechnical asset management programs develop nationwide.

Cost Guide Improvement

A significant challenge of the Cycle 1 inventory involved the development of meaningful cost estimates for various levels of wall repair and total wall replacement. Because of the historic nature of the vast majority of wall structures in the parks inventoried, cost data on specialized repair options was limited, including such things as stone masonry work, repointing, foundation underpinning, etc. As a result, the current Cost Guide provides an agglomeration of historical pay item unit pricing, rolled up specialized repair item pricing, and total wall replacement estimates based on an assortment of documented and internally-developed pricing sources (e.g., specific FLH projects, regional pay item bid tabs, RS Means pricing data, FHWA/NHI published resources). At the completion of the Cycle 1 inventory, it was determined that very few of the cost items listed in the WIP Cost Guide were actually used in developing work orders. This fact was likely a combination of simply not needing a large range of cost items coupled with cost estimates that did not adequately include all of the tasks required.

To enhance future estimation of wall repair and replacement costs, the current database should be queried to determine what and how often specific pay items are being used to develop work orders and if the work orders submitted are sufficient to meet the program needs of the NPS FMSS asset management system. In the coming years, and prior to initiating a second inspection cycle, actual costs for recommended wall repairs and wall replacements from Cycle 1 inspections should be evaluated to determine the accuracy of the original work order cost estimates.

Updated Training Program

In order to best benefit from the enormous technical and program management educational opportunities afforded by the WIP, it was decided to deliver the Cycle 1 inspection program primarily via staff within the three FLH division field offices. Although this approach to program delivery paid big dividends in terms of technical staff at the three field offices getting to work with one another and become intimately familiar with the cross-functional asset issues at the major parks across the U.S., the program seriously strained available technical resources during summer construction months, often impacting forest highway project delivery. As a result, the recently developed Traffic Barrier/Guardrail Inventory Program (GIP), built on the experiences of the WIP, opted to deliver the requested NPS guardrail/guardwall inventory across selected major parks with contracted inspection. This approach required significant control by FLH program management over contractor training and inventory QC/QA practices. The lessons learned from the GIP contracting effort should directly translate to future WIP inspections should the program grow substantially beyond the current 32 park asset database. If WIP Cycle 2 inspections are confined to the existing park inventory, and assuming that only a sampling of the current already-located wall inventory would require visual re-inspection, internal staff would once again be the preferred inspection resource.

Coordination with RIP, BIP and GIP

At present, WIP wall information is provided to the Road Inventory Program (RIP) to update the features tables in the RIP inventory report. Features, including not only retaining wall structures but also such things as signs, guardrails, sidewalks, culverts, buildings, etc., are only listed by type and milepoint and are not shown on the published RIP route maps. The data are, however, readily available and can be uploaded to any number of GIS applications.

Conversely, WIP wall data are not currently provided to the BIP inventory as bridges are also compiled under the RIP features listing per park. However, BIP could directly benefit from the WIP inventory data, and vice versa, to ensure that a clear distinction is made between bridge structure walls evaluated under BIP and bridge-related walls evaluated under WIP. Aside from providing data to the RIP features table, no coordinated effort has been undertaken thus far to clarify the inspection roles of each asset group (including the GIP inventory). Broader guidance is needed across the entire FLH asset management program to clarify roles and responsibilities and ensure that data formats and management systems are comprehensive, robust, secure, and aligned with partner agency needs.

With regards to the technical requirements for merging WIP data within the parent RIP inventory, as RIP moves into successive data collection cycles milepoint references can change since the Automatic Road Analyzer (ARAN) surveys are not milepoint repeatable. The current Cycle 4 RIP survey is attempting to standardize the milepoint reference for all future surveys to avoid accumulating conversion errors throughout successive surveys. This requires that the current WIP inventory milepoint references, collected per RIP Cycle 3 survey data, need to be updated to accurately locate wall features within the RIP Cycle 4 milepoint reference system. This work is currently underway, but is expected to take one or more years to complete as resources become available in the RIP program to convert tabled park features to Cycle 4 milepoints.

Culvert Inventory Issues

At the time of the WIP Cycle 1 inventory, the NPS was in the process of establishing guidelines for culvert inspections conducted by park maintenance personnel. These draft guidelines primarily focused on the ability of the culvert to convey water as originally designed, and did not directly relate culvert performance to roadway performance or require culverts to be located per the RIP milepoint reference system. Therefore, and considering that many culverts have associated headwall/wingwall structures supporting overlying roadway embankments, it became necessary to include qualifying culvert headwall/wingwall structures in the WIP inventory (per the acceptance criteria in Chapter 3). As a result, culvert structures comprise a substantial percentage of the total wall inventory. Moving forward, and in an effort to simplify the WIP wall acceptance criteria and wall definitions, it is recommended that a separate culvert inventory be developed to manage this critical asset, tying the data to the RIP milepoint reference system. Recent comprehensive culvert inspection guideline developments within FLH should provide a good place to begin developing a separate and well-defined culvert asset management program for the NPS.

Realizing the Intent of "Life Cycle" Asset Management

Wall inventory and assessment information has been provided to the NPS FMSS asset management systems resident at each of the inventoried parks. The information has been used to schedule maintenance activities and minor wall repairs, as well as begin the process of programming complete wall replacement projects. Based on just one inspection cycle, the parks are only able to simply address burning needs with respect to retaining structure performance, having no long term performance data from which to establish life-cycle maintenance-repair-replace strategies. The unique nature of the database (i.e., high percentage of 50+year-old stone masonry walls), coupled with limited information on wall age and periodic maintenance/repair expenditures, makes it nearly impossible to "back-calculate" a life cycle curve per family of wall types within the database. Realizing true life cycle asset management for earth retaining structures will require a commitment to regularly inspect a portion of the database on a scheduled basis and to retain detailed annual maintenance expense records for each structure. Earth retaining structures, the majority of which are well over 50 years old, account for well over $400M in assets within just those parks included in the current WIP inventory (possibly greater than $1B agency-wide), making this a critical asset to effectively manage in the decades to come.

APPENDIX A – PRE-FIELD DOCUMENTS AND FORMS

This appendix contains supporting documents for pre-field activities:

- Pre-Inventory Phone Interview Checklist
- Park Notification Letter
- Kick-Off Meeting Agenda
- Retaining Wall Questionnaire
- RIP Route Identification Report – Example
- Visidata Preliminary Wall Location Form
- Documents and Equipment Checklist

Pre-Inventory Phone Interview Checklist

The following provides general guidance on the information to provide/acquire during the initial phone interview.

WIP Retaining Wall Definition:

- All classes of paved Park roadways and parking areas are included in the inventory, as either described in the Park RIP Route Identification Report or further identified by Park facilities management staff.
- The retaining wall must reside within the existing roadway/parking area prism, generally defined within the known or assumed construction limits, and support or protect the roadway/parking area.
- The maximum wall height – including only that portion of the wall structure intended to actively retain soil and/or rock – must be greater than or equal to four feet, 6 ft for culvert headwalls.
- When known or verifiable, wall embedment is considered in determining maximum retaining wall height for wall acceptance (embedment is *not* used for wall face area dimensioning or condition rating). Include fully buried retaining structures in the inventory when locations are known or verifiable.
- Walls are further defined by an internal wall face angle greater than or equal to 45^{o} (≥1H:1V face slope ratio).
- When wall acceptance based on the above criteria is marginal or difficult to discern, include the wall in the inventory, particularly where the intent is to support or protect the roadway/parking area and where failure would significantly impact the roadway/parking area and/or require replacement with a similar structure.

Discussion Checklist:

- Overview of the Retaining Wall Inventory Program, general site inspection procedures, data exchange and reporting processes and responsibilities, etc.

- FHWA personnel traveling to the site and their originating FLH office.

- Desired travel dates, availability of Park personnel, and alternate travel dates.

- Requirements of Park staff:
  - Pre-site information gathering (information package, described below).
  - Kick-off meeting (~1-2 hrs), attended by Facilities Manager, Maintenance Foreman, Cultural Resource Specialist, FMSS Specialist (individuals most knowledgeable with wall locations, repairs, stability issues, historical aspects, etc.).
  - Wall reconnaissance support (typically no more than a day).
  - Traffic control support (manpower and/or signage, as needed).
  - Close-out meeting (~1 hr).

- General WIP safety requirements/standards of practice.

- General retaining wall information:
  - Approximate number of walls in the Park?
  - General types, sizes and ages of walls?
  - Presence of failing or damaged walls?
  - General wall locations (including distance between walls)?
  - Known cultural resource issues?
  - Environmental access issues?
  - Are walls exclusively on RIP-inventoried roads, or do non-RIP roads/gravel roads exist with retaining walls?

- Overview of information package to be sent to the Park:
  - Pre-site questionnaire (describe level of effort required from the Park staff, including general mapping of wall locations within the Park and the approximate age of all wall types).
  - Kick-off meeting agenda.

- Park and FHWA contact information exchange.

- Recommended inventory team lodging?

- Anticipated weather conditions throughout the Park (in particular, high elevation roads)?

Park Notification Letter

U.S. Department of Transportation
Federal Highway Administration

<Office> Federal Lands Highway Division
Street Address
City, State, Zip

Superintendent
XYZ National Park
Road/Hwy/Street Address
City, State, Zip

<Date>

Subject: NPS Retaining Wall Inventory Program (WIP)

Dear <Superintendent Name>,

The Federal Highway Administration (FHWA) has been requested by NPS WASO to assist with the inventory and condition assessment of retaining walls associated with Park roadways. This effort is in support of on-going NPS asset management actions that are documented in annual "FMP update" memoranda from the Deputy Director to Regional Directors. The most recent was sent on March 6th, 2007.

On-site inspection will provide information for the Facility Management Software System (FMSS) pertaining to roadway retaining walls throughout the Park. This will include static information such as type, size and location, as well as dynamic information about the condition of these facilities. Where deficiencies are identified, repair recommendations with estimated costs will be provided, which can then be used in FMSS as work orders.

FHWA staff will be performing most of the direct inspection work; however, some assistance from the Park is requested, including the following:

- Completion of a brief questionnaire regarding various aspects of retaining walls in your Park. This information, particularly that pertaining to wall locations and cultural resources, will *greatly* assist the inspection team in planning and completing their work. The questionnaire and a filled-in example are attached to this transmittal. We would ask that this information be completed prior to our arrival on-site to help expedite the inventory.
- Participation in an approximate 1-hour inventory kick-off meeting to discuss the inspection process, expected deliverables, logistics, safety, FMSS issues, etc. A preliminary agenda

accompanies this transmittal. During this meeting we would like to coordinate activities with the Facilities Manager, discuss wall locations and general conditions with maintenance staff, and cover data transfer procedures with staff responsible for maintaining the Park's FMSS database. We would also like to discuss cultural and historical aspects of Park retaining walls with cultural resource staff. Although the inventory does not directly assess the cultural/historical aspects of the structure, we do note its resource value and incorporate this information into any repair recommendations that may arise.

- Assistance with wall reconnaissance in the Park. Knowledgeable Park staff will accompany the inspection team immediately following the kick-off meeting to quickly recon wall locations throughout the Park prior to initiating wall inspections. This effort will assist the inventory team in better determining the total number of walls to be inspected, their location within the Park, and the manner in which to most efficiently conduct the inventory.
- Assistance with traffic control. Park personnel are not generally required for traffic control; however, the Park shall provide the inspection team with appropriate roadway signage warning motorists of roadside work crews. Inspection team members will be responsible for performing all needed traffic control duties (sign placement, traffic spotting, limited flagging, etc.). Road closures will not be required.
- Participation in an approximate 1-hour close-out meeting to discuss inventory findings, FMSS issues, data reporting and transfer, and deliverable schedules.

On behalf of our inspection team, I want to thank you in advance for your assistance with this effort. I have contacted Mr. <Facility Manager> to initiate early planning for inspection activities, and we are currently planning on coming to your Park the week of <Date>. If I can be of any assistance or answer any questions regarding the Park inventory, please feel free to contact me at <Phone Number>. For additional Wall Inventory Program (WIP) information, please contact <NPS WASO Program Coordinator>, NPS WASO Program Coordinator, at <Phone Number>, or < FLH WIP Coordinator>, FLH WIP Coordinator, at <Phone Number>. We look forward to working with you and your staff.

Sincerely,

Team Lead
Title

cc: <Facility Manager, XYZ National Park>
<NPS WASO Program Coordinator>, NPS WASO
<FLH WIP Database Administrator>, FHWA-CFLHD

Kick-Off Meeting Agenda

Introductions/Meeting Logistics

Overview of the NPS Retaining Wall Inventory Program

- **Intent of the WIP**
  - Provide Parks with information regarding roadway retaining walls for FMSS. This includes static spec temp information and dynamic condition and work order information.
  - Provide FHWA with baseline retaining wall condition information to assist with future project analysis and development.
- **General Site Inventory Procedures** – Overview wall location/ages, measurement, description, condition assessment, work order, and cultural resource considerations.
- **Integrating Cultural Resource Needs** – Discussion of cultural/historic wall resources and repair/replace requirements.
- **Data Access and Management (FMSS)** – Overview of FMSS Spec template, NPS transmittal of equipment numbers to FHWA, and data transmittal process.

WIP Safety Program

- **Overview Wall Data Collection Practices** – Roadway and wall measurement procedures.
- **Roadside Safety Practices** – Number of personnel, parking, wall access, safety equipment, designated traffic spotter, etc.
- **Traffic Control** – Warning signs, flaggers/spotters (inspection team) when occupying pavement edge or centerline.
- **General Fall Protection/Hazard Management** – Wall access philosophy (limited to top and toe of walls), and Park-specific safety requirements.
- **Communication Planning** – Emergency contacts/procedures, Park-provided radios.
- **Wildlife/environmental precautions** – Predatory animals, poisonous snakes, insects, plants, water levels in adjacent streams, etc.

Inventory Schedule Review

- **Pre-Site Questionnaire Review** – In-office pre-location of retaining walls, identification of problem walls, preparation for wall reconnaissance. Review pre-site questionnaire.
- **Wall Location Reconnaissance** – Conduct maintenance staff interview (or other facilities knowledgeable Park personnel) and perform wall reconnaissance.
- **Retaining Wall Inventory** – Discuss general strategy for systematically conducting the inventory (safety/traffic considerations), refine preliminary wall inventory schedule (developed based on Park questionnaire prior to arriving on-site), set up tentative close-out meeting schedule.
- **Close-Out Meeting** – Review inventory findings, discuss FMSS products, discuss forthcoming inspection report, establish tentative schedule for reporting and data delivery.

Additional Questions/Discussion

Retaining Wall Questionnaire

***Note*:** This questionnaire is intended to provide cursory information that will assist the retaining wall inspection team during on-site wall inventories. Field visits by Park personnel for preliminary wall locations and/or extensive file review are NOT required to answer any of the following questions. The intent of this questionnaire is to quickly query knowledgeable personnel and obtain most of this information based on current experience and knowledge.

Retaining Wall Acceptance Criteria:

- All classes of paved Park roadways and parking areas are included in the inventory, as either described in the Park RIP Route Identification Report or further identified by Park facilities management staff.
- The retaining wall must reside within the existing roadway/parking area prism, generally defined within the known or assumed construction limits, and support or protect the roadway/parking area.
- The maximum wall height – including only that portion of the wall structure intended to actively retain soil and/or rock – must be greater than or equal to four feet, six feet for culvert headwalls.
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- Walls are further defined by an internal wall face angle greater than or equal to 45^o ($\geq$1H:1V face slope ratio).
- When wall acceptance based on the above criteria is marginal or difficult to discern, include the wall in the inventory, particularly where the intent is to support or protect the roadway/parking area and where failure would significantly impact the roadway/parking area and/or require replacement with a similar structure.

Preliminary Information Needs

(1) Estimated number of walls in the park and their approximate age?

(2) Which routes have retaining walls and approximately where along the routes are they located? (Provide RIP route names/numbers when possible, approximate mileposts defining retaining wall areas, and/or standard page-size Park maps indicating approximate wall locations.)

(3) Have any repairs been done to existing retaining walls? If so, are repair cost data/plans/drawings available (do not provide the actual plans, just note whether or not they exist and are accessible)?

(4) Are there any anticipated cultural resource issues associated with retaining walls in the Park? If so, does documentation exist describing the cultural aspects of the walls?

(5) Does the park currently maintain a retaining wall inventory or similar source of structures information? If yes, please provide to inventory team.

(6) Are there specific walls with serious or known problems? If yes, please list RIP route name and number and approximate milepoint location.

RIP Route ID Report - Example

Roadway Inventory Program

NPS/RIP Route ID Report

(Numerical By Route #)

Page 1 of 3

Shading Color Key: Red text denotes approx. mileage			
	White = Paved Routes, ARAN Driven	Yellow = Unpaved Routes, ARAN not Driven	Blue = All Paved Parking Areas
	Grey = Paved Routes, ARAN not Driven	Red =	Green = All Unpaved Parking Areas
	Black = Paved State, Local or Private non-NPS Routes, ARAN Driven	Purple =	

COLM

Colorado National Monument

Rte. #	FMSS Asset #	Route Name	Route Description From	To	Paved Miles	Un-Paved Miles	Rte. Lgth	Func. Class	Rte. Lanes	Manual Rated SQ/FT	Surf. Type
0010	80034	RIMROCK DRIVE	From Northwest Entrance	To East Entrance	22.41	0.00	22.41	1	2	0	AS
0011		GLADE PARK ROAD	From Route 0010 at MP 18.4	To Park Boundary	0.72	0.00	0.72	1	2	0	AS
0100		WEST GLADE PARK ROAD	From Route 0010 at MP 10.92	To West Boundary	0.00	0.13	0.13	2	2	0	GR
0200		SADDLEHORN AMPHITHEATER/ CAMPGROUND ROAD	From Route 0010 at MP 4.3	To end of loop	0.95	0.00	0.95	3	2,1	0	AS
0201A		SADDLEHORN CAMPGROUND LOOP A	From Route 0200	To End of Loop	0.22	0.00	0.22	3	1	0	OC
0201B		SADDLEHORN CAMPGROUND LOOP B	From Route 0201A	To End of loop	0.31	0.00	0.31	3	2,1	0	AS
0201C		SADDLEHORN CAMPGROUND LOOP C	From Route 0200	To Route 0200	0.26	0.00	0.26	3	1	0	OC
0202		DEVILS KITCHEN PICNIC AREA RD	From Route 0010 at MP 19.44	To Route 0918	0.12	0.00	0.12	3	2	0	OC
0400		MAINTENANCE/ RESIDENCE AREA ROAD	From Route 0010 at MP 4.2	To Dead End	0.33	0.00	0.33	4	2	0	AS
0401		WATER TANK ROAD	From Route 0010 at MP 4.38		0.00	0.27	0.27	4	2	0	GR
0402		EAST SHOP ROAD	From Route 0010 at MP 19.28	To End of Pavement at Gate	0.11	0.00	0.11	4	2	0	AS
0403		STONE HOUSE SERVICE RD	From Route 0200	To Behind Visitor Center	0.08	0.00	0.08	4	1	8,268	OC
0700	80045	R3-Unpaved Admin Use Road	From	To	0.00	1.00	1.00	ZZ		0	GR
0900		VISITOR CENTER PARKING	Adjacent To Route 0010 at MP 4.4		0.00	0.00	0.00	9		26,488	OC
0901		VISITOR CENTER ANNEX PARKING	Adjacent To Route 0200		0.00	0.00	0.00	9		2,151	OC
0902		AMPITHEATER PARKING	Adjacent To Route 0200		0.00	0.00	0.00	9		43,463	OC
0903		OTTO'S TRAILHEAD PARKING	Adjacent To Route 0010 at MP 5.3		0.00	0.00	0.00	9		3,838	OC
0904		WINDOW ROCK NATURE TRAIL PARKING	Adjacent To Route 0200		0.00	0.00	0.00	9		3,820	OC
0905		PARK MAINTENANCE LOT PARKING	Adjacent To Route 0400		0.00	0.00	0.00	9		30,740	OC
0906		BOOK CLIFF VIEW PARKING	Adjacent To Route 0200		0.00	0.00	0.00	9		4,401	OC
0907		INDEPENDENCE MONUMENT VIEW PARKING	Adjacent To Route 0010 at MP 5.5		0.00	0.00	0.00	9		11,442	OC
0908		GRAND VIEW PARKING	Adjacent To Route 0010 at MP 6.04		0.00	0.00	0.00	9		5,770	OC
0909		COKE OVENS OVERLOOK PARKING	Adjacent To Route 0010 at MP 7.94		0.00	0.00	0.00	9		4,907	OC
0910		HIGHLAND VIEW PARKING	Adjacent To Route 0010 at MP 9.9		0.00	0.00	0.00	9		6,271	OC
0911		UPPER UTE CANYON PARKING	Adjacent To Route 0010 at MP 13		0.00	0.00	0.00	9		3,560	OC
0912		FALLEN ROCK OVERLOOK PARKING	Adjacent To Route 0010 at MP 13.3		0.00	0.00	0.00	9		3,993	OC

10/10/2004

Visidata Preliminary Wall Location Form

Visidata Retaining Wall Location Form						
Park Name:	Prepared By:				Date:	
RIP Route Name and/or Number	Side of Road	~Wall Start Visidata Milepoint	~Wall End Visidata Milepoint	Wall Function	Wall Type	Access/Comments

Documents and Equipment List

Electronic Files
WIP Team and Park Contacts
Visidata Park Files
WIP Database for the Park
WIP Field Forms
WIP Field Guide
WIP Cost Guide
WIP Procedures Manual
RIP Route Inventory Report (comprehensive report)
RIP Route Identification Report (summary route listing)

Hard Documents
WIP Pre-Inventory Interview Checklist (phone interview notes)
Park Notification Letter (as sent to the Park)
WIP Kick-off Meeting Agenda (extra copies)
WIP Retaining Wall Questionnaire
Visidata Wall Location Form (filled out)
WIP Retaining Wall Reconnaissance Form (extra copies)
WIP FMSS Data – Manual Input Procedure and Test Guide
FMSS Spec Data Template
RIP Route Inventory Report (comprehensive report)
RIP Route Identification Report
RIP Intersection Report
Visidata Quick Start Guide
Field Forms (3x expected wall count – weather-proof paper)
Park Maps
WIP Field Guide
WIP Cost Guide
WIP Procedures Manual

Equipment
Laptop (with writeable CD, USB ports, mouse, etc.)
External Hard Drive (RIP report and Visidata-loaded)
Power Adaptor (with two standard AC outlets)
Field Form (clipboard case for forms management)
Wall Measuring Tools (tapes (hand/reel), clinometers, distance meter, etc.)
Rock Hammer
Camera (with spare storage card/batteries)
Safety equipment (vests, hard hats, gloves, boots, harnesses/ropes/hardware, first aid box)
Field glasses
Spare Batteries/car fuses
Flashlight
Surveyors Tape
Spray Paint

APPENDIX B – FIELD DOCUMENTS AND FORMS

This appendix contains supporting documents for field inspection activities:

- Retaining Wall Reconnaissance Form
- Field Inspection Form (blank)
- WIP Field Guide
- WIP Cost Guide
- Visidata Quick Start Guide

Retaining Wall Reconnaissance Form

Retaining Wall Reconnaissance Form

Park Name: Inspected By: Date:

RIP Route Name and/or Number (include odometer start location)	Side of Road	~Wall Start Milepoint	~Wall Length	Wall Function	Wall Type	~Year Built	Access/Comments

WIP Wall Reconnaissance Form 4-15-2007

Field Inspection Form (Front Page)

-NPS RETAINING WALL INVENTORY PROGRAM (WIP) FIELD FORM-					
NPS Park Name		Route/Parking No.		Wall Start Milepoint	
Inspected By		Route/Parking Name		Wall End Milepoint	
Inspection Date		Side of Centerline	(R/L/P# #)	Visidata Event Milepoint	
WALL FUNCTION, DIMENSIONS, and DESCRIPTION					
Wall Function		Primary Wall Type		Architectural Facings	
Approx. Year Built		Secondary Wall Types		Surface Treatments	
Wall General Description Notes: *(e.g., wall purpose, setting, construction, consequence of failure, special design, etc.)*					
Wall Length (ft)		Wall Face Area (ft²)		Wall Start Offset (ft)	
Max. Wall Height (ft)		Vertical Offset (+/- ft)		Wall End Offset (ft)	
Photo Description/No. *(e.g., approach, elevation, wall top, alignment, face detail, deficiencies, etc.)*				Face Angle (deg)	
Park Designated Wall ID					
REPAIR /REPLACE RECOMMENDATIONS AND WORK ORDER					
Wall Condition Rating		Design Criteria		Failure Consequence	
Investigation Req'd?	(Y/N)	Cultural Concern?	(Y/N)	Action	
Brief Work Order Description *(5-10 word maximum, key work elements)*					
Repair/Replace Recommendations *(itemized description of wall repairs, methods, estimated quantities, and costs per repair item, including consideration of constructability issues such as access, traffic control, staging, safety hazards, etc.)*					
Rev. 07-10-2007				**Repair/Replace COST:**	

Field Inspection Form (Back Page)

Element	Condition Narrative	Condition Rating X	Weighting Factor =	Condition Score	Data Reliability
Primary Wall Elements					
Piles and Shafts		1-10	8		1-3
Lagging		1-10	8		1-3
Anchor Heads		1-10	8		1-3
Wire/Geosynthetic Facing Elements		1-10	8		1-3
Bin or Crib		1-10	8		1-3
Concrete		1-10	8		1-3
Shotcrete		1-10	8		1-3
Mortar		1-10	8		1-3
Manufactured Block/Brick		1-10	8		1-3
Placed Stone		1-10	8		1-3
Stone Masonry		1-10	8		1-3
Wall Foundation Material		1-10	8		1-3
Other Primary Wall Element		1-10	8		1-3
Secondary Wall Elements (WF=0.5 for CR=8-10/ WF=1.0 for CR=4-7/WF=5 for CR=1-3)					
Wall Drains		1-10	0.5-5		1-3
Architectural Facing		1-10	0.5-5		1-3
Traffic Barrier/Fence		1-10	0.5-5		1-3
Road/Sidewalk/ Shoulder		1-10	0.5-5		1-3
Upslope		1-10	0.5-5		1-3
Downslope		1-10	0.5-5		1-3
Lateral Slope		1-10	0.5-5		1-3
Vegetation		1-10	0.5-5		1-3
Culvert		1-10	0.5-5		1-3
Curb/Berm/Ditch		1-10	0.5-5		1-3
Other Secondary Wall Elements		1-10	0.5-5		1-3
Wall Performance					
Performance		1-10	8		
WALL RATING	Weighting Factor (x10) and Condition Score Totals				
	Wall Condition Rating (= [Condition Score Total/Weighting Factor Total (x10)] X 100)				

WIP Field Guide (Page 1)

- NPS Retaining Wall Inventory Program Field Guide (WIFG)-

Retaining Wall Acceptance Criteria

*All classes of paved roadways and parking areas included in the RIP Route Investigation Report and/or identified by Park staff.
*Walls must reside within the constructed roadway/parking area prism.
*Maximum wall height, including only that portion actively retaining soil and/or rock, must be ≥ 4 ft (≥ 6 ft for culvert headwalls).
*Consider known/verifiable wall embedment in determining maximum retaining wall height. Include fully buried retaining structures.
*Walls have an internal wall face angle ≥ 45° (≥ 1H:1V face slope ratio).
*Include all walls where the intent is to support/protect the travelway, and where failure would require replacement with a retaining wall.

Definitions

Design Criteria	Measure of how well current design criteria are satisfied: **None** - Does not meet any known standards. **Non-AASHTO** - Does not meet AASHTO, but is consistent with other structures of its type/period with good performance. **AASHTO** - Apparently meets current AASHTO Geometric, Design, Materials, and Construction Standards.
Consequence of Failure	**Low** - No loss of roadway, no to low public risk, no impact to traffic during wall repair/replacement **Moderate**- Hourly to short-term closure of roadway, low-to-moderate public risk, multiple alternate routes available **High**- Seasonal to long-term loss of roadway, substantial loss-of-life risk, no alternate routes available
Action	Select from: **No Action, Monitor, Maintenance, Repair Elements, Replace Elements, and Replace Wall**
Weighting Factor	Weighting Factor to be applied to the Condition Rating (CR). When indicated on the Condition Assessment Input Form: WF=**0.5** for CR=8-10; WF=**1.0** for CR=4-7; and WF=**5** for CR=1-3.
Data Reliability	Estimate of how well observed conditions represent wall performance, and if additional investigations may be warranted. **1-Poor** Conditions cannot be sufficiently observed to rate element(s), warranting additional investigations to better define element performance and/or to determine the cause(s) or poor performance. **2-Good** Observed conditions are sufficient to rate the conditions of wall element(s); however, additional investigations would be useful to better understand element performance. **3-Very Good** Observed conditions clearly describe wall performance. Additional investigations are not needed.

Wall Function Codes

[FW] Fill Wall [CW] Cut Wall
[BW] Bridge Wall [SW] Switchback Wall [HW] Head Wall [SP] Slope Protection [FL] Flood Wall

Wall Type Codes

[AH] Anchor, Tieback H-Pile	[CC] Crib, Concrete	[MG] MSE, Geosynthetic Wrapped Face
[AM] Anchor, Micropile	[CM] Crib, Metal	[MP] MSE, Precast Panel
[AS] Anchor, Tieback Sheet Pile	[CT] Crib, Timber	[MS] MSE, Segmental Block
[BC] Bin, Concrete	[GB] Gravity, Concrete Block/ Brick	[MW] MSE, Welded Wire Face
[BM] Bin, Metal	[GC] Gravity, Mass Concrete	[SN] Soil Nail
[CL] Cantilever, Concrete	[GD] Gravity, Dry Stone	[TP] Tangent/ Secant Pile
[CP] Cantilever, Soldier Pile	[GG] Gravity, Gabion	[OT] Other, User Defined
[CS] Cantilever, Sheet Pile	[GM] Gravity, Mortared Stone	[NO] None

Architectural Facing Type Codes

[BV] Brick Veneer	[PF] Planted Face	[SS] Simulated Stone
[CO] Cementitious Overlay	[SC] Sculpted Shotcrete	[SV] Stone Veneer
[FF] Fractured Fin Concrete	[SH] Shotcrete (nozzle finish)	[TI] Timber
[FL] Formlined Concrete	[SM] Steel/Metal	[OT] Other, User Defined
[PC] Plain Concrete (float finish or light texture)	[SO] Stone	[NO] None

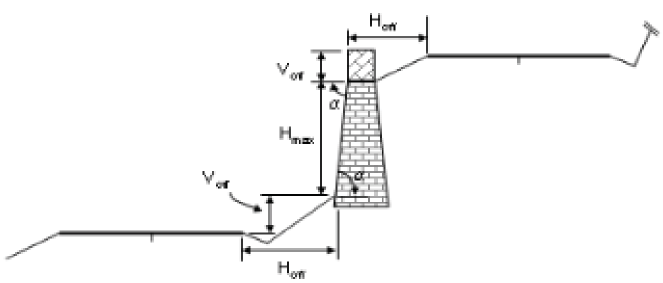
Surface Treatment Codes

[BG] Bush Gun (tool-textured concrete)	[PS] Preservative	[WS] Weathering Steel
[CA] Color Additive	[SE] Silane Sealer	[OT] Other, User Defined
[GL] Galvanized	[ST] Stain	[NO] None
[PA] Painted	[TR] Tar Coated	

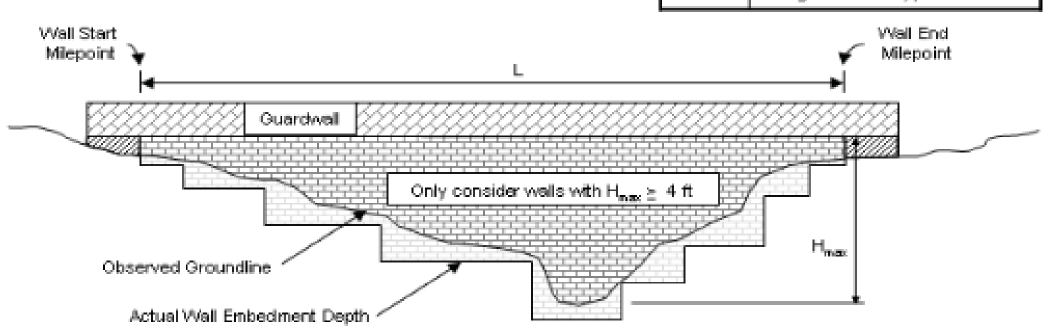
WIP Field Guide (Page 2)

Condition Ratings	
Condition Ratings apply to all Primary and Secondary Wall Elements, and are intended to assist in consistently defining element severity, extent, and repair/replace urgency of wall element distresses.	
9-10 (Excellent)	-Any defects are minor and are within normal range for *newly constructed or fabricated* elements. -Defects may include those typically caused from fabrication or construction.
7-8 (Good)	-Low-to-moderate extent of low severity distress. -Distress present does not significantly compromise the element function, nor is there significantly severe distress to major structural components of an element.
5-6 (Fair)	-High extent of low severity distress and/or low-to-medium extent of medium to high severity distress. -Distress present does not compromise element function, but lack of treatment may lead to impaired function/elevated risk of element failure in the near term.
3-4 (Poor)	-Medium-to-high extent of medium-to-high severity distress. -Distress present threatens element function, and strength is obviously compromised and/or structural analysis is warranted. -The element condition does not pose an immediate threat to wall stability and road closure is not necessary.
1-2 (Critical)	-Medium-to-high extent of high severity distress. -Element is no longer serving intended function. Element performance threatening overall stability of the wall at the time of inspection.

Wall Performance Condition Ratings		
Performance	Evaluation of overall wall performance as indicated by observations not necessarily captured by observed distresses for specific elements, including global wall distresses (rotation, settlement, translation, displacement, etc.) and/or evidence of prior repairs that may further indicate component problems.	**Good to Excellent** - No observation of distresses not already captured by individual element condition assessment. No combination of element distresses indicating unseen problems or creating significant performance problems. No history of remediation or repair to wall or adjacent elements.
		Fair - Some observed global distress is not associated with specific elements. Some observation of element distress combinations that indicate wall component problems. Minor work on primary elements or major work on secondary elements has occurred improving overall wall function.
		Poor to Critical - Global wall rotation, settlement, and/or overturning is readily apparent. Combined element distresses clearly indicate serious stability problems with components or global wall stability. Major repairs have occurred to wall structural elements, though functionality has not improved significantly.



H_{max}	Maximum exposed wall height, ft
V_{off}	Average vertical distance from pavement to cut wall toe or groundline at top of fill wall (+ above/ - below roadway), ft
H_{off}	Horizontal distance to wall face from edge of roadway, ft
α	Wall face angle measured from the horizontal, degrees
L	Maximum earth retaining length of the wall (excluding guardwalls). Wall length is the actual length of the structure, not simply the projected length along the roadway, ft



WIP Field Guide (Page 3)

Element	Element Definition
Primary Element Condition Ratings	
Piles and Shafts	Soldier piles, sheet piles, micropiles or drilled shafts; supplemental structures such as walers, comprising all/part of the visible wall.
Lagging	Structural lagging between piles and walers.
Anchor Heads	All visible parts of tieback anchor, including pad (observed without removing cap).
Wire/Geosyn. Facing Elements	Visible facing/basket wire, soil reinforcing elements, hardware cloth, geotextile/geogrids, and facing stone.
Bin or Crib	Visible portion of cellular gravity wall.
Concrete	Visible precast or cast-in-place concrete wall and footing elements (does not include piles, lagging, crib blocks, manufactured block/brick, and architectural facing).
Shotcrete	Visible shotcrete (does not include piles, lagging, architectural facing or other specific elements).
Mortar	Visible mortar used between uncut or masoned rock, manufactured blocks or brick, or used for wall repairs.
Manufactured Block/Brick	Manufactured blocks and bricks, including CMU's segmental blocks, large gravity blocks, etc. (does not include concrete lagging or crib wall components).
Placed Stone	Dry-laid or mortar-set *uncut* rock.
Stone Masonry	Dry-laid or mortar-set cut rock.
Wall Foundation Material	Soil or rock immediately adjacent to and supporting the wall.
Other Primary Wall Element	Any primary wall element not listed (provide detailed narrative definition).
Secondary Element Condition Ratings	
Wall Drains	Function and capacity of visible drain holes, pipes, slot drains, etc., that provide wall subsurface drainage.
Architectural Facing	Facing that is not relied on for structural capacity, including concrete, shotcrete, stone, timber, vegetation, etc.
Traffic Barrier/ Fence	Traffic barrier or fence above or below wall, and within the influence of the wall.
Road/ Sidewalk/ Shoulder	Road and/or sidewalk surface above or below a wall, and within the influence of the wall.
Upslope	Groundslope area above a wall affecting wall condition and/or performance.
Downslope	Groundslope area below the wall, distinct from the Wall Foundation Material element, affecting wall condition and/or performance.
Lateral Slope	Groundslope laterally adjacent to a wall affecting wall condition and/or performance.
Vegetation	Vegetation near wall or on wall face affecting wall condition and/or performance.
Culvert	Culverts and inlets/outlets through, below, or adjacent to walls.
Curb/ Berm/ Ditch	Lined or unlined surface drainage feature above or below wall.
Other Secondary Wall Element	Any secondary wall element not listed (provide detailed narrative definition).

Element Condition Rating Guidance

Good to Excellent Rating (minor to no distress, minimal to no impact, few to no occurrences)

Corrosion/Weathering
- No evidence of corrosion/staining, contamination or cracking/spalling due to weathering or chemical attack.
- Compacted, placed or masoned rock, and associated chinking, is dense, angular, fresh, and without post-placement fracturing or chemical degradation.
- No significant weathering/weakening of bedrock, softening of soil, or saturated ground conditions evident.
- No impacts from vegetation noted within the wall or within adjacent elements.

Cracking/Breaking
- No evidence of element cracking, breaking, or construction/post-construction damage, opening of discontinuities in rock, or cracks or gullies in soils.
- Concrete, shotcrete, and mortar is sound, durable, and shows little or no signs of shrinkage cracking or spalling.
- Drains are clearly open (flowing), and in full working order.

Distortion/Deflection
- Wall elements are as constructed, and/or show no signs of significant settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits.

Lost Bearing/Missing Elements
- No wall elements are missing.
- Wall elements are fully bearing against retained soil/rock units.
- Foundation soils/rock are more than adequate to support the wall, consistently dense, drained and strong.
- No slope failures have occurred either removing or adding materials to the wall area.

Fair Rating (moderate distress, significant to substantial impact, multiple occurrences)

Corrosion/Weathering
- Moderate corrosion/staining, contamination or cracking/spalling due to weathering or chemical attack.
- Compacted, placed or masoned rock is not fresh or angular, showing significant weathering, post-placement fracturing, chemical degradation, and/or localized loosening.
- Significant weathering/weakening of bedrock, softening of the soil, or saturated ground conditions evident.
- Moderate impacts from vegetation are evident within the wall or within adjacent elements.

Cracking/Breaking
- Localized element cracking, breaking, abrasion and/or construction/post-construction damage, opening or discontinuities in rock or cracks or gullies in soil.
- Concrete, shotcrete, and mortar is occasionally soft or drummy, has lost durability, and shows occasional cracking and/or spalling sufficient to intercept reinforcement.
- Drains cannot be clearly determined to be fully operational.

Distortion/Deflection
- Wall elements show significant localized settlement, bulging, bending, heaving, misalignment, distortion, deflection, and/or dispacement beyond normal prescribed post-construction limits (e.g., wall face rotation, basket buldging, anchor head displacement, bin displacement).

Lost Bearing/Missing Elements
- Some wall elements are missing (e.g., chinking, lagging, brick-work) or non-functional.
- Wall elements are generally bearing against retained soil/rock units, but localized open voids may exist along the back and top of the wall.
- Foundation soils/rock are adequate to support the wall, but susceptible to shrink-swell, erosion, scour, or vegetation impacts.
- Isolated slope failures have occurred either removing or adding material from the wall area.

Poor to Critical Rating (severe distress, failure is imminent, pervasive occurrences)

Corrosion/Weathering
- Metallic wall elements are corroded and have lost significant section affecting strength.
- Concrete/shotcrete is extensively spalled, cracked, and/or weakened, and may show evidence of widespread aggregate reaction.
- Compacted, placed or masoned rock is highly weathered, showing extensive post-placement fracturing, chemical degradation, and/or loosening within the placed volume.
- Extensive weathering/weakening of bedrock, softening of soil, or saturated ground conditions evident.
- Severe impacts from vegetation are evident within the wall or within adjacent elements.

Cracking/Breaking
- Extensive severe element cracking, breaking, abrasion or construction/post-construction damage, opening of discontinuities in rock, or cracks or gullies in soils.
- Concrete, shotcrete, and mortar is consistently soft, drummy, or missing, has lost durability and strength, and shows pervasive cracking and/or spalling intercepting corroding/weathering reinforcement.
- Drainage is missing, clearly damaged, and/or obviously clogged and non-functional.

Distortion/Deflection
- Wall elements show extensive settlement, bulging, bending, distortion, misalignment, deflection, and/or dis-placement well beyond normal post-construction limits, including loss of ground reinforcement and retention.

Lost Bearing/Missing Elements
- Many or key wall elements are missing (e.g., placed wall stone, chinking, lagging) or non-functional.
- Many or key wall elements are no longer bearing against retained soil/rock units, with visible open voids evident behind a large portion of the wall.
- Foundation soils/rock show signs of failure, excessive settlement, scour, erosion, substantial voids, bench failure, slope oversteepening, and/or may be adversely impacted by vegetation.
- Substantial slope failures have occurred either removing or adding materials to the wall area.

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WALL TYPE	PRIMARY ELEMENTS	Piles and Shafts	Lagging	Anchor Heads	Wire/Geosyn. Facing Elements	Bin or Crib	Concrete	Shotcrete	Mortar	Manufactured Block/Brick	Placed Stone	Stone Masonry	Wall Foundation Material	Other Primary Element	SECONDARY ELEMENTS	Wall Drains	Architectural Facing	Traffic Barrier/Fence	Road/Sidewalk/Shoulder	Upslope	Downslope	Lateral Slope	Vegetation	Culvert	Curb/Berm/Ditch	Other Secondary Element	WALL PERFORMANCE	Performance
[AH] Anchor, Tieback H-Pile		●	●	●									●			●			○	○	○	●						●
[AM] Anchor Micropile		●		●									●			●			○	○	○	●						●
[AS] Anchor, Tieback Sheet Pile		●		●									●			●			○	○	○	●						●
[BC] Bin, Concrete						●							●			●			○	○	○	●						●
[BM] Bin, Metal						●							●			●			○	○	○	●						●
[CL] Cantilever, Concrete							●						●			●			○	○	○	●						●
[CP] Cantilever, Soldier Pile		●	●										●			●			○	○	○	●						●
[CS] Cantilever, Sheet Pile		●											●			●			○	○	○	●						●
[CC] Crib, Concrete						●							●			●			○	○	○	●						●
[CM] Crib, Metal						●							●			●			○	○	○	●						●
[CT] Crib, Timber						●							●			●			○	○	○	●						●
[GB] Gravity, Concrete Block/Brick									●	●			●			●			○	○	○	●						●
[GC] Gravity, Mass Concrete							●						●			●			○	○	○	●						●
[GD] Gravity, Dry Stone											○	○	●			●			○	○	○	●						●
[GG] Gravity, Gabion					●								●			●			○	○	○	●						●
[GM] Gravity, Mortared Stone									●		○	○	●			●			○	○	○	●						●
[MG] MSE, Geosyn. Wrapped Face					●								●			●			○	○	○	●						●
[MP] MSE, Precast Panel							●						●			●			○	○	○	●						●
[MS] MSE, Segmental Block										●			●			●			○	○	○	●						●
[MW] MSE, Welded Wire Face					●								●			●			○	○	○	●						●
[SN] Soil Nail								●					●			●			○	○	○	●						●
[TP] Tangent/Secant Pile		●											●			●			○	○	○	●						●
[OT] Other, User Defined													●			●			○	○	○	●						●

● Wall elements that should always be rated for the given wall type (others may also apply).

○ 1 of 2 primary wall elements required depending on material observed.
2 of 3 secondary wall elements required depending on wall location relative to roadway.

Road/Sidewalk/Shoulder: Rate only when these elements lie within the influence of the wall. The shoulder is generally defined as extending no greater than 5 ft horizontally from the roadway/sidewalk, and less than -5 ft vertical offset.

Upslope: Rate the upslope condition for all walls above roadway grade, regardless of slope ratio. Rate the upslope condition for all walls below roadway grade, regardless of slope ratio, when the vertical offset to the wall from the roadway/shoulder is greater than 5 ft (otherwise evaluate the condition of the upslope under the "Road/Sidewalk/Shoulder" element).

Downslope: Rate the downslope condition for all walls below roadway grade, regardless of slope ratio. Rate the downslope condition for all walls above roadway grade, regardless of slope ratio, when the vertical offset to the wall from the roadway/shoulder is greater than 5 ft (otherwise evaluate the condition of the downslope under the "Road/Sidewalk/Shoulder" element).

WIP Cost Guide

NPS Retaining Wall Inventory Cost Guide

Average Wall Replacement Costs

Wall Code	Wall Description	Units	FY07 Item Cost
AH	Anchor, Tieback H-Pile**	SQFT	175.00
AS	Anchor, Tieback Sheet Pile*	SQFT	165.00
AM	Anchor Micropile*	SQFT	90.00
BC	Bin, Concrete*	SQFT	55.00
BM	Bin, Metal*	SQFT	55.00
GD	Gravity, Dry Stone**	SQFT	50.00
GM	Gravity, Mortared Stone**	SQFT	160.00
GB	Gravity, Concrete Block/Brick*	SQFT	80.00
GC	Gravity, Mass Concrete*	SQFT	60.00
GG	Gravity, Gabion**	SQFT	75.00
CC	Crib, Concrete*	SQFT	55.00
CT	Crib, Timber**	SQFT	185.00
CM	Crib, Metal*	SQFT	55.00
CL	Cantilever, Concrete**	SQFT	170.00
CP	Cantilever, Soldier Pile*	SQFT	110.00
CS	Cantilever, Sheet Pile*	SQFT	80.00
MP	MSE, Precast Panel*	SQFT	40.00
MS	MSE, Segmental Block*	SQFT	35.00
MG	MSE, Geosynthetic Wrapped Face**	SQFT	70.00
MW	MSE, Welded Wire Face**	SQFT	60.00
SN	Soil Nail*	SQFT	110.00
TP	Tangent Pile*	SQFT	110.00
OT	Other, User Defined	SQFT	TBD

* High average estimate based on Phase I report tabled cost ranges.

** Estimate based on recent FLH construction project data.

Average Architectural Facing Costs (FLH project data)

Facing Code	Facing Description	Units	FY07 Item Cost
BV	Brick Veneer	SQFT	135.00
CO	Cementitious Overlay	SQFT	65.00
FF	Fractured Fin	SQFT	NA
FL	Formlined Concrete	SQFT	50.00
PC	Plain Concrete (float finish/light texture)	SQFT	NA
PF	Planted Face	SQFT	5.00
SC	Sculpted Shotcrete	SQFT	80.00
SH	Shotcrete (nozzle finish)	SQFT	NA
SM	Steel/Metal	SQFT	NA
SO	Stone	SQFT	45.00
SS	Simulated Stone	SQFT	50.00
SV	Stone Veneer	SQFT	135.00
TI	Timber	SQFT	NA
OT	Other, User Defined	SQFT	NA

Average Barrier Replacement Cost (FLH project data)			
Barrier Code	Barrier Description	Units	FY07 Item Cost
WBE	Standard W Beam	LNFT	15.00
CFL	Formlined Concrete	LNFT	360.00
SMR	Stone Masonry-Reinforced (conc. core)	LNFT	2025.00
CAB	Cable	LNFT	NA
SBW	Steel-Backed Wood	LNFT	95.00
SBWR	Steel-Backed Wood (Removable)	LNFT	1600.00
SMU	Stone Masonry Unreinforced	LNFT	2895.00
SVC	Concrete w/ Stone Veneer	LNFT	705.00
PRECAST	Precast Concrete w/ Stone Veneer	LNFT	NA
CT	CoreTen	LNFT	30.00
R&R	Remove and Reset Guardrail	LNFT	25.00
Average Wall Repair Unit Costs (FLH project data)			
Repair Code	Repair Description	Units	FY07 Item Cost
RPT	Stone Masonry Repointing	SQFT	75.00
TBS	Tie-Back Anchor Stab./Reinforcement	SQFT	355.00
RMS	Remove/Replace Masonry Stone	SQFT	620.00
MUS	Micropile Underpinning/Stabilization	SQFT	170.00
SUS	Soil Nail Underpinning/Stabilization	SQFT	NA
RUS	Rock Bolt Underpinning/Stabilization	SQFT	150.00
SHUS	Shotcrete Underpinning/Stabilization	SQFT	375.00
CUS	Concrete Underpinning/Stabilization	SQFT	NA
GUS	Gabion Underpinning/Stabilization	SQFT	110.00
SMUS	Stone/Mortar Underpinning/Stabilization	SQFT	NA
IGR	Injection Grouting	SQFT	105.00
HOD	Hor. Drains/Angle Drains thru Back	SQFT	25.00
Average FY07 Pay Item Costs (CFLHD EE Data)			
FP03 Pay Item	Pay Item Description	Units	FY07 Item Cost
151 Mobilization			
15101-0000	MOBILIZATION	LPSM	11% EE
152 Construction Survey and Staking			
15206-0000	SLOPE, REF., CLEARING STAKING	STA	530.00
15214-2000	SURVEY/STAKING RETAIN WALL	LPSM	15050.00
15217-1000	SURVEY/STAKING, MISC.	HOUR	235.00
154 Contractor Sampling and Testing			
15401-0000	CONTRACTOR TESTING	LPSM	4% EE
157 Soil Erosion Control			
15705-0100	EROSION CONTROL, SILT FENCE	LNFT	5.00
15705-0300	EROSION CONTROL, SLOPE DRAIN	LNFT	35.00
15705-1400	EROSION CONTROL, SED. LOG	LNFT	20.00
15705-1500	EROSION CONTROL, WATTLE	LNFT	10.00
15706-0100	EROSION CONTROL, BALE	EACH	40.00
158 Watering for Dust Control			
15801-0000	WATERING, DUST CONTROL	MGAL	40.00
201 Clearing and Grubbing			

Average FY07 Pay Item Costs (cont'd)			
FP03 Pay Item	Pay Item Description	Units	FY07 Item Cost
20103-0000	CLEARING AND GRUBBING	SQYD	5.00
202 Additional Clearing and Grubbing			
20220-1000	REMOVAL, INDIVIDUAL TREE	EACH	955.00
203 Removal of Structures and Obstructions			
20301-0100	REMOVAL OF BOLLARD	EACH	20.00
20301-0200	REMOVAL OF BOULDERS	EACH	210.00
20301-1200	REMOVAL OF HEADWALLS	EACH	1050.00
20301-1900	REMOVAL OF PIPE CULVERT	EACH	1675.00
20302-0300	REMOVAL OF CURB AND GUTTER	LNFT	10.00
20302-0400	REMOVAL OF CURB, ASPHALT	LNFT	5.00
20302-0500	REMOVAL OF CURB, CONCRETE	LNFT	10.00
20302-0600	REMOVAL OF CURB, STONE	LNFT	15.00
20302-0700	REMOVAL OF FENCE	LNFT	5.00
20302-1200	REMOVAL OF GUARDRAIL	LNFT	15.00
20303-0300	REMOVAL OF CONCRETE	SQYD	55.00
20303-1600	REMOVE PAVEMENT, ASPHALT	SQYD	10.00
20303-2000	REMOVE ASPHALT, 4-IN DEPTH	SQYD	20.00
20303-2300	REMOVE PAVEMENT, CONCRETE	SQYD	55.00
20303-3000	REMOVE SIDEWALK, ASPHALT	SQYD	20.00
20303-3200	REMOVE SIDEWALK, CONCRETE	SQYD	30.00
20304-1000	REMOVE STRUCTURES/OBSTRUC.	LPSM	3%EE
20315-0000	SAWCUTTING PAVEMENT	LNFT	5.00
204 Excavation and Embankment			
20401-0000	ROADWAY EXCAVATION	CUYD	25.00
20402-0000	SUBEXCAVATION	CUYD	35.00
20403-0000	UNCLASSIFIED BORROW	CUYD	35.00
20410-0000	SELECT BORROW	CUYD	60.00
20415-0000	SELECT TOPPING	CUYD	45.00
20420-0000	EMBANKMENT CONSTRUCTION	CUYD	40.00
20441-0000	WASTE	CUYD	20.00
205 Rock Blasting			
20501-0000	CONTROLLED BLAST HOLE	LNFT	10.00
207 Earthwork Geotextiles			
20701-ALL	EARTHWORK GEOTEXTILE	SQYD	5.00
20703-ALL	GEOGRID	SQYD	15.00
208 Structure Excavation and Backfill for Selected Major Structures			
20801-0000	STRUCTURE EXCAVATION	CUYD	40.00
20802-0000	FOUNDATION FILL	CUYD	45.00
20803-0000	STRUCTURAL BACKFILL	CUYD	60.00
20811-0000	SHORING AND BRACING	SQFT	35.00
251 Riprap			
25101-1000	PLACED RIPRAP, CLASS 1	CUYD	80.00
25101-2000	PLACED RIPRAP, CLASS 2	CUYD	220.00
25101-3000	PLACED RIPRAP, CLASS 3	CUYD	200.00
25101-4000	PLACED RIPRAP, CLASS 4	CUYD	130.00
25101-5000	PLACED RIPRAP, CLASS 5	CUYD	85.00
25101-6000	PLACED RIPRAP, CLASS 6	CUYD	120.00
25101-7000	PLACED RIPRAP, CLASS 7	CUYD	215.00

Average FY07 Pay Item Costs (cont'd)			
FP03 Pay Item	Pay Item Description	Units	FY07 Item Cost
25110-ALL	GROUTED RIPRAP	CUYD	330.00
25125-0000	BOULDER	EACH	425.00
25126-0000	REMOVE AND RESET BOULDER	EACH	260.00
252 Special Rock Embankment and Rock Buttress			
25201-ALL	SPECIAL ROCK EMBANKMENT	CUYD	185.00
25205-0000	ROCK BUTTRESS	CUYD	80.00
25210-0000	ROCKERY WALL	SQYD	290.00
253 Gabions and Revet Mattresses			
25302-1000	GABIONS, GALVANIZED	CUYD	345.00
255 Mechanically-stabilized Earth Walls			
25501-0000	MSE WALL	SQFT	80.00
256 Permanent Ground Anchors			
25601-0000	GROUND ANCHOR	EACH	8020.00
25605-0000	PERFORMANCE TEST	EACH	3255.00
258 Reinforced Concrete Retaining Walls			
25801-ALL	RC RETAINING WALL, 6FT	SQFT	285.00
259 Soil Nail Retaining Walls			
25901-0000	SOIL NAIL	LNFT	60.00
25903-0000	VERIFICATION TEST NAIL	EACH	2760.00
260 Rock Bolts			
26001-0000	ROCK BOLT	LNFT	90.00
301 Untreated Aggregate Courses			
30101-0000	AGGREGATE BASE	TON	30.00
30110-0000	AGGREGATE SURFACE COURSE	TON	45.00
303 Road Reconditioning			
30302-1000	DITCH RECONDITIONING	LNFT	5.00
30306-ALL	PULVERIZING, 4-8IN DEPTH	SQYD	5.00
403 Hot Asphalt Concrete Pavement			
40301-0800	HACP, GRADING C/E	TON	120.00
404 Minor Hot Asphalt Concrete			
40401-0000	MINOR HOT ASPHALT CONCRETE	TON	360.00
411 Asphalt Prime Coat			
41101-ALL	PRIME COAT	TON	630.00
412 Asphalt Tack Coat			
41201-1000	TACK COAT	TON	580.00
413 Asphalt Pavement Milling			
41301-ALL	ASPHALT PAVEMENT MILLING	SQYD	10.00
414 Asphalt Pavement Crack and Joint Sealing			
41410-1000	CRACK, CLEANING AND SEALING	LNFT	5.00
428 Flexible Pavement Restoration			
None	FLEXIBLE PAVEMENT RESTORATION	SQFT	10.00
551 Driven Piles			
55101-0200	CONCRETE, STEEL PIPE PILES	LNFT	175.00
55101-0300	PRESTRESSED CONCRETE PILES	LNFT	135.00
55101-ALL	STEEL H-PILES	LNFT	185.00
55103-2000	VINYL SHEET PILES	SQYD	205.00
55115-ALL	PREBORING	LNFT	105.00
552 Structural Concrete			

Average FY07 Pay Item Costs (cont'd)			
FP03 Pay Item	Pay Item Description	Units	FY07 Item Cost
55201-0200	STRUCTURAL CONCRETE, CLASS A	CUYD	1230.00
557 Timber Structures			
55701-2000	STRUCTURAL TIMBER/LUMBER	MFBM	5715.00
563 Painting			
56305-0000	ROCK STAIN	SQFT	1.00
56311-1000	WEATHERING AGENT, DESERT	SQFT	0.50
565 Drilled Shafts			
56501-0400	DRILLED SHAFTS, 36-INCH	LNFT	715.00
56501-0600	DRILLED SHAFTS, 48-INCH	LNFT	1265.00
56501-0800	DRILLED SHAFTS, 60-INCH	LNFT	3170.00
566 Shotcrete			
56603-ALL	REINFORCED SHOTCRETE	SQYD	410.00
569 Micropiles			
56901-0000	MICROPILE	LNFT	360.00
56905-0000	MICROPILE LOAD TEST	EACH	26250.00
601 Minor Concrete Structures			
60101-0000	CONCRETE	CUYD	1470.00
60103-0140	HEADWALL FOR 24-INCH CULVERT	EACH	8435.00
60103-0220	HEADWALL FOR 48-INCH CULVERT	EACH	7365.00
60110-0000	CONCRETE COLORING AGENT	LB	10.00
602 Culverts and Drains			
60201-0800	24-INCH PIPE CULVERT	LNFT	205.00
60201-1000	36-INCH PIPE CULVERT	LNFT	165.00
60201-1200	48-INCH PIPE CULVERT	LNFT	210.00
60201-1600	72-INCH PIPE CULVERT	LNFT	330.00
605 Underdrains, Sheet Drains, and Pavement Edge Drains			
60501-0000	STANDARD UNDERDRAIN SYSTEM	LNFT	60.00
60504-0000	GEOCOMPOSITE SHEET DRAIN	SQYD	45.00
609 Curb and Gutter			
60902-ALL	CONCRETE CURB	LNFT	35.00
60901-3100	CURB, STONE, TYPE 1, 8-INCH	LNFT	75.00
60902-1000	CURB&GUTTER, CONCRETE, 12-IN	LNFT	50.00
60905-1000	GUTTER, CONCRETE	LNFT	45.00
60915-1000	WHEELSTOP, CONCRETE	EACH	125.00
610 Horizontal Drains			
61001-0000	HORIZONTAL DRAIN PIPE	LNFT	40.00
61002-0000	COLLECTOR SYSTEM	LNFT	40.00
613 Simulated Stone Masonry Surface			
61301-0000	SIMULATED STONE MASONRY	SQYD	425.00
614 Lean Concrete Backfill			
61401-0000	LEAN CONCRETE BACKFILL	CUYD	175.00
615 Sidewalks, Drive Pads, and Paved Medians			
61501-0100	SIDEWALK, CONCRETE	SQYD	110.00
61501-0200	SIDEWALK, COLORED CONCRETE	SQYD	105.00
61501-1100	SIDEWALK, ASPHALT	SQYD	45.00
61502-1000	DRIVE PAD, CONCRETE	SQYD	135.00
61504-1000	ACCESSIBILITY RAMP, CONCRETE	SQYD	190.00
617 Guardrail			

Average FY07 Pay Item Costs (cont'd)			
FP03 Pay Item	Pay Item Description	Units	FY07 Item Cost
61701-1250	GUARDRAIL, TYPE 2, WOOD POST	LNFT	35.00
61702-0600	TERMINAL SECTION, FLARED	EACH	2360.00
61702-0800	TERMINAL SECTION, TANGENT	EACH	4170.00
61704-2000	REPLACEMENT POST, WOOD	EACH	180.00
61708-1000	REMOVE AND RESET, GUARDRAIL	LNFT	46.00
618 Concrete Barriers and Precast Guardwalls			
61801-0000	CONCRETE BARRIER	LNFT	100.00
61802-0000	CONCRETE GUARDWALL	LNFT	360.00
620 Stone Masonry			
62001-0100	CLASS A MASONRY, FINE POINTED	CUYD	735.00
62001-ALL	RUBBLE MASONRY	CUYD	1255.00
62010-1000	STONE MASONRY GUARDWALL	LNFT	645.00
62010-7000	STONE MASONRY PARAPET	LNFT	825.00
62011-ALL	STONE MASONRY HEADWALL	EACH	5085.00
62025-1000	REMOVE/RESET STONE MASONRY	CUYD	3195.00
62027-1000	REMOVE/RESET STN GUARDWALL	LNFT	475.00
62028-1000	REMOVE/RESET STN HEADWALL	EACH	4430.00
622 Rental Equipment			
62201-ALL	DUMP TRUCK	HOUR	120.00
62201-0350	BACKHOE	HOUR	150.00
62201-0950	WHEEL LOADER, 3 CUBIC YARD	HOUR	170.00
62201-ALL	BULLDOZER	HOUR	195.00
62201-2050	ROLLER	HOUR	165.00
62201-2100	COMPACTOR	HOUR	210.00
62201-2750	MOTOR GRADER	HOUR	175.00
62201-3600	MANLIFT	HOUR	100.00
623 General Labor			
62301-0000	GENERAL LABOR	HOUR	55.00
62302-0100	SPECIAL LABOR, SLOPE SCALING	HOUR	890.00
624 Topsoil			
62401-ALL	FURNISHING/PLACING TOPSOIL	SQYD	10.00
625 Turf Establishment			
62511-1000	SEEDING, DRY METHOD	SQYD	2.00
62511-2000	SEEDING, HYDRAULIC METHOD	SQYD	2.00
629 Rolled Erosion Control Products			
62901-0300	ROLLED EROSION CONTROL	SQYD	5.00
634 Permanent Pavement Markings			
63401-ALL	PAVEMENT MARKINGS	LNFT	0.50
635 Temporary Traffic Control			
63501-0000	TEMPORARY TRAFFIC CONTROL	LPSM	3% EE
645 Locating Utilities			
None	LOCATE UTILITIES	PER WL	600.00
647 Environmental Mitigation			
None	ENVIRONMENTAL MITIGATION	LPSM	5% EE
650 Temporary Diversions			
None	TEMPORARY DIVERSIONS	LNFT	50.00
651 Rockfall Protection			
None	ROCKFALL PROTECTION - MESH	SQFT	15.00

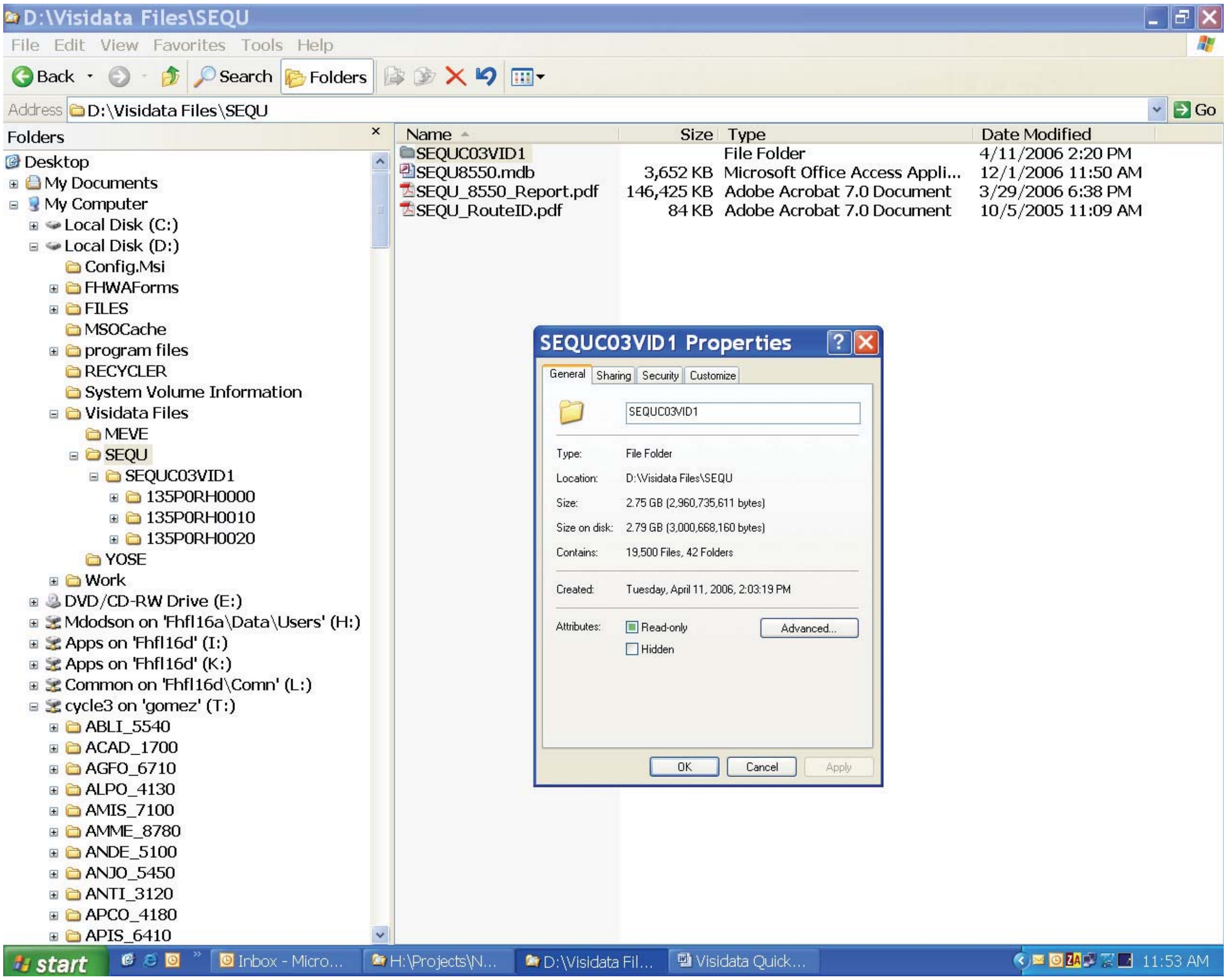
Visidata Quick Start Guide

The purpose of this Quick Start Guide is to give a basic overview on how to open and view the RIP database and video files using the VisiData application. Brief instructions for copying Visidata files onto the field storage devices are also included. Please read these instructions carefully as selecting the wrong option may cause the VisiData application to crash. For further information and detailed instructions on how to use the VisiData application, please refer to the "Visidata Tutorial and User Guide".

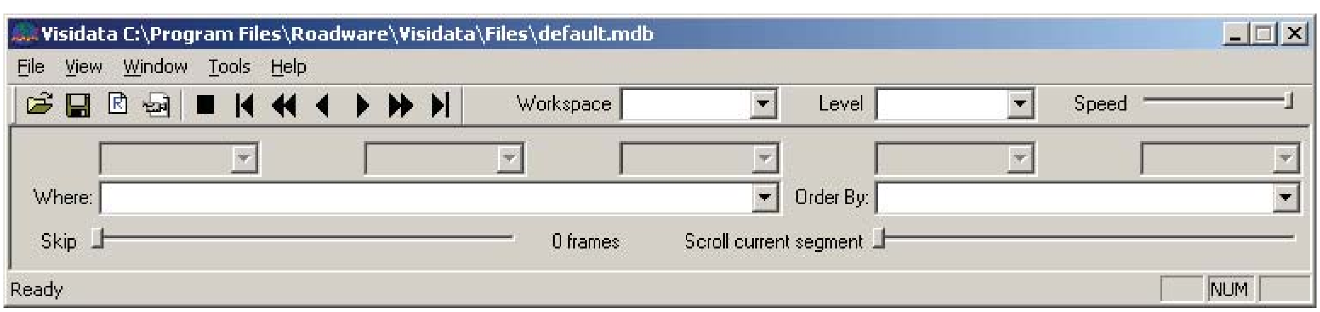
(1) Install VisiData software onto the laptop that will be taken into the field. You may need assistance from the IT Help Desk.

(2) Copy VisiData files onto the field storage device, which will usually be an external hard drive (a regular laptop hard drive may not have enough storage space for all of the files, which can be >20GB, depending on the park). This can be done through the coordination with the Division RIP Coordinator, or by the following procedure having once located the proper RIP storage drive location:

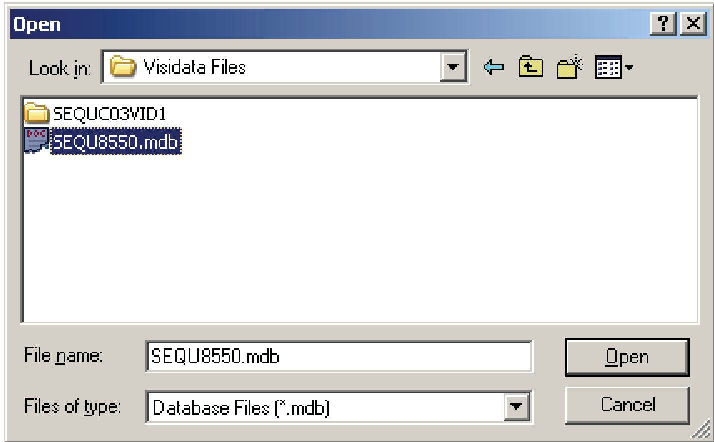
- There are three folders containing RIP information that needs to be copied to the field laptop:
    - **Database** folder
    - **RIP Report pdf** folder
    - **PARK####VID1** folder
- Open the Database folder and copy the PARK#####.mdb and PARK_RouteID.pdf files (Not the PARK_Route_Info.mdb) from this folder to the laptop D:\VisiData Files folder (if you do not have a "Local Drive D", you may create/locate this folder under C:\VisiData Files). These files range from 3 to 15 MB in size.
- Open the RIP Report pdf folder and copy the PARK_####_Report.pdf file from this folder to the laptop D:\VisiData Files folder. This report should be printed out and taken in the field for easy reference (preferably color, 2-sided, comb-bound).
- Copy the entire PARK####VID1 folder to the laptop D:\VisiData Files folder. These files can be >20GB in size.



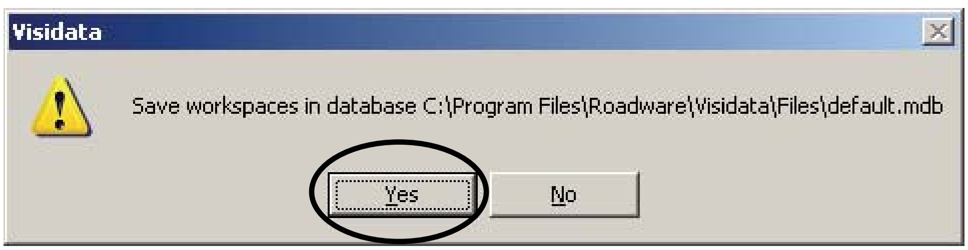
(3) Open the Visidata software



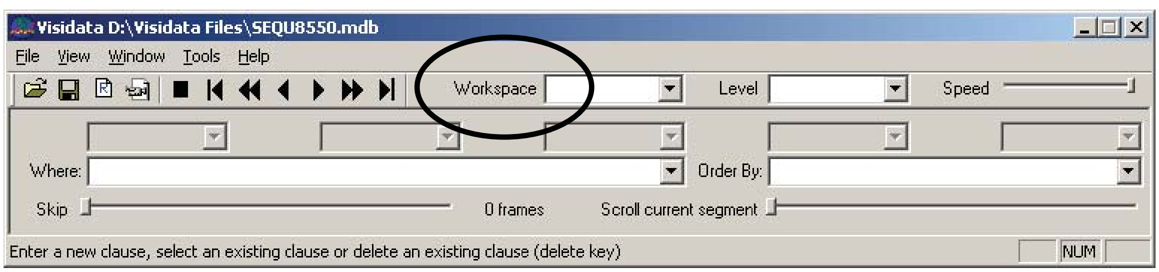
(4) Open the *.mdb Visidata file for the park using the "File" then "Open" commands. In this case the file name is "SEQU8550.mdb".



Click “No” when the following warning screen pops up asking to save workspace. (If you select “Yes”, be sure to hit “Cancel” in the next window that opens.)

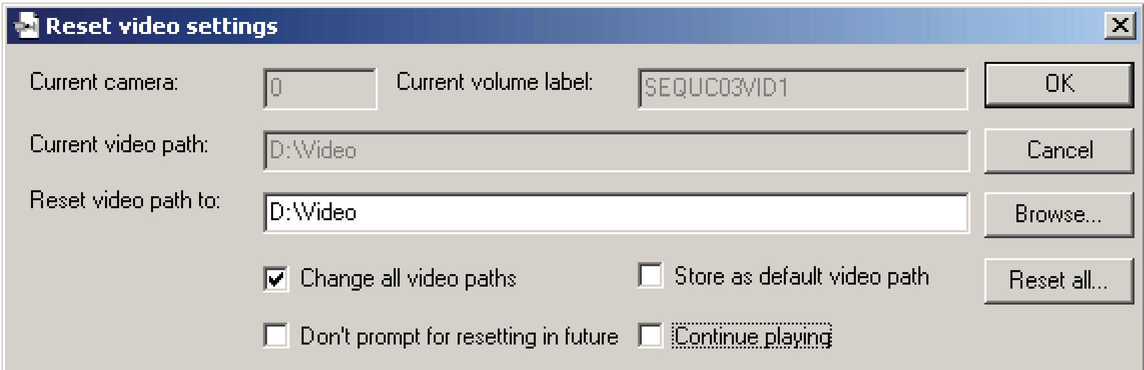


You will then see the following:

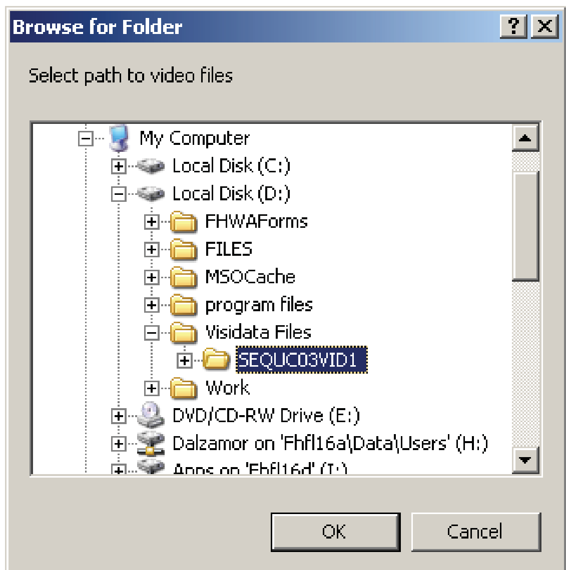


(5) From the Workspace drop-down menu, select the workspace you want to view. There are two that will be used in the field. They are the “Panorama” and “Features”. The Panorama workspace continuously runs thought the entire route. The Features workspace is the most useful for the NPS Retaining Wall Inventory Program (WIP). It skips through the route from one feature to the next. The features table associated with this workspace tells you exactly what the feature is and at what milepost it is located.

Then click “OK”. The following screen appears. Uncheck “Continue playing” then click “Browse”. Locate the directory were the image files are located.



Then Click "OK".

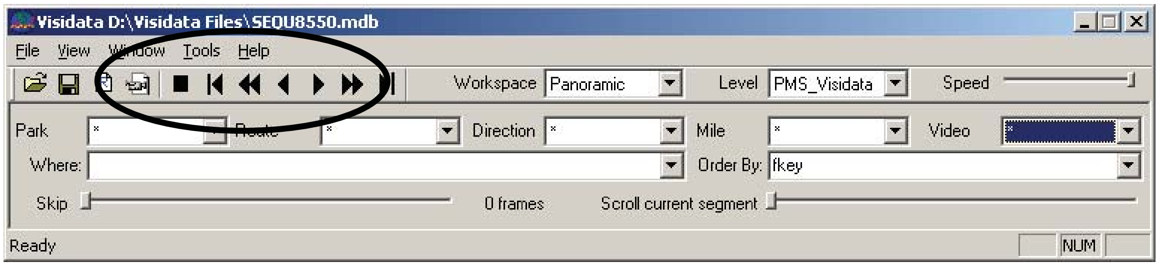


Click "OK" when you return to the "Reset video settings" screen.

(6) Now you will see the panorama images in the three forward cameras. You will need to place the cameras so they overlap properly, as follows:

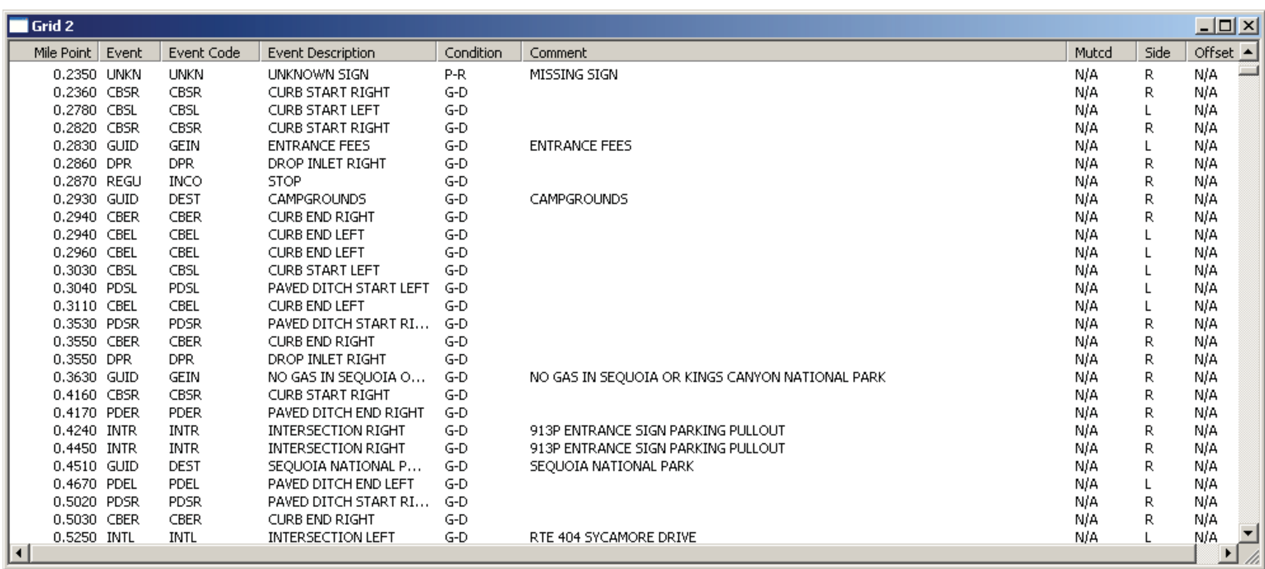
(7) In the main Visidata window, under the Route drop-down menu, choose the route you want to view. To view only the route's primary direction, under the Direction drop-down menu, select PRI.

(8) Then you can use the camera buttons to navigate through the route.



You will now also see a features table which tells you what the feature is and were it is located.

Note: The Mile Point in the Features Table is the value to record on the Field Form. The Mile Point on the bottom right-hand corner of each camera is the INCORRECT value, as it will show a Mile Point prior to the feature in the video so the feature can be seen in the view.



Grid 2

Mile Point	Event	Event Code	Event Description	Condition	Comment	Mutcd	Side	Offset
0.2350	UNKN	UNKN	UNKNOWN SIGN	P-R	MISSING SIGN	N/A	R	N/A
0.2360	CBSR	CBSR	CURB START RIGHT	G-D		N/A	R	N/A
0.2780	CBSL	CBSL	CURB START LEFT	G-D		N/A	L	N/A
0.2820	CBSR	CBSR	CURB START RIGHT	G-D		N/A	R	N/A
0.2830	GUID	GEIN	ENTRANCE FEES	G-D	ENTRANCE FEES	N/A	L	N/A
0.2860	DPR	DPR	DROP INLET RIGHT	G-D		N/A	R	N/A
0.2870	REGU	INCO	STOP	G-D		N/A	R	N/A
0.2930	GUID	DEST	CAMPGROUNDS	G-D	CAMPGROUNDS	N/A	R	N/A
0.2940	CBER	CBER	CURB END RIGHT	G-D		N/A	R	N/A
0.2940	CBEL	CBEL	CURB END LEFT	G-D		N/A	L	N/A
0.2960	CBEL	CBEL	CURB END LEFT	G-D		N/A	L	N/A
0.3030	CBSL	CBSL	CURB START LEFT	G-D		N/A	L	N/A
0.3040	PDSL	PDSL	PAVED DITCH START LEFT	G-D		N/A	L	N/A
0.3110	CBEL	CBEL	CURB END LEFT	G-D		N/A	L	N/A
0.3530	PDSR	PDSR	PAVED DITCH START RI...	G-D		N/A	R	N/A
0.3550	CBER	CBER	CURB END RIGHT	G-D		N/A	R	N/A
0.3550	DPR	DPR	DROP INLET RIGHT	G-D		N/A	R	N/A
0.3630	GUID	GEIN	NO GAS IN SEQUOIA O...	G-D	NO GAS IN SEQUOIA OR KINGS CANYON NATIONAL PARK	N/A	R	N/A
0.4160	CBSR	CBSR	CURB START RIGHT	G-D		N/A	R	N/A
0.4170	PDER	PDER	PAVED DITCH END RIGHT	G-D		N/A	R	N/A
0.4240	INTR	INTR	INTERSECTION RIGHT	G-D	913P ENTRANCE SIGN PARKING PULLOUT	N/A	R	N/A
0.4450	INTR	INTR	INTERSECTION RIGHT	G-D	913P ENTRANCE SIGN PARKING PULLOUT	N/A	R	N/A
0.4510	GUID	DEST	SEQUOIA NATIONAL P...	G-D	SEQUOIA NATIONAL PARK	N/A	R	N/A
0.4670	PDEL	PDEL	PAVED DITCH END LEFT	G-D		N/A	L	N/A
0.5020	PDSR	PDSR	PAVED DITCH START RI...	G-D		N/A	R	N/A
0.5030	CBER	CBER	CURB END RIGHT	G-D		N/A	R	N/A
0.5250	INTL	INTL	INTERSECTION LEFT	G-D	RTE 404 SYCAMORE DRIVE	N/A	L	N/A

Note: When changing options within a specific park, you may need to repeat setting up the video location. This is normal.

Note: When closing the VisiData application, you may receive a message asking to Save Workspace in Database. Always select **NO**.

APPENDIX C – POST-FIELD DOCUMENTS AND FORMS

This appendix contains supporting documents for post-field data management and reporting activities:

- Park Summary Letter
- FMSS Specification Data Template
- FMSS Data Input Procedures and Test Guide

Park Summary Letter

U.S. Department
of Transportation
**Federal Highway
Administration**

<Office> Federal Lands Highway Division
Street Address
City, State, Zip

<Date>

Superintendent
XYZ National Park
Road/Hwy/Street Address
City, State, Zip

Subject: NPS Retaining Wall Inventory Program (WIP)

Dear <Superintendent Name>,

In support of the NPS Facility Management Software System (FMSS) asset management program, FHWA and NPS engineering staff have recently completed retaining wall inspection work within the Park under the newly developed NPS Retaining Wall Inventory Program (WIP). As you may recall, this inventory provides information to FMSS regarding such things as type, size and location of retaining structures, as well as the assessed condition of these facilities. In addition, when wall and/or adjacent element deficiencies are identified, repair recommendations and estimated costs are also provided, suitable for use as FMSS work orders.

Retaining wall inspections were conducted at <Park Name> during the week of <Dates Here>, and encompassed all known retaining wall structures associated with Park roadways – including structures retaining cuts and fills, as well as headwalls at culverts. Walls at bridge abutments, currently evaluated as part of the Bridge Inspection Program, are not included in the WIP assessment. For the purposes of this assessment, walls must be a minimum of 4 feet in maximum height of retained earth. This does not include the height of parapet or guardwall above a retaining wall. In general, guardwall or parapets are not included in this assessment; however, when required, guardwall treatments are included in the work order.

Using the tabled summary inventory information provided by the WIP database following completion of the Park data upload, describe such things as the routes inspected, the approximate number, types, and sizes of walls inspected per route, specific walls requiring immediate action, etc. Include any other pertinent findings from the field inspections, including overall impressions of the condition of retaining structures throughout the Park. The following is an example of the brief summary provided to Mesa Verde NP following completion of the WIP inventory:

The following tables and attachment provide an overview of the general findings of this inspection effort. All roadways and parking areas listed in the Road Inventory Program (RIP) Route Identification Report were inspected. In all, 37 walls of various type, function, and size were inventoried per the routes listed. None of the walls inventoried required significant repair – generally only minor maintenance. Of the twelve walls noted for maintenance, only six required work totaling more than $500/wall, with the remaining six walls generally requiring little more than vegetation clearing. Although it was thought, prior to the site inspection, that the anchor tieback walls along Chapin Mesa Road may require substantial lagging repair, this was not the case. However, several of these walls would benefit from cleaning and repainting piles, walers, and anchor caps as minor corrosion was routinely evident on these structures.

Overall, the retaining walls inspected during this inventory appear to be functioning as intended, with only minor signs of distress evident. Routine inspection and performing the noted maintenance will greatly aid in the continued performance of all walls at Mesa Verde.

Rte No.	No. of Walls
0010, Chapin Mesa Road	19
0100, Balcony House Road	3
0101, Sun Point Road	4
0200, Wetherill Mesa Road	4
0209, HQ Loop Road	2
0211, Sun Temple Road	1
0415, HQ Residence Road	1
0918, Farview Parking Lot	1
0925, Side HQ & Post Office	2
Total	37

Wall Function	No. of Walls
FW - Fill Wall	35
HW – Culvert Head Wall	2

Primary Wall Type	No. of Walls
Anchor, Tieback H-Pile	9
Bin, Metal	2
Cantilever, Concrete	4
Crib, Metal	1
Gravity, Dry Stone, Rockery	11
Gravity, Mortared Stone	3
MSE, Welded Wire	7

Action Required	No. of Walls
Monitor / No Action	25
Minor Maintenance	12

Rte. – RIP Milepoint	Repair Cost
0010 – 2.599	$1,500.00
0010 – 2.678	$5,175.00
0010 – 3.057	$4,065.00
0010 – 3.281	$6,275.00
0010 – 6.847	$2,140.00
0010 – 7.707	$1,642.00

As an integral part of the inventory process, we will soon be sending <Facility Manager> a compilation of pertinent field inspection data required to update the status of retaining wall facilities within FMSS. The data will be provided in an Excel spreadsheet in a file format compatible with the FMSS equipment specification template. Included in this data file will be specifics regarding wall type, function, location, dimensions, work orders, etc. Once this data has been uploaded by Park staff to FMSS, we request that FMSS wall equipment numbers be sent back to our database management team so that we might complete the Central WIP database for your Park. To further assist your staff in updating FMSS with WIP spec template info, I have included a brief instruction guide regarding WIP/FMSS data transfer procedures developed by David Keough, NPS WASO. Any questions on the spec template information and/or data transfer procedures may be forwarded directly to <WIP Database Administrator>, WIP Database Administrator, CFLHD, at <Phone Number> or by e-mail at <WIP Database Administrator e-mail address>.

On behalf of the FHWA inventory team, I would like to thank you and your staff for the outstanding assistance we received prior to and during the site inspections. If I can be of any assistance or answer any questions regarding the Park inventory, please feel free to contact me at <Phone Number>. For additional Wall Inventory Program (WIP) information, please contact <NPS WASO Program Coordinator >, NPS WASO Program Coordinator, at <Phone Number>, or < FLH WIP Coordinator>, FLH WIP Coordinator, at <Phone Number>.

We look forward to working with you and your staff again as we move forward in supporting NPS asset management efforts.

Sincerely,

Team Lead
Title

cc: <Facility Manager, XYZ National Park>
<NPS WASO Program Coordinator>, NPS WASO
<FLH WIP Database Administrator>, FHWA-CFLHD

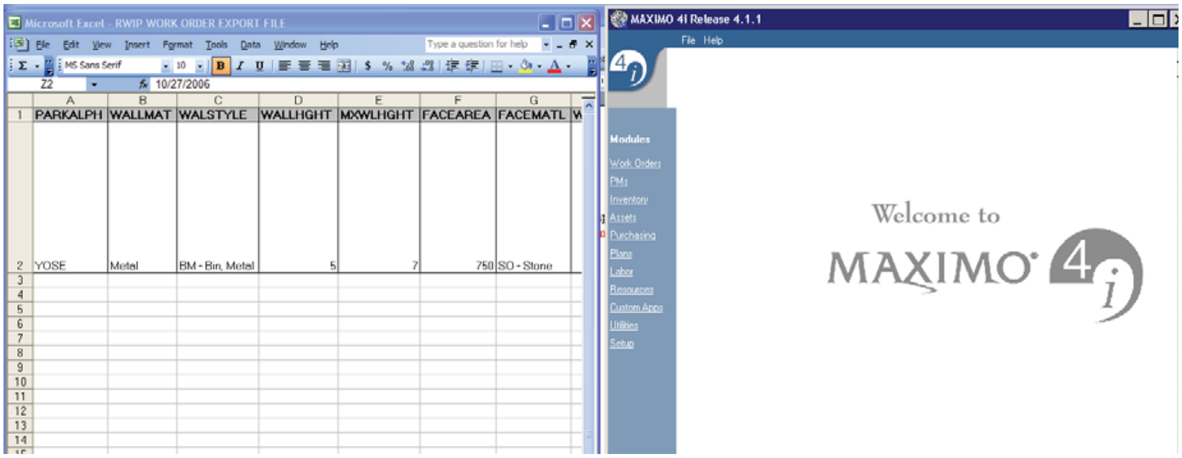
FMSS Specification Data Template

FMSS DATA FIELD NAME	DESCRIPTION	TYPE
ACTREPCOST	Actual repair costs. The Park provides this information only after a wall is repaired.	Numeric
ASSETNO	Asset Number: assigned by the FMSS system for each retaining wall.	Numeric
COSTSRCE	Cost Source: A constant value of "FHWA" which used historical cost data to estimate repairs.	Character
DATESENT	Date the Wall Inventory export file was sent to a Park's Superintendent.	Date
ESTREPCOST	Total estimated repair or replacement costs based on itemized repair elements identified in the work order using the FHWA cost guide.	Numeric
EVENT	Event = RETAINING WALL.	Character
FACE_ANGLE	Wall face batter angle in degrees measured from the horizontal. No decimals.	Numeric
FACEAREA	Field-calculated exposed area of the wall face. Measured in square feet.	Numeric
FACEMATL	The face material, or surface treatment, if any, that has been applied to the retaining wall. Paint; Sealant; Stain; etc.	Character
GPSTALAT	Latitude Start: Interpolation in the field of the GPS Latitude Coordinate for the Wall starting point.	Numeric
GPSTALNG	Longitude Start: Interpolation in the field of the GPS Longitude Coordinate for the Wall starting point.	Numeric
MLPNTST	Calculated wall start milepoint based on measurement from a Visidata event milepoint, or on odometer mileage.	Numeric
MLPNTND	Calculated wall end milepoint based on adding the measured length of the wall along the roadway to the wall start milepoint.	Numeric
MXWLHGHT	Maximum exposed height of the wall. Measured in feet.	Numeric
OFFSETND	Horizontal distance in feet from pavement edge to the wall face at the end of the wall.	Numeric
OFFSETST	Horizontal distance in feet from pavement edge to the wall face at the start of the wall.	Numeric
PARENTEQN	Parent Equipment Number. A field assigned by the FMSS system for each retaining wall.	Numeric
PARKALPH	NPS alpha codes for Park names (YOSE, ZION, MEVE, etc.)	Character
REPORTBY	The system that reported data to NPS. Default value is value "WIP". This is a required field for the export file to the FMSS system.	Character
REPRECS	Repair / Replace Recommendations: Itemized description of recommended wall repairs: elements, methods, estimated quantities, including costs per repair item. Constructability issues are included: (access, staging, traffic control, safety hazards, etc.)	Character
RTENO	Route Number for a Park road. Provided in the RIP Route Identification Report.	Character
SIDE	Side of the centerline where the wall is located; in the direction of increasing mileposts (R, L, N/A).	Character
WALLHGHT	Average exposed height of the wall (generally based on multiple measurements along the wall). Measured in feet.	Numeric

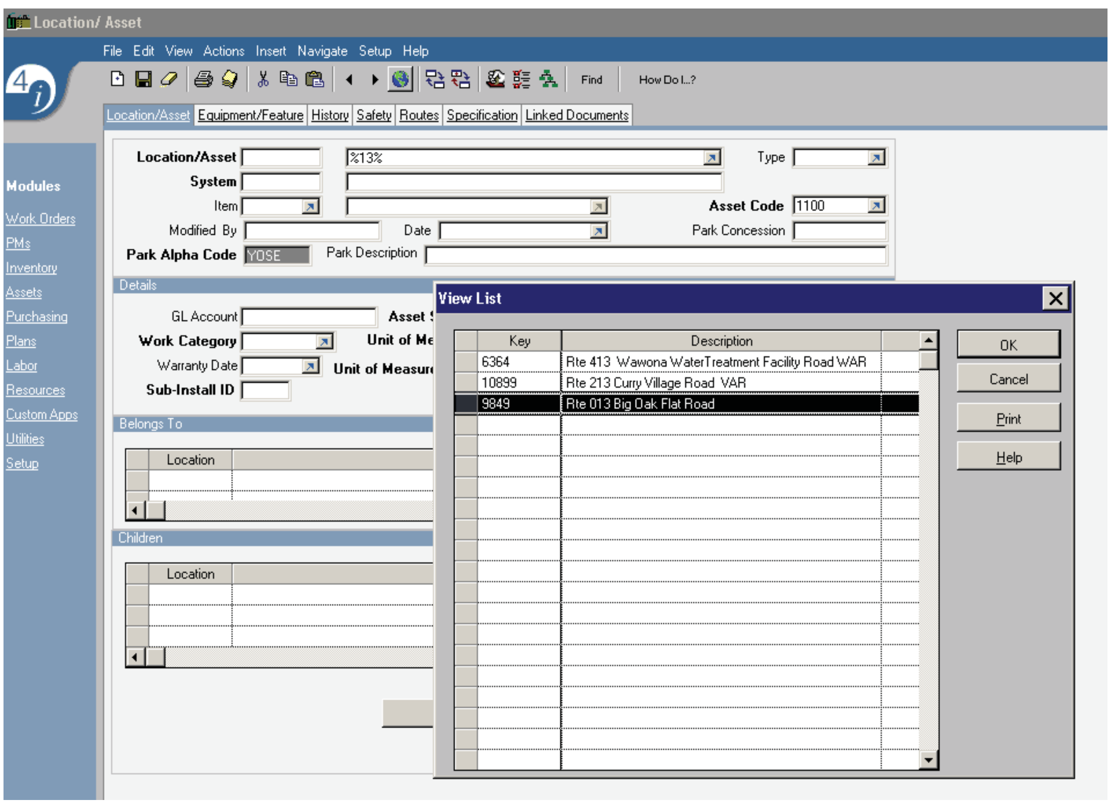
FMSS DATA FIELD NAME	DESCRIPTION	TYPE
WALLMAT	Primary construction material of the retaining wall. (Concrete, Metal, Timber, etc.)	Character
WALLNGTH	Total constructed wall length at the top of wall ground line. Measured in feet; no decimals.	Numeric
WALLSTAT	Wall Status: the recommended action for the retaining wall - No Action, Monitor, Maintenance, Repair Elements, Replace Elements, Replace Wall.	Character
WALLSTYLE	A description of the predominant style or type of the retaining wall based on support mechanism and construction material. (Anchor, Tieback H-Pile; Gravity Mortared Stone; etc.)	Character
WIPWLID	Wall ID: Unique identifier for retaining walls based on combining: PARK_ALPHA + RTE_NO + WALL_BEG_MP + SIDE. (e.g., **YOSE-0013-12.240-R**)	Character
WORKORDR	Work Order Description: Brief narrative about the type of repair, what is to be repaired, etc.	Character
WORKORDER NO	Number assigned to the work order by the FMSS system.	Numeric

FMSS Data Input Procedures and Test Guide

Begin with loading the WIP output data file as well as FMSS.

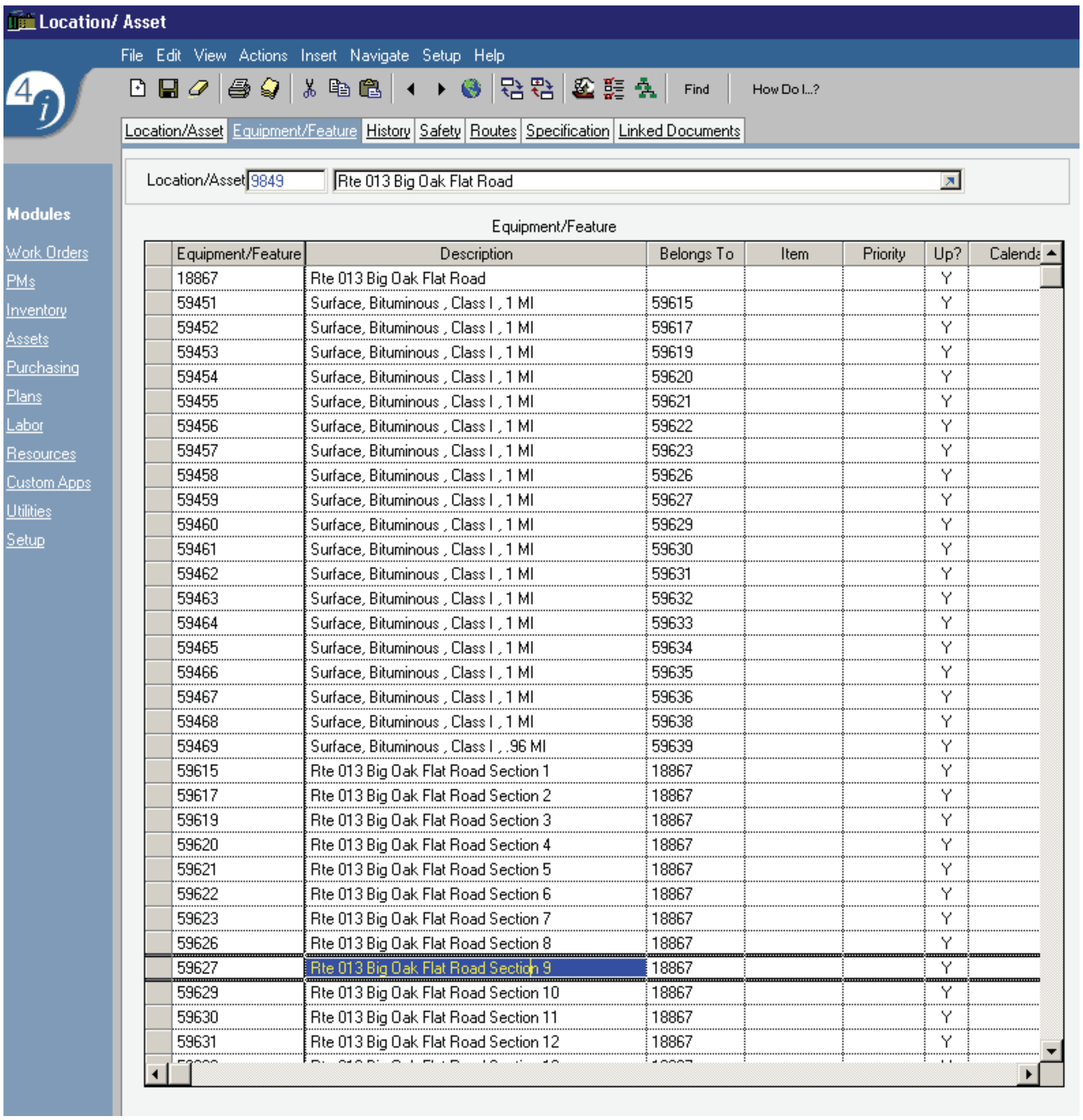


In FMSS, find the Asset to which this retaining wall resides. A query could be done on the route number, park alpha code and asset code. Load appropriate asset into the location/asset module.



Go to the Equipment/Feature tab and scan through the list to see if the retaining wall has already been created.

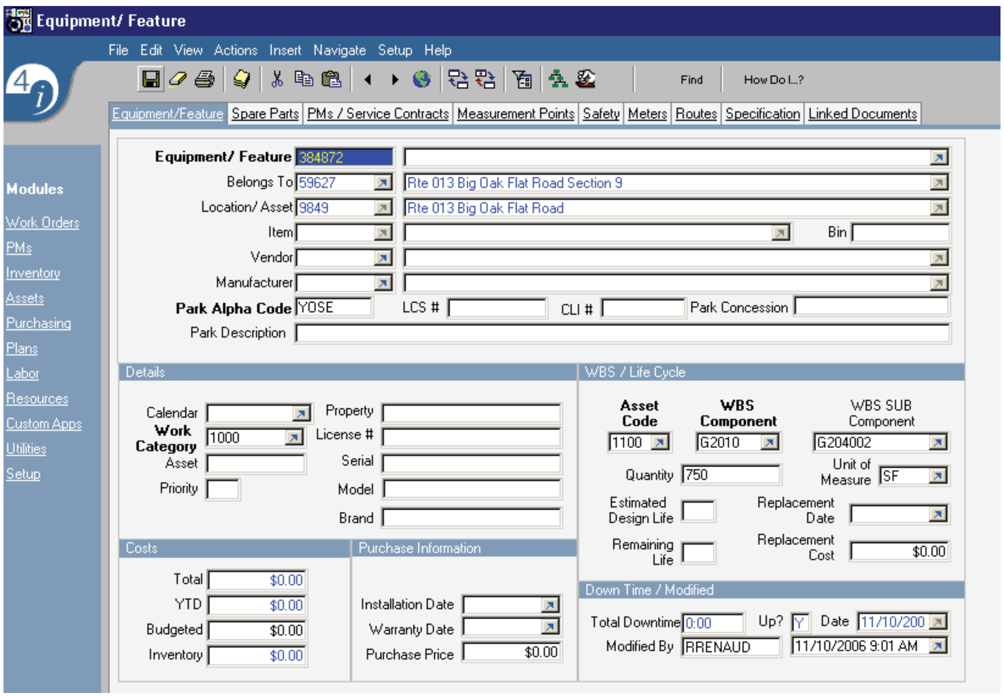
- If it has been created, indicate the Equipment/Feature number in the EQNO field on the WIP spreadsheet.
- If there is no Equipment/Feature, determine where in the equipment/feature hierarchy this new E/F belongs.
    - Note: In most cases, a RETAINING WALL parent E/F will be created for an asset and all retaining walls for that asset will belong to this parent E/F as child E/F's.
    - In this example, YOSE manages the road in sections as determined by E/F. In this case, the retaining wall will become a child of the particular section parent E/F and therefore the data person inputting the data will need to indicate the parent E/F number in order to create the child retaining wall.



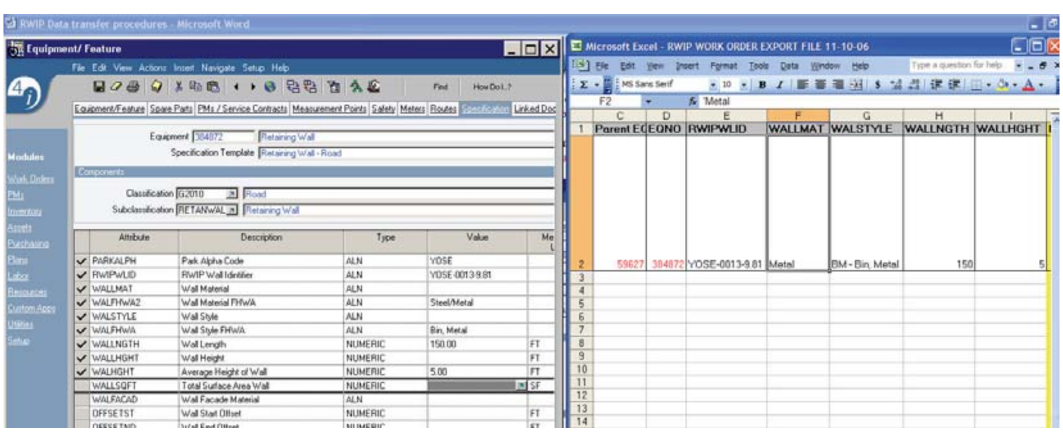
Equipment/Feature	Description	Belongs To	Item	Priority	Up?	Calenda
18867	Rte 013 Big Oak Flat Road				Y	
59451	Surface, Bituminous , Class I , 1 MI	59615			Y	
59452	Surface, Bituminous , Class I , 1 MI	59617			Y	
59453	Surface, Bituminous , Class I , 1 MI	59619			Y	
59454	Surface, Bituminous , Class I , 1 MI	59620			Y	
59455	Surface, Bituminous , Class I , 1 MI	59621			Y	
59456	Surface, Bituminous , Class I , 1 MI	59622			Y	
59457	Surface, Bituminous , Class I , 1 MI	59623			Y	
59458	Surface, Bituminous , Class I , 1 MI	59626			Y	
59459	Surface, Bituminous , Class I , 1 MI	59627			Y	
59460	Surface, Bituminous , Class I , 1 MI	59629			Y	
59461	Surface, Bituminous , Class I , 1 MI	59630			Y	
59462	Surface, Bituminous , Class I , 1 MI	59631			Y	
59463	Surface, Bituminous , Class I , 1 MI	59632			Y	
59464	Surface, Bituminous , Class I , 1 MI	59633			Y	
59465	Surface, Bituminous , Class I , 1 MI	59634			Y	
59466	Surface, Bituminous , Class I , 1 MI	59635			Y	
59467	Surface, Bituminous , Class I , 1 MI	59636			Y	
59468	Surface, Bituminous , Class I , 1 MI	59638			Y	
59469	Surface, Bituminous , Class I , .96 MI	59639			Y	
59615	Rte 013 Big Oak Flat Road Section 1	18867			Y	
59617	Rte 013 Big Oak Flat Road Section 2	18867			Y	
59619	Rte 013 Big Oak Flat Road Section 3	18867			Y	
59620	Rte 013 Big Oak Flat Road Section 4	18867			Y	
59621	Rte 013 Big Oak Flat Road Section 5	18867			Y	
59622	Rte 013 Big Oak Flat Road Section 6	18867			Y	
59623	Rte 013 Big Oak Flat Road Section 7	18867			Y	
59626	Rte 013 Big Oak Flat Road Section 8	18867			Y	
59627	Rte 013 Big Oak Flat Road Section 9	18867			Y	
59629	Rte 013 Big Oak Flat Road Section 10	18867			Y	
59630	Rte 013 Big Oak Flat Road Section 11	18867			Y	
59631	Rte 013 Big Oak Flat Road Section 12	18867			Y	

Creating the Retaining Wall Equipment/Feature: Go to the Equipment/Feature module.

- Select Insert, new equipment/feature by auto-number. Indicate this number on the WIP spreadsheet.
- In the “belongs to” field, type the parent equipment/feature number and tab. This will automatically populate the location/asset.
- Type in the park alpha code, the work category (1000) and the asset code (1100).
- From the drop list, select the WBS component (G2010 – Roads) and WBS sub-component (G204002 - Retaining Walls).
- Select the U/M of S.F. and input the quantity as indicated in the FACEAREA field on the RWIP spreadsheet and Save.

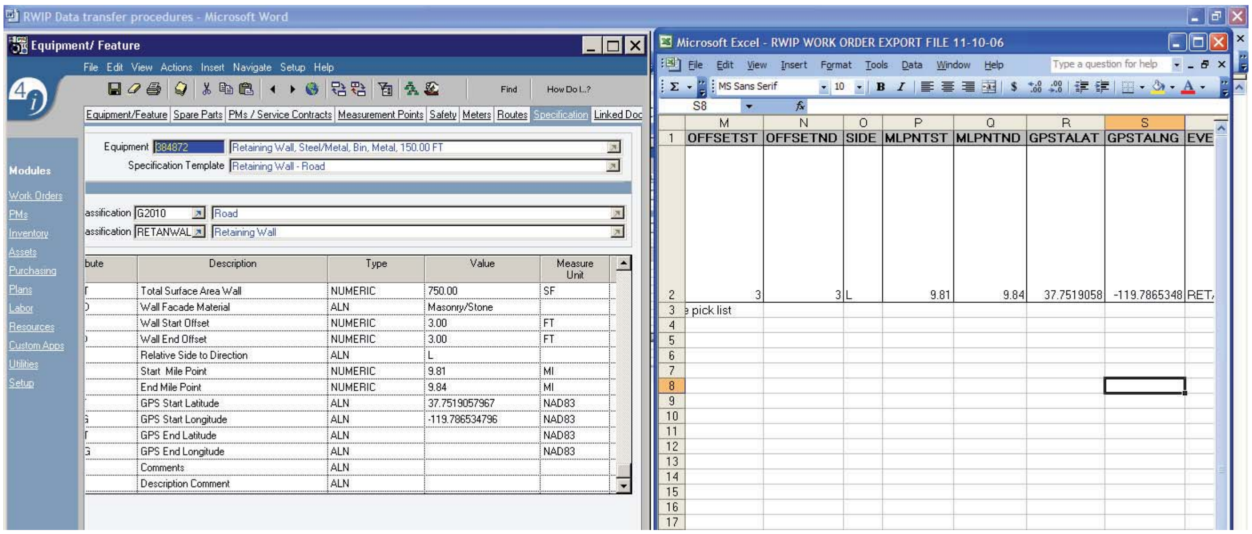


Filling out the Specification Template: Go to the Specification Tab.



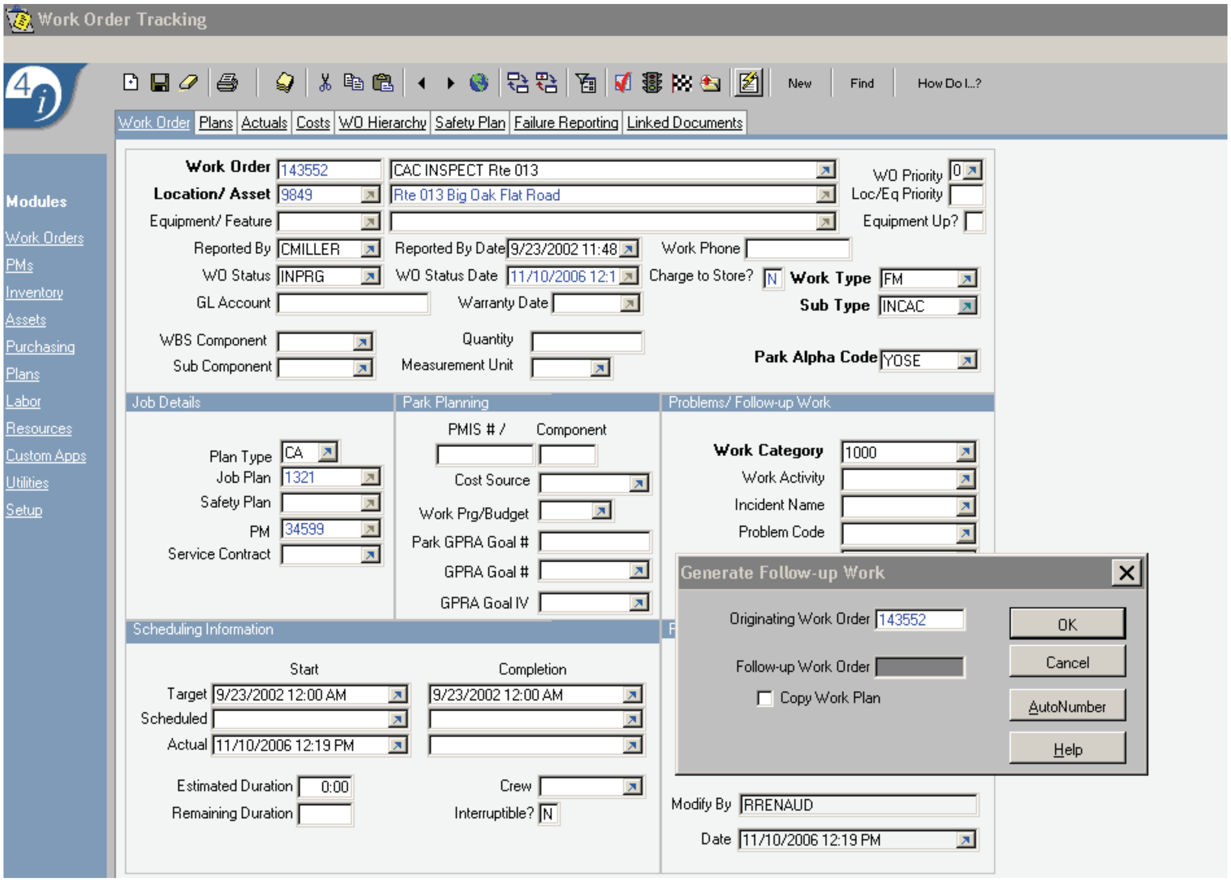
- In the classification field, select roads. In the sub-classification field, select retaining wall. This will attach the appropriate specification template to the E/F. [Note that the template shown here has not been loaded into FMSS Production as of 2-23-07.]
- Using the WIP spreadsheet, begin populating the value column for each matching field.
- Continue filling out the specification template. Save when complete.

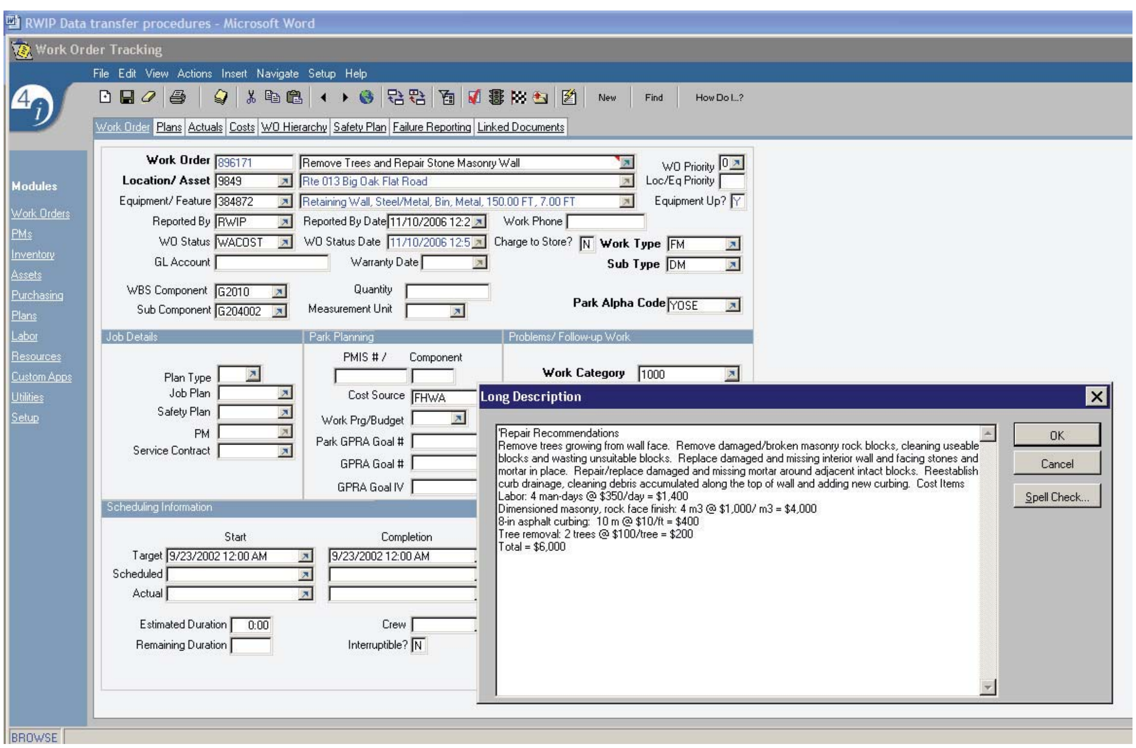
Note that the Equipment description is auto-populated with values fields from the specification. For example: Retaining Wall, Steel/Metal, Bin, Metal, 150.00 FT.



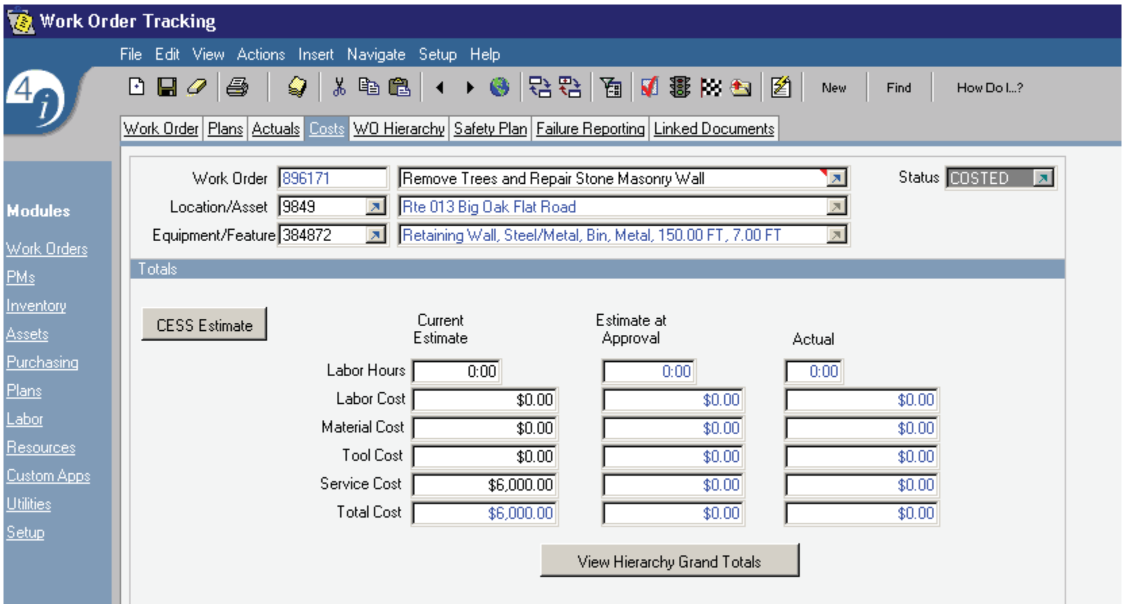
Creating the Work Order(s): Go to the work order tracking module.

- To be considered part of the condition assessment process, the repair work order should be created as a follow-up work order to an INCAC inspection work order. Create an INCAC work order from the PM module and then find the open INCAC work order in work order tracking (Query on Location/asset number and sub work type of IN%). Change the status of the INCAC work order to INPRG. Select the “generate follow-up work” icon, auto-number and OK.
- Change work order Description as stated in the work order field on the WIP spreadsheet.
- Cut and past the repair/replace recommendations from the WIP spreadsheet into the long description of the work order.
- Select the E/F pick button to find the Retaining wall E/F or type in the retaining wall E/F number. Tab to fill in E/F description, WBS Component and Sub Component.
- In the reported by field, type WIP.
- Change status to WACOST.
- Change to Sub Work Type to reflect the type of work described in the long description.
- Delete CA from the plan type.
- Select FHWA as the cost source.
- Save the work order.


Work Order Tracking
New
Find
How Do I...?
Work Order
Plans
Actuals
Costs
WO Hierarchy
Safety Plan
Failure Reporting
Linked Documents
Modules
Work Orders
PMs
Inventory
Assets
Purchasing
Plans
Labor
Resources
Custom Apps
Utilities
Setup
Work Order 143552 CAC INSPECT Rte 013
Location/ Asset 9849 Rte 013 Big Oak Flat Road
Equipment/ Feature
Reported By CMILLER
Reported By Date 9/23/2002 11:48
WO Status INPRG
WO Status Date 11/10/2006 12:1
GL Account
Warranty Date
WO Priority 0
Loc/Eq Priority
Equipment Up?
Work Phone
Charge to Store? N
Work Type FM
Sub Type INCAC
WBS Component
Sub Component
Quantity
Measurement Unit
Park Alpha Code YOSE
Job Details
Plan Type CA
Job Plan 1321
Safety Plan
PM 34599
Service Contract
Park Planning
PMIS # / Component
Cost Source
Work Prg/Budget
Park GPRA Goal #
GPRA Goal #
GPRA Goal IV
Problems/ Follow-up Work
Work Category 1000
Work Activity
Incident Name
Problem Code
Generate Follow-up Work
Originating Work Order 143552
Follow-up Work Order
Copy Work Plan
OK
Cancel
AutoNumber
Help
Scheduling Information
Start
Completion
Target 9/23/2002 12:00 AM
9/23/2002 12:00 AM
Scheduled
Actual 11/10/2006 12:19 PM
Estimated Duration 0:00
Remaining Duration
Crew
Interruptible? N
Modify By RRENAUD
Date 11/10/2006 12:19 PM


RWIP Data transfer procedures - Microsoft Word
Work Order Tracking
File Edit View Actions Insert Navigate Setup Help
New
Find
How Do I...?
Work Order
Plans
Actuals
Costs
WO Hierarchy
Safety Plan
Failure Reporting
Linked Documents
Modules
Work Orders
PMs
Inventory
Assets
Purchasing
Plans
Labor
Resources
Custom Apps
Utilities
Setup
Work Order 896171 Remove Trees and Repair Stone Masonry Wall
Location/ Asset 9849 Rte 013 Big Oak Flat Road
Equipment/ Feature 384872 Retaining Wall, Steel/Metal, Bin, Metal, 150.00 FT, 7.00 FT
Reported By RWIP
Reported By Date 11/10/2006 12:2
WO Status WACOST
WO Status Date 11/10/2006 12:5
GL Account
Warranty Date
WO Priority 0
Loc/Eq Priority
Equipment Up? Y
Work Phone
Charge to Store? N
Work Type FM
Sub Type DM
WBS Component G2010
Sub Component G204002
Quantity
Measurement Unit
Park Alpha Code YOSE
Job Details
Plan Type
Job Plan
Safety Plan
PM
Service Contract
Park Planning
PMIS # / Component
Cost Source FHWA
Work Prg/Budget
Park GPRA Goal #
GPRA Goal #
GPRA Goal IV
Problems/ Follow-up Work
Work Category 1000
Long Description
'Repair Recommendations
Remove trees growing from wall face. Remove damaged/broken masonry rock blocks, cleaning useable blocks and wasting unsuitable blocks. Replace damaged and missing interior wall and facing stones and mortar in place. Repair/replace damaged and missing mortar around adjacent intact blocks. Reestablish curb drainage, cleaning debris accumulated along the top of wall and adding new curbing. Cost Items
Labor: 4 man-days @ $350/day = $1,400
Dimensioned masonry, rock face finish: 4 m3 @ $1,000/ m3 = $4,000
8-in asphalt curbing: 10 m @ $10/ft = $400
Tree removal: 2 trees @ $100/tree = $200
Total = $6,000
OK
Cancel
Spell Check...
Scheduling Information
Start
Completion
Target 9/23/2002 12:00 AM
9/23/2002 12:00 AM
Scheduled
Actual
Estimated Duration 0:00
Remaining Duration
Crew
Interruptible? N
BROWSE

- Go to the Costs tab.
- In the Current Estimate Column, Service Cost field, type in the repair cost from the WIP spreadsheet.
- Change the status of the work order to COSTED and Save. For those who are proficient in FMSS, input the cost elements as shown in the long description for labor, materials and tools, on the Plans tab.



Continue/repeat in the same manner for other retaining walls or repair recommendations as indicated on the WIP spreadsheet. Return marked up spreadsheet to your FLHP coordinator after data input in complete. Note: If the Park determined that the work order should be a DM work order, verify that the cost was reflected in the deferred costs on the location/asset.

APPENDIX D – DATABASE DOCUMENTS

This appendix contains the WIP Database Users Manual:

- WIP Database Users Manual
    - Overview
    - Steps for Entering Wall Inspection Data
    - Steps for Editing Wall Inspection Data
    - Saving and Printing Data Reports
    - Assigning Wall ID Names to Photographs
    - Instructions for Downloading and Uploading the WIP Database

WIP Database Users Manual

Overview

Main Menu Selections
When the database opens, a Main Menu screen appears with four options:
1. Enter New Retaining Wall Data
2. Edit Existing Retaining Wall Data
3. Open Reports Menu
4. Exit the WIP Database

Entering New Retaining Wall Data
The application has three forms (screens) for entering field inspection data:
1. Wall function, dimensions, and description data entry
2. Wall element condition assessment data entry
3. Wall condition rating, action status, consequence of failure, repair/replace costs, work order description, and repair recommendations data entry.

Editing Retaining Wall Data
The application has three data input forms (screens) for editing data residing in the database that are identical to the forms for entering new field inspection data, with the exception that a function is provided on the first form to select a specific wall record to be edited.
1. Wall function, dimensions, and description data editing
2. Wall Element condition assessment rating data editing
3. Wall condition rating, action status, consequence of failure, repair/replace costs, brief work order description, and repair recommendations data editing.

Reports for Reviewing Data
The application provides users with a selection of prepared reports for reviewing and printing all the data entered on the forms. Users can also select from several prepared reports that contain summarized and aggregated wall inventory data.

Navigating Through the Fields on the Data Entry Forms
Navigating from one data field to another in any data entry form is best accomplished through using either the “Tab” or “Enter” keys on the computer keyboard. Using the mouse or touch pad to move between data fields is not recommended because certain database processes, such as updating a new record, are triggered by the using the “Tab” or “Enter” keys.

Locating a Park-Specific WIP Database
Park-specific WIP databases are placed on the CFLHD ftp site to which Federal Land Highway Division personnel have access. Users locate a specific database by opening the appropriate directory and folder on the ftp site, then selecting the database identified with the unique national park four character acronym in its name, e.g., YOSE WIP Database 1.0.mdb. Detailed directions for using the WIP database are provided in the following sections.

Open the WIP Database

Double click on the selected park-specific WIP database. The database "Main Menu" will open.

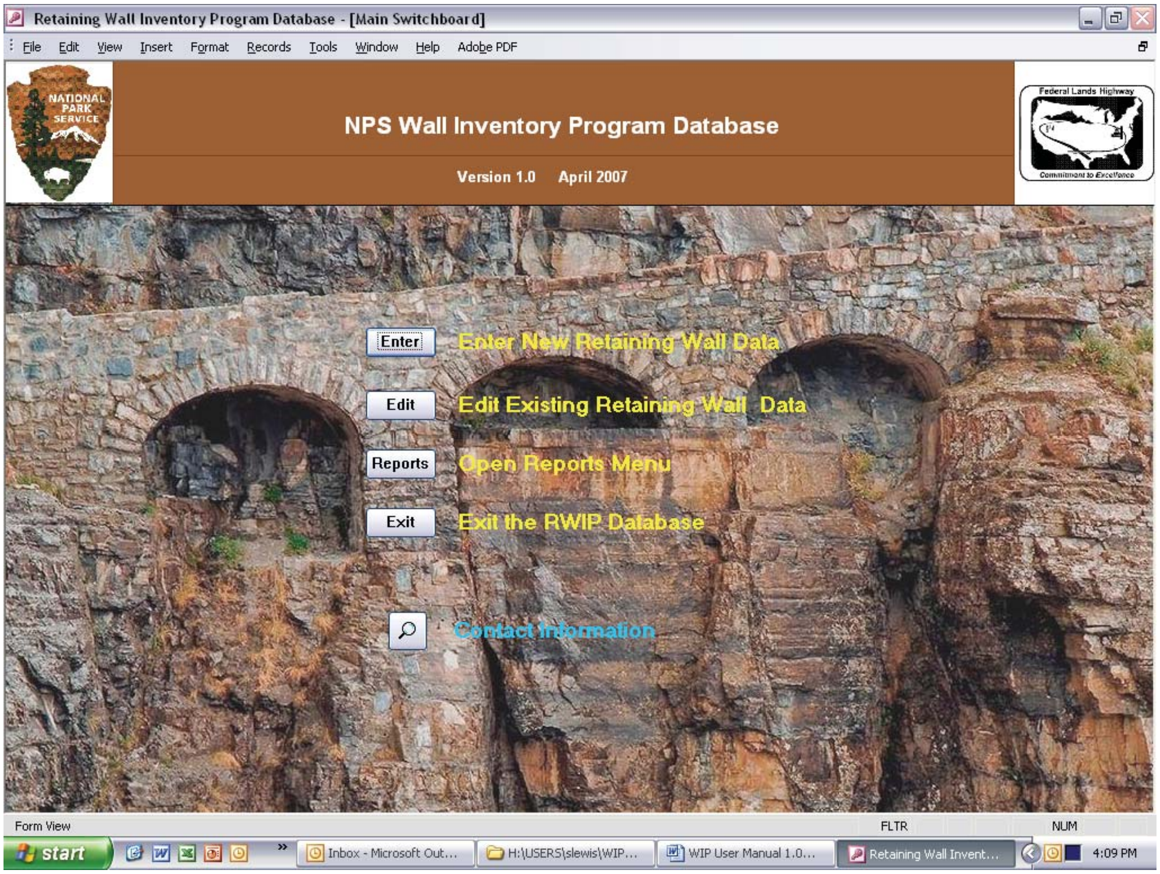


Figure D1. Example of the WIP Database Main Menu opening page.

From the Main Menu, options are provided to either enter new or edit existing retaining wall data. Both of these functions are described in detail in the following sections. In addition, a variety of reports may be viewed and printed from the "Open Reports Menu". Upon selecting a particular report from this menu, the toolbar options at the top of the print/preview screen can be used to view, print, and close reports.

Upon completion of data entry and/or report access, always click on "EXIT THE WIP DATABASE" to safely close the WIP database program.

Steps for Entering Wall Inspection Data

Step 1 - Wall Function, Dimensions, and Description
Click on the "Enter" button to open the first data entry form. The "Wall Function, Dimensions, and Description" data entry form will open, as shown in Figure D2.

Use either the "Tab" or "Enter" keys to navigate through the data fields to enter data. Delete incorrect data entries by putting the cursor in the appropriate data entry box and use the "Delete" key. Many of the data fields in this form have "pop-up" notes with additional information for inputting data. To see these notes, place the cursor in any data box and the "pop-up" will appear.

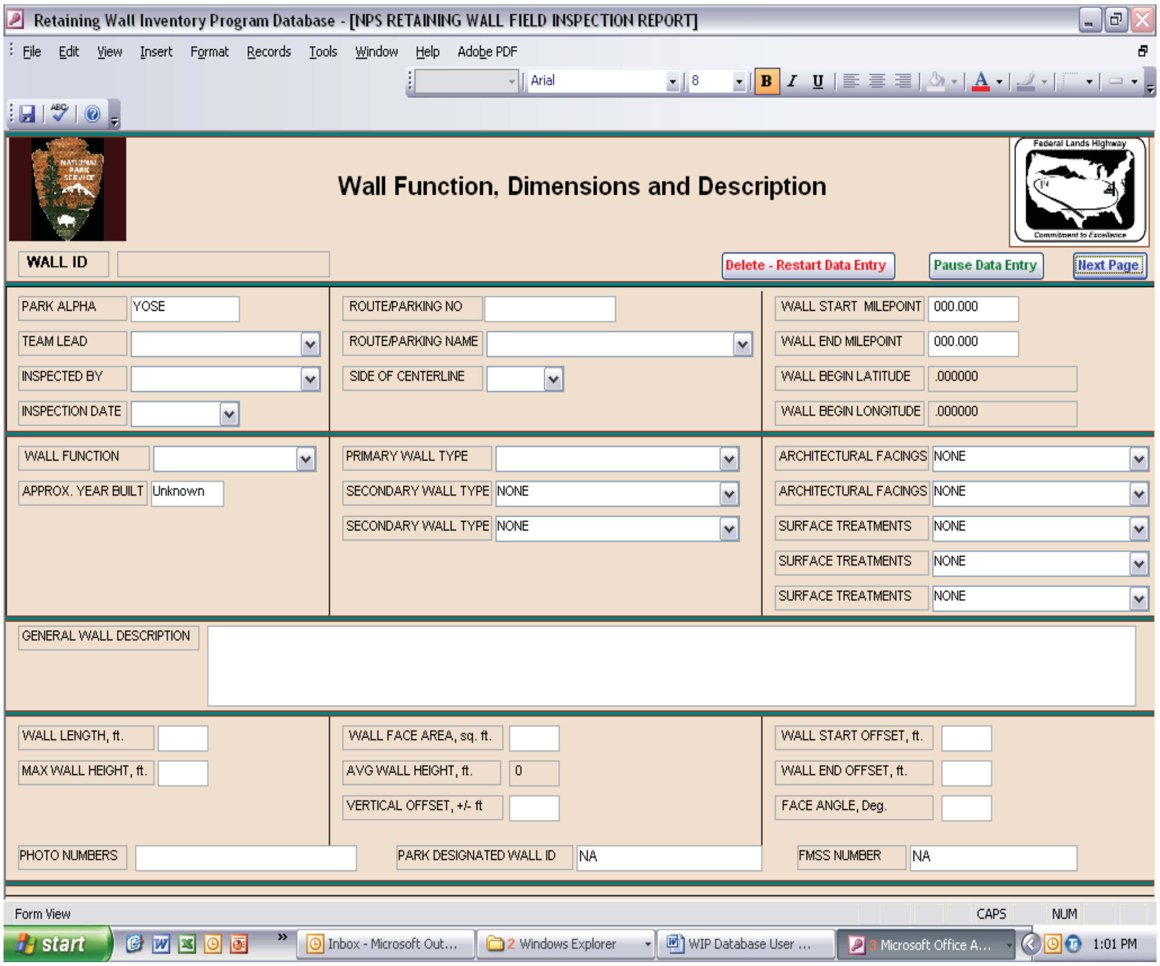


Figure D2. Example of the "Wall Function, Dimensions and Description" data input form in the selected Park database.

Several data fields are automatically populated as data are entered, including:

PARK NAME
WALL ID
WALL BEGIN LATITUDE
WALL BEGIN LONGITUDE
AVG. WALL HEIGHT

Drop down lists, accessed by clicking on the down arrow (▼), are also provided to simplify data entry for the following fields:

TEAM LEAD
INSPECTED BY
SIDE OF CENTERLINE
WALL FUNCTION
PRIMARY WALL TYPE
SECONDARY WALL TYPES
ARCHITECTURAL FACINGS
SURFACE TREATMENTS

To begin entering data, place the cursor in the "TEAM LEAD" box and select the appropriate name from the drop down list. If a name is not included on the list, type in the new name in the box. The application will add the new name to the database. Continue to enter data using the "Tab" or "Enter" button to navigate through the data fields in the proper sequence.

There are three command buttons located at the top right corner of the screen that provide additional functions during and after data entry. To delete all of the data entered for the given wall record and start over from the beginning click on "Delete - Restart Data Entry". To save entered data and return to finish data entry later, click on "Pause Data Entry". After data entry is complete on this first form, click on "Next Page" to move to the "Wall Element Condition Assessment" data entry form (shown in Figure D3).

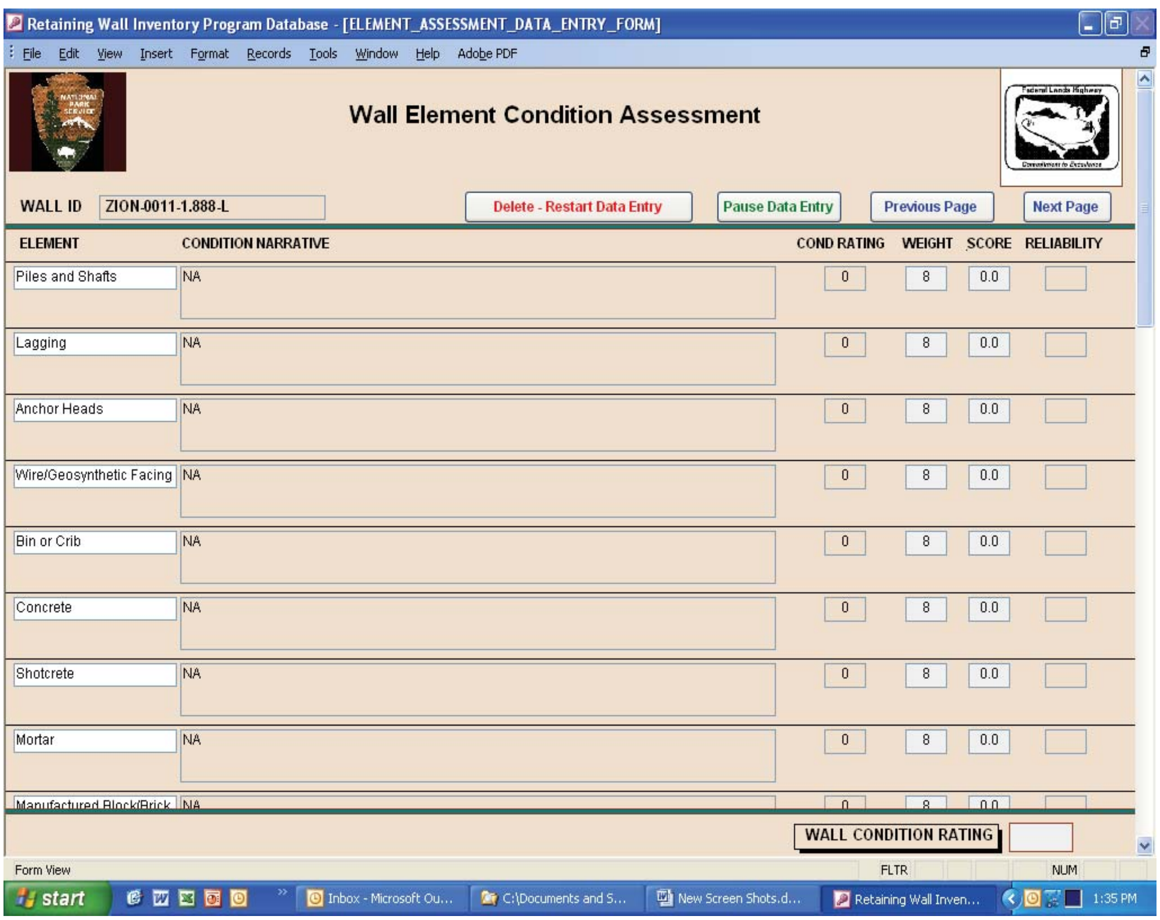


Figure D3. Example of the "Wall Element Condition Assessment" data input form in the selected Park database.

Step 2 - Wall Element Condition Assessment
Within the "Wall Element Condition Assessment" data entry form, select the appropriate "CONDITION NARRATIVE" box and type in the element condition narrative. Tab to the "COND RATING" box and enter the 1-10 element condition rating. Tab to the "RELIABILITY" box and enter the 1-3 data reliability rating. Repeat this data entry sequence for each Primary and Secondary wall element assessed, and for the overall wall performance. The "COND SCORE" is automatically calculated, and the application will keep a running total of the "WALL CONDITION RATING" value at the bottom of the screen as data are entered.

As with the previous data entry form, there are several command buttons located at the top right corner of the screen that provide additional functions during and after data entry. To delete all of the condition assessment data entered click on "Delete - Restart Data Entry". To save entered data and return to finish data entry later, click on "Pause Data Entry". To return to data entry on the prior "Wall Function, Dimensions and Description" data input form, click on "Previous Page". After data entry is complete on this second form, click on "Next Page" to move to the "Wall Repair/Replace Recommendations" data entry form (shown in Figure D4).

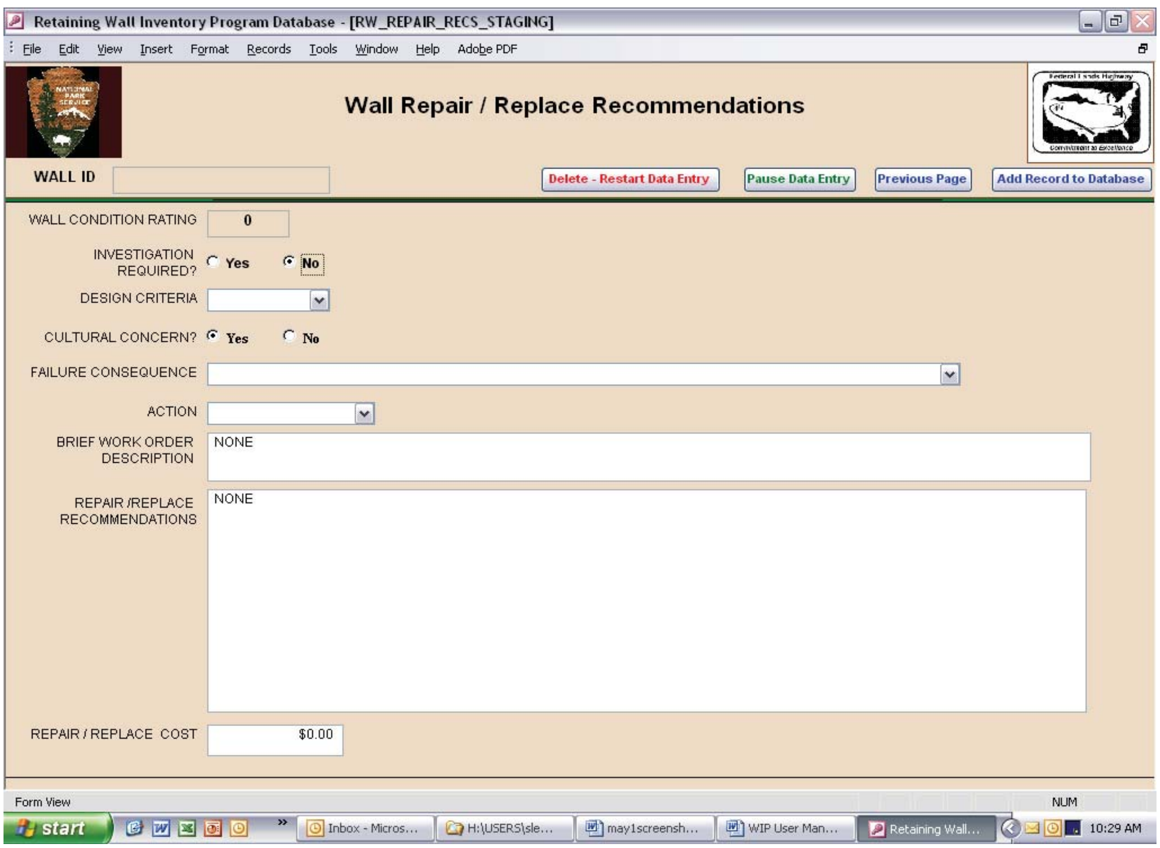


Figure D4. Example of the "Wall Repair/Replace Recommendations" data input form in the selected Park database.

Step 3 - Wall Repair/Replace Recommendations
To begin data entry within the “Wall Repair/Replace Recommendations” data input form, select the appropriate response in the “INVESTIGATION REQUIRED?” field (“No” is the default value). Next, using the drop down arrow, select the appropriate option in the “DESIGN CRITERIA” box (“None”, “Non-AASHTO”, “AASHTO”). Move to the “CULTURAL CONCERN?” field and select the appropriate response (“No” is the default value). Tab on to the “FAILURE CONSEQUENCE” and “ACTION” fields and select the appropriate response from the drop down lists.

Enter a very brief description of the work required, if any, in the “BRIEF WORK ORDER DESCRIPTION” box. The description is limited to no more than 125 characters. The default in this field is “None”.

If work is required, enter the detailed work order information in the “REPAIR/REPLACE RECOMMENDATIONS” box. This box will expand as needed to accommodate complete data entry. For this data field, use “Ctrl Enter” to start a new line; use “Enter” to exit the text box.

As with the previous data entry form, there are several command buttons located at the top right corner of the screen that provide additional functions during and after data entry. To delete all of the repair/replace data entered, click on “Delete - Restart Data Entry”. To save entered data and return to finish data entry later, click on “Pause Data Entry”. To return to data entry on the prior “Wall Element Condition Assessment” data input form, click on “Previous Page”. After data entry is complete on this third form, click on “Add Record to Database” to add the data to the database and return to the Main Menu.

NOTE: Clicking on the “Delete - Restart Data Entry” button on the first data entry form (“Wall Function, Dimensions and Description”) will result in the deletion of the entire data record. Clicking on this option on the subsequent two data entry forms (“Wall Element Condition Assessment” and “Wall Repair/Replace Recommendations”) will only delete data within those forms. For example, upon completion of data entry within the third “Wall Repair/Replace Recommendations” data form, the user may select the “Delete - Restart Data Entry” button to delete all data entries on this form. The user may also return to the previous condition assessment form, select “Delete - Restart Data Entry”, and delete just the data entered in this form. However, if the user returns to the first “Wall Function, Dimensions and Description” form and clicks on the “Delete - Restart Data Entry” button, all data entries on all three forms will be deleted, allowing the user to start over on the wall record.

Steps for Editing Wall Inspection Data

Step 1 – Edit Wall Function, Dimensions, Description
In the Main Menu, click on “Edit Existing Retaining Wall Data” to begin editing wall inspection data previously entered into the WIP database. The “Edit Wall Function, Dimensions, Description” data form will open, as shown in Figure D5.

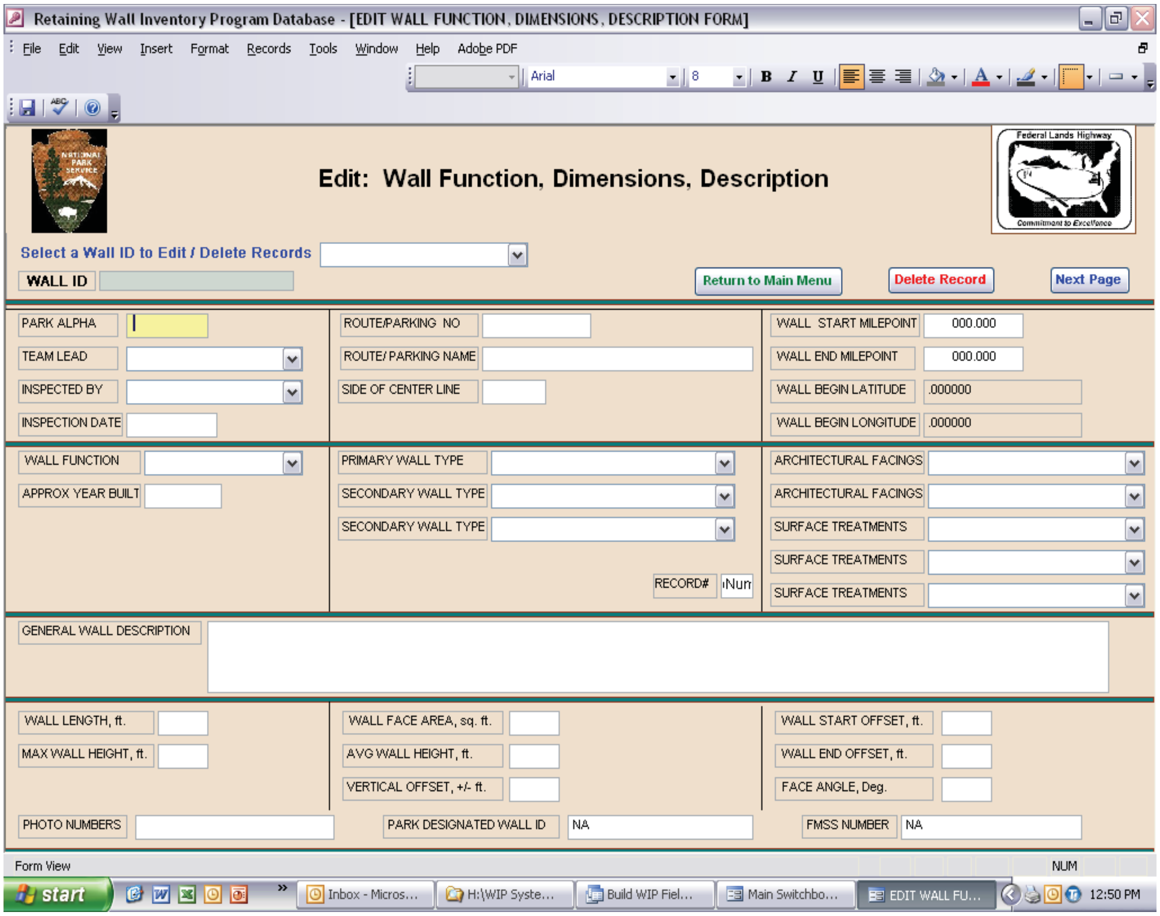


Figure D5. Example of the "Edit Wall Function, Dimensions, Description" data edit form.

Place the cursor in the "Select a Wall ID to Edit/Delete Records" box and select the Wall ID to be edited from the drop down list. The application will load the previously saved wall record for the selected Wall ID. To edit data in the selected record, place the cursor in any of the data fields to make the necessary changes. The application will automatically update the database as changes are made.

NOTE: When editing the "WALL MILEPOINT START" field, the "WALL BEGIN LATITUDE" and "WALL BEGIN LONGITUDE" fields must also be updated. To automatically update these fields, simply Tab into these fields. The "WALL ID" field will also update automatically.

Similar to the data entry form, there are several command buttons located at the top right corner of the screen that provide additional functions prior to, during and after data editing. At any time the user can opt to click on the "Return to Main Menu" button to immediately return to the Main Menu without saving the edits to the current record. To delete the selected record altogether from the database, simply click on "Delete Record". Upon completing data edits on the "Edit Wall Function, Dimensions, Description" data form, click on "Next Page" to move to the "Edit Element Condition Assessment Data" form (shown in Figure D6).

NOTE: Once deleted, a wall record cannot be restored.

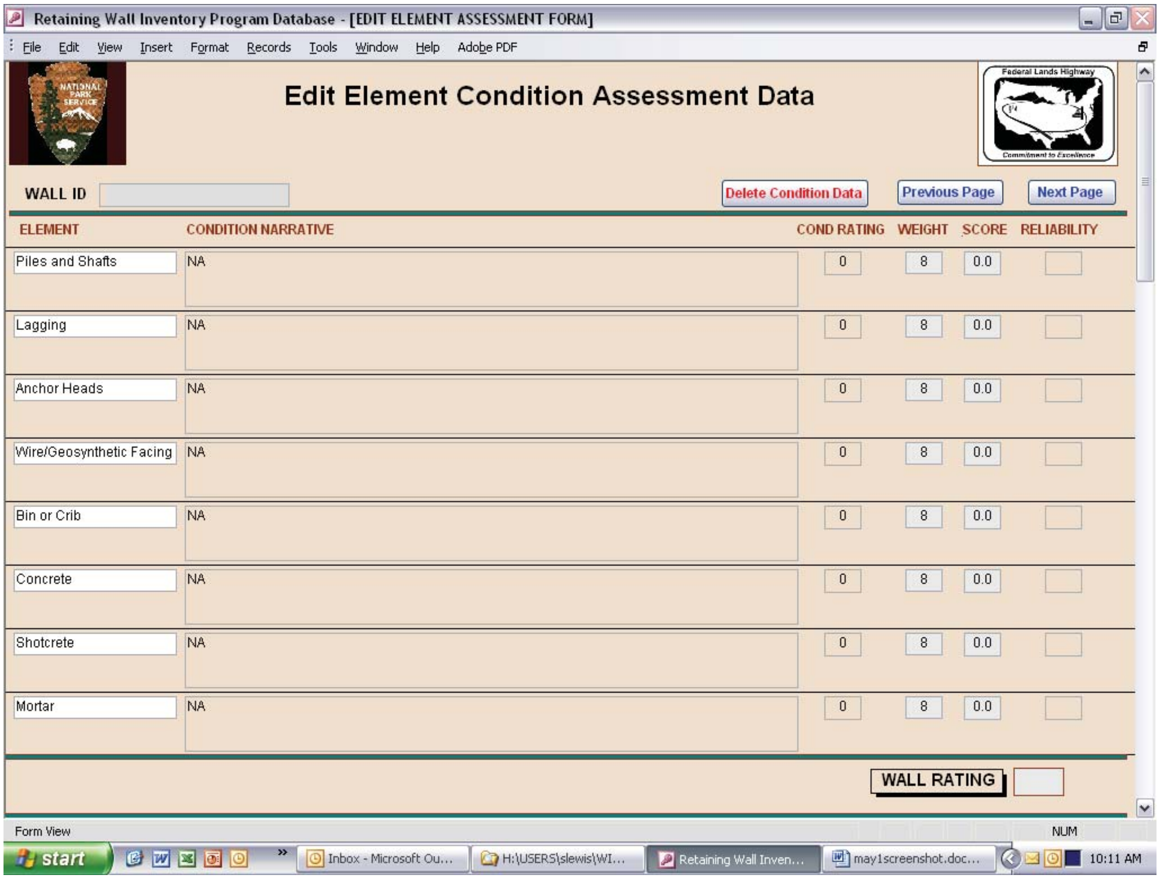


Figure D6. Example of the "Edit Element Condition Assessment Data" data edit form.

Step 2 - Edit Element Condition Assessment Data
Follow the exact same steps for editing element condition assessment data as for entering the original data. All calculated fields will automatically update as edits are made to element ratings.

Similar to the data entry form, there are several command buttons located at the top right corner of the screen that provide additional functions prior to, during and after data editing. Clicking on the "Delete Condition Data" button permanently deletes all of the data contained within the "Edit Element Condition Assessment Data" form, including condition narratives and related element ratings. This is a convenient option to use when substantial changes are required; however, simple edits can be made by simply clicking within a specific field. At any time the user can opt to return to the first page by clicking on the "Previous Page" button. Edits to the condition assessment form will be temporarily saved while in edit mode. Upon completing data edits on the "Edit Element Condition Assessment Data" data form, click on "Next Page" to move to the "Edit Repair Recommendations Data" form (shown in Figure D7).

NOTE: Returning to the previous page and then clicking on the "Return to Main Menu" button will return the user to the Main Menu without saving edits to the selected wall record.

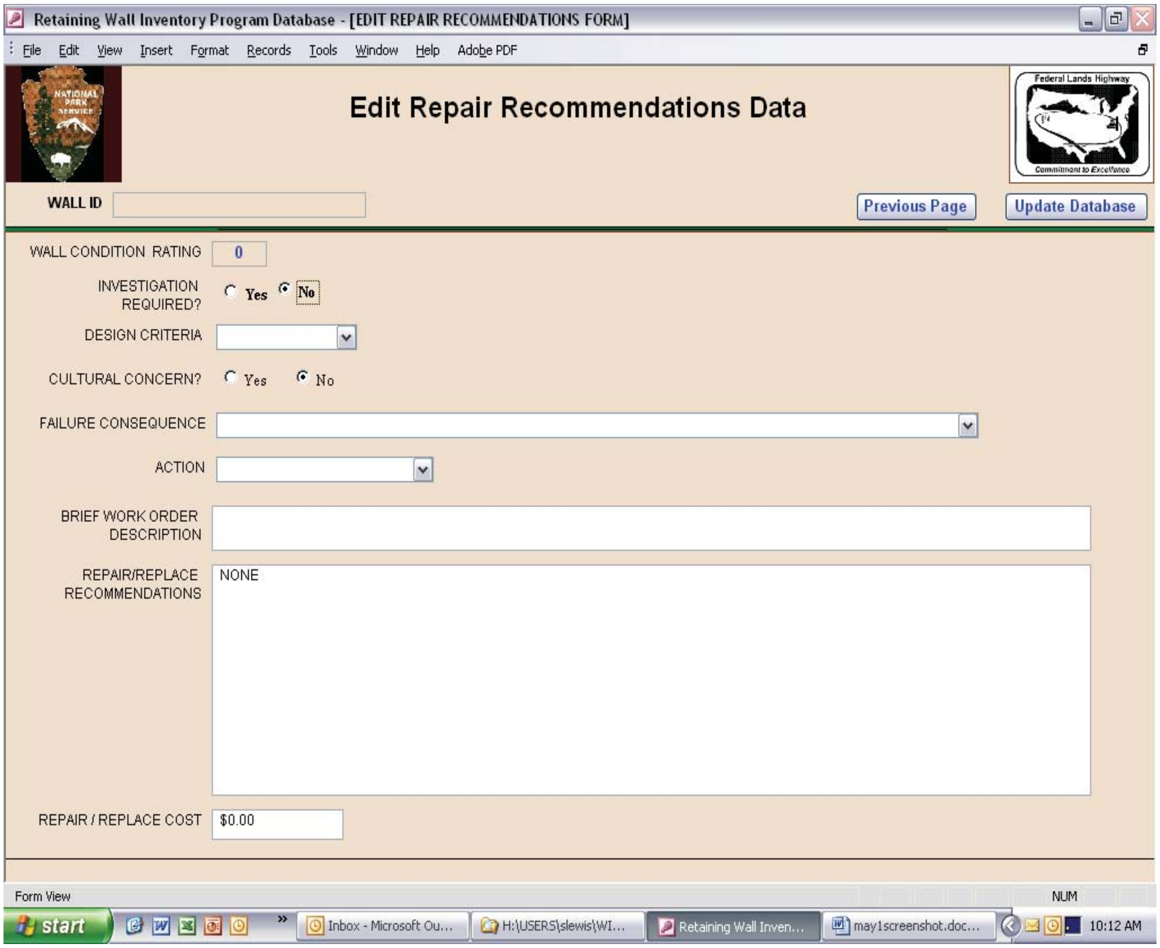


Figure D7. Example of the "Edit Repair Recommendations Data" data edit form.

Step 3 - Edit Repair Recommendations Data
Follow the exact same steps for editing wall repair/replace recommendations data as for entering the original data.

On this form, there are only two command buttons located at the top right corner of the screen that provide additional functions prior to, during and after data editing. At any time the user can opt to return to the condition assessment form by clicking on the "Previous Page" button. Edits to the repair recommendations form will be temporarily saved while in edit mode. Upon completing data edits on the "Edit Repair Recommendations Data" data form, click on "Update Database" to permanently save the updated record and be automatically taken back to the Main Menu.

At the Main Menu, the user may opt to continue to enter/edit wall data, view/print reports, or exit the database.

Saving and Printing Data Reports

At the Main Menu, click on the "Open Reports Menu" button and the "Report Menu" screen will be displayed (as shown in Figure D8).

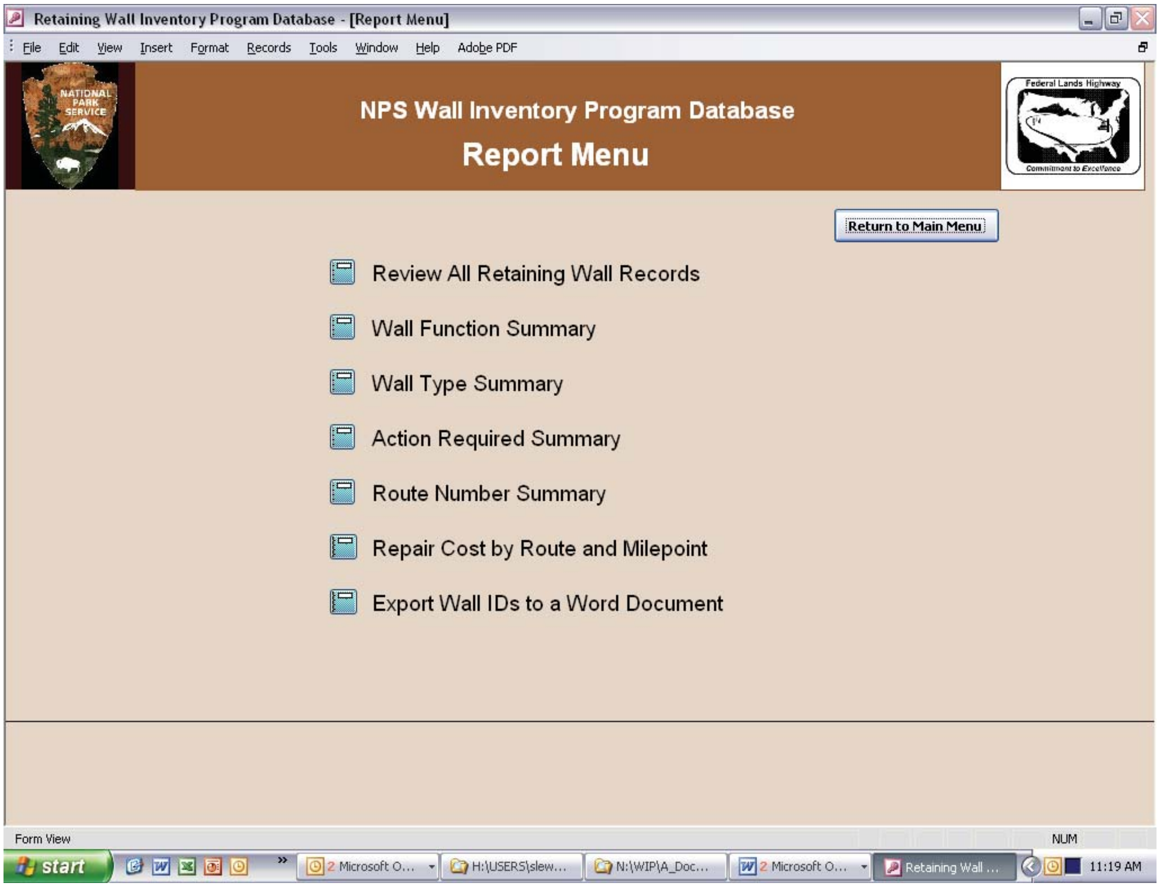


Figure D8. Example of typical canned reports available on the "Report Menu" screen.

To navigate to a particular canned report, click on the button next to the desired report title. A second screen will open displaying the selected report (example shown in Figure D9). Menu buttons/icons at the top of this screen provide the user such options as printing the report as it is displayed, viewing the report and closing the screen.

Data cannot be copied from the displayed report. However, the report can be easily converted to a Microsoft Word document from which data can be saved, copied and printed. In the toolbar menu, click on the Word icon to the right of the "Setup" button and select "Publish It with Microsoft Office Word". The report will be converted automatically into an .rtf text document in an MS Word screen where it can be saved, copied and/or printed. Save the report as a .doc Word document for future use.

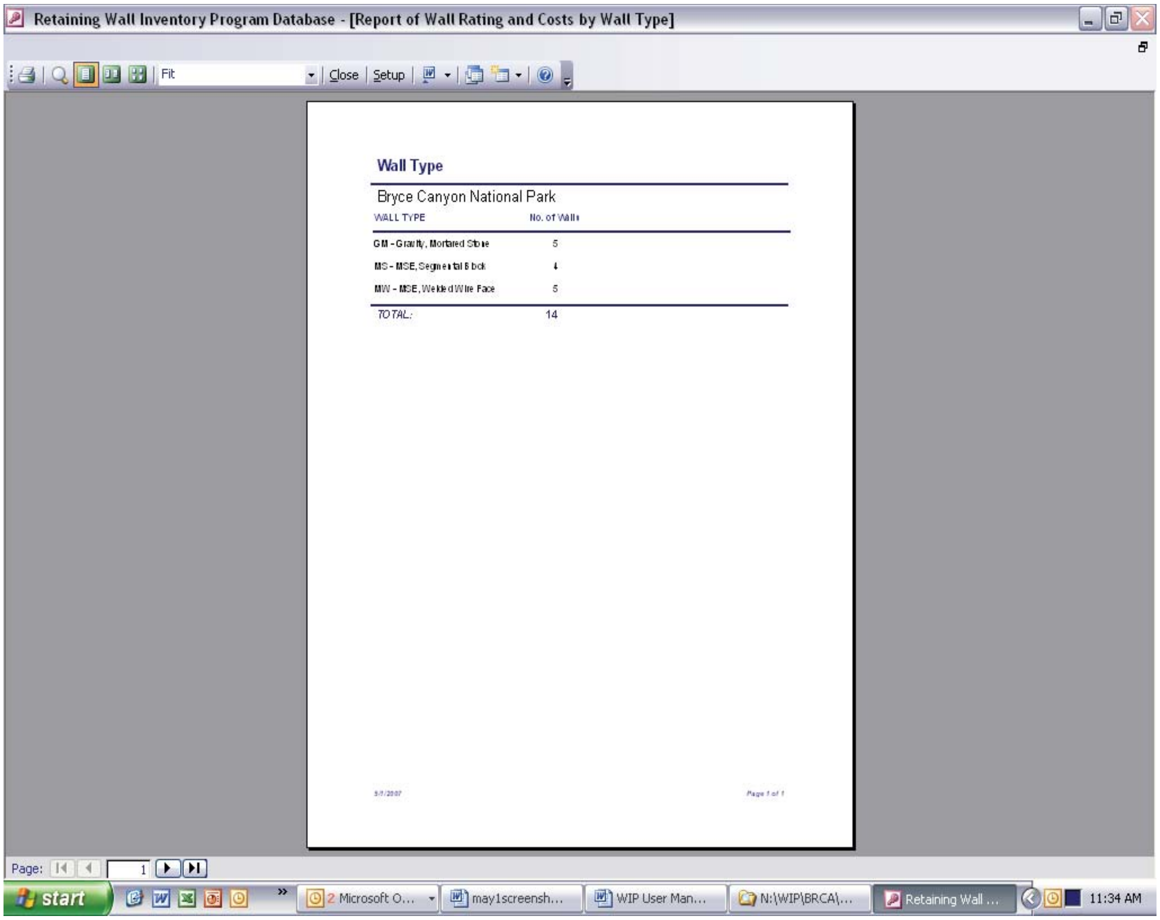


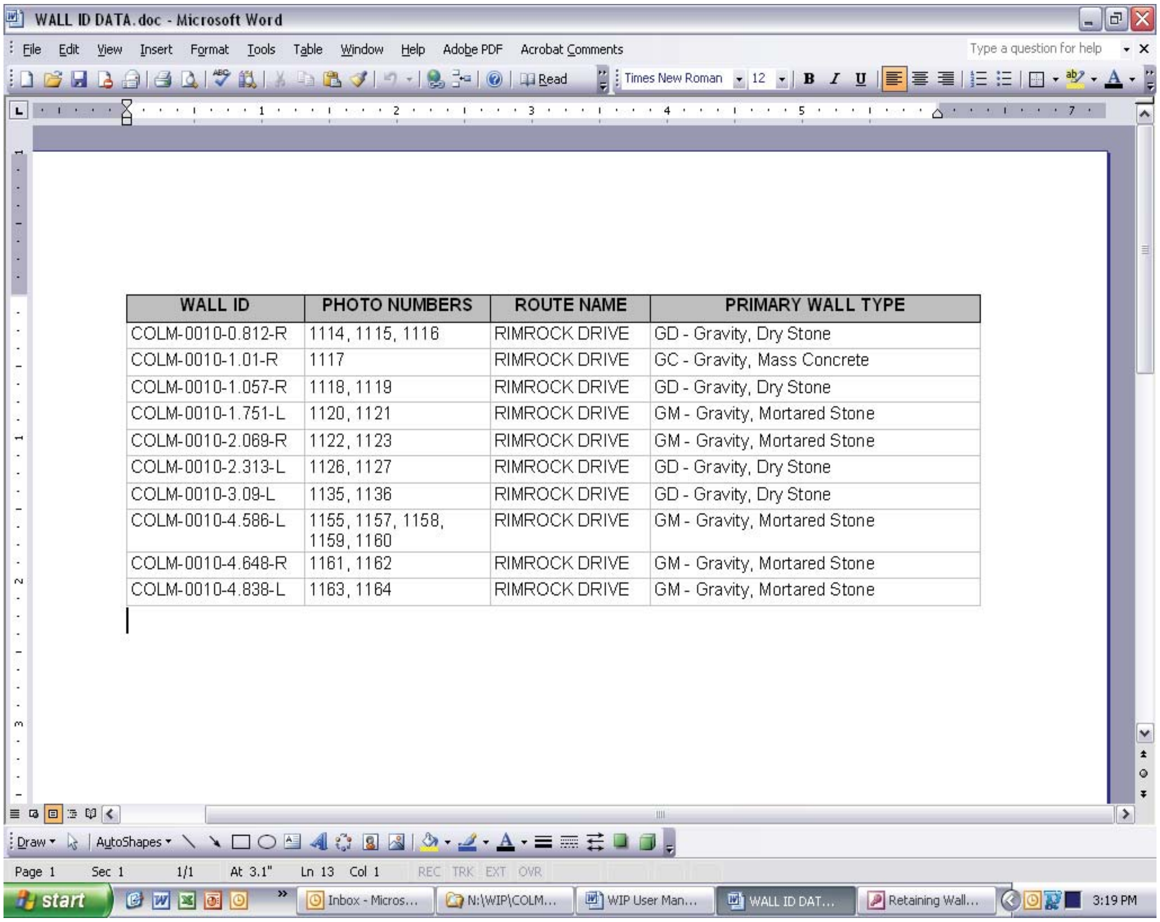
Figure D9. Example of report available in the WIP Database.

To return to the "Report Menu" database screen, click on the "Close" button in the toolbar. Continue to open, print and save reports from the Report Menu.

Assigning Wall ID Names to Photographs

Upon return from the field, wall photos are downloaded to the appropriate Park folder on the CFLHD WIP server. Once the field data is loaded to the WIP database and Wall IDs are assigned, the photos are renamed according to Wall ID. The photo naming convention is simply the Wall ID plus a sequential photo number for the wall, starting with "1". For example, the first photo of a wall in Bryce Canyon National Park with Wall ID BRCA-0010-6.202-L would be BRCA-0010-6.202-L-1.jpg.

To assist in renaming wall photos, click on the "Export Wall IDs to a Word Document" on the Report Menu screen. An MS Word document opens with a table of Wall IDs, Photo Numbers, Route Numbers, and Primary Wall Types, as shown in Figure D10. With this document open, copy a Wall ID name from the displayed table (use Ctrl C to copy). Navigate to the appropriate photo in the Park photo folder and paste the Wall ID (use Ctrl V to paste) over the existing photo name, adding a dash and the photo sequence number to the Wall ID as shown in the example above.



WALL ID	PHOTO NUMBERS	ROUTE NAME	PRIMARY WALL TYPE
COLM-0010-0.812-R	1114, 1115, 1116	RIMROCK DRIVE	GD - Gravity, Dry Stone
COLM-0010-1.01-R	1117	RIMROCK DRIVE	GC - Gravity, Mass Concrete
COLM-0010-1.057-R	1118, 1119	RIMROCK DRIVE	GD - Gravity, Dry Stone
COLM-0010-1.751-L	1120, 1121	RIMROCK DRIVE	GM - Gravity, Mortared Stone
COLM-0010-2.069-R	1122, 1123	RIMROCK DRIVE	GM - Gravity, Mortared Stone
COLM-0010-2.313-L	1126, 1127	RIMROCK DRIVE	GD - Gravity, Dry Stone
COLM-0010-3.09-L	1135, 1136	RIMROCK DRIVE	GD - Gravity, Dry Stone
COLM-0010-4.586-L	1155, 1157, 1158, 1159, 1160	RIMROCK DRIVE	GM - Gravity, Mortared Stone
COLM-0010-4.648-R	1161, 1162	RIMROCK DRIVE	GM - Gravity, Mortared Stone
COLM-0010-4.838-L	1163, 1164	RIMROCK DRIVE	GM - Gravity, Mortared Stone

Figure D10. Example of "Export Wall IDs to a Word Document" table accessed from the Report Menu.

Instructions for Downloading and Uploading the WIP Database

To download the WIP Park Database to a workstation computer:

1. Go to ftp://ftp.cflhd.gov.
2. Log in: User ID = cflhd; Password = fhwa-cflhd.
3. Open the GEOTECH folder.
4. Open the Retaining Wall Database System sub-folder.
5. Open the appropriate Park sub-folder.
6. Copy the entire Park Database sub-folder to the workstation computer, including the Park specific "WIP Field Database", "Mousehook.dll" file, and "Pre-Field Work Database to Change Settings.mdb" file.

7. At the workstation computer, open the downloaded Park Database folder, and then open the "Pre-Field Work Database to Change Settings.mdb" database. Follow the instructions for setting database options, and then close the database. The WIP Field Database is now ready for use.

To upload the completed WIP Park Database to the ftp site:

1. Go to ftp://ftp.cflhd.gov.
2. Log in: User Id = cflhd; Password = fhwa-cflhd.
3. Open to the GEOTECH folder.
4. Open the Retaining Wall Database System sub-folder.
5. Open the appropriate Park sub-folder.
6. Copy the completed WIP Field Database and the folder with retaining wall photos from the workstation computer to the Upload Database sub-folder.
7. Send the Database Administrator an email that the field database and photos have been uploaded to the ftp site.