Use of Technology for the Periodic Inspection of Flood Reduction Structures

Fort Worth District

Dam & Levee Safety Program

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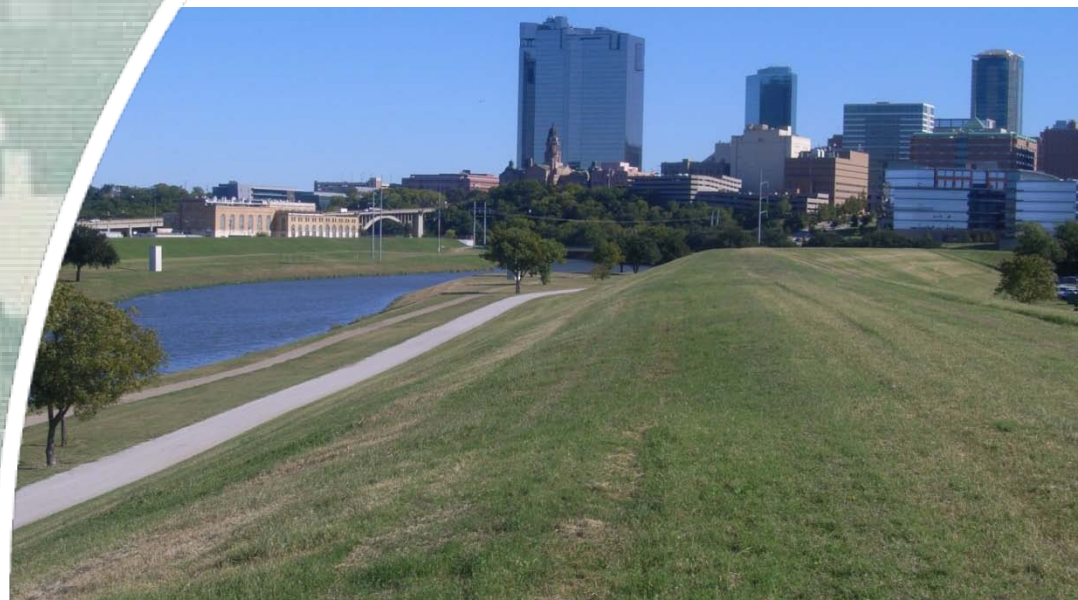
SAME Infrastructure Forum

1 December 2011



US Army Corps of Engineers

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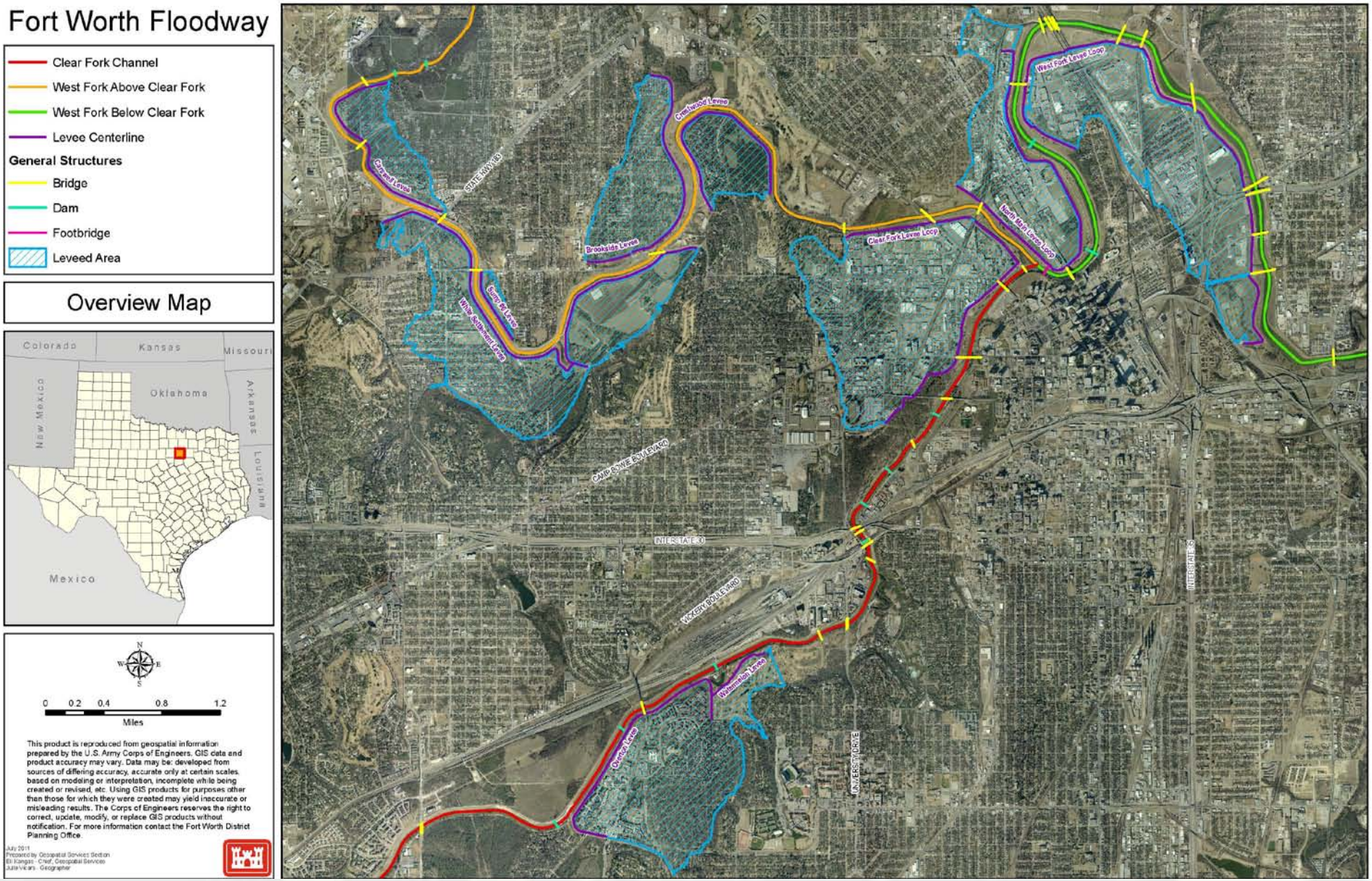
Overview of Discussion Topics

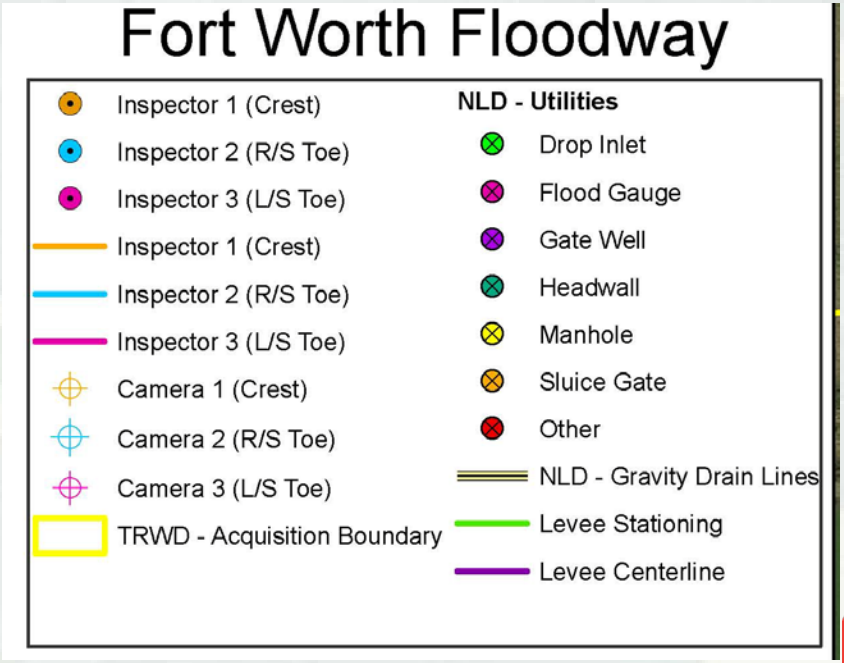
- **Inspection Data Management Technology**
  - Geographic Information System (GIS) Maps for Project Data
  - USACE Levee Inspection System (LIS) on Tablet PCs in Field
  - 100's of Items/Photos used to document the Project condition
  - GoogleEarth™ for compatibility and field use w/iPAD®
  - Video and Sonar Inspection Tools and Guidance
- **SWF Use of Technology for Civil Works Inspections**
  - 1st Introduced for Dallas Floodway PI#9 in 2009
  - Extensive use for Fort Worth Floodway PI#10 in 2011
  - Currently being used for Dam Inspections and Evaluations
- **Evaluation of Inspected Items and Corrective Actions**
  - Spreadsheet of rated items with remarks and location
  - Includes photo reference for documenting corrective actions
- **Geospatial Databases for Portfolio Risk Management**
  - National Levee Database (NLD)
  - National Inventory of Dams (NID)

Inspection Data Management Technology
GIS Maps to Identify/Document the Project Components



Inspection Data Management Technology
LIS Shapefile Data for Field Inspection and Use with NLD

- Tablet PCs are preloaded with Levee Baseline and Survey Data
- Shapefiles are generated from the LIS tool during the inspection
- Spatial information is linked to create Geodatabase of rated items
- This data is consistent with the format of the NLD
- This format is also consistent with most GIS platforms and data



Inspection Data Management Technology
Inspection Items are Rated per the National USACE Template

USACE Inspection Rated Items	Description of Rated Items
1. Unwanted Vegetation Growth	Unwanted vegetation includes overgrown grass and weeds that limit or prohibit proper inspection. This also includes woody growth along the system that may negatively impact the integrity of the system. Establishment of a 15 foot Vegetation Free Zone (VFZ) is required as defined in ETL 1110-2-571.
2. Sod Cover	Grass or sod cover is one of the most effective and economical means of protecting flood control levees and drainage swales against erosion caused by rain runoff, channel flows, and wave wash. Failure to properly maintain the grass cover can result in unnecessary erosion and possible embankment failure.
3. Encroachments	Encroachments include obstructions or inappropriate activities being conducted within the system's ROW and easement. Lack of appropriate easement to minimize impacts of adjacent activities on performance of the system, will also be considered. Encroachments shall reviewed by USACE in accordance with 33 USC § 408 and 33 CFR § 208.10 to determine the effect on the system.
4. Closure Structures (Stop Log, ECS)	Closure structures should be in proper condition with all required materials and equipment readily available. Installation instructions should be available and trial closures shall be conducted per the requirements of the O&M Manual. Records should be provided for the inspection.
5. Slope Stability	The stability of the levee embankment is critical with respect to the systems integrity during a flood event. Steep levee slopes are difficult to maintain and are susceptible to sloughs and slides.
6. Erosion/ Bank Caving	Erosion of Levee Embankments, Interior Drainage Features, Structures, and Channels should be monitored. Revetments and other improvements shall be made as necessary.
7. Settlement	The settlement of the system should be measured using a topographic crest survey, with datum per the requirements of EC 1110-2-6065.
8. Depressions/ Rutting	Ruts and depressions allow water to pond on the levee embankment, which can lead to seepage and stability problems for the system.
9. Cracking	Cracking due to desiccation and differential settlement should be kept minimal with no vertical movement.
10. Animal Control	Burrows created by animals (and insects) can lead to rapid levee failures during floods. For this reason, an active abatement program needs to be implemented to remove these rodents (and pests).
11. Culverts/ Discharge Pipes	All pipes and culverts within the levee template shall be inspected on a periodic basis to establish the condition of the utility. Reports shall be made available to USACE for review.
12. Riprap Revetments/Bank Protection	Riprap revetments should be in proper condition with minimal displacement, degradation, or unwanted vegetation.
13. Revetments other than Riprap	Other revetments, such as blankets and blocks, should be in proper condition with minimal displacement, degradation, or unwanted vegetation.
14. Underseepage Relief Wells/ Toe Drainage Systems	Relief wells and toe drains are used to relieve hydrostatic pressures in the foundation of a levee, caused by fluctuation in the water table or seepage under a levee or flood control structure during a flood. Maintenance of these features should be conducted per the requirements of the O&M Manual and records should be provided for the inspection.
15. Seepage	Seepage problems are critical with respect to the system's integrity during a flood event. Continuously saturated soils (not caused by ponded water or poor drainage) are an indication of seepage areas of concern. This is a rating of the history and/or evidence of seepage and does not fully evaluate potential seepage concerns.

Levee Embankments

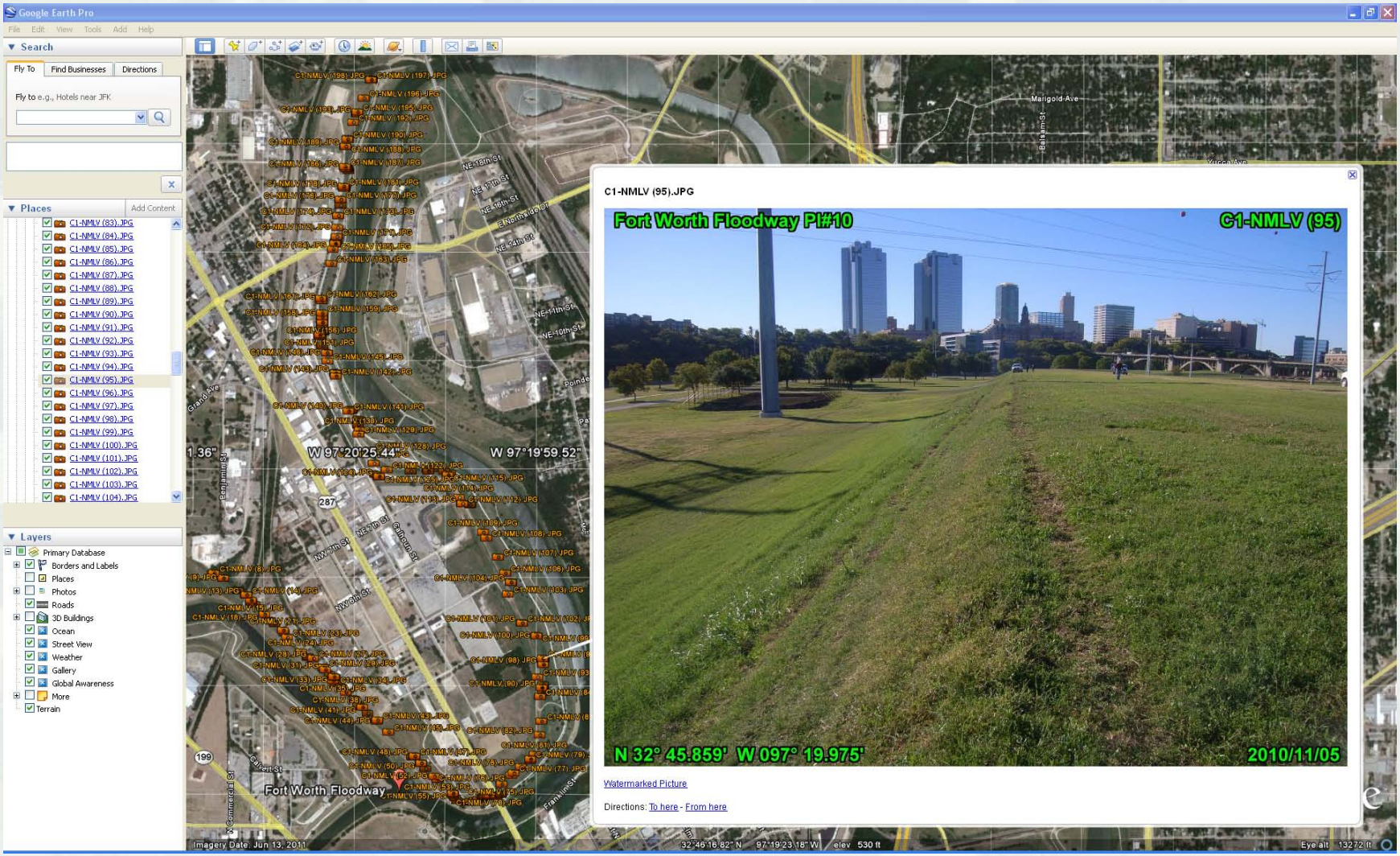
For use during Initial and Continuing Eligibility Inspections of levee segments / systems

Rated Item	Rating	Rating Guidelines	
1. Unwanted Vegetation Growth[1]	A	A	The levee has little or no unwanted vegetation (trees, bush, or undesirable weeds), except for vegetation that is properly contained and/or situated on overbuilt sections, such that the mandatory 3-foot root-free zone is preserved around the levee profile. The levee has been recently mowed. The vegetation-free zone extends 15 feet from both the landside and riverside toes of the levee to the centerline of the tree. If the levee access easement doesn't extend to the described limits, then the vegetation-free zone must be maintained to the easement limits. Reference EM 1110-2-301 or Corps policy for regional vegetation variance.
		M	Minimal vegetation growth (brush, weeds, or trees 2 inches in diameter or smaller) is present within the zones described above. This vegetation must be removed but does not currently threaten the operation or integrity of the levee.
		U	Significant vegetation growth (brush, weeds, or any trees greater than 2 inches in diameter) is present within the zones described above and must to be removed to reestablish or ascertain levee integrity.

- **Template includes typical deficiencies noted during field inspections**
- **Criteria is based on the condition that promotes *Acceptable* performance**

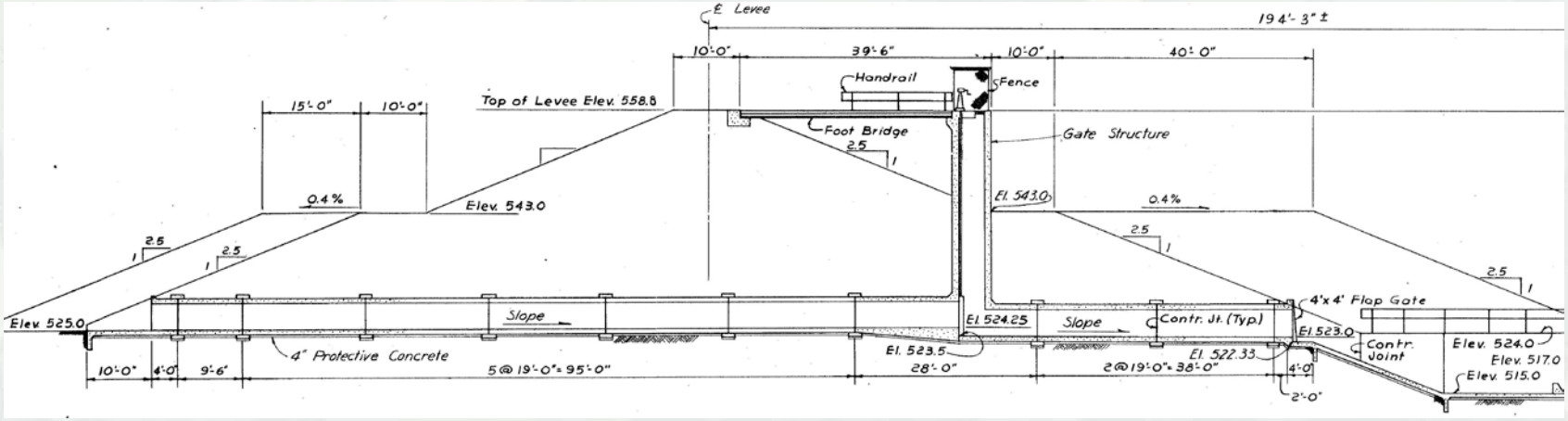
Inspection Data Management Technology
GPS Photos with Watermarks for Identifying Information

Inspection Data Management Technology
GoogleEarth Files with Linked Photos for Virtual Inspection



- **Inspection data as GoogleEarth files for compatibility**
  - ► **Can be used on PCs, MACs, PDAs and Smart Phone's**

Inspection Data Management Technology
Video Inspection of Penetrating Utilities to Record Condition



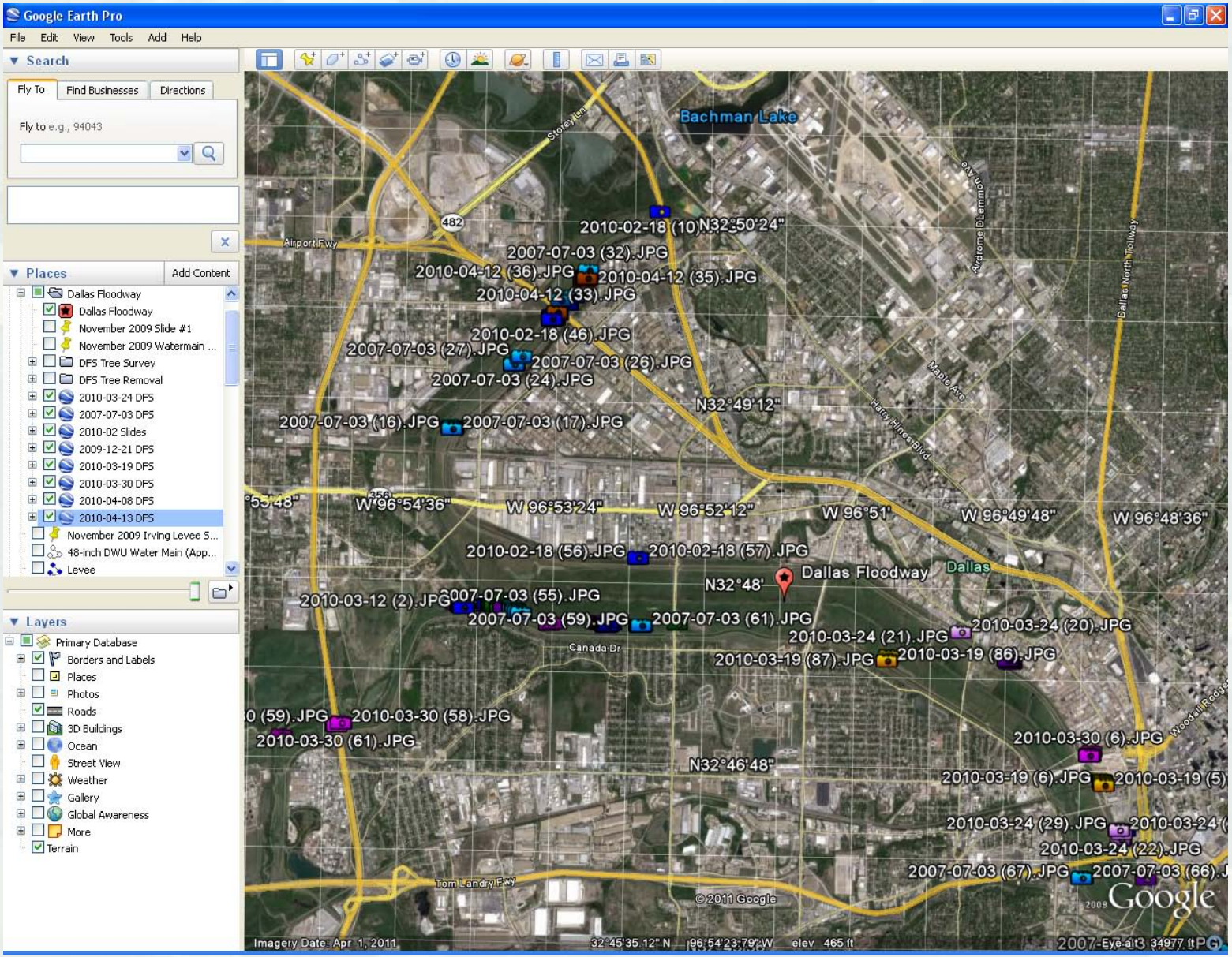
- Provides continuous documentation of pipe structure and defects
- NASSCO PACP Grading allows estimate of remaining service
- Sonar can be used for pressurized pipes or flowing culverts

Distance: 63.4 Ft. Grade: 5
Condition: HVV - Hole Void Visible
Remarks:

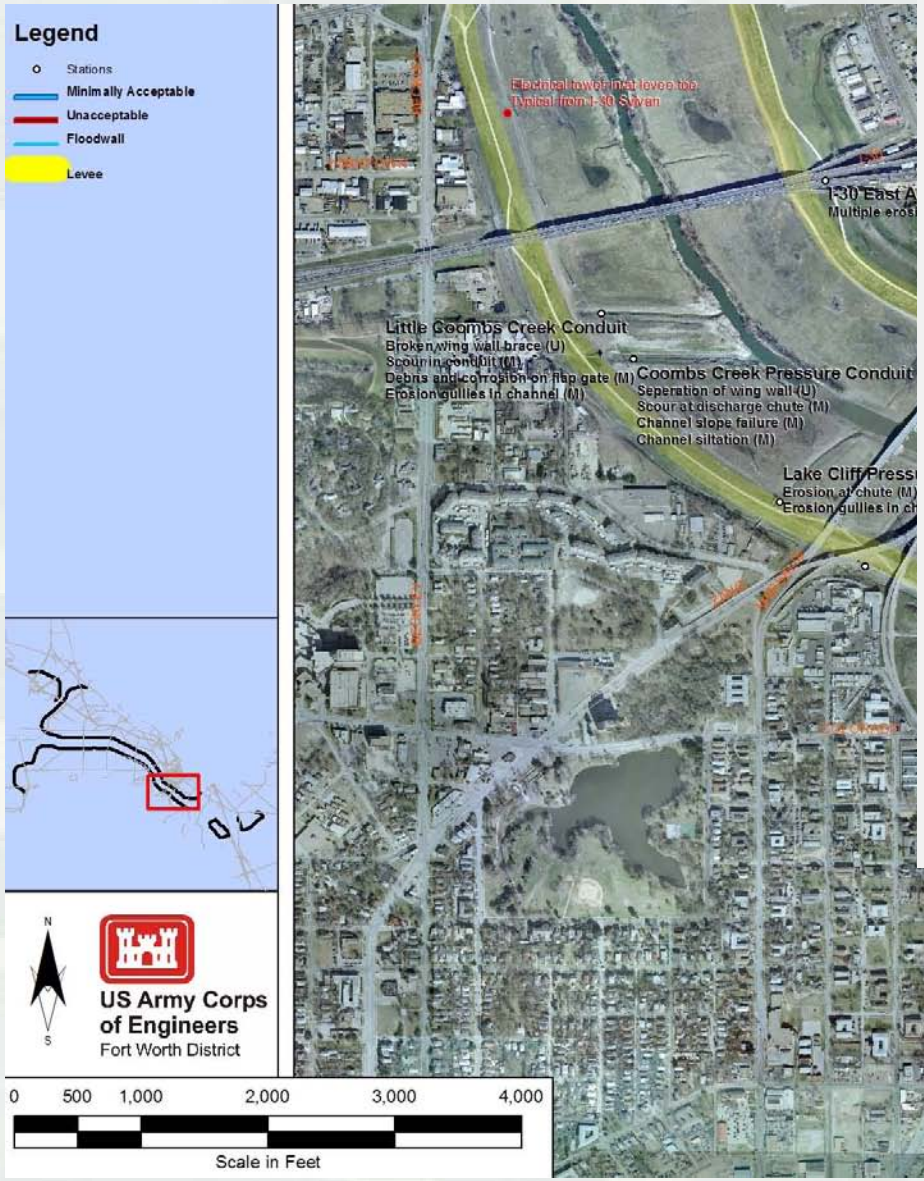
Distance: 67.8 Ft. Grade: 5
Condition: HVV - Hole Void Visible
Remarks:

Grade	Description	Estimated Time to Failure
1	EXCELLENT: Minor Defects.	Unlikely in the foreseeable future
2	GOOD: Defects that have not begun to deteriorate.	20 years or more
3	FAIR: Moderate defects that will continue to deteriorate.	10 to 20 years
4	POOR: Severe defects that will become grade 5 defects within the foreseeable future.	5 to 10 years
5	IMMEDIATE ATTENTION: Defects requiring immediate attention.	Has failed or will likely fail within the next 5 years

Virtual Inspection of SWF Civil Works Projects Beginning at the Dallas Floodway

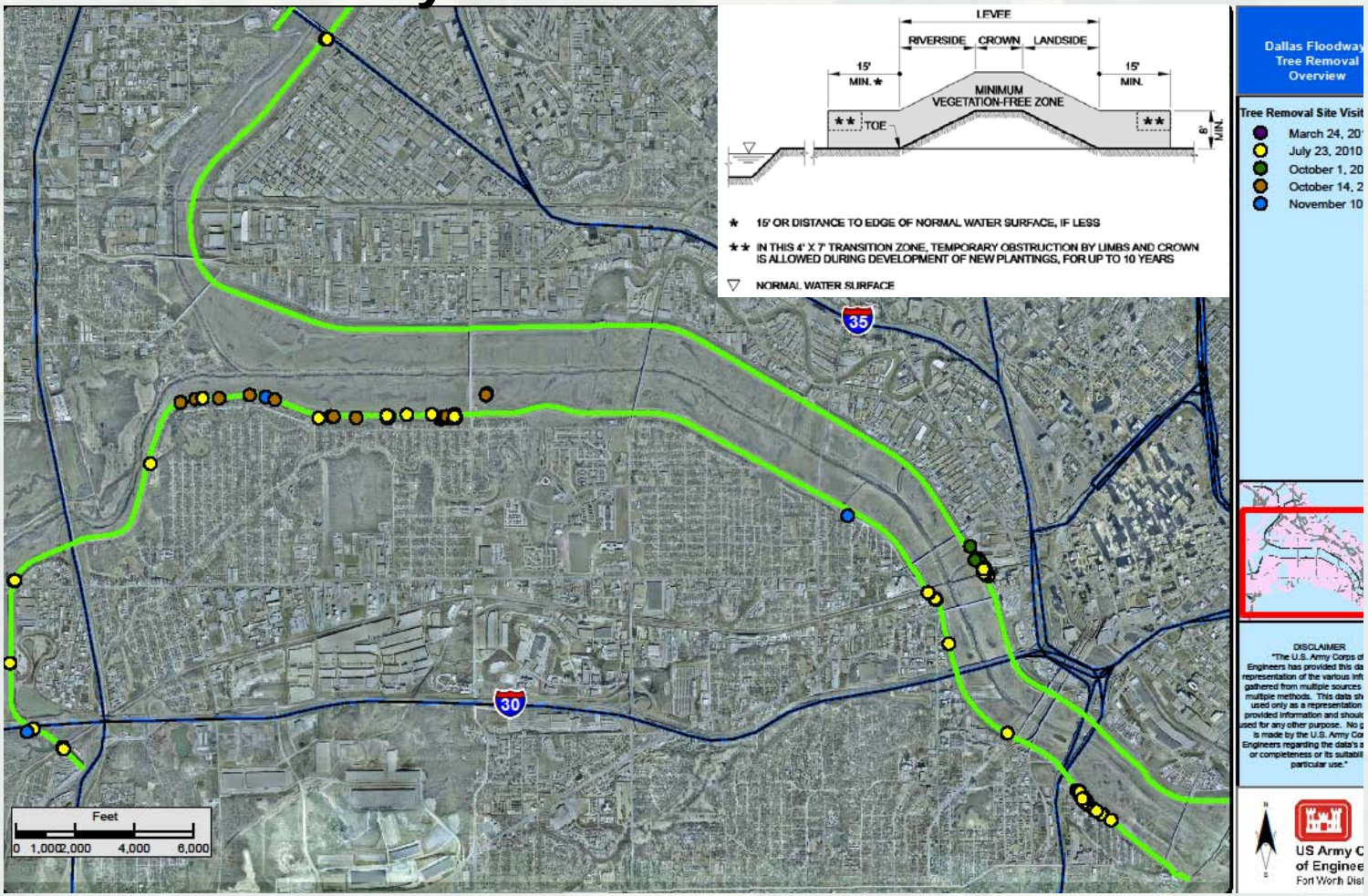


SWF Use of Technology for Civil Works Inspections
Dallas Floodway Periodic Inspection and Corrective Actions



- **Dallas Floodway PI #9**
  - 4 Levee Systems
  - 26 Miles of Levee
    - Including FDR Channel
  - 10 Interior Drainage Systems
    - Including Pump Stations
  - 231 Deficiencies Identified
- **CoD Maintenance Deficiency Correction Plan (MDCP)**
  - 198 items to be corrected as O&M Program responsibilities
  - 193 deficiencies corrected and documented to date

SWF Use of Technology for Civil Works Inspections
Dallas Floodway PI#9 & MDCP – Tree Removal Plan

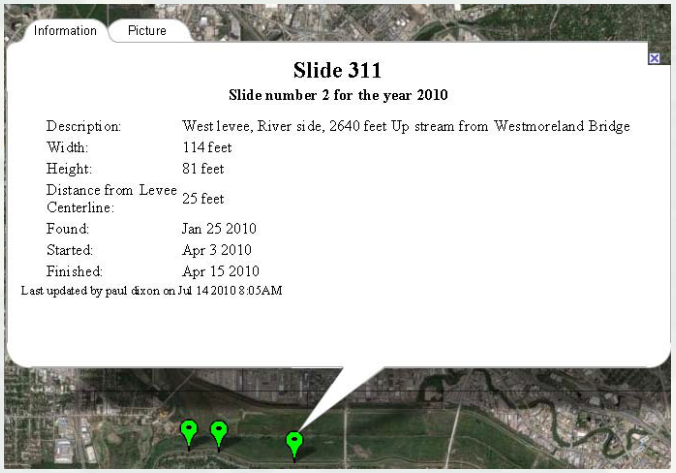


- Used to Track Tree Removal Plan per ETL 1110-2-571
  - ► 15 foot minimum Vegetation Free Zone (VFZ) from Levee Toe
- Geographic data can be used for monitoring during flooding

SWF Use of Technology for Civil Works Inspections
Dallas Floodway PI#9 & MDCP – Tree Removal Plan

SWF Use of Technology for Civil Works Inspections
Dallas Floodway PI#9 & MDCP – Tree Removal Plan

SWF Use of Technology for Civil Works Inspections
Dallas Floodway PI#9 & MDCP – CoD Slide Database

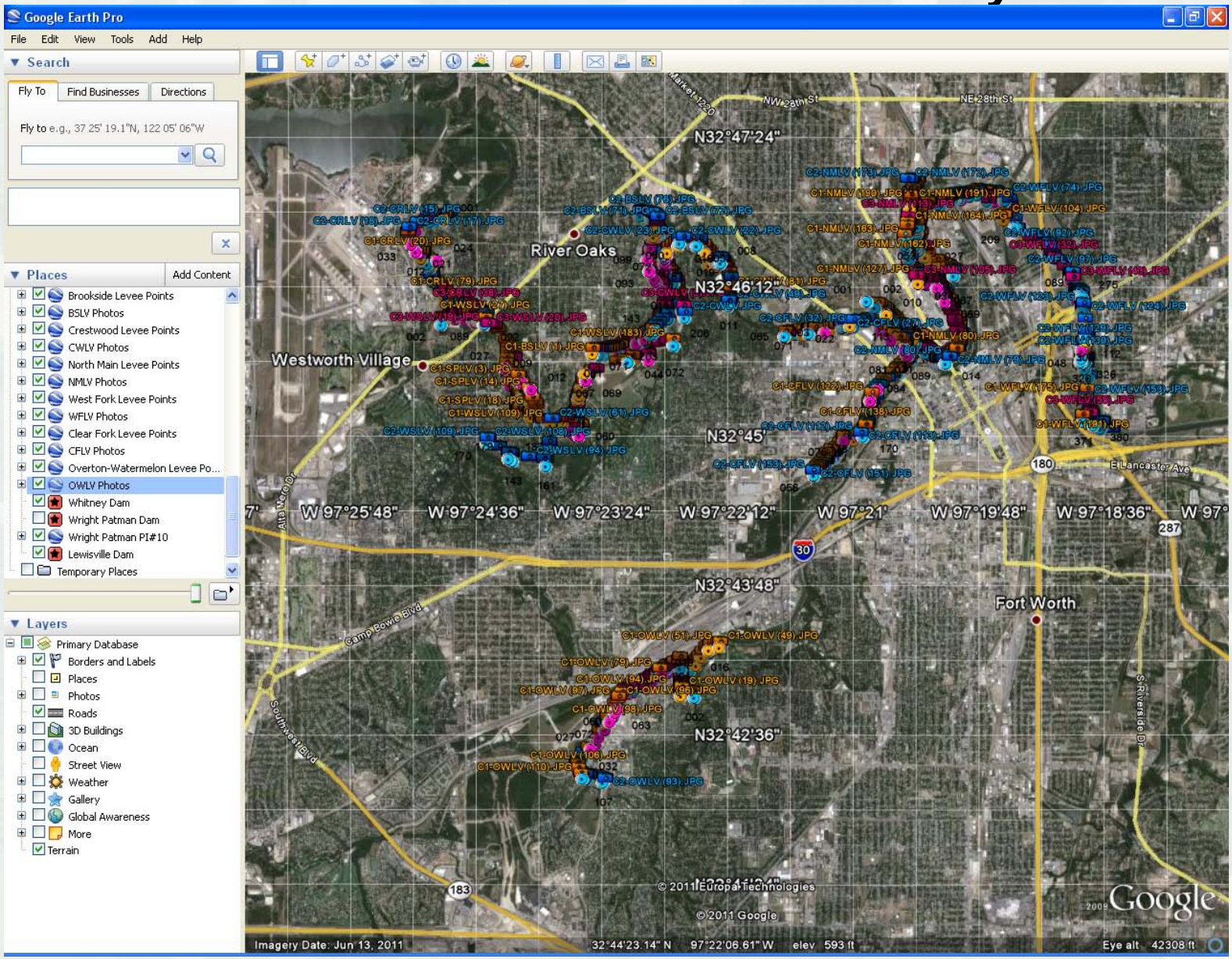


- Graphic courtesy of the Dallas slide database at http://fc.dallascityhall.com/maps/slides.html, current as of 15 April 2010.
- This database includes a description of the slide with location and photos

SWF Use of Technology for Civil Works Inspections
Dallas Floodway PI#9 & MDCP – Slide Repairs/Tracking

SWF Use of Technology for Civil Works Inspections
Dallas Floodway PI#9 & MDCP – Slide Repairs/Tracking

Virtual Inspection of SWF Civil Works Projects Now to the Fort Worth Floodway



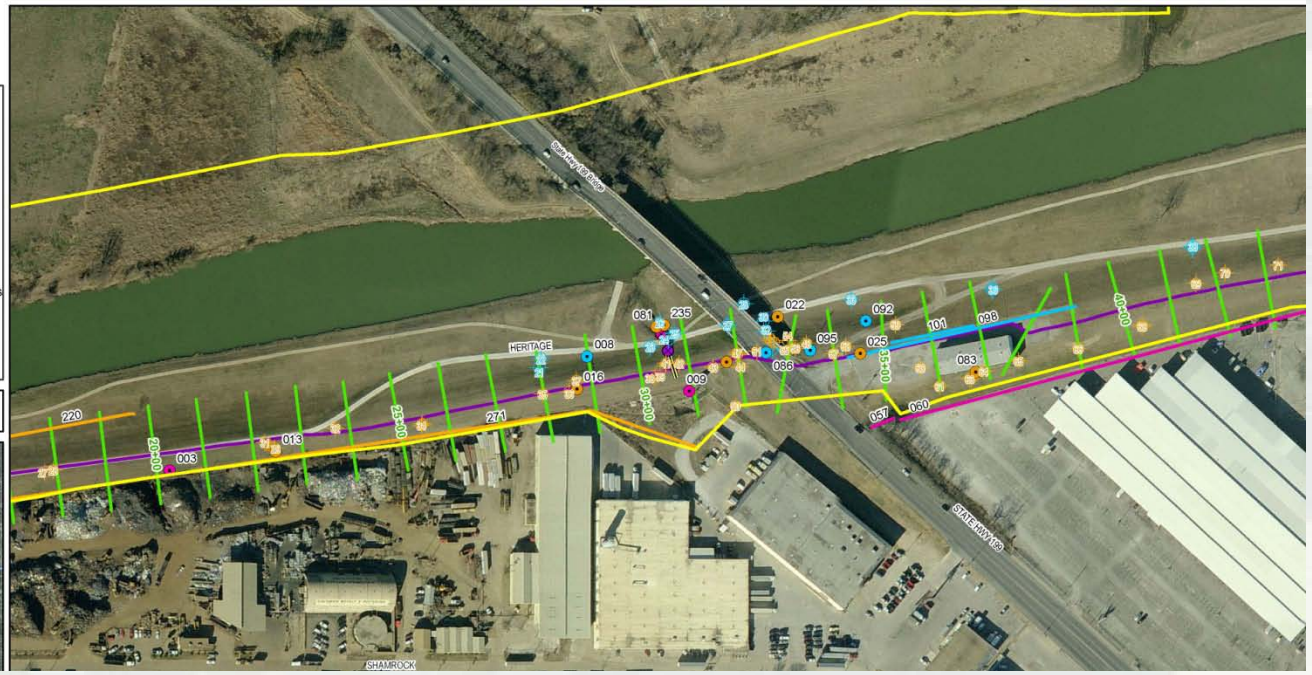
SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway Periodic Inspection and Corrections

- Fort Worth Floodway PI#10
  - ~ 22 Miles of Levee
  - ~ 600 Foot of Floodwall
  - > 30 Miles of FDR Channel
  - > 800 Inspection Points
  - > 3,200 Inspection Photos
- > 165 Corrective Actions Complete

Clear Fork Levee Loop
Fort Worth Floodway

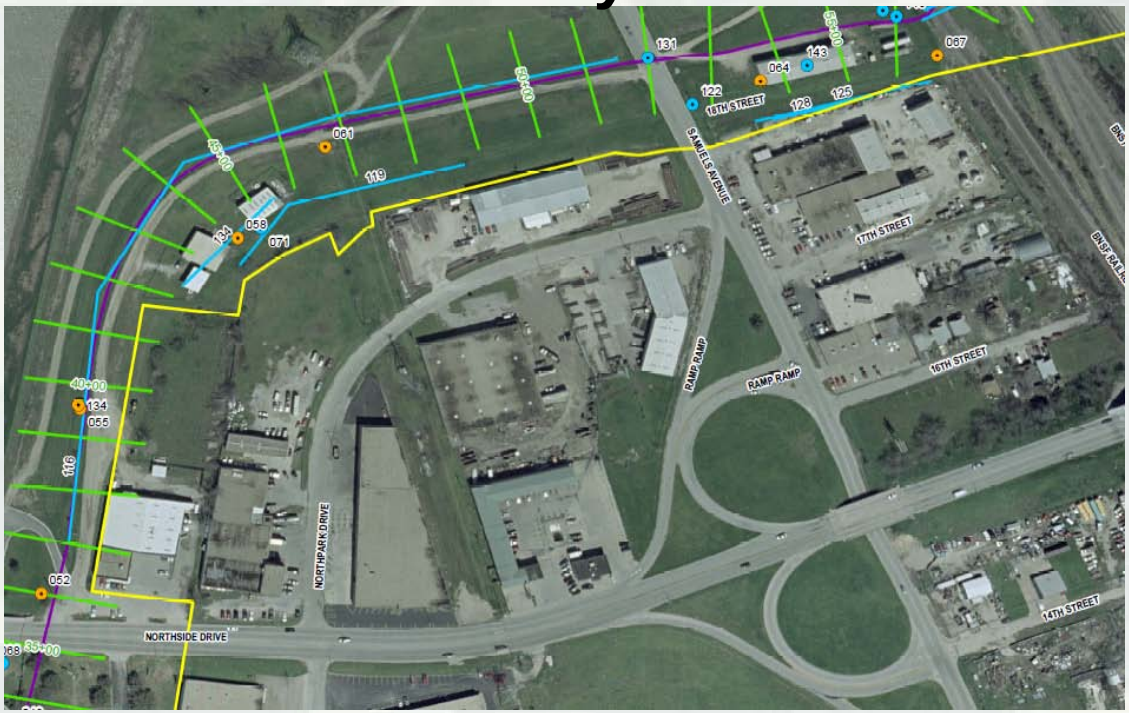
Inspector 1 (Crest)	NLD - Utilities
Inspector 2 (R/S Toe)	Drop Inlet
Inspector 3 (L/S Toe)	Flood Gauge
Inspector 1 (Crest)	Gate Well
Inspector 2 (R/S Toe)	Headwall
Inspector 3 (L/S Toe)	Manhole
Camera 1 (Crest)	Sluice Gate
Camera 2 (R/S Toe)	Other
Camera 3 (L/S Toe)	NLD - Gravity Drain Lines
TRWD - Acquisition Boundary	Levee Stationing
	Levee Centerline

Inspection Map Page 2/7



SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Encroachment Documentation

SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Encroachment Documentation

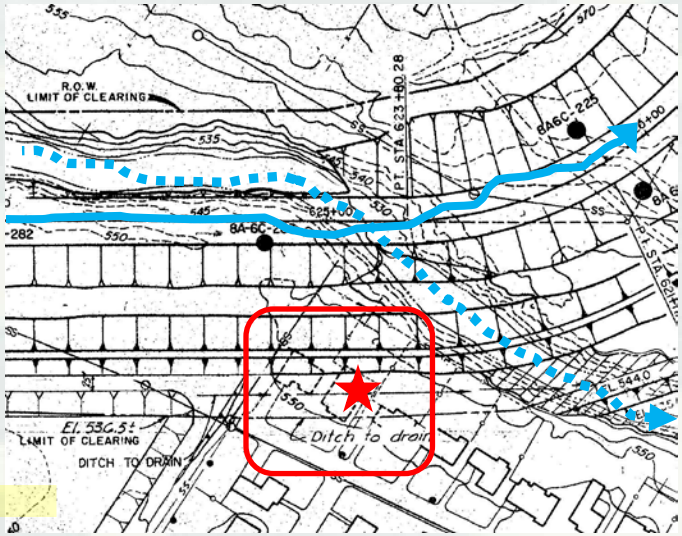


- Private Buildings have been constructed on the levee embankment and adjacent to the levee toe.

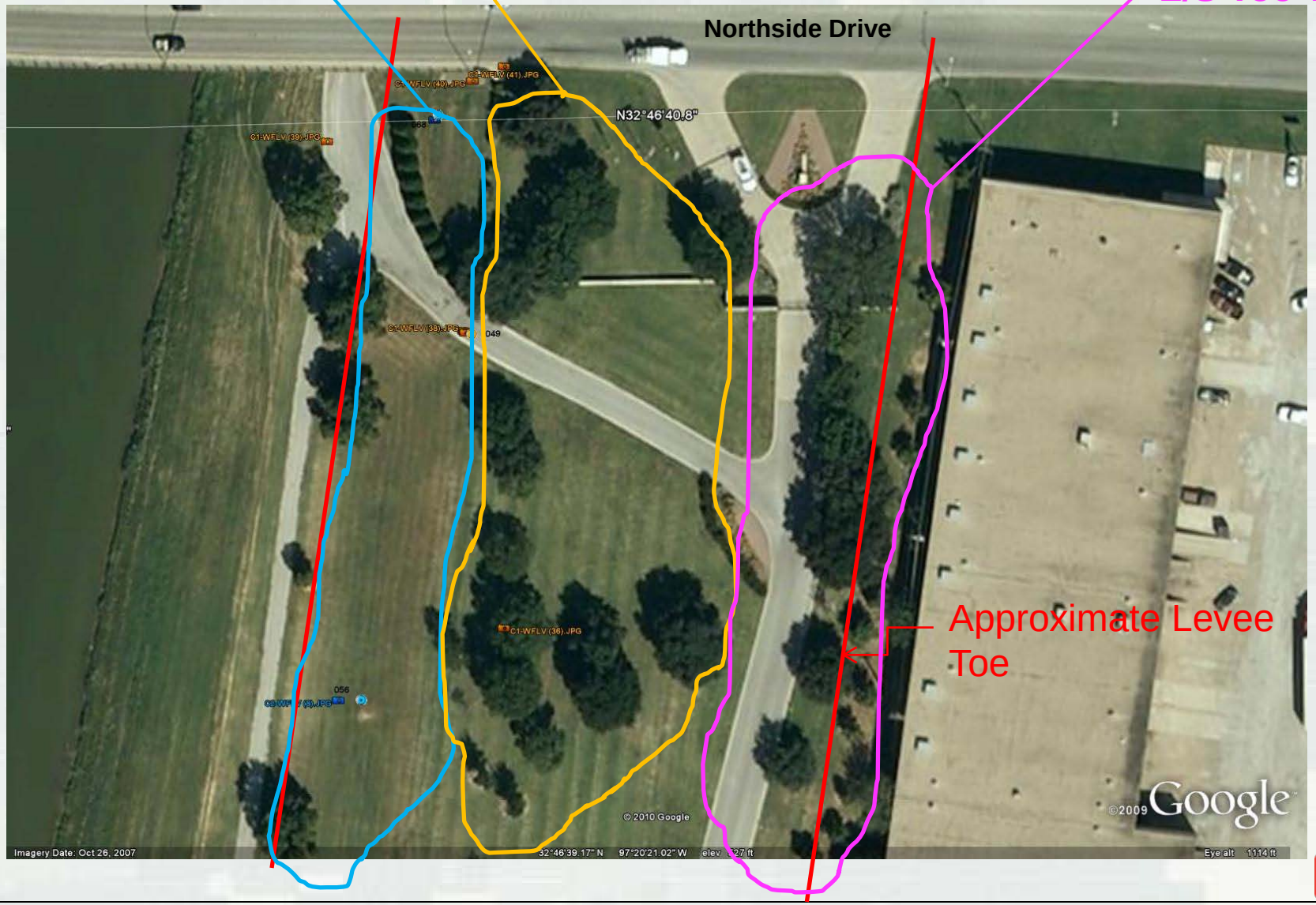
- Vegetation/Erosion are common around the buildings.
- Project ROW is not consistent with the as-built plans.

SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Encroachment Documentation

- Levee Embankment built into structure
- 1964 Design Plans indicate clearing
- 1968 SWF Correspondence to remove
- 1970 O&M Manual as Superintendant
- Sponsor has retained as the residence for Floodway Superintendant
- Being evaluated for Corrective Action



SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Vegetation Evaluation



SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Vegetation Evaluation

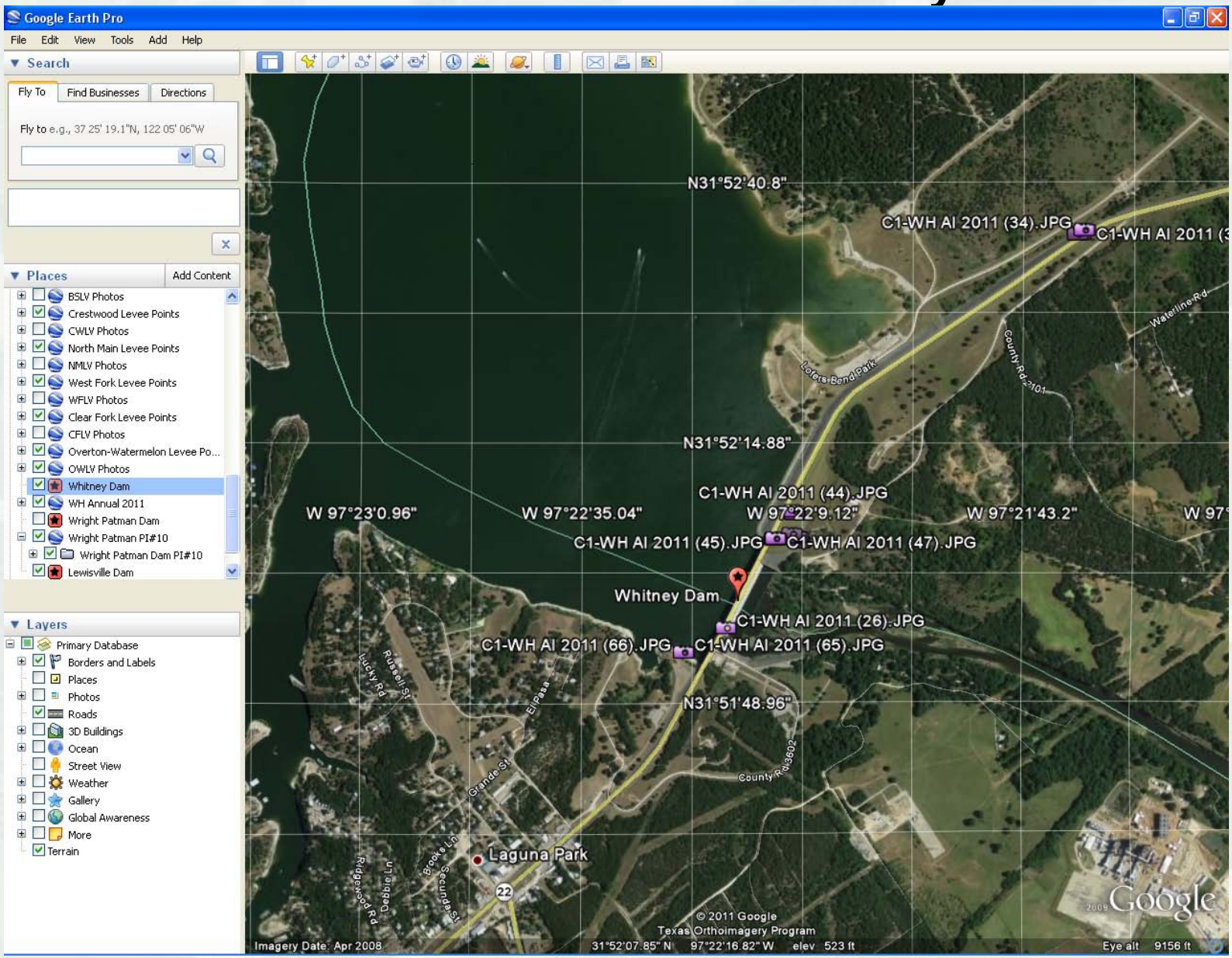
SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Vegetation Evaluation

SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Penetrating Utility Evaluation

Sump 14

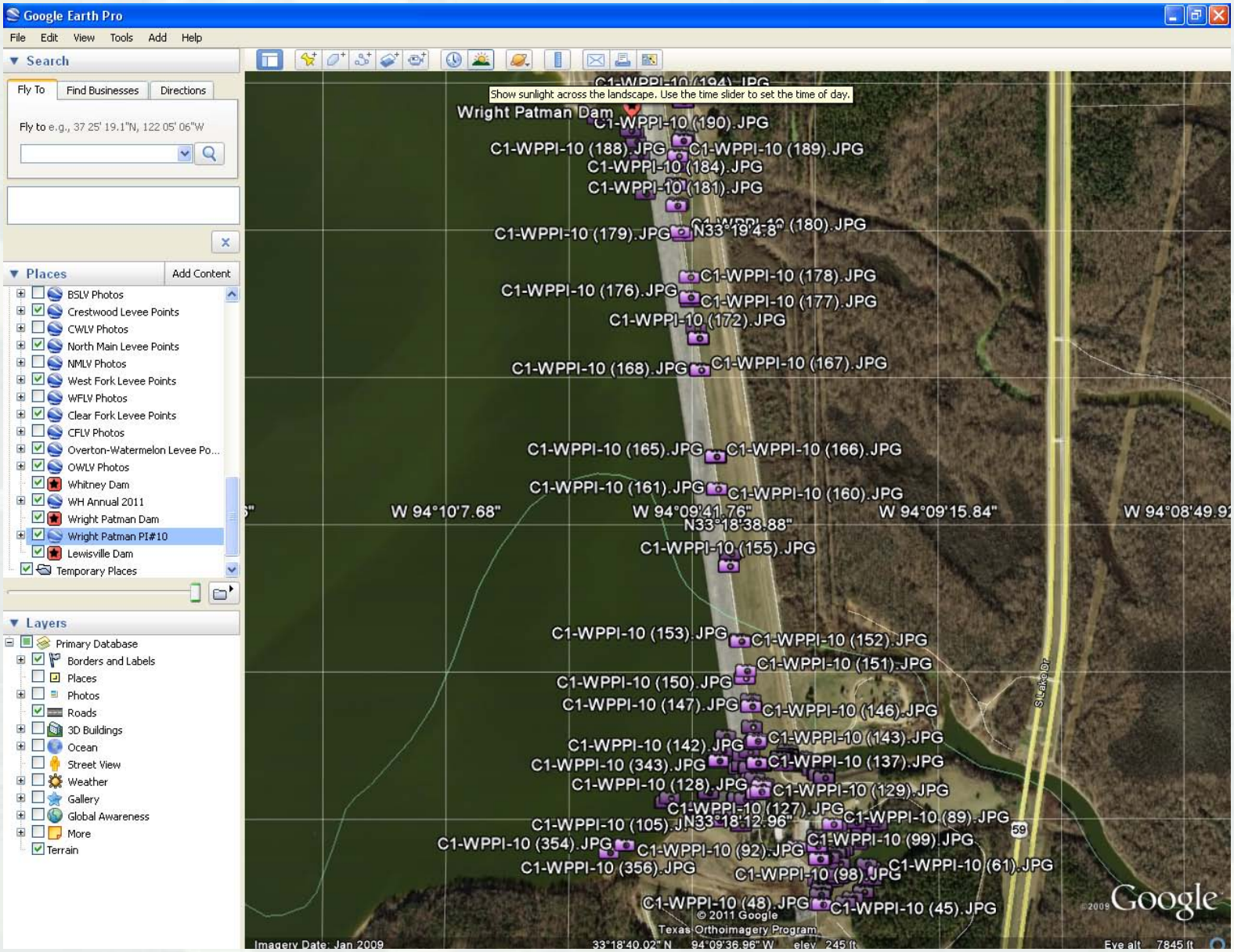
SWF Use of Technology for Civil Works Inspections
Fort Worth Floodway PI#10 – Penetrating Utility Evaluation

Virtual Inspection of SWF Civil Works Projects
Now Lets Take a Look at Whitney Dam

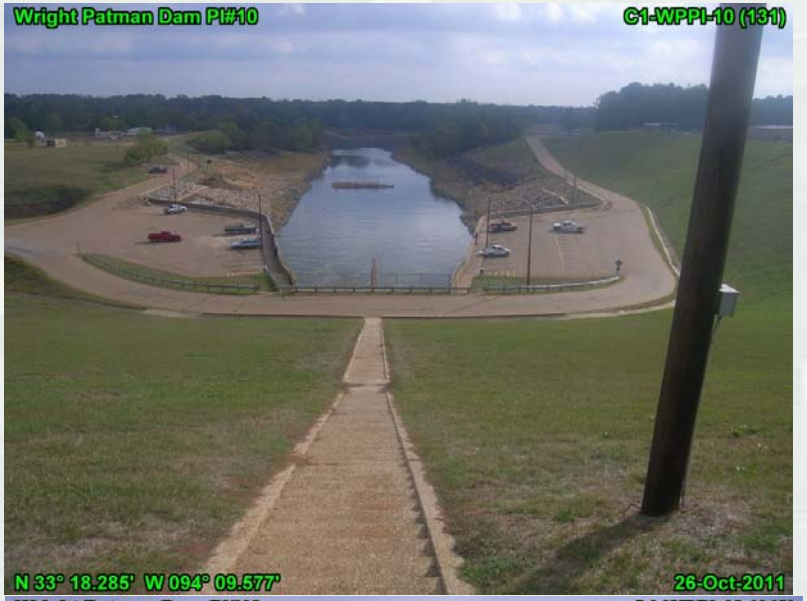


SWF Use of Technology for Civil Works Inspections
Whitney Dam – Annual Inspection 2011

Virtual Inspection of SWF Civil Works Projects
Finally a Trip to Wright Patman Dam in Texarkana



SWF Use of Technology for Civil Works Inspections
Wright Patman Dam – Periodic Inspection #10



SWF Use of Technology for Civil Works Inspections
Wright Patman Dam – Periodic Inspection #10

SWF Use of Technology for Civil Works Inspections
Wright Patman Dam – Periodic Inspection #10

SWF Use of Technology for Civil Works Inspections
Wright Patman Dam – Periodic Inspection #10

GIS Maps to Identify/Document the Inspected Items

Wright Patman Dam
Periodic Inspection #10

Inspection Map

0 325 650 1,300 1,950
Feet

Prepared by Geospatial Services Section
Eli Kangas - Chief, Geospatial Services
Julie Vicars - Geographer

Video Inspection of Upstream Rip Rap Erosion Protection

Evaluation of Inspected Items w/Recommendations
Photo Referencing Corrective Actions

Corps. ID No. 074 – Hampton Pump Station, East Levee – There are slides on the right and left slopes downstream of the displaced riprap.

This item was repaired concurrently with the items in paragraph 2.1 and is further illustrated in the photos below.

Corps. ID No. 062 – East Levee, Baker Pump Station – Erosion (4'W x 35'L) on the slope above the discharge chute, erosion (15'W x 35'L) on the left slope and erosion (50'W x 80'L) on the right side of the discharge channel.

Evaluation of Inspected Items w/Recommendations
Photo Referencing Corrective Actions

- CFLV-0089: Erosion at SH 199 Bridge #1, corrected on 14 February 2011.
- CFLV-0007: Ramp for emergency drainage on L/S embankment, removed on 9 March 2011.

Figure J9-13: CFLV-0089 Erosion

Figure J9-14: CFLV-0089 Repaired

Figure J9-17: CFLV-0007 Structure

Figure J9-18: CFLV-0007 Removed

Evaluation of Inspected Items w/Recommendations
Photo Referencing Corrective Actions

Figure F9-1: WSLV-0016 Tilting/Erosion

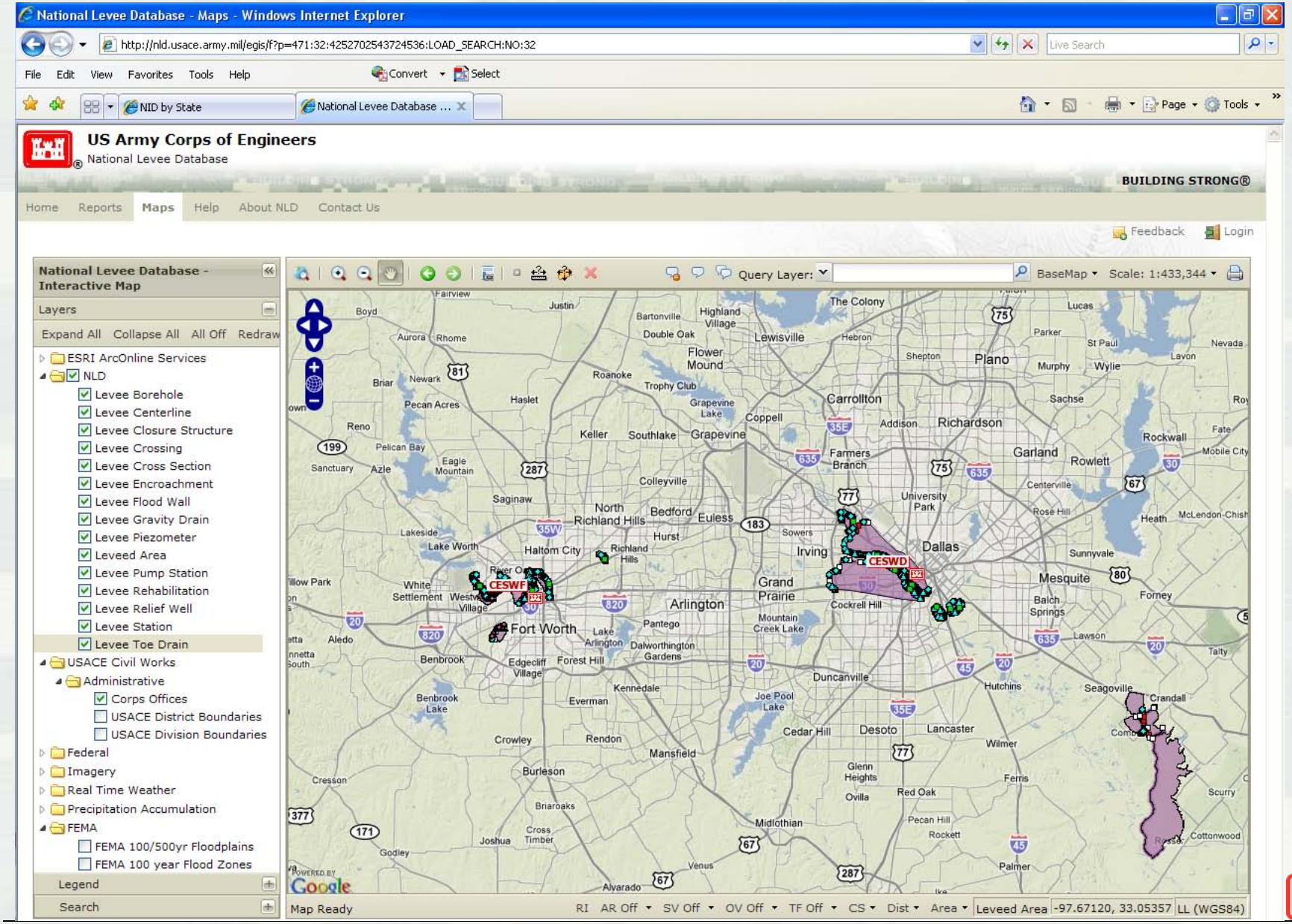
Figure F9-2: WSLV-0016 Repaired

Figure F9-3: WSLV-0016 Tilting

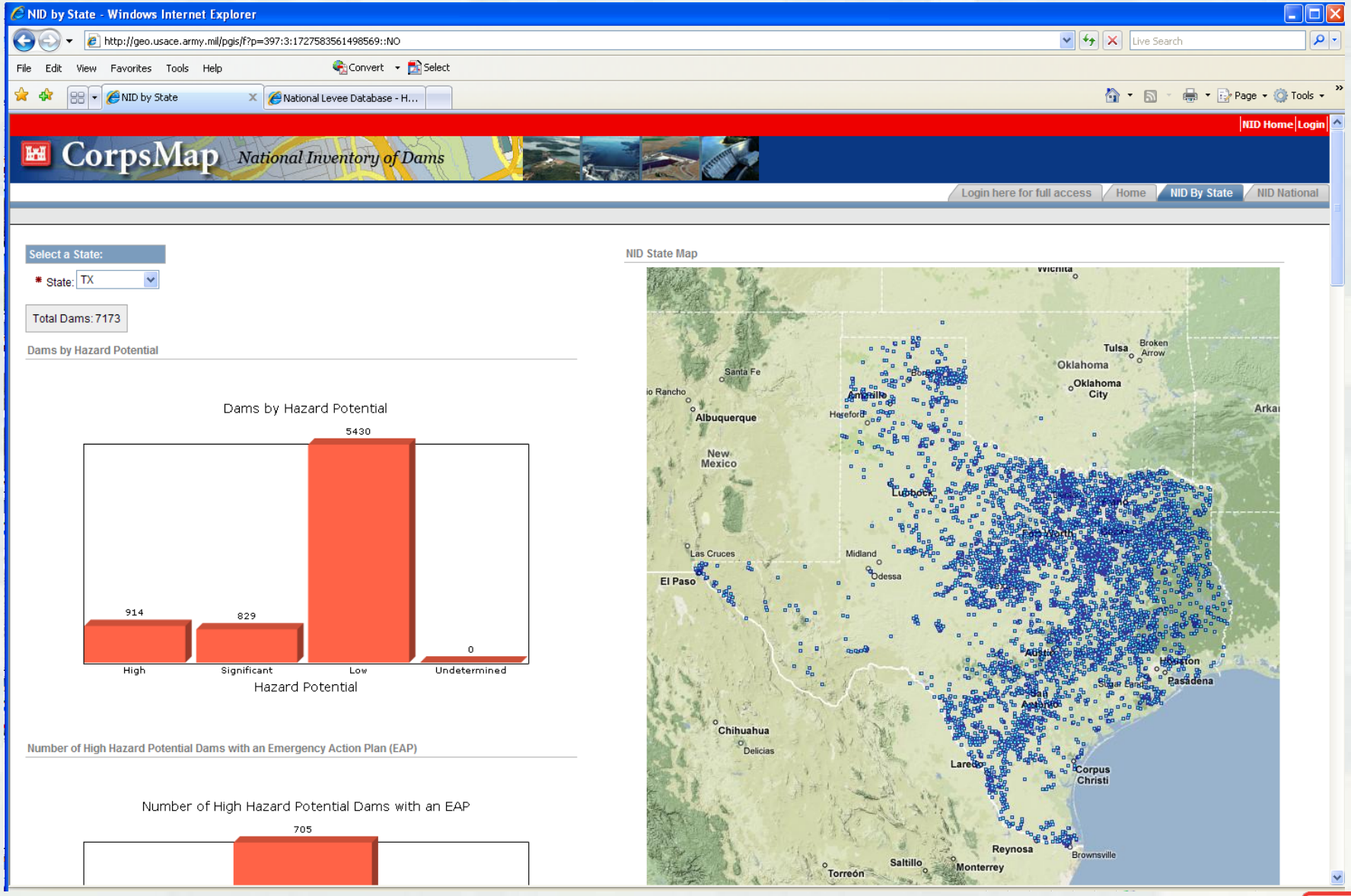
Figure F9-4: WSLV-0016 Repaired

- **WSLV-0016: Tilting and deterioration of sump inlet**
  - **Installed a PVC drainage culvert and repaired the eroded embankment**
  - **Corrected on 23 February 2011**

National Levee Database (NLD) - http://nld.usace.army.mil



National Inventory of Dams (NID) - http://nid.usace.army.mil



Technology for Infrastructure Inspections – Any Questions?