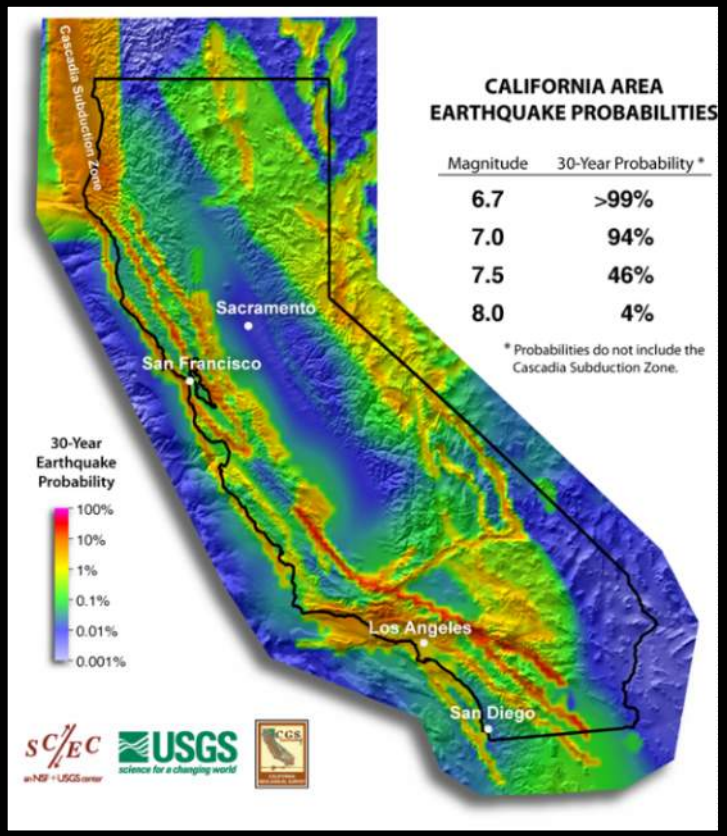
Guidance for California Accidental Release Prevention Seismic Assessments

Overview

- Why a Seismic Assessment?
- Primary Earthquake hazards
- History of the Guidance Document
- Changes and Updates to 2019 Guidance Document
- Seismic Evaluation / Hazard Assessment Process
- Walkdowns
- Seismic Assessment Deficiencies

Why a Seismic Assessment?



Primary Earthquake Hazards

- Ground Shaking
- Landslides
- Liquefaction
- Surface Rupture
- Tsunami

Ground Shaking

- Result of rapid ground acceleration
- Can vary over an area due to factors such as topography, bedrock type, location and orientation of fault rupture

Liquefaction

- Can occur when seismic shaking agitates saturated ground material of certain types
- Buildings and other surface structures supported by liquefied ground can subside or tilt over
- Underground hollow structures, such as pipes and tanks, may rise to the surface due to buoyancy forces

Surface Rupture

- Caused by vertical or horizontal displacement on either side of a ruptured fault, which can affect enormous areas of land (tectonic shift)

Tsunami and Seiche

- Tsunami — a series of waves in a water body caused by displacement of a large volume of water, generally in an ocean or a large lake

- Seiche — a temporary disturbance or oscillation in water level of a lake or partially enclosed body of water, especially one caused by changes in atmospheric pressure

Health and Safety Code Chapter 6.95, Article 2

- **25534.05.**

  (c) The regulations shall provide that the process hazard analysis shall include the consideration of external events, including **seismic** events, if applicable.

RMP Prevention Program Component

The owner or operator shall submit the following external events analysis information:

- (1) The types of natural and human caused external events considered in Hazard Review Section 2755.2 (Program 2) , PHA Sections 2760.2 (Program 3) or 2762.2. (Program 4)
- (2) The estimated magnitude or scope of external events which were considered. If not known, the owner or operator of the stationary source shall work closely with the UPA to determine what is required. If seismic events are applicable, the parameters used in the consideration of the seismic analysis and which edition of the Building Code was used when the process was designed.

19 CCR §§ 2745.6, 2745.7, 2745.7.5

RMP Prevention Program Component

- (3) For each external event, with a potential to create a release of a regulated substance that will reach an endpoint offsite, apply sections (e)(1) through (e)(6); and
- (4) The date of the most recent field verification that equipment is installed and maintained as designed.

19 CCR §§ 2745.6, 2745.7, 2745.7.5

External Events Analysis

Natural

- Earthquake
- Flood
- Tsunami/Seiche
- Tornado/Hurricane
- Volcano

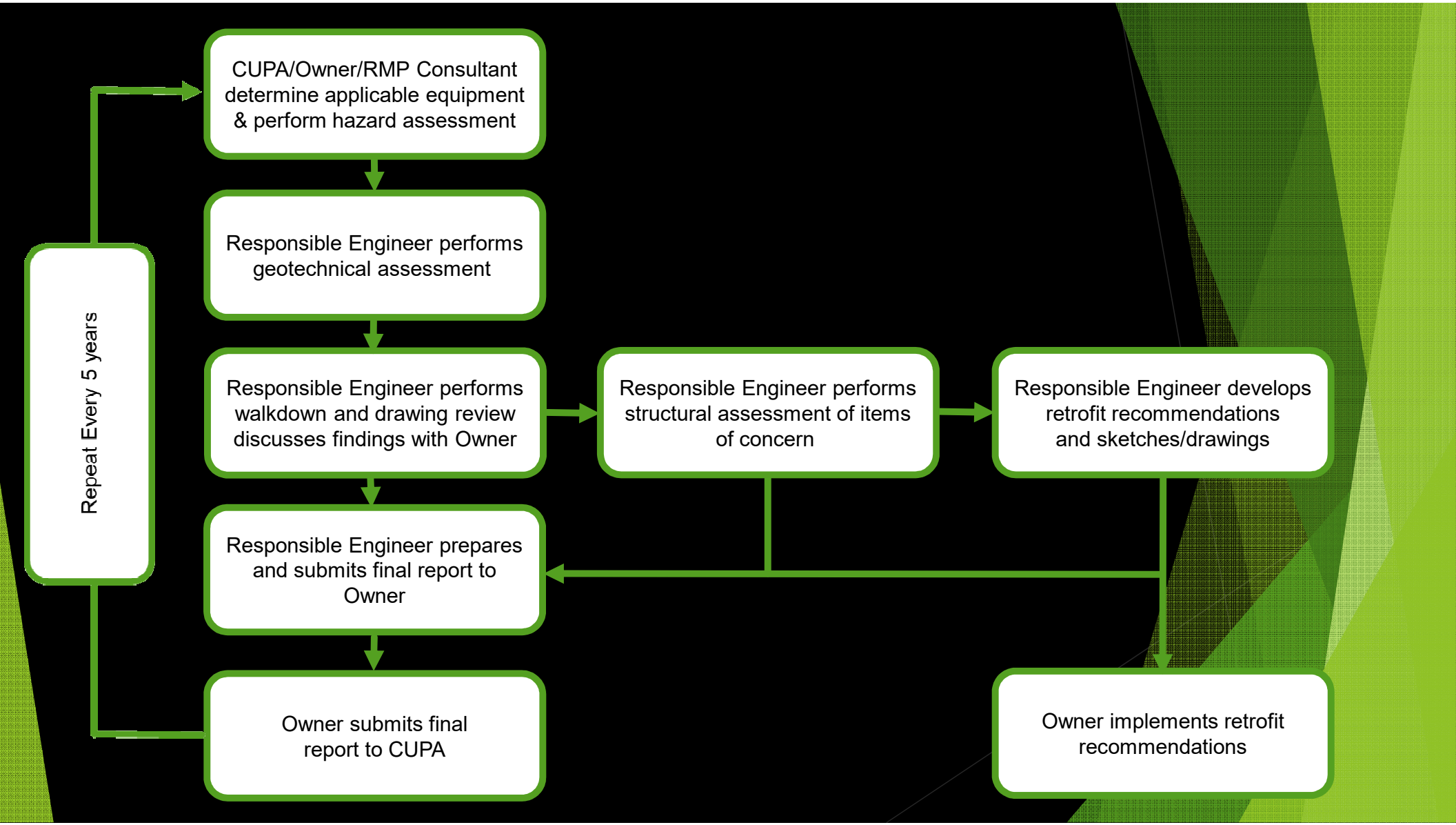
Human Caused

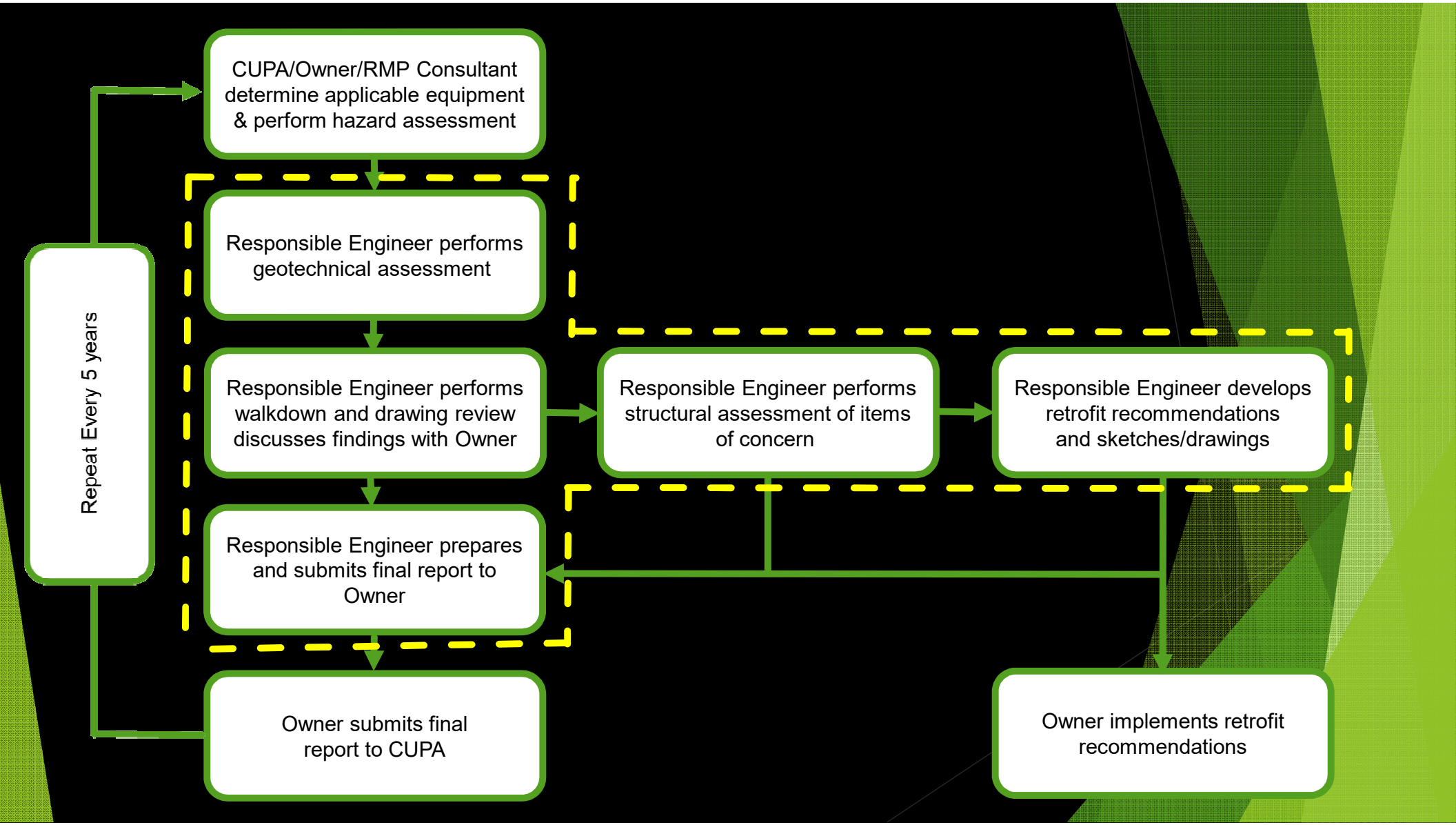
- Airplane/Auto/Rail
- Explosion
- Fire
- Sabotage
- Terrorism

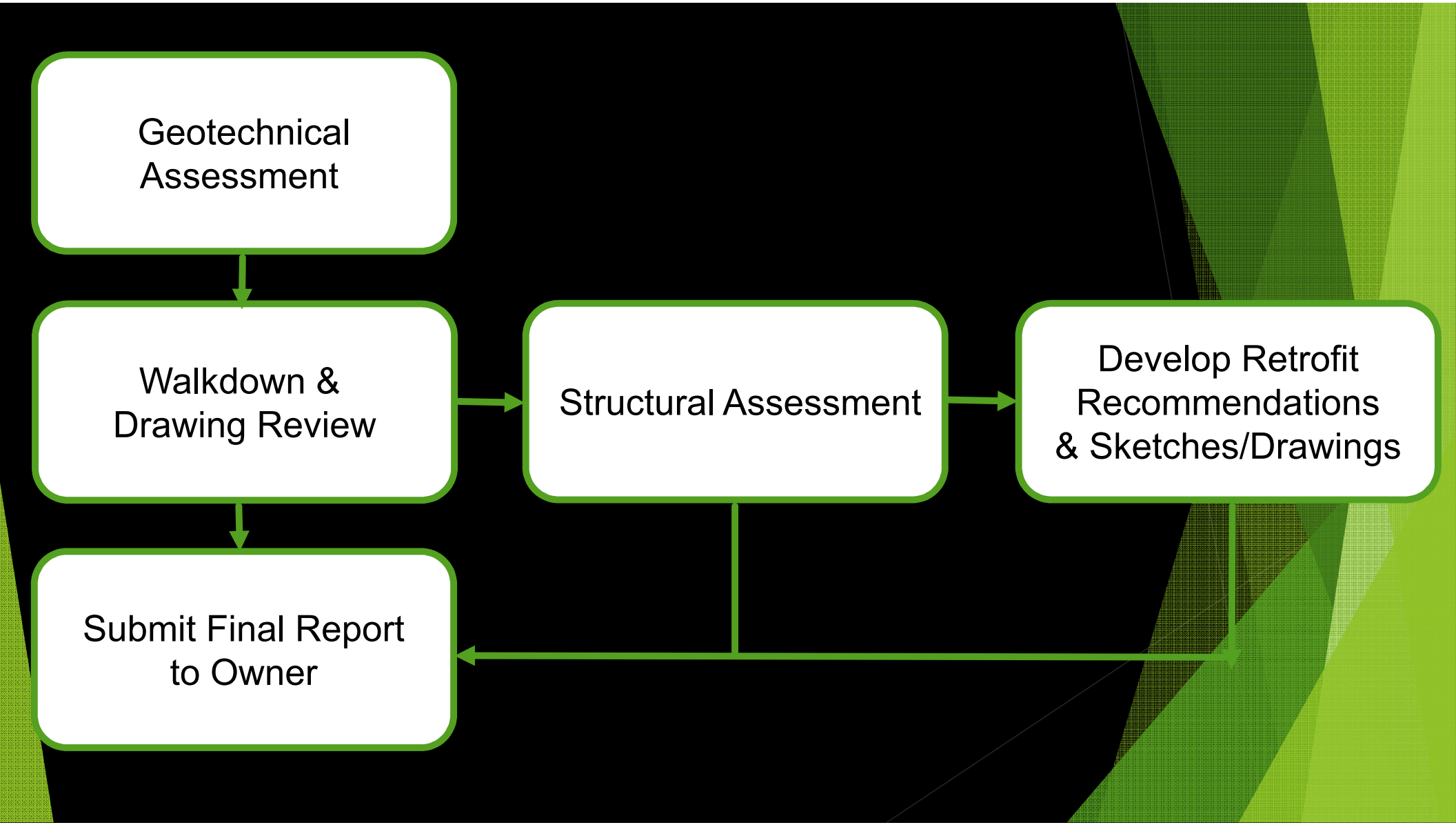
RMP Roles and Responsibilities

- UPA (CUPA or PA)
- Owner/Operator
- RMP Consultant
- Seismic Assessment Responsible Engineer

Seismic Assessment Process


CUPA/Owner/RMP Consultant determine applicable equipment & perform hazard assessment
Responsible Engineer performs geotechnical assessment
Responsible Engineer performs walkdown and drawing review discusses findings with Owner
Responsible Engineer performs structural assessment of items of concern
Responsible Engineer develops retrofit recommendations and sketches/drawings
Responsible Engineer prepares and submits final report to Owner
Owner submits final report to CUPA
Owner implements retrofit recommendations
Repeat Every 5 years


CUPA/Owner/RMP Consultant determine applicable equipment & perform hazard assessment
Responsible Engineer performs geotechnical assessment
Responsible Engineer performs walkdown and drawing review discusses findings with Owner
Responsible Engineer performs structural assessment of items of concern
Responsible Engineer develops retrofit recommendations and sketches/drawings
Responsible Engineer prepares and submits final report to Owner
Owner submits final report to CUPA
Owner implements retrofit recommendations
Repeat Every 5 years


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

California Risk Management and Prevention Program (RMPP) - 1986 to 1996

- No formal guidance for seismic assessments provided at commencement of RMPP
- Some seismic assessments were purely probabilistic evaluations
- In 1989, engineers advised the Southern California Fire Chiefs Association (SCFCA) deterministic evaluations would be better
- SCFCA stated if owners had $100k to spend: $10k on seismic evaluation report and $90k on actual seismic improvements

California Risk Management and Prevention Program (RMPP) Guidance Document

- 1990 "Proposed Seismic Assessment Guidance for RMPP Studies" developed by Structural Engineers experienced with non-building structures
- In 1991 Chevron RTC Seismic Hazard Mitigation Program developed caveats for assigning "Q factors" based on structural detailing
- 1992 "Proposed Guidance for RMPP Seismic Assessments" added regulators and owners to committee per request from California OES

PROPOSED GUIDANCE

FOR

RMPP SEISMIC ASSESSMENTS

Prepared for the

RMPP SUB-COMMITTEE of the

SOUTHERN CALIFORNIA FIRE CHIEFS ASSOCIATION

Prepared by the

RMPP SEISMIC GUIDANCE COMMITTEE

June 1992

California Risk Management and Prevention Program (RMPP) Guidance Document

- In 1992, Los Angeles Metropolitan Water District (MWD) performed RMPP seismic evaluations for their facilities
- In 1993, LA MWD implemented recommended seismic retrofits (except for 2 items which were more difficult)
- On Jan 17, 1994, the Northridge Earthquake, a moment magnitude 6.7 (Mw), occurred
- MWD facilities suffered little damage, except for remaining 2 unretrofitted items

LEPC I CalARP Seismic Committee – Guidance for Seismic Assessments

GUIDANCE

FOR

CALIFORNIA

ACCIDENTAL RELEASE PREVENTION (CalARP) PROGRAM

SEISMIC ASSESSMENTS

Prepared for the

UNIFIED PROGRAM AGENCY (UPA) SUBCOMMITTEE

REGION I LOCAL EMERGENCY PLANNING COMMITTEE (LEPC)

Prepared by the

CalARP PROGRAM SEISMIC GUIDANCE COMMITTEE

January 2019

Approved by Region I LEPC on August 7, 2019

Changes and Updates to 2019 Guidance Document

- Added glossary of terms and list of acronyms
- Addressed regulatory changes
- Re-organization and consolidation
- Addressed building codes updates
- Minor seismic engineering updates and clarifications

Seismic Guidance Document

- Intended to provide a starting point for Seismic Assessment criteria
- Provides deterministic evaluation of existing structural systems and components based on understanding of performance during past earthquakes
- Major emphasis is the facility/site walkdown (borrowed from Nuclear Industry)
- Reduces, not eliminates, likelihood of a Regulated Substance release
- Relies on experience and judgement
- **Meant to mitigate, not prevent, damage**


SODIUM
HYPOCHLORITE

Shifted Unanchored Tanks


Shifted Unanchored Tanks


Concrete Cooling Tower
(Soft-Story)


Concrete Cooling Tower
(Soft-Story)

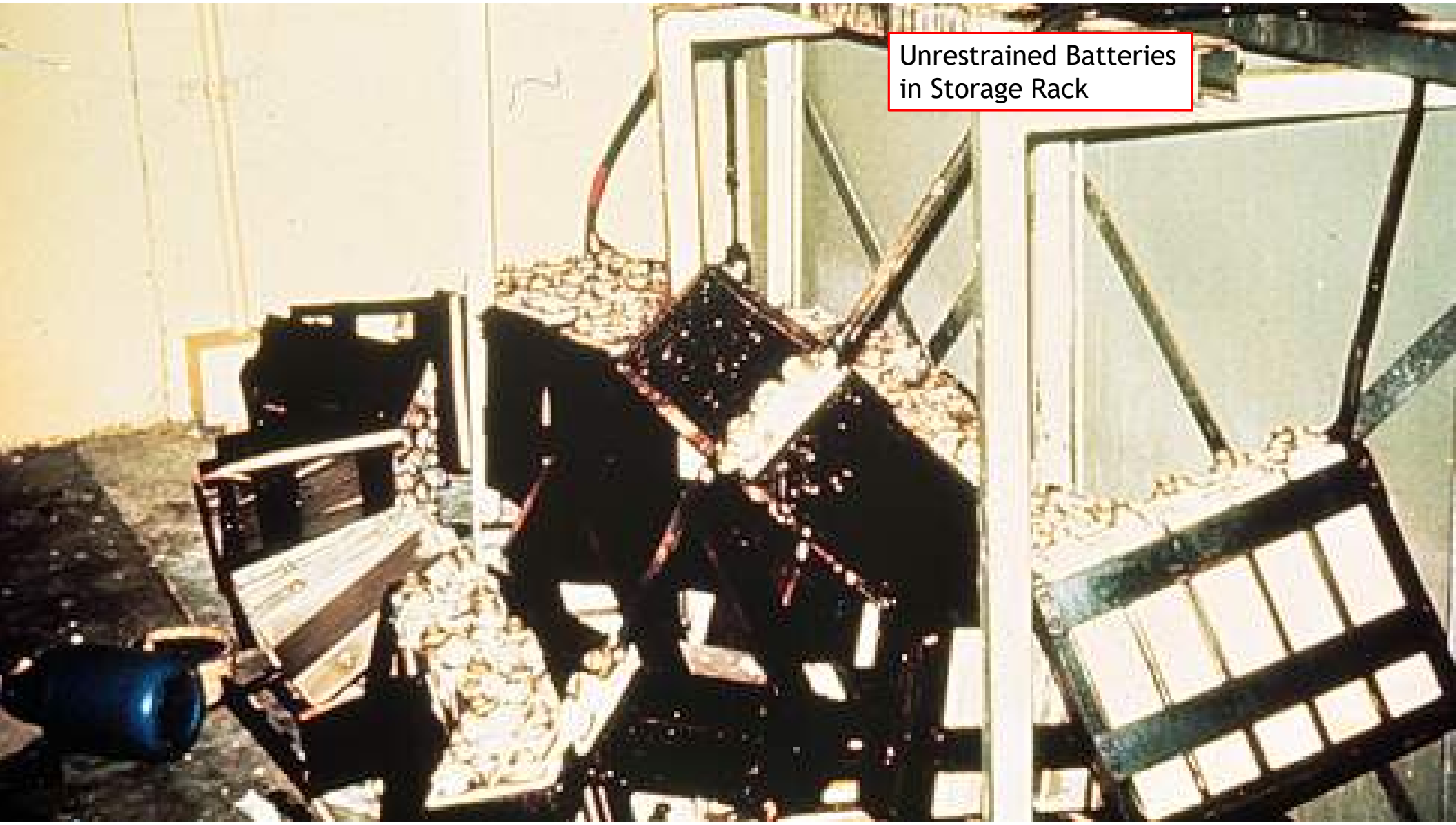

Differential Settlement
Separated Flanged Connections


Collapsed Vertical Tank Supports

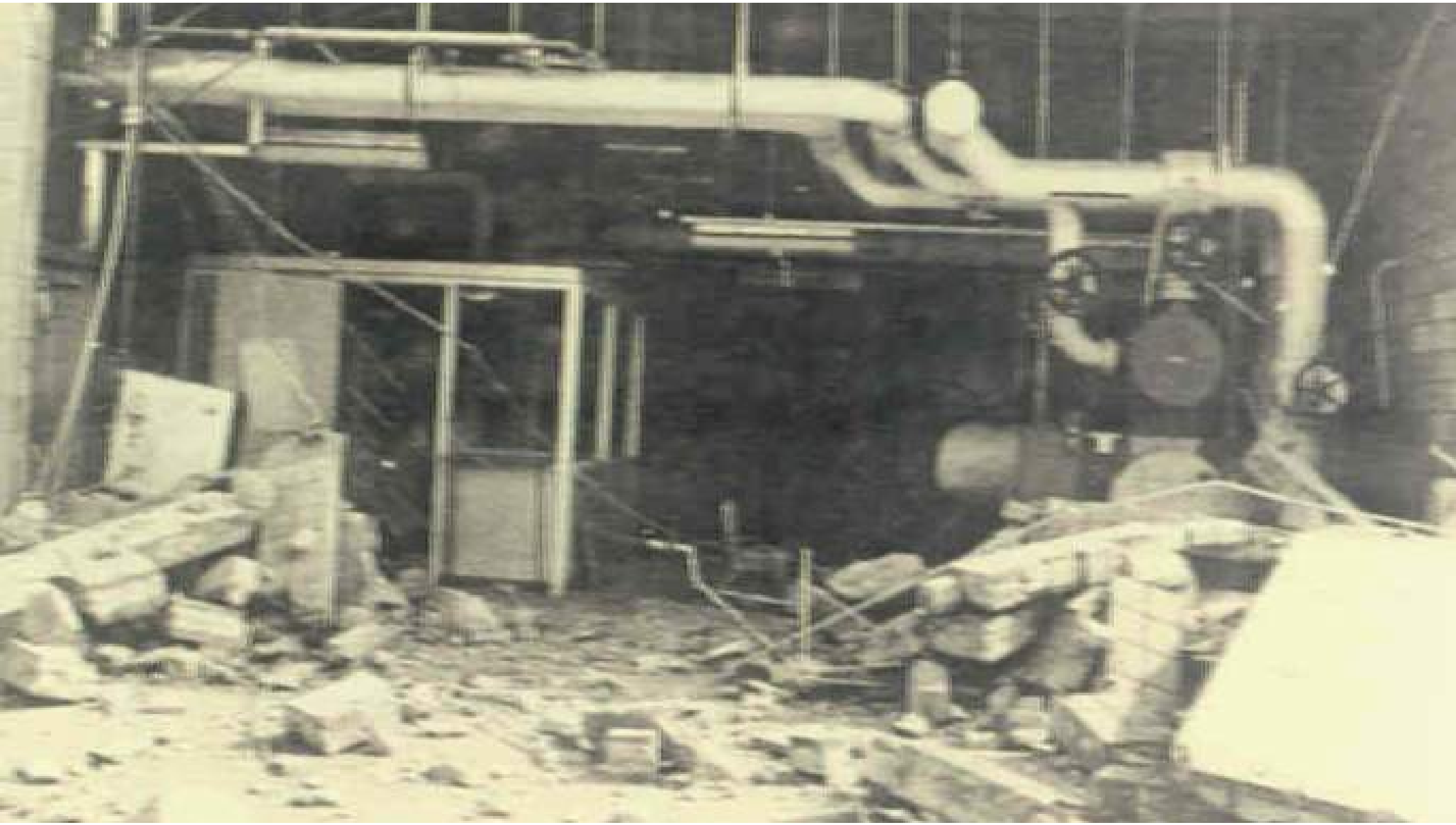

Collapsed Vertical Tank
Supports


Unanchored Electrical Equipment


Buckled Bracing


Unrestrained Batteries
in Storage Rack

Restrained Batteries
in Storage Rack



Lessons Learned-Building Code Changes

- 1989 Loma Prieta Earthquake
  - Creation of Acceptable Risk Policy by California Seismic Safety Commision (CSSC)
  - Tested tagging system of California Office of Emergency Services (CalOES)
  - Ground motions and soil conditions lead to near field effects
  - Identified problems with soft story, unreinforced masonry and non-ductile concrete

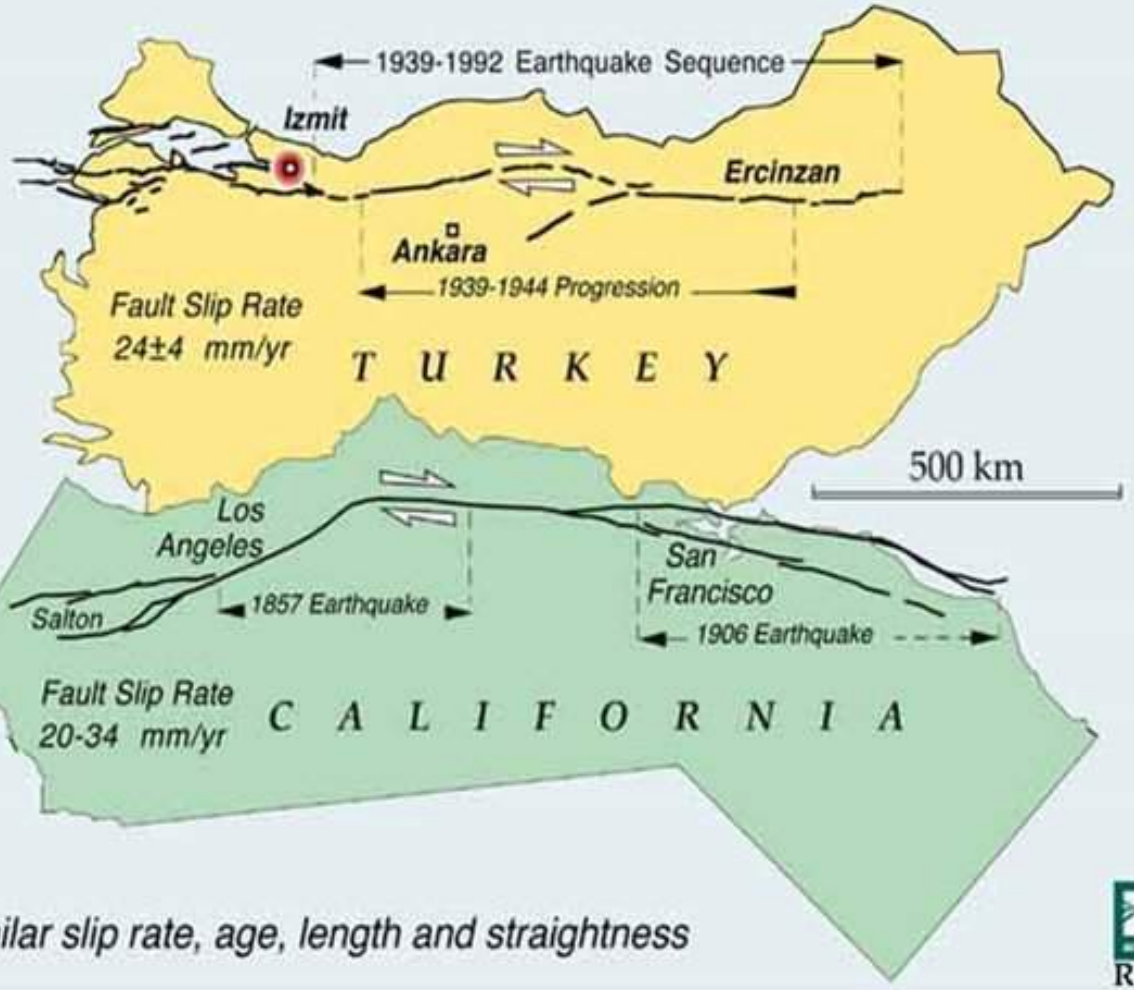
Lessons Learned-Building Code Changes

- 1994 Northridge Earthquake
  - Creation of California's Office of Statewide Health Planning and Development (OSHPD)
  - Mapping of faults is important
  - Vertical seismic accelerations can be high
  - Engineering changes for steel bracing and moment frame connection details

Example of Code Changes from Other Earthquakes

- 1999 Turkey Earthquake (magnitude 7.4)
- Along fault similar to San Andreas Fault in California
- 45 seconds of strong shaking
- Fault rupture, liquefaction, even tsunami
- Heavy industry near epicenter
  - Industrial construction typical to western codes
- Large refinery close to "ground zero"

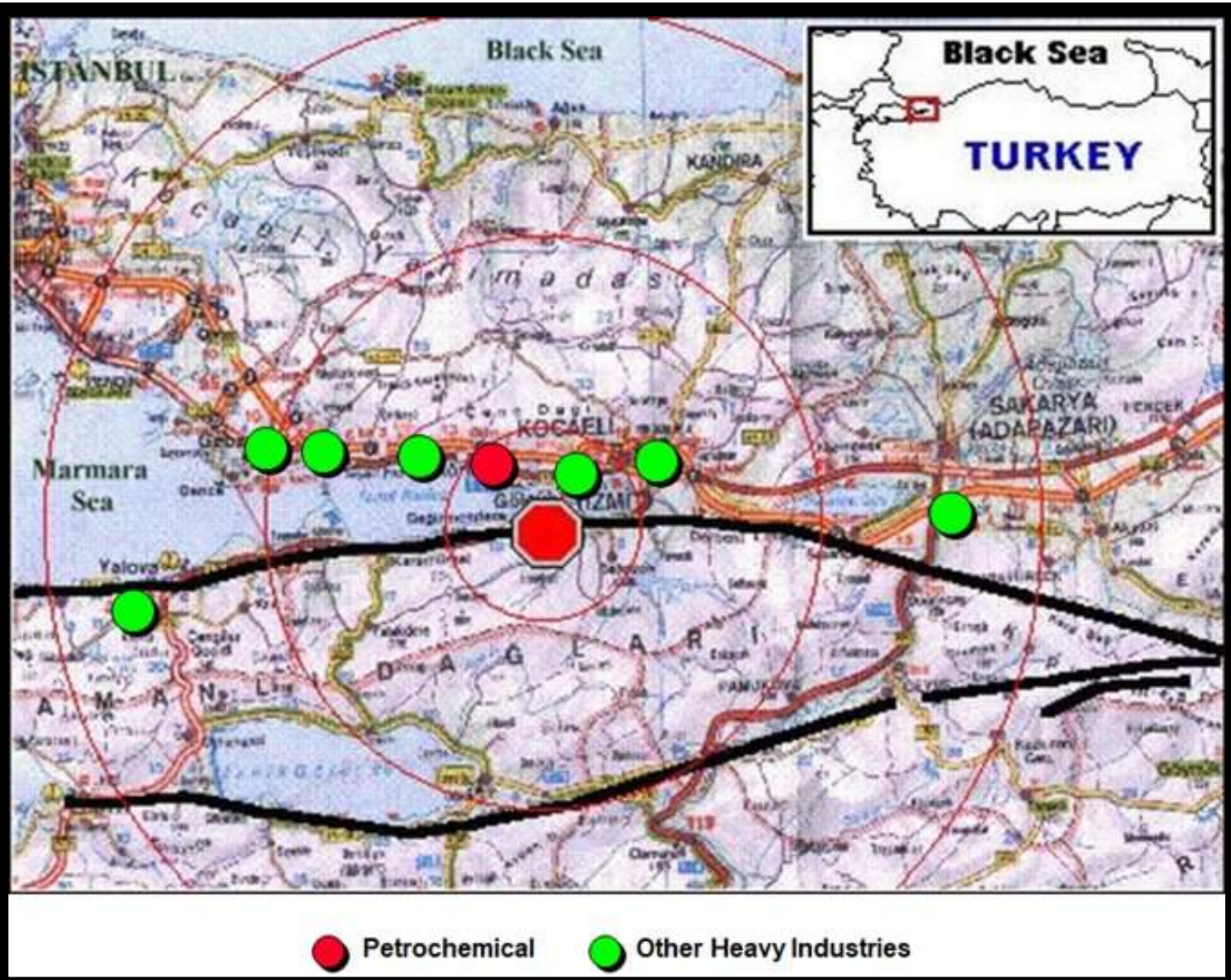
Comparison of the North Anatolian and San Andreas Faults



- *Similar slip rate, age, length and straightness*

USGS

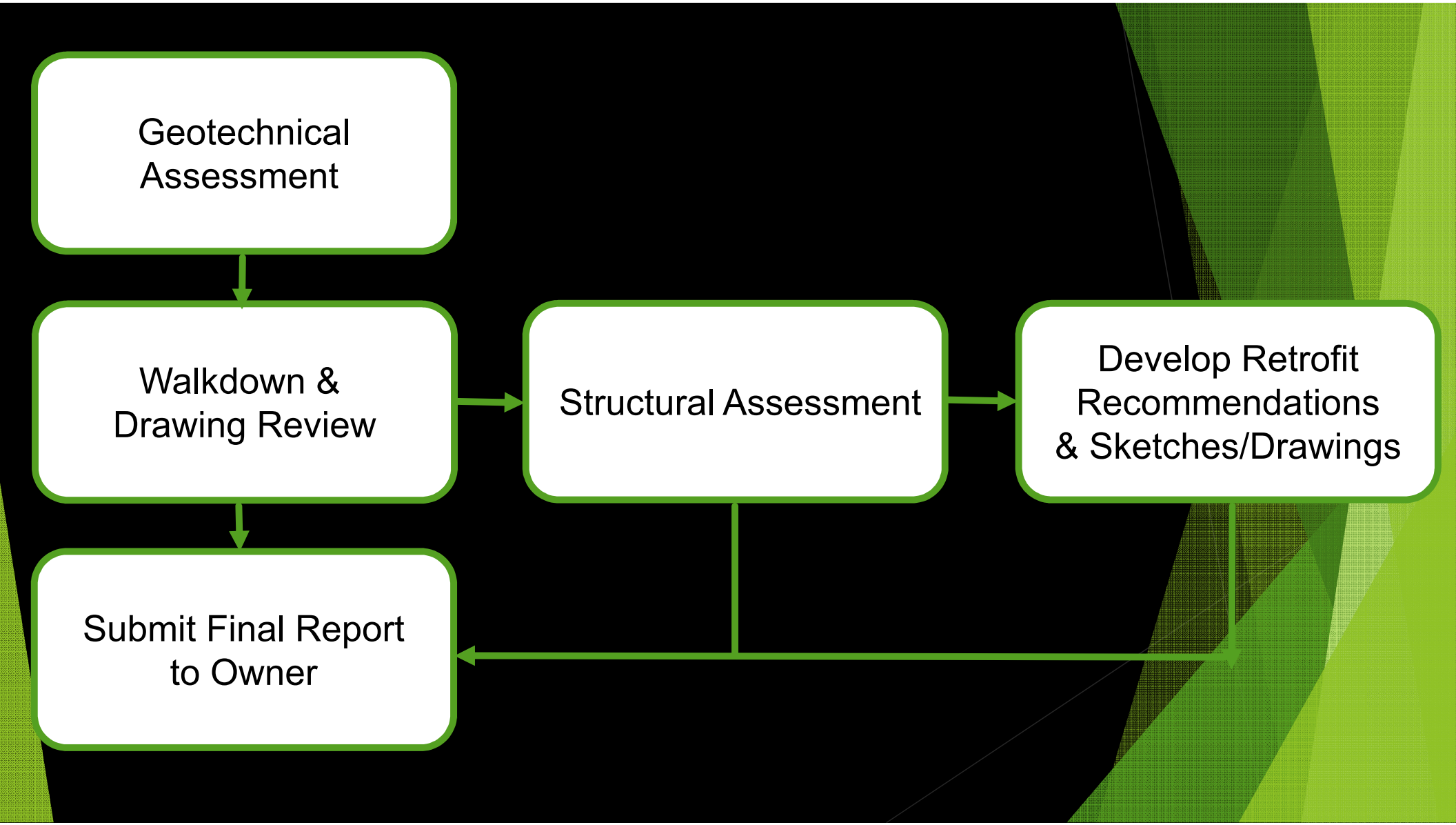
Ross S. Stein


Black Sea
ISTANBUL
KANDIRA
Marmara Sea
KOCAELI
SAKARYA (ADAPAZARI)
Yalova
Black Sea
TURKEY
Petrochemical
Other Heavy Industries


Collapsed Stack

Subsequent Code Changes

- Chimney designed and constructed in 1960's
- National Science Foundation (NSF) grant secured to determine reasons for failure
- American Concrete Institute (ACI) Concrete Chimney Committee performed separate evaluation
- Changes to detailing around breaches added to ASCE 7-10
- Adopted in 2013 California Building Code (CBC)
- Changes effective January 1, 2014


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

Seismic Evaluation / Hazard Assessment

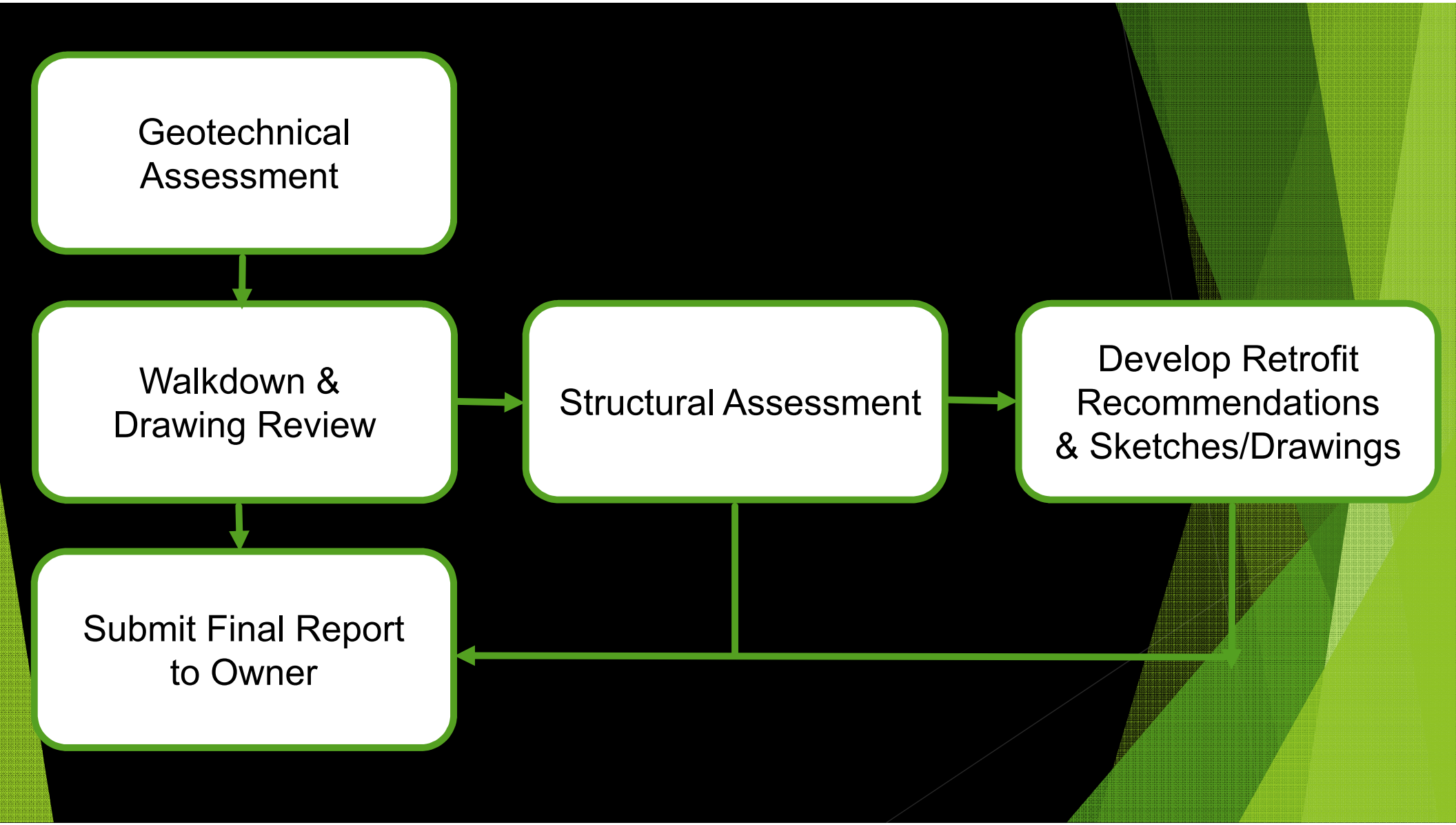
- Initial vs. re-validation
- Site Location
- Age

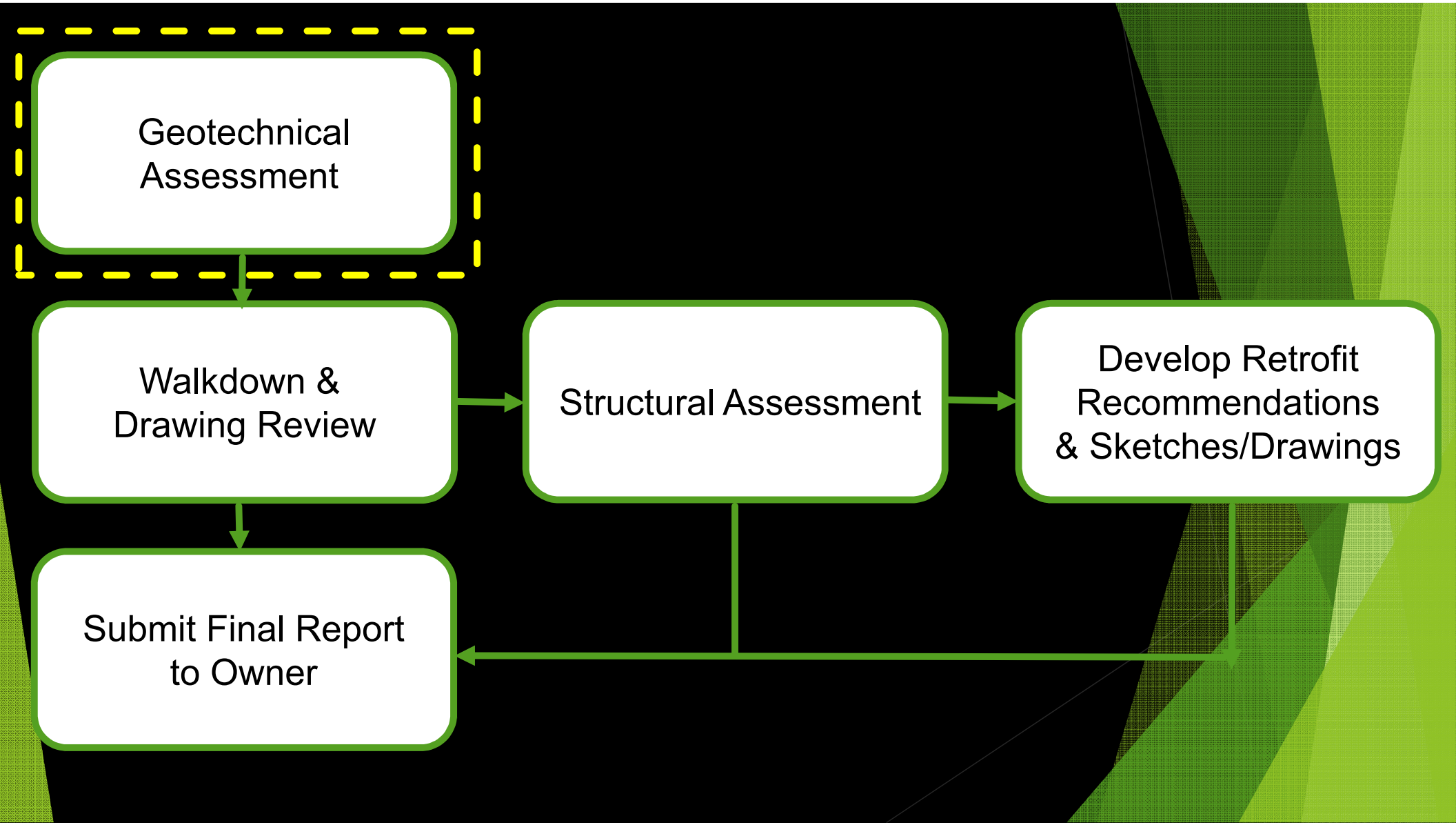
Industry Types

- Petrochemical (Refineries)
- Ammonia Refrigeration
- Water Treatment/Municipal
- Chemical/Manufacturing

Size of Facility and Initial Seismic Evaluation Cost

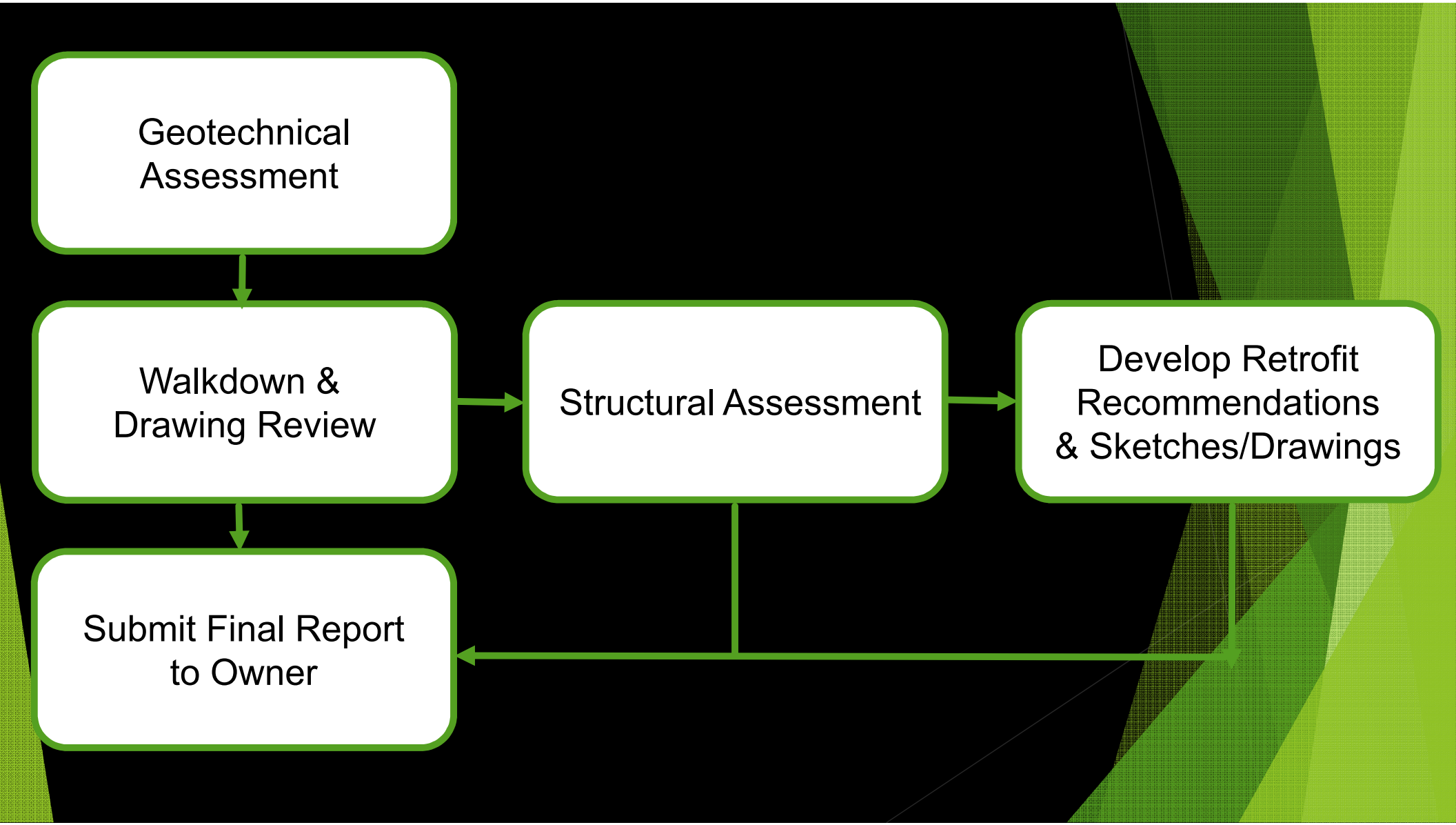
- Large Refinery (<$100,000+)
- Single Refinery Process Unit or Medium Size Facility (<$50,000)
- Small Size Facility or Single System (<$10,000)

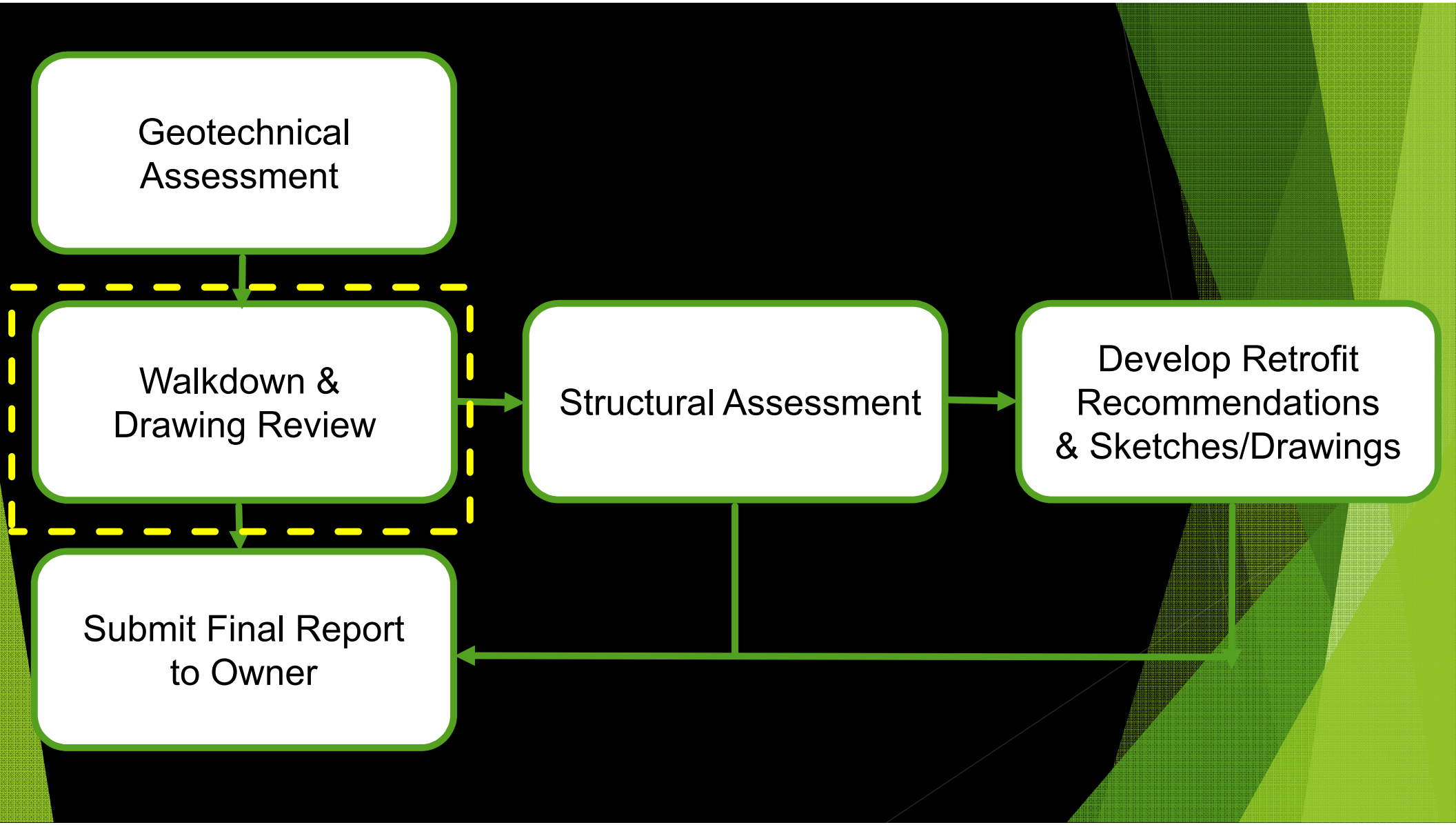

Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

Geotechnical Assessment

- Usually performed by Geotechnical Engineer
- Ground Shaking
- Landslides
- Liquefaction
- Surface Rupture
- Tsunami


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

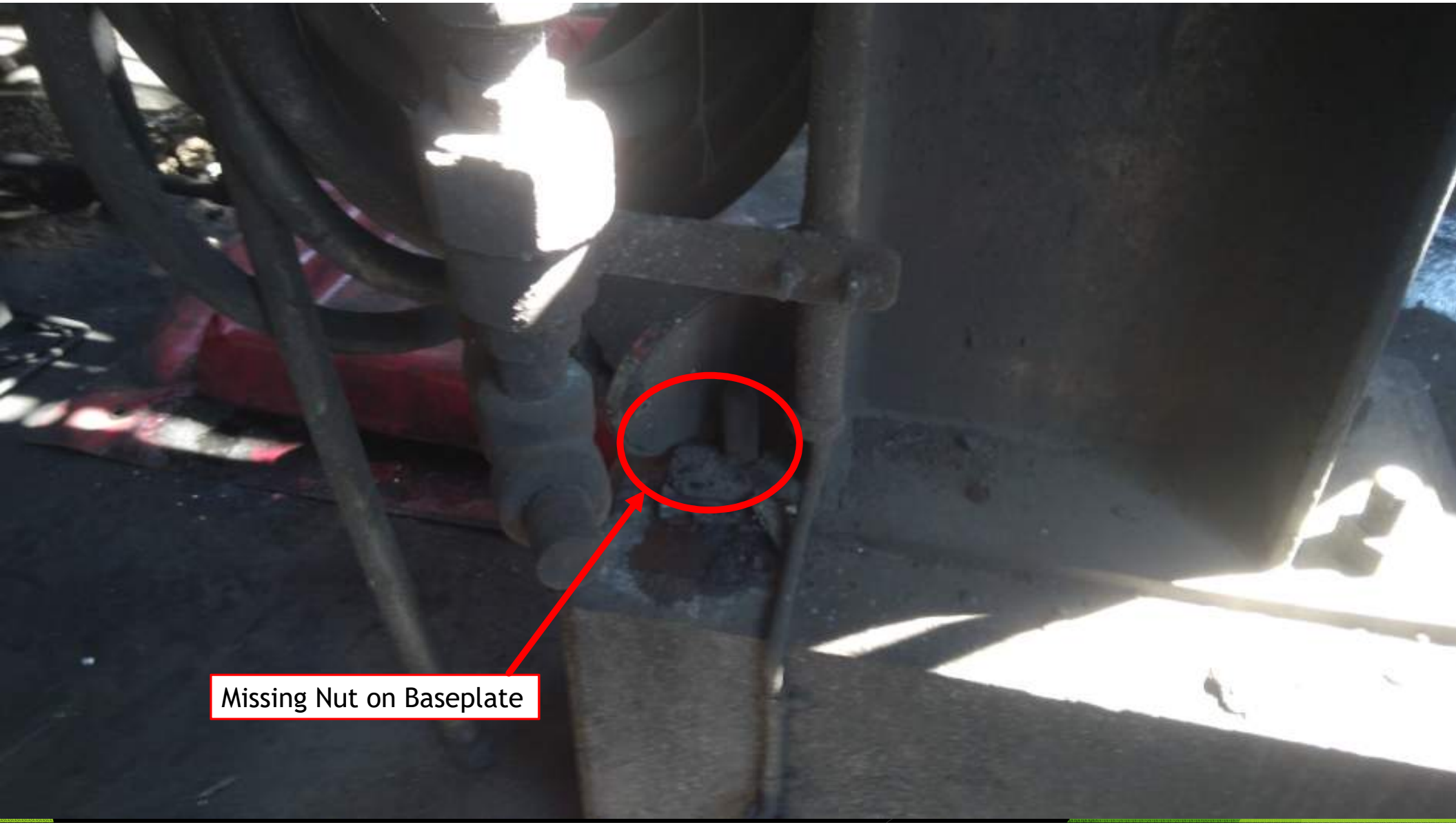
Walkdown Emphasis - General

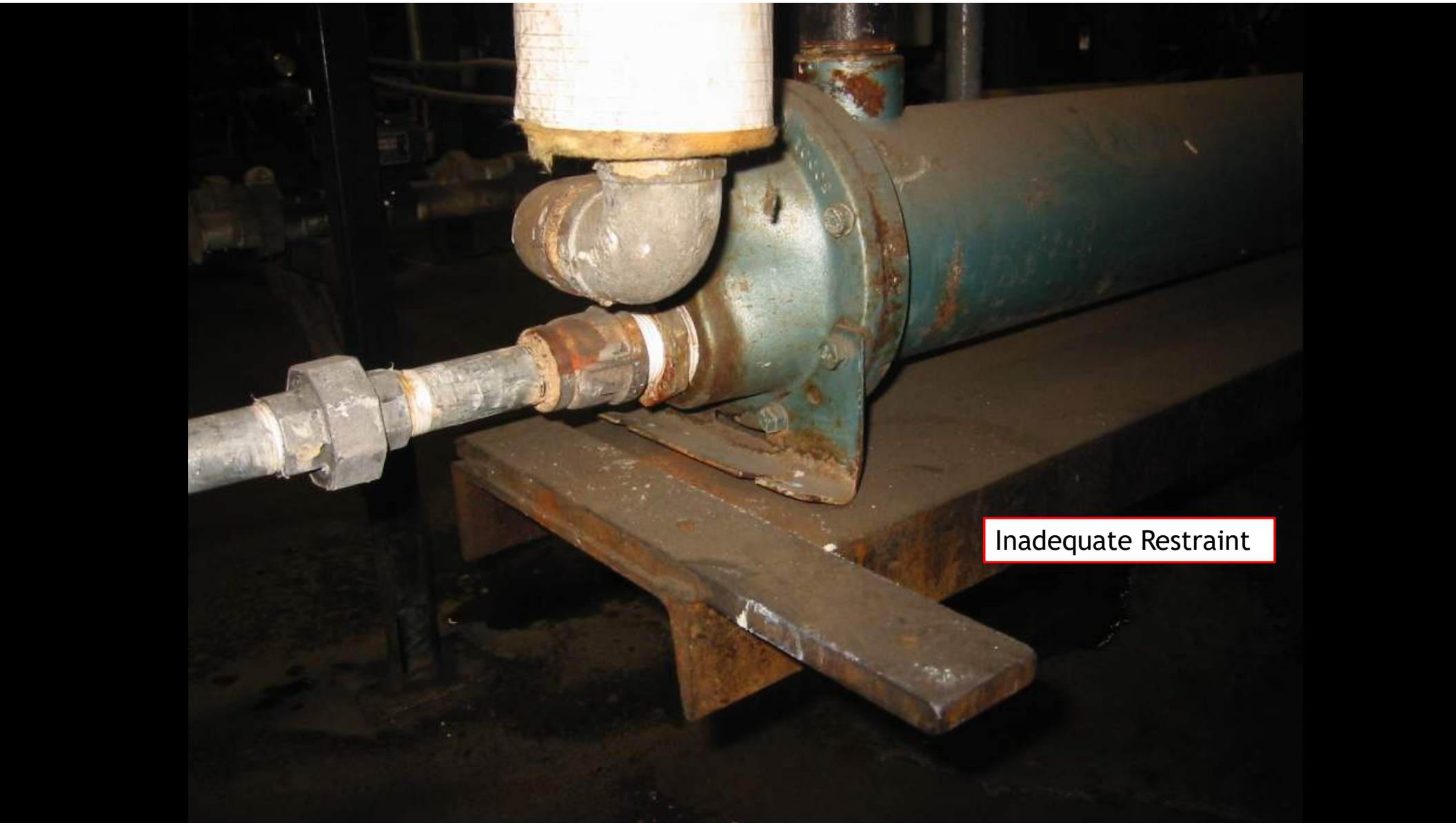
- Review 1 to 300+ items per walkdown (depending on facility)
- Support configuration
- Damage
- Modifications

Walkdown Emphasis - Equipment

- Inadequate anchorage
- Modified supports
- Damaged supports
- Inadequate supports
- Visible excessive corrosion
- Condition of fittings

Inadequate Anchorage


Missing Nut on Baseplate

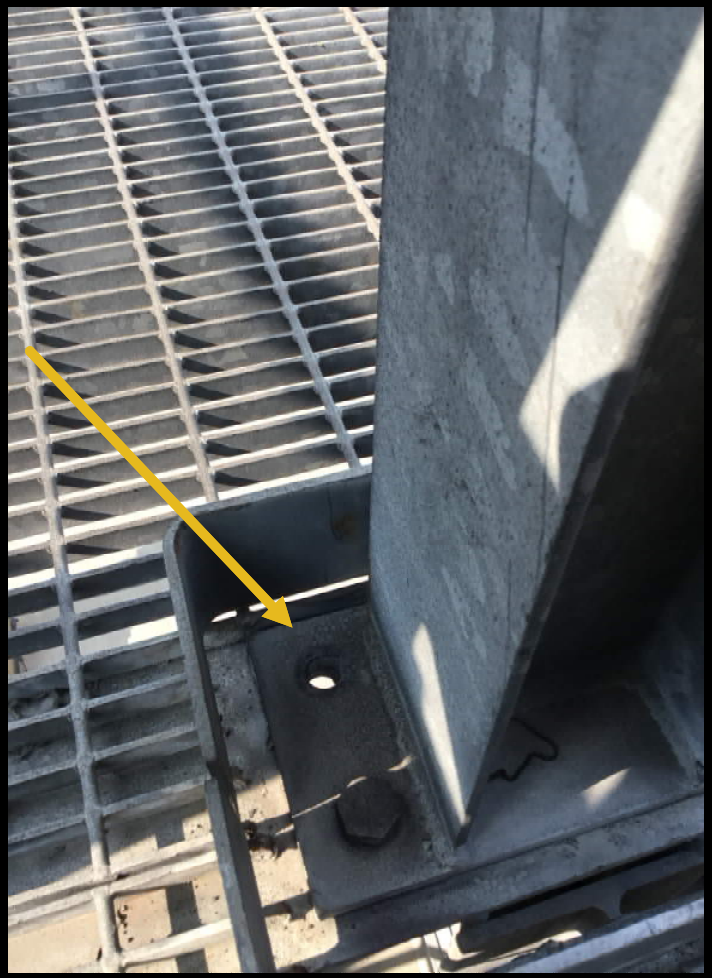

Inadequate Restraint

Anchorage Suspect

Modified Supports


FLARE

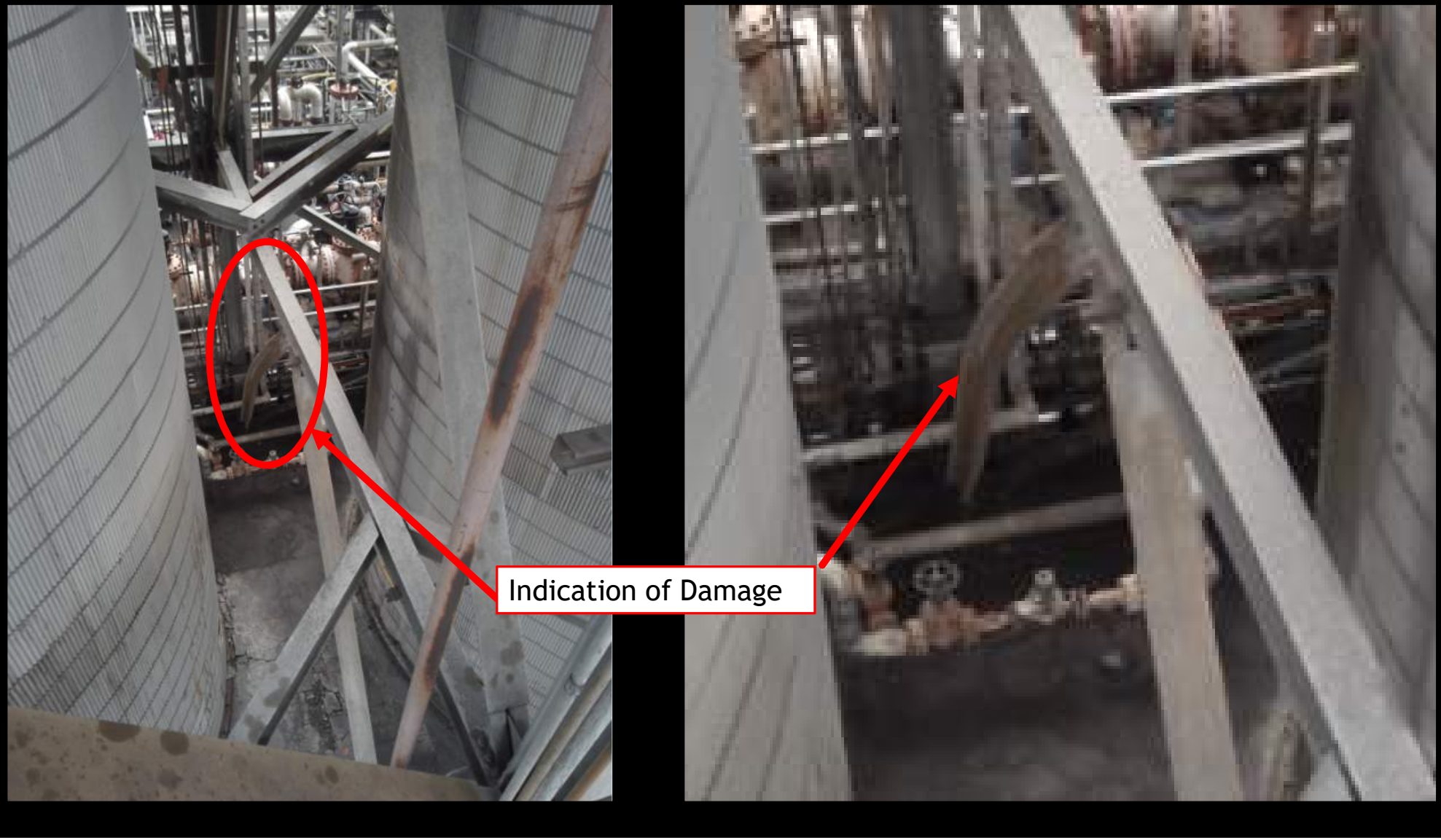

10/12/2018 11:30




0
1
0
Modified Tank? Foundation?


Modified and Loose
Tension Bracing

Damaged Supports


Indication of Damage


Obvious Damage

Inadequate Supports

Unique Supports (legs)

Suspect Bracing

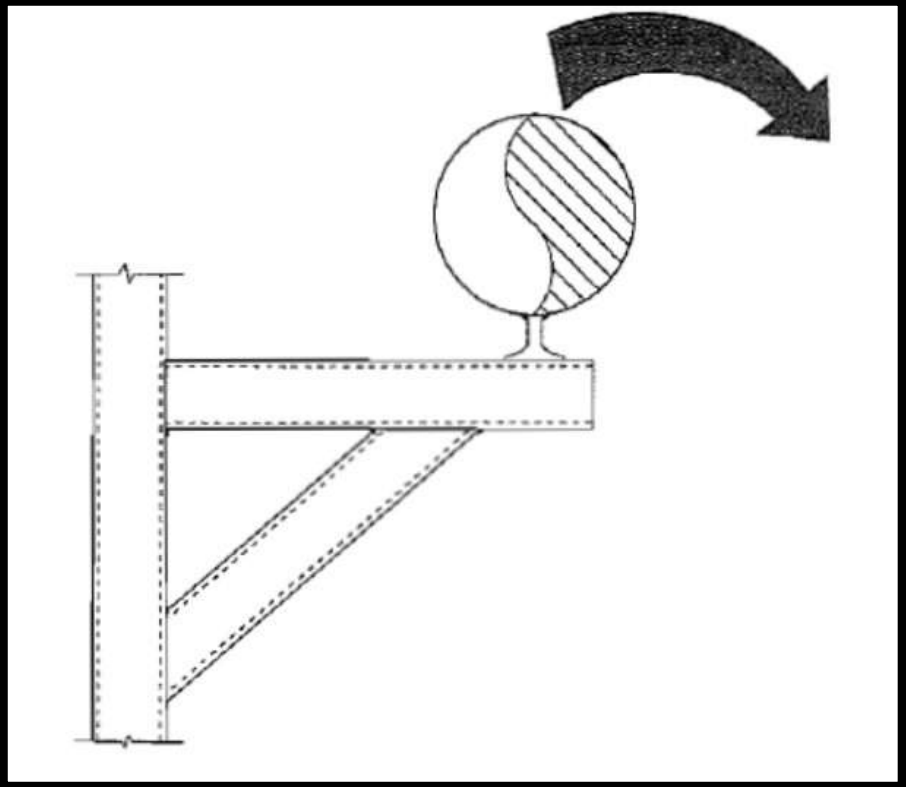
Expected Bracing

Visible Excessive Corrosion

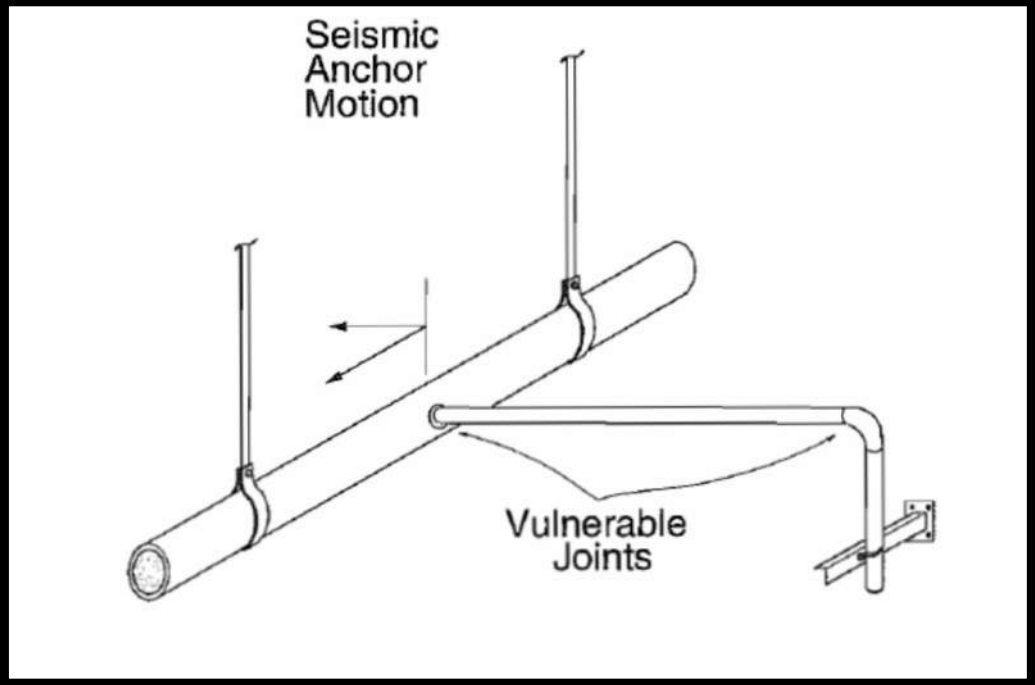
Walkdown Emphasis - Piping

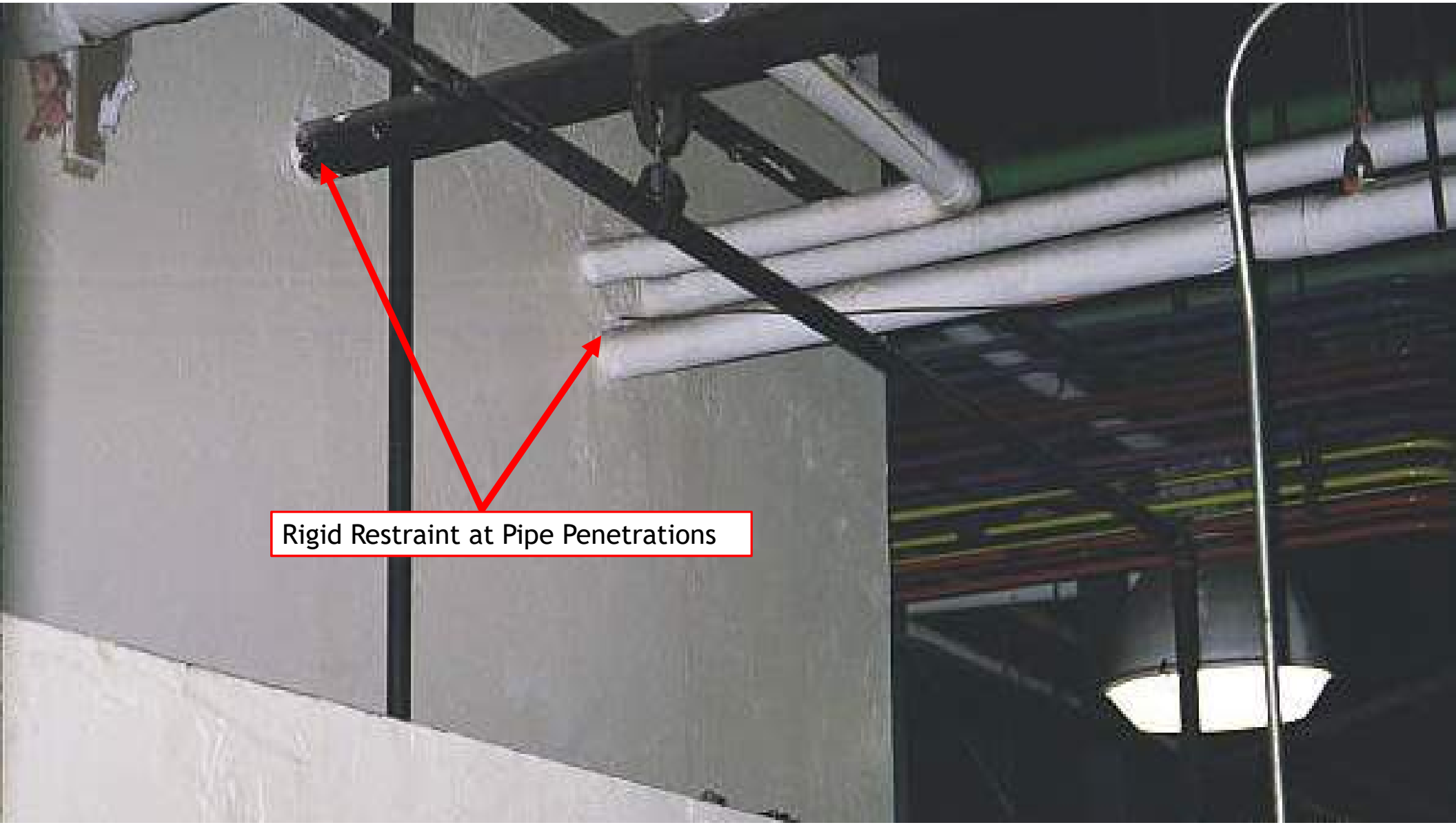
- Damage to pipe supports
- Inadequate supports
- Possibilities of excessive seismic anchor movement
- Visible excessive corrosion
- Condition of fittings
- Large unsupported spans
- Short rigid span

Inadequate Supports

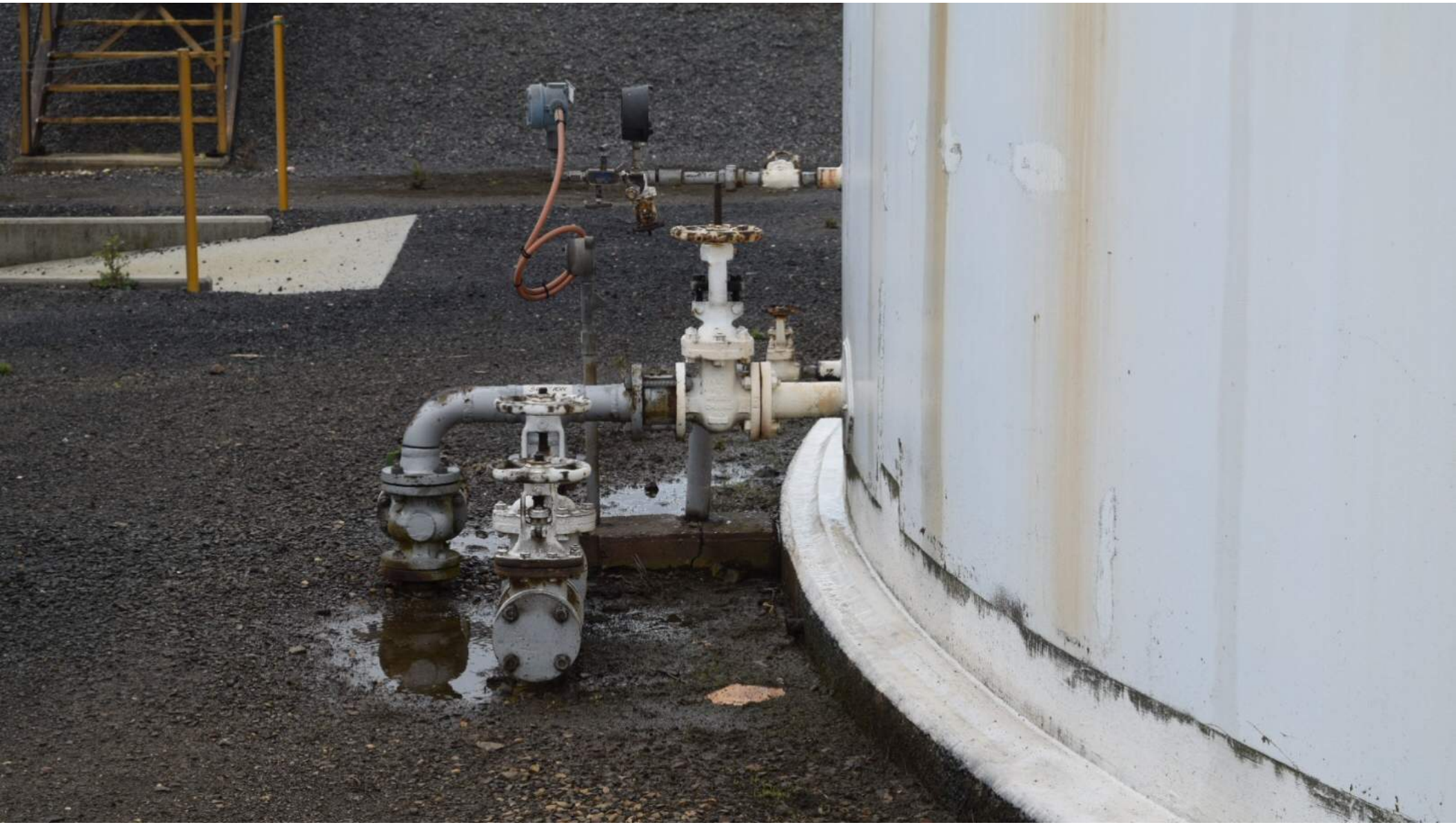


Possibilities of Excessive Seismic Anchor Movement



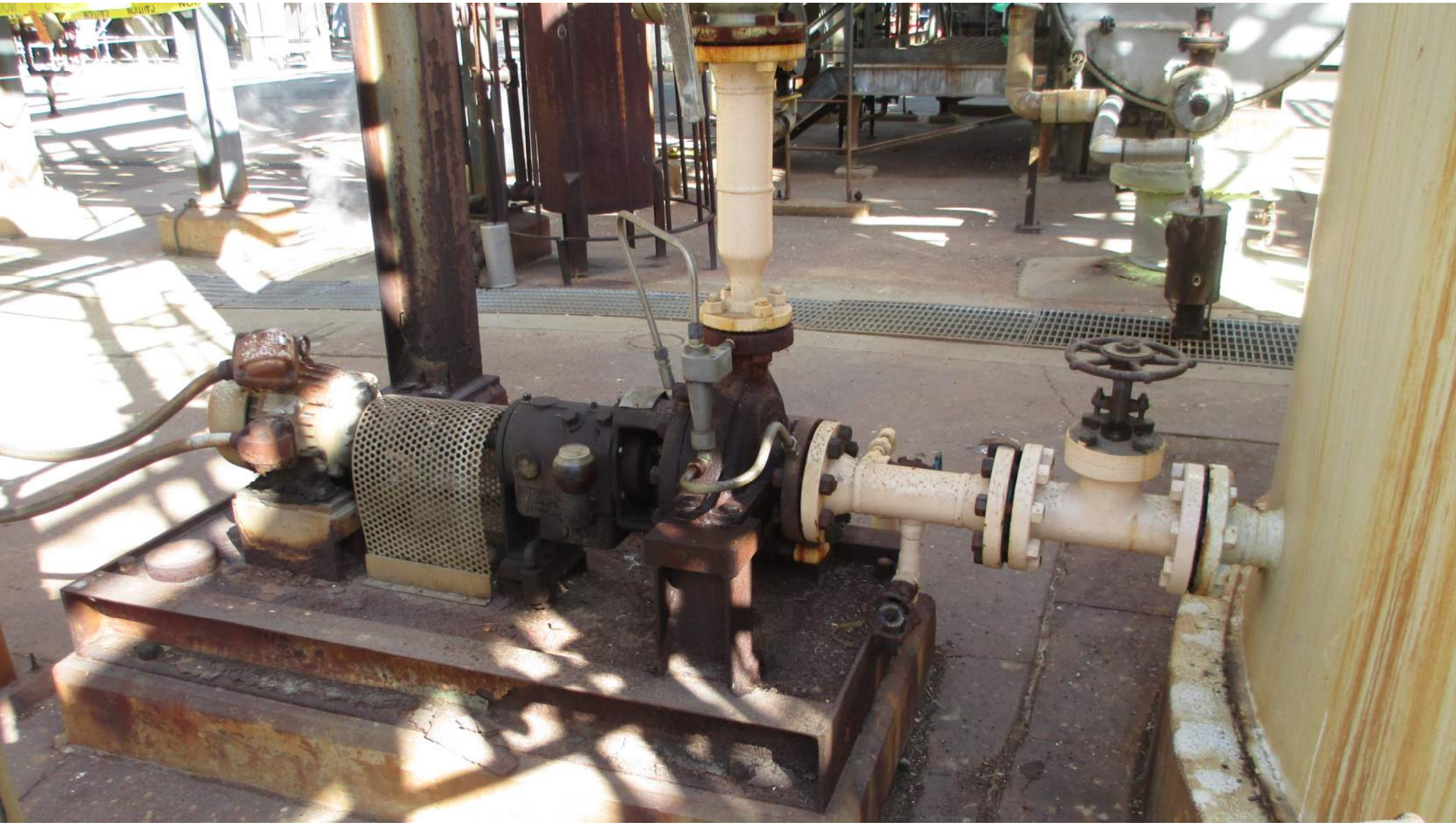

Rigid Restraint at Pipe Penetrations

Short Rigid Span



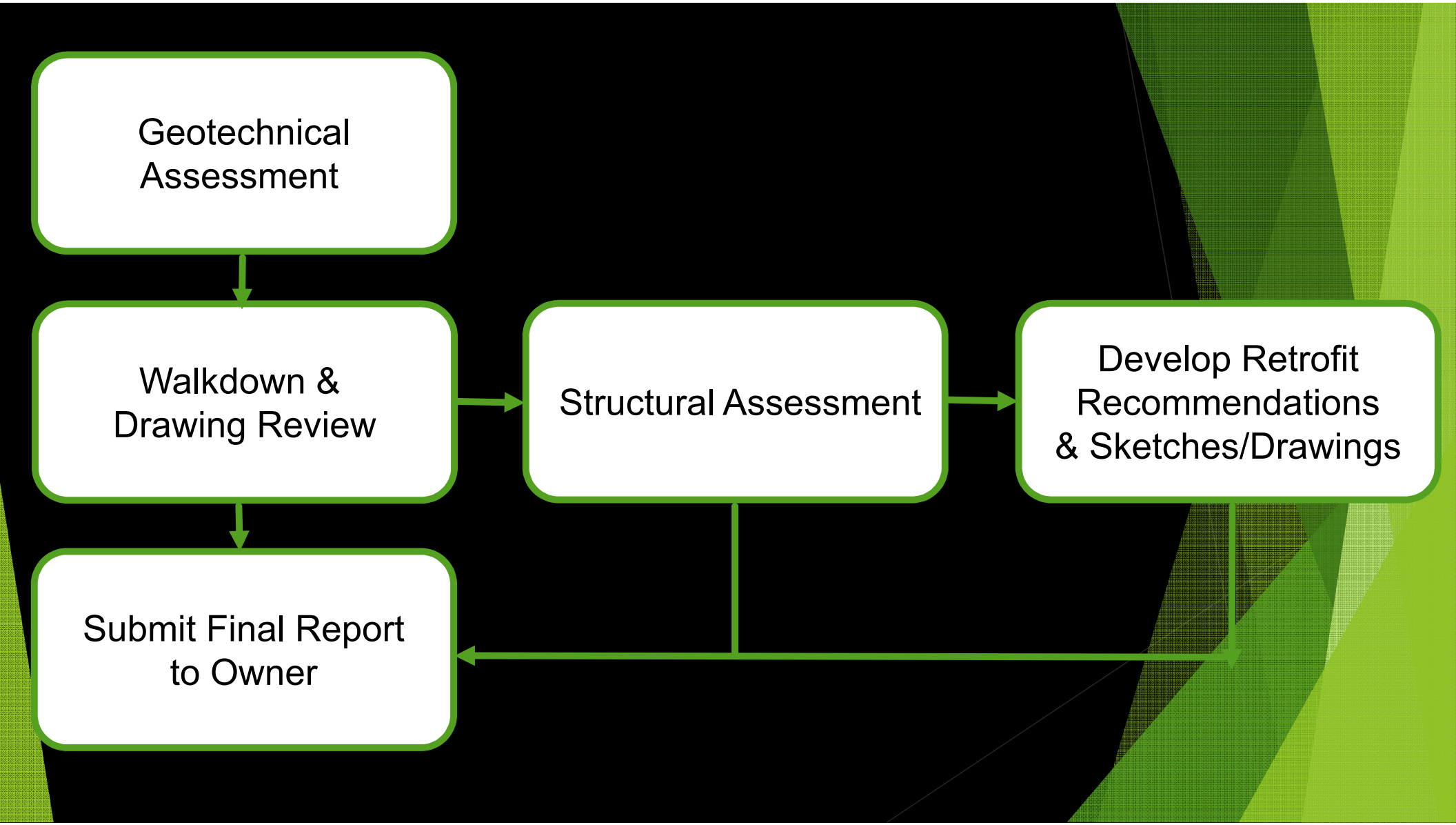
Flexible Pipe Connection, but Still Short

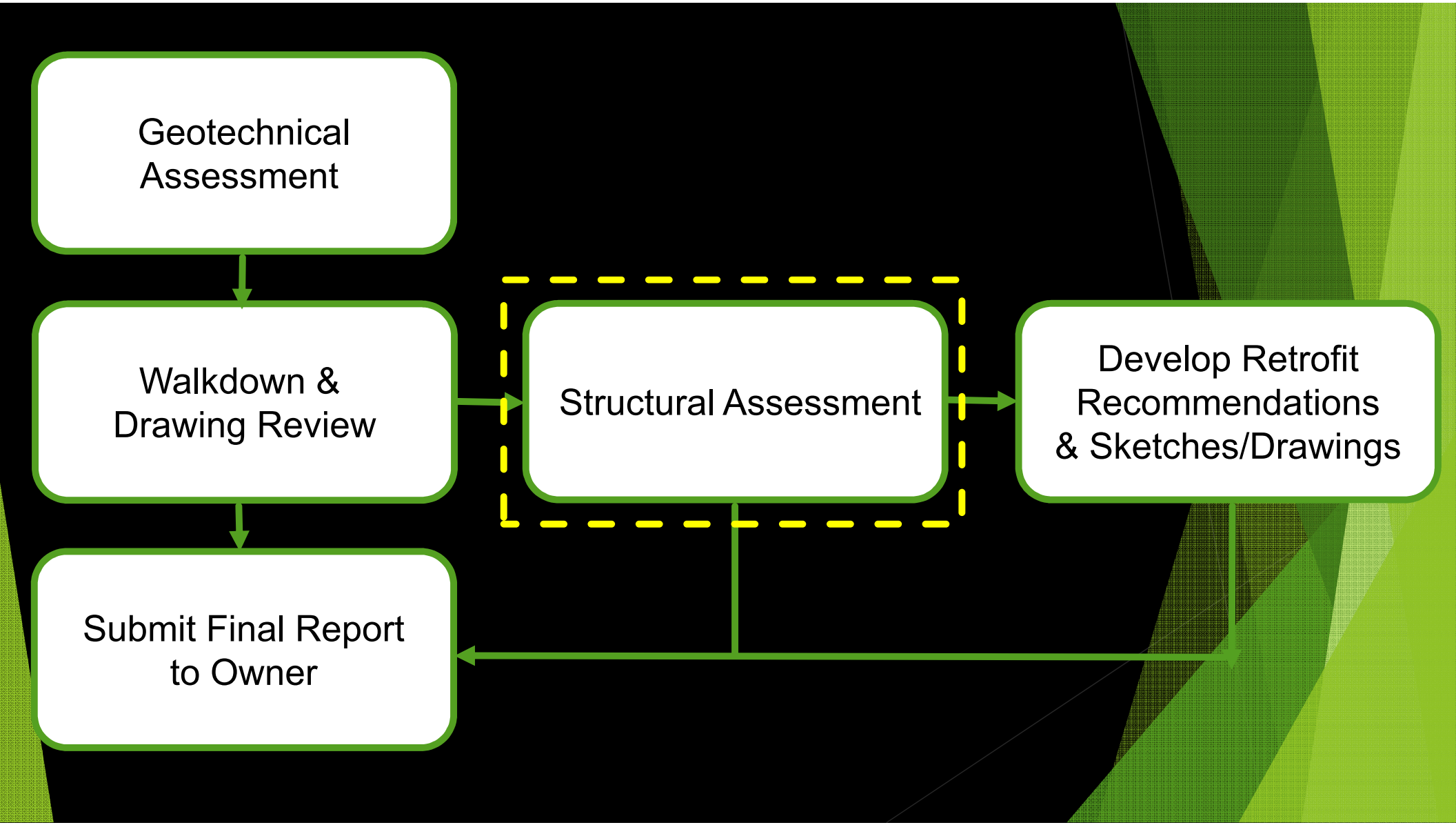
Connection with Flexible Joints




Indication of Potential Rigid Stair Attachment

Platform Modification and Resulting Rigid Attachment


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

Type of Assessments

Qualitative **Quantitative**

Walkdown Review

- Used to identify whether or not calculations are needed to complete evaluation and for what items
- Amount of calculations will depend on several factors, including experience of reviewer, size, age and condition of facility, type of construction, etc.
- Engineer may choose to evaluate several “bounding cases” or “questionable items” and use those as a basis for further assessments

Qualitative

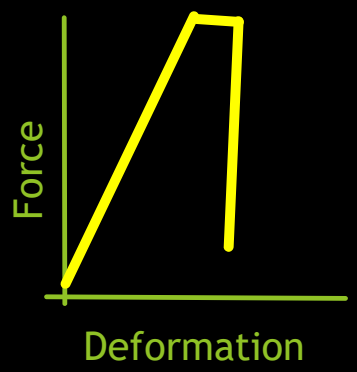
DEMAND*		CAPACITY BASED ON
$D + L \pm \frac{E_{horiz}}{Q} + E_{vert}$	$\leq$	ϕR_n
$D \pm \frac{E_{horiz}}{Q} - E_{vert}$	$\leq$	ϕR_n

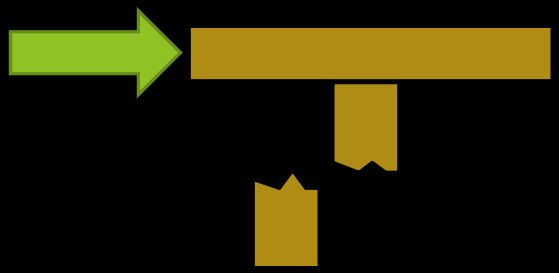
Qualitative

- "D" - Dead Loads
- "L" - Live loads
- "E_{horiz}" - unreduced horizontal earthquake load
- "E_{vert}" - vertical earthquake load
- "Q" - ductility based reduction factor
- "R_n" - nominal member strength
- "ΦR_n" - design member strength

Strength and Ductility

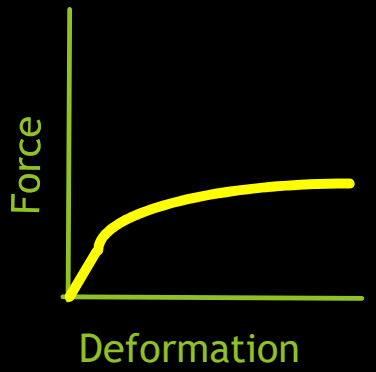
Q = 1

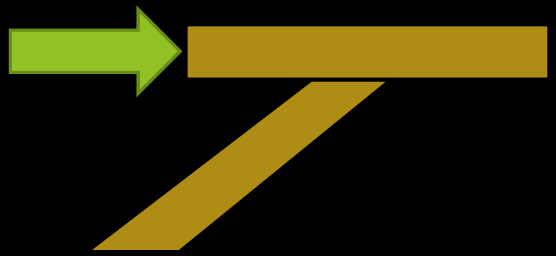




Analogy: Chalk

Q = 8





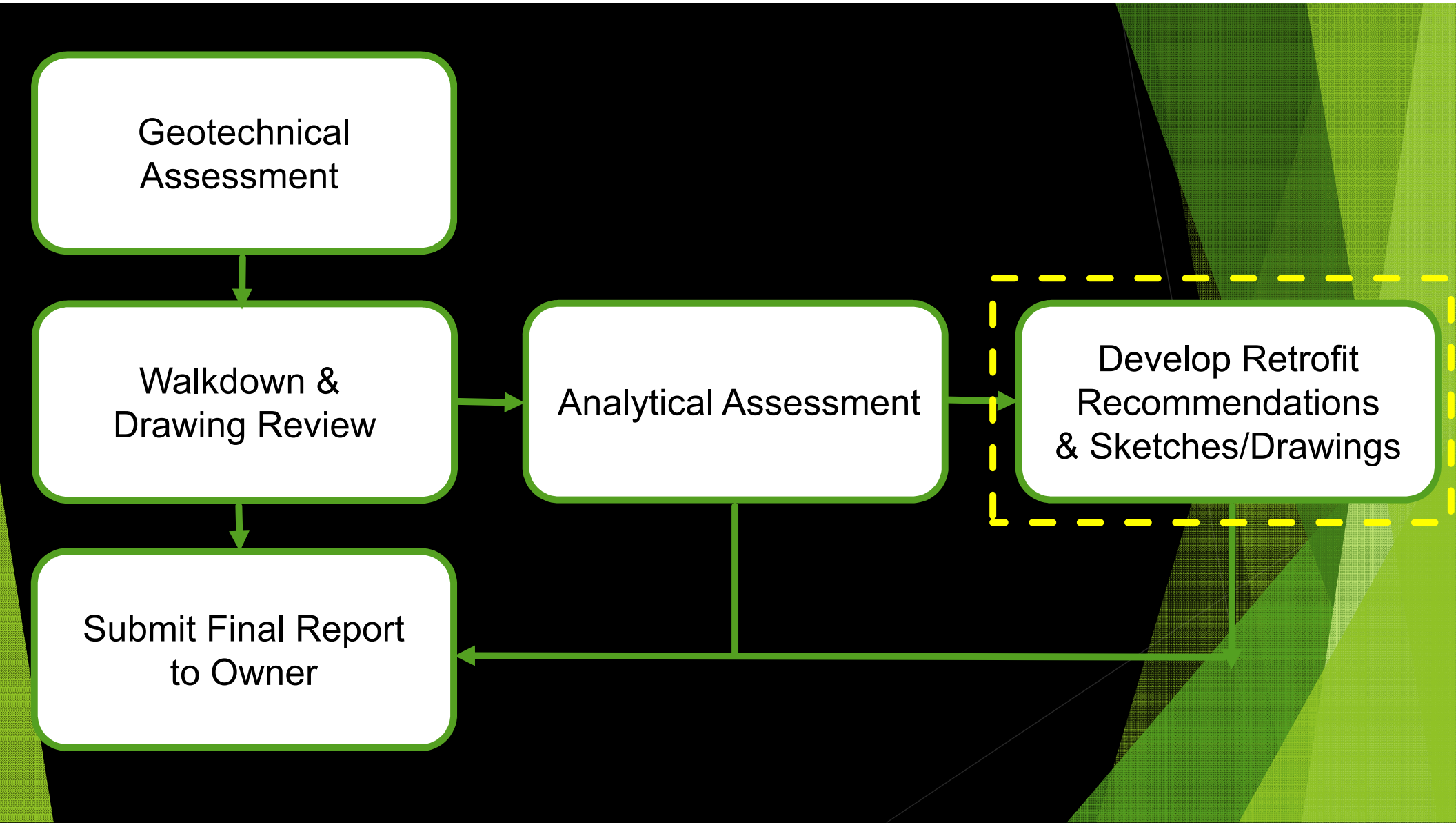
Rubber

Qualitative

Cantilever Pier/Column *(See Notes 3 and 7)* *A value of Q = 1.5 is usually indicative of a cantilever pier/column that has one or more of the following structural characteristics:* *a. There is visible deterioration of concrete or reinforcing steel in any of the elements, and this damage may lead to a brittle failure mode.* *b. Axial load demand represents more than 20% of the axial load capacity.* *A value of Q = 2.5 is usually indicative of a cantilever pier/column that has one or more of the following structural characteristics:* *c. The ties are not anchored into the member cores with hooks of 135° or more.* *d. Columns have ties spaced at greater than d/4 throughout their length. Piers have ties spaced at greater than d/2 throughout their length.* *e. Any pier/column bar lap splice is less than $35d_b$ long. Any pier/column bar lap splice is not enclosed by ties spaced at $8d_b$ or less.* *f. Development length for longitudinal bars is less than $24d_b$.* *g. Cantilever pier/column that does not satisfy the seismic design provisions of Section 2625 of the 1988 UBC or later* *h. Cantilever pier/column that has a natural period greater than 0.1 seconds in the direction being evaluated.* *A value of Q = 3.5 is usually indicative of a cantilever pier/column that satisfies the seismic design provisions of Section 2625 of the 1988 UBC or later.*	1.5, 2.5 or 3.5

Qualitative

Cantilever Pier/Column *(See Notes 3 and 7)* *A value of Q = 1.5 is usually indicative of a cantilever pier/column that has one or more of the following structural characteristics:* *a. There is visible deterioration of concrete or reinforcing steel in any of the elements, and this damage may lead to a brittle failure mode.* *b. Axial load demand represents more than 20% of the axial load capacity.* *A value of Q = 2.5 is usually indicative of a cantilever pier/column that has one or more of the following structural characteristics:* *c. The ties are not anchored into the member cores with hooks of 135° or more.* *d. Columns have ties spaced at greater than d/4 throughout their length. Piers have ties spaced at greater than d/2 throughout their length.* *e. Any pier/column bar lap splice is less than $35d_b$ long. Any pier/column bar lap splice is not enclosed by ties spaced at $8d_b$ or less.* *f. Development length for longitudinal bars is less than $24d_b$.* *g. Cantilever pier/column that does not satisfy the seismic design provisions of Section 2625 of the 1988 UBC or later* *h. Cantilever pier/column that has a natural period greater than 0.1 seconds in the direction being evaluated.* *A value of Q = 3.5 is usually indicative of a cantilever pier/column that satisfies the seismic design provisions of Section 2625 of the 1988 UBC or later.*	1.5, 2.5 or 3.5


Geotechnical Assessment
Walkdown & Drawing Review
Analytical Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

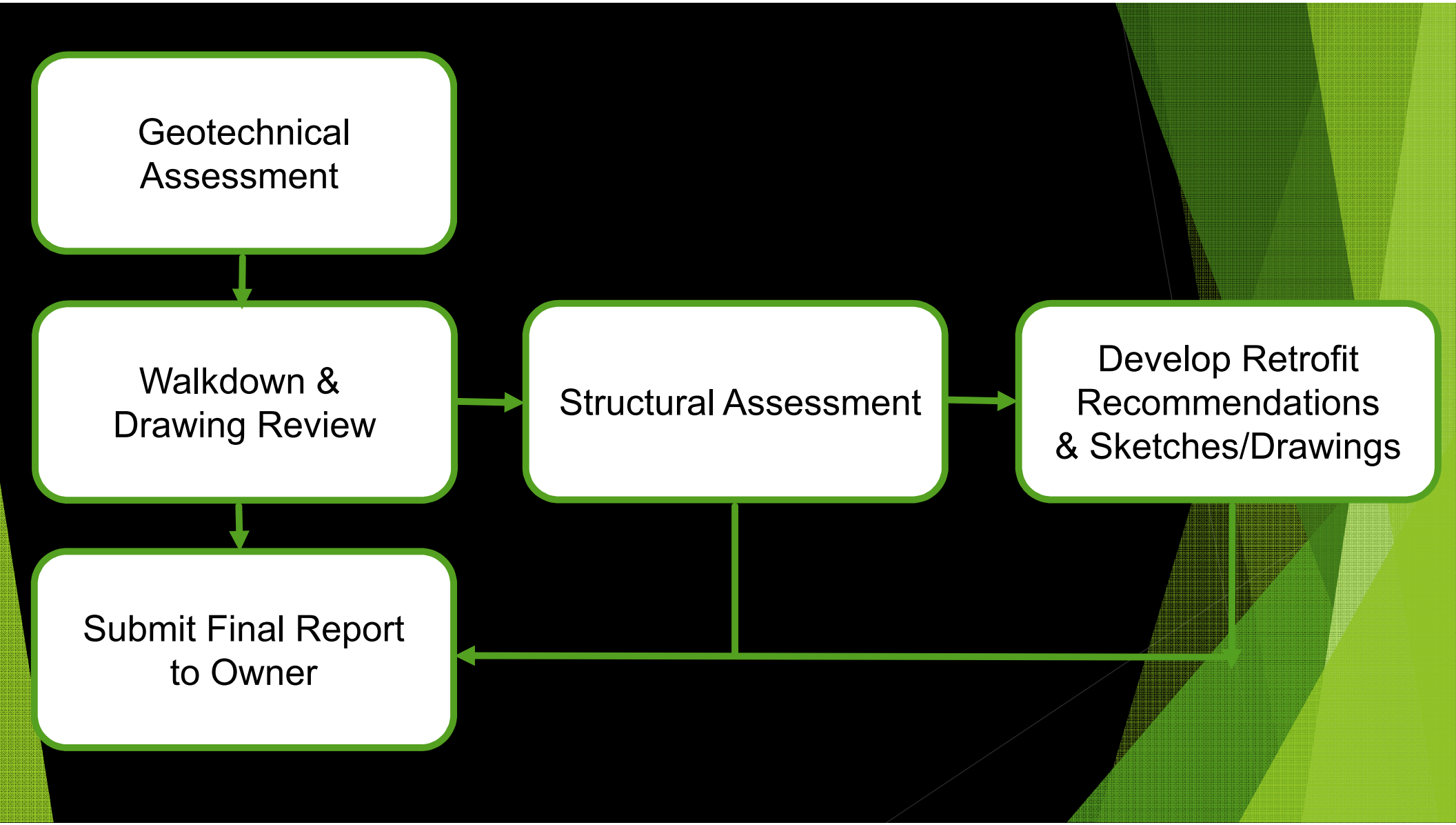

Inadequate Foundation - Before

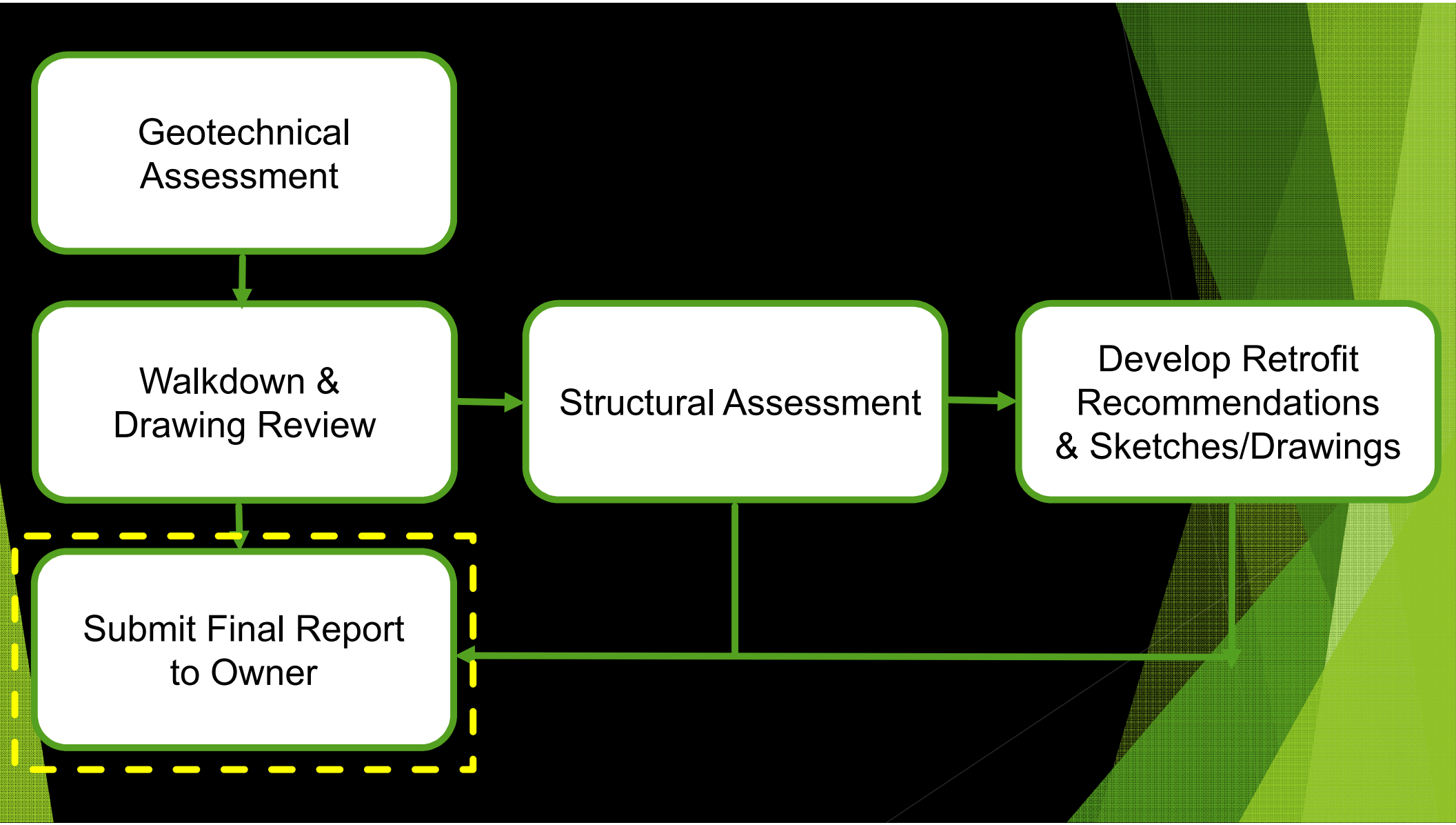
Strengthened Foundation - After


Retrofit Tank Anchorage
Not Maintained
Original Tank Anchorage
Highly Suspect


Evidence of that
Maintenance was
Performed

Retrofitted Slender Concrete Table Top


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner


Geotechnical Assessment
Walkdown & Drawing Review
Structural Assessment
Develop Retrofit Recommendations & Sketches/Drawings
Submit Final Report to Owner

Documentation / Report

- Engineer's Stamp
- Define hazards at site
- Reference prior report (if applicable)
- Walkdown summary
- Photographs
- Summary of findings/recommendations
- Supporting calculations

Walkdown Findings

Table 2
Walkdown Assessment Findings

No.	Item	Comments	Photos	Recommendations
53	**Sulfur Loading Rack**	• **Unbraced frame with 4 wide flange columns, approx. 10' tall** • **Reported in 2014 report that the outer column that supports the loading arm is dented near the bottom. This condition was repaired by strengthening the base** • **2014 report mentions corrosion on the south cross beam, especially at the east end, with delamination of the flange. This has been repaired by welding new plates, leaving the delaminated flange in place** • **2014 report mentions that the north-south beam, on the west side near the center also appeared to be corroding and delaminating. This has not been repaired**	**21-25**	**Repair the corrosion in the north-south beam**
54	P-5009	• Horizontal pump • Anchored		
55	TK-1110 Fresh 49 BE* Caustic	• Unanchored tank • 20' high x 15' diam. • Contains caustic, so no offsite consequences per 2014 report		
56	V-683	• Anchored vertical vessel		
57	**Spent Acid Rack**	• **4 column steel frame** • **Northeast corner column has the base of column corroded through and concrete is damaged** • **Northwest corner column is corroded and losing section** • **South columns have damaged concrete**	**26-33**	**Repair steel on northeast and northwest columns** **Repair concrete base at northeast column** **Repair concrete at south columns**
58	**V-836/837/838**	• **3 vessels end to end to create large vessel above E-972/973/974** • **Tall pier supports each end, 8" x 9' x 11'** • **Called out in 2010 report to further evaluate longitudinal capacity** • **Evaluation done as part of this study determined that supports do not have sufficient capacity for longitudinal loading. Retrofit required (see Sections 6.3 and 6.4)**	**34-35**	**Retrofit supports for longitudinal loading**

Walkdown Findings

Table 2
Walkdown Assessment Findings

No.	Item	Comments	Photos	Recommendations
53	**Sulfur Loading Rack**	• **Unbraced frame with 4 wide flange columns, approx. 10' tall** • **Reported in 2014 report that the outer column that supports the loading arm is dented near the bottom. This condition was repaired by strengthening the base** • **2014 report mentions corrosion on the south cross beam, especially at the east end, with delamination of the flange. This has been repaired by welding new plates, leaving the delaminated flange in place** • **2014 report mentions that the north-south beam, on the west side near the center also appeared to be corroding and delaminating. This has not been repaired**	**21-25**	**Repair the corrosion in the north-south beam**
54	P-5009	• Horizontal pump • Anchored		
55	TK-1110 Fresh 49 BE* Caustic	• Unanchored tank • 20' high x 15' diam. • Contains caustic, so no offsite consequences per 2014 report		
56	V-683	• Anchored vertical vessel		
57	**Spent Acid Rack**	• **4 column steel frame** • **Northeast corner column has the base of column corroded through and concrete is damaged** • **Northwest corner column is corroded and losing section** • **South columns have damaged concrete**	**26-33**	**Repair steel on northeast and northwest columns** **Repair concrete base at northeast column** **Repair concrete at south columns**
58	**V-836/837/838**	• **3 vessels end to end to create large vessel above E-972/973/974** • **Tall pier supports each end, 8" x 9' x 11'** • **Called out in 2010 report to further evaluate longitudinal capacity** • **Evaluation done as part of this study determined that supports do not have sufficient capacity for longitudinal loading. Retrofit required (see Sections 6.3 and 6.4)**	**34-35**	**Retrofit supports for longitudinal loading**

Walkdown Findings

54	P-5009	• Horizontal pump • Anchored		
58	**V-836/837/838**	• **3 vessels end to end to create large vessel above E-972/973/974** • **Tall pier supports each end, 8" x 9' x 11'** • **Called out in 2010 report to further evaluate longitudinal capacity** • **Evaluation done as part of this study determined that supports do not have sufficient capacity for longitudinal loading. Retrofit required (see Sections 6.3 and 6.4)**	**34-35**	**Retrofit supports for longitudinal loading**

Seismic Assessment/Report

Engineer's Stamp

Walkdown Checklist

Photographs

Summary of findings/recommendations

Seismic Assessment Deficiencies

- Lack of seismic assessment or report contents
- Lack of current walkdown
- Lack of seismic assessment on covered process components
- Failure to implement seismic recommendations
- Qualifications to conduct seismic assessment

Future

- Changing regulations
- Changing building codes
- Lessons learned from earthquakes and other natural disasters
- Improvements/comments to Guidance Document

Summary

Questions?

Thank you!

Presenters: Fariba Khaledan, SHMS
Fariba.khaledan@fire.lacounty.gov

Justin Reynolds, P.E.
Jdreynolds@sgh.com

Contributor: Curtis Yokoyama, S.E., P.E.
Curtis.yokoyama@fluor.com