Another action-packed adventure of Congress-Man
Worst-Superhero-Ever

What's this... A crack in the infrastructure dam?
THE CITY DOWNSTREAM IS IN PERIL!
LIVES ARE AT STAKE!!
TIME TO...
...TAKE ACTION!

UP, UP, AND FORM A COMMITTEE!
ANNUAL CONFERENCE
FLOODPLAIN MANAGEMENT ASSOCIATION
SEPTEMBER 3-6, 2019 | SHERATON HOTEL & MARINA – SAN DIEGO, CA

Knowledge is power!
Keeping the lights on floodplains, resilience planning and risk reduction
2019 annual conference
San Diego, California

RiverSmith ENGINEERING
Design and Construction Lessons for Bank Protection Projects in Sacramento Valley

Floodplain Management Association
2019 Annual Conference

Thomas W. Smith, PE, GE
STANDARD DESIGNS

THE CURRENT PRACTICE OF THE INDUSTRY HAS EVOLVED A LONG WAY FROM THE PAST STANDARDS

AND... AS IT SHOULD!
PRE-1950’s STANDARD

• THIN LAYER OF COBBLES PLACED ON A UNIFORMLY PREPARED BANK SLOPE USING A DRAGLINE

• NO TOE TRENCH
PRE-1950’s STANDARD
POST 1950’s TEMPLATE
POST 1950’s TEMPLATE
ESA PASSED IN 1973

Endangered Species Act  
40th Anniversary  
Protecting Imperiled Animals and Plants Since 1973
ESA PASSED IN 1973

AND...

THE USF&W SERVICE BECAME THE OFFICIAL SOURCE FOR BIOLOGICAL OPINIONS FOR CORPS ON BANK PROTECTION PROJECTS
IT WAS NOT EXACTLY A MARRAGE MADE IN HEAVEN!

ESA PASSED IN 1973
SLOW LEARNING CURVE

• VERY LITTLE BANK PROTECTION INSTALLED IN THE 1980’s AND 90’s

• LACK OF ABILITY TO “COMMUNICATE” ON THE NEED FOR ENVIRONMENTAL MITIGATION
ERA OF TRIALS

CORPS OF ENGINEERS
SECTION 32
DEMONSTRATION PROJECTS
(Late 1970’s AND 1980’s)
ERA OF TRIALS

LOOKING FOR ALTERNATIVES TO ROCK
ERA OF TRIALS

Photo 3. Board fencing
ERA OF TRIALS

Photo 13. Double-row wire fence with tiebacks
ERA OF TRIALS

Photo 11. Sand-cement bags with toe launching
ERA OF TRIALS

Photo 14. Timber pile groins
ERA OF TRIALS

Photo 9. Tire mattress
“FIRESTONE” ARMOR

1969

RiverSmith
ENGINEERING
“DETROIT” REVETMENT
“DETOIIT” REVETMENT
SEVERAL “EXPERIMENTAL” PROJECTS ON SAC RIVER

• PALISADES - SAC RIVER

• “GRECIAN COLUMNS” ANOTHER ON THE VANDUZEN RIVER
ERA OF TRIALS

• PALISADES AT WOODSON BRIDGE, SAC RIVER
ERA OF TRIALS

- PALISADES AT WOODSON BRIDGE, SAC RIVER
- FELL INTO DISREPAIR
- ACCOUNTED FOR ONE DROWNING
- REMOVED BY DWR
ERA OF TRIALS

“GRECIAN COLUMNS” PROJECT AT RM 179 SAC RIVER
ERA OF TRIALS

“GRECIAN COLUMNS” AT RM 179
ERA OF TRIALS

“GRECIAN COLUMNS” AT RM 179
ERA OF TRIALS

• THE GROINS WERE FLANKED LEAVING ONLY THE DEEPER-SEATED PILES OUT IN THE RIVER

• CORPS PAID FOR THE DEMOLITION
WHAT DID WE LEARN?

MANY OF THE TRIALS Didn’t PERFORM AS EXPECTED...

AND STONE ARMOR IS STILL A RELIABLE/COST EFFECTIVE, TECHNICAL ALTERNATIVE
EARLY SUCCESSES

LOWER AMERICAN RIVER EXAMPLES FROM EARLY 2000’s COMPROMISES THAT GAVE “EQUAL” VALUE TO PUBLIC SAFETY AND ENVIRONMENT VALUES
EARLY SUCCESSES
ANOTHER LULL...

AFTER THE LAR SUCCESS IT WAS STILL DIFFICULT TO GET ANY BANK PROTECTION DONE ESPECIALLY ON THE SACRAMENTO RIVER
ASCE LEVEE REPORT CARD

- Flood Control Capacity
- Maintenance
- Infrastructure at Risk
- Age of Facilities
- Master Plan
- Condition
- Preparedness
- Past Performance

2006 Report Card for Northern California

ASCE

Sacramento Section

RiverSmith
REPORT CARD RESULTS

**D** **UPPER SACRAMENTO RIVER**
This reach extends from Colusa to the upstream end of the flood control levees near Ord Bend. The levees are in need of some maintenance.

**D** **MIDDLE SACRAMENTO RIVER**
This reach is from Verona to Colusa. The levees are mostly close to the river and also need active maintenance.

**D** **METRO SACRAMENTO RIVER**
This area has a poor record for flooding but has an aggressive master plan to improve all levees.

**C** **AMERICAN RIVER**
The American River levees have had many recent upgrades including slurry walls and new bank protection and there is a strong plan to increase the level of protection to greater than the 100-year event.

**F** **SAN JOAQUIN RIVER/DELTA**
The Delta levees are old and continue to deteriorate. Their overall condition is such that even a "Sunny Day" failure has a high probability of causing damage.

**F** **CACHE CREEK**
The Cache Creek levees have a low level of protection and many erosion sites. There is no active master plan for upgrading.

For more information visit www.asce-sacto.org

2006 Report Card for Northern California Infrastructure Levee/Flood Protection

RiverSmith
ENGINEERING
February 24, 2006 – Governor Schwarzenegger declares a state of Emergency.

Initially identified 25 critical levee erosion sites for repair before the next flood season.
EMERGENCY REPAIRS

THIS EMERGENCY FORCED ALL OF US TO WORK TOGETHER...

AND WE DID!

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EMERGENCY REPAIRS

BETWEEN 2006 AND 2009 INVOLVED WITH APPROX 36 NEW BANK PROTECTION REPAIR SITES ON AMERICAN AND SAC RIVERS
EMERGENCY REPAIRS

- EMERGENCY PROJECTS
- TIGHT TIMELINES
- ALL WERE CUSTOM DESIGNS
- GOAL TO BE SELF MITIGATING
EMERGENCY REPAIRS

- NO STANDARD DESIGNS
- MANY NEW IDEAS EVOLVED
LESSONS LEARNED

THIS STUFF ISN’T IN THE BOOK!
LESSONS LEARNED

OUR GOAL IS TO MINIMIZE DISTURBANCE AND ARMOR WHICH MINIMIZES MITIGATION
LESSON 1 – CLEARING AND GRUBBING

CLEARING CAN BE LIMITED TO SHRUBS AND LIMBING

CONSIDER LEAVING ESTABLISHED TREES IN PLACE
LESSON 1 – CLEARING AND GRUBBING
LESSON 1 – CLEARING AND GRUBBING
LESSON 1 – CLEARING AND GRUBBING
LESSON 1 – CLEARING AND GRUBBING

GRUBBING IN MOST CASES IS NOT NECESSARY ON THE RIVERBANK (Maybe on levee)

LEAVING ROOTS INTACT HAS SOME BENEFIT AND MINIMIZES DISTURBANCE
LESSON 2 – FILTER AND BEDDING LAYERS

THESE TERMS HAVE BEEN USED INTERCHANGEABLE...

BUT HAVE DIFFERENT PURPOSES
LESSON 2 – FILTER AND BEDDING LAYERS

A FILTER IS NEEDED TO PREVENT PIPING OF SOIL PARTICLES FROM WITHIN THE RIVER BANK OR THE LEVEE EMBANKMENT THROUGH THE ARMOR LAYER
LESSON 2 – FILTER AND BEDDING LAYERS

A BEDDING IS NEEDED TO PREVENT EROSION OF UNDERLYING SOILS FROM THE FLOW VELOCITY WITHIN THE ROCK VOIDS
LESSON 2 – FILTER AND BEDDING LAYERS

NO BEDDING IS NEEDED WHEN THE VELOCITY WITHIN THE VOIDS IS LESS THAN 2 FPS
THERE IS A PROCEDURE FOR COMPUTING FLOW VELOCITY WITHIN THE ROCK VOIDS

\[ V_i = 0.23 (gD_{10}S)^{1/2} \]
THIN ROCK SECTIONS MIGHT REQUIRE A BEDDING
THICK ROCK SECTIONS, PROBABLY NOT
USE OF FABRICS UNDER LOOSE ROCK ARMOR IS PROBLEMATIC!

- INHIBITS RE-GROWTH
- BUILT IN SLIP PLANE
MINIMIZE THE HEIGHT OF ARMOR PROTECTION TO MINIMIZE ENVIRONMENTAL IMPACTS
LESSON 3 – HEIGHT OF ROCK ARMOR

ONLY ARMOR AS HIGH AS THERE IS A POTENTIAL FOR EROSION
LESSON 3 – HEIGHT OF ROCK ARMOR
LESSON 3 – HEIGHT OF ROCK ARMOR

NEED TO UNDERSTAND MECHANISMS OF FAILURE AND ONLY ARMOR TO ADDRESS THAT NEED
LESSON 3 – HEIGHT OF ROCK ARMOR

2-D MODEL BEST TOOL

ONLY ARMOR WHERE VELOCITY EXCEEDS ALLOWABLE
LESSON 3 – HEIGHT OF ROCK ARMOR

SLOPE STABILITY MODEL NEED IF SLOPE FAILURE IS THE ISSUE

USE ROCK TO BUTTRESS THE LOWER SLOPE
LESSON 4 – BERM OR TOE TRENCH

NEED TO UNDERSTAND MECHANISMS OF SCOUR AND BED MOBILIZATION
LESSON 4 – BERM OR TOE TRENCH

IF LOSS OF HYDRAULIC CAPACITY DOESN’T ALLOW FOR THE ENCROACHMENT OF A BERM, TOE TRENCH MAY BE NECESSARY
LESSON 4 – BERM OR TOE TRENCH

A LOW BERM CAN PROVIDE A ROCK RESERVOIR FOR SCOUR AND DOWNCUTTING AS WELL AS PLANTING SURFACE CLOSE TO THE LOW FLOW WATER ELEVATION
LESSON 4 – BERM OR TOE TRENCH

LOWER AMERICAN RIVER
LESSON 4 – BERM OR TOE TRENCH

CAN BE CONSTRUCTED FIRST AND SERVE AS CONSTRUCTION ACCESS LESS UPPER SLOPE DISTURBANCE
LESSON 5 – BERM DIVERSITY

• VARY ELEVATION
• UNDULATING EDGE
• UNDULATING SURFACE
• WATER FEATURES/DITCHES
LESSON 6 – PLANTING TRENCH ON BERMS

SOIL FILLED PLANTING TRENCH ON BERMS FIRST SUCCESSFULLY USED ON LOWER AMERICAN RIVER – SITES 1 THRU 5
LESSON 7 – WOODY DEBRIS FEATURES

- NEW WOOD LASTS LONGER
- SUBMERGED WOOD LASTS EVEN LONGER
LESSON 7 – WOODY DEBRIS

- BEAVERS PREFER FRESH WOOD w/BARK ON
- FISHERMEN PREFER THE SMALLER DRY BRANCHES FOR USE AS FIREWOOD
LESSON 7 – WOODY DEBRIS

• THERE ARE SAFETY ISSUES WHERE THERE IS HEAVY RECREATION USAGE

• ANGLE DOWNSTREAM
LESSON 7 – WOODY DEBRIS

• NO DOCUMENTED SAFETY INCIDENTS

• NEED TO BE PROTECTIVE OF RIVER REC. USERS
LESSON 8– SOIL FILLED ROCK ARMOR

SOIL FILLED ROCK ARMOR CAN PROVIDE ADDITIONAL PLANTING MEDIUM FOR GRASSES, SHRUBS AND VINES
THE MAJOR CONCERN IS GET PROPER MIXING AND NOT TOO MUCH SOIL. NEED TO MAINTAIN ROCK TO ROCK CONTACT, USUALLY 30% SOIL MAX.
LESSON 8 – SOIL FILLED ROCK ARMOR

SOIL NEAR THE SURFACE WILL ERODE TO ABOUT ONE HALF OF THE SURFACE ROCK GRAIN SIZE
LESSON 9 – SOIL ON TOP OF ROCK ARMOR

• SOIL SPREAD ON TOP OF THE ARMOR HAS HAD VERY LIMITED SUCCESS

• SOME MAY MIGRATE INTO THE VOIDS AND PROVIDE A MEDIUM FOR FUTURE PLANTINGS
LESSON 10 – SAND BEACH ON TOE ROCK

SOME SUCCESS AT SEVERAL SAC RIVER SITES WITHIN TIDAL ZONE
LESSON 10 – SAND BEACH ON TOE ROCK

- USED AS AN IN-FILL W/IN TOE ROCK IN THE TIDAL ZONE
- WORKS BEST WHERE THERE IS BEDLOAD FOR REPLACEMENT
LESSON 11 - ROCK COLOR

- CHEAPEST ROCK IS FROM IONE AREA AND IS A GREENISH COLOR
- NOT A GOOD GEOLOGIC MATCH FOR CENTRAL VALLEY RIVERS
LESSON 12 – SETBACK

LEVEES

- NEED AFFORDABLE R/W
- DO FLOODPLAIN LOWERING
LESSON 12 – SETBACK LEVEE AT RM 57.2R
LESSON 12 – SETBACK LEVEES

ADVANTAGES:

MUCH LESS RIVERBANK AND IN-RIVER DISTURBANCES...

LESS REQUIRED MITIGATION
LESSON 12 – SETBACK LEVEES

ADVANTAGES:

OPPORTUNITY TO RECAPTURE FLOODPLAIN
LESSON 12 – SETBACK LEVEES

**DISADVANTAGES:**

- **UNWILLING SELLERS** ... **USUALLY REQUIRES CONDEMNATION**
- **$$$$’s**
LESSON 13 - CONTRACTING

SEPARATE HARD FEATURES FROM VEGETATION MAINTENANCE CONTRACT
LESSON 13 - CONTRACTING

PHASE THE CONSTRUCTION OVER 2 SEASONS IF A LATE START
Sacramento River, RM 62.5R

SACRAMENTO RM 62.5 R CONCEPTUAL CROSS SECTION

RiverSmith ENGINEERING
Sacramento River, RM 62.5R

Phase 1
Sacramento River, RM 62.5R

Seasoned Site After Phase 2

RiverSmith ENGINEERING
LESSON 13 - CONTRACTING

CORPS PROCESS OF "CONTRACTOR SELF INSPECT" HAS BEEN PROBLEMATIC
“LEARN” HOW THE CONTRACTOR ACTUALLY BUILDS THE JOB...
LESSON 14 – RIGHT OF WAY

- STILL A TRADITIONAL HOLD-UP

- START EARLY WITH PROJECT FOOTPRINT AND ACCESS NEEDS
CONCLUSIONS

• DON’T RELY ON “STANDARD” DESIGNS

• EVERY PROJECT IS A CUSTOM DESIGN
CONCLUSIONS

- DESIGN TO THE SPECIFIC NEEDS OF EACH SITE
- ONE SIZE DOES NOT FIT ALL
- KEEP LEARNING FROM THE PAST DESIGNS
THANK YOU

QUESTIONS

AND

COMMENTS?
LESSON 6 – PLANTING TRENCH ON BERMS

- TRENCH DEPTH TO LOW SUMMER WATER LEVEL
- MAX. CAPILLARY RISE ABOUT 3 FT. FOR SILTY SOILS
LESSON 9 – SOIL ON TOP OF ROCK ARMOR
LESSON 10 – SAND BEACH ON TOE ROCK

- THE EXCAVATED TOE TRENCH MATERIALS COULD BE RELOCATED THE SURFACE OF TOE TRENCH TO MATCH EXISTING GRADE
ERA OF TRIALS
ERA OF TRIALS

“GRECIAN COLUMNS”
AT RM 179

SKETCH OF PLAN
LESSON 2 – FILTER AND BEDDING LAYERS

Groundwater table

Seepage flow

Normal water level

Flood water level

a) Normal (baseflow) conditions

Seepage flow

b) During flood peak

Elevated groundwater after flood

Area of high seepage gradients and uplift pressure

Seepage flow

c) After flood recession
LESSON 2 – FILTER AND BEDDING LAYERS

IF INTERNAL EROSION IS NOT EVIDENT OR PART OF THE PROBLEM AT THE SITE, NO FILTER IS NEEDED
LESSON 2 – FILTER AND BEDDING LAYERS

BEDDING IS MUCH CHEAPER THAN FILTER AND EASIER TO PLACE
LESSON 4 – BERM OR TOE TRENCH
LESSON 4 – BERM OR TOE TRENCH
LESSON 6 – PLANTING TRENCH ON BERMS

EXCAVATED ROCK FROM TRENCH WAS USED ON UPPER SLOPE. MINIMIZING UPPER BANK DISTURBANCE
LESSON 7 – WOODY DEBRIS

WOOD ANCHOR DETAIL

MAKE 3 INCH SLIT IN COIR FABRIC TO THREAD CHAIN THROUGH FABRIC DURING CONSTRUCTION. TEMPORARY BOUY MAY BE USED TO SUPPORT CHAINS DURING PLACEMENT.

2 LAYERS COIR FABRIC AS PER SPEC 02080 STONE PROTECTION

BURIED ANCHOR BLOCKS AND CHAINS (SEE DETAIL 2 THIS SHEET)

BRUSH BUNDLE (SEE DETAIL 3 THIS SHEET)
LESSON 7 – WOODY DEBRIS

• BEST IF IT CAN ACT AS RECRUITMENT FOR NEW WOOD
LESSON 9 – SOIL ON TOP OF ROCK ARMOR
LESSON 9 – SOIL ON TOP OF ROCK ARMOR
LESSON 4 – BERM OR TOE TRENCH

BERM CAN ALSO SERVE AS A STABILITY FEATURE IF SLOPE FAILURE IS AN ISSUE
LESSON 6 – PLANTING TRENCH ON BERMS

AT SOIL/ROCK INTERFACE
USE A DOUBLE LAYER OF “TOUGH” GEOTEXTILE FABRIC

MIGHT COUNT AS “SOFT BANK”
• DEEP EMBAYMENTS CAN BE A HAVEN FOR PREDATORS
LESSON 12 – SETBACK LEVEE AT RM 57.2R
SURFACE PROTECTION CAN BE FABRICS SINCE THE NEED IS TEMPORARY

MATURE PLANTINGS WILL PROTECT SOIL SURFACE IN THE LONG RUN
LESSON 12 – SETBACK LEVEE AT RM 57.2R

OFFSET INTERSECTING CROSS SECTIONS G-G' THROUGH H-H'

CROSS SECTION G-G'

CROSS SECTION H-H'

CROSS SECTION I-I'

NOTES:
1. FOR THE EXACT LOCATION OF THESE CROSS SECTIONS SEE SHEET C-381.
2. LINES SHOWN ON CROSS SECTIONS DO NOT ACCURATELY REPRESENT THE LOCATION OF SETBACK LEVEE TO REMAIN IN PLACE.