Peter C. Wiisman, MSC

Peter Wijsman is a Water Resources Consultant, NWP and ARCADIS. Mr. Wiisman's focus is water resource planning and knowledge transfer of delta technology between the Netherlands and the United States. He contributes to the adaptation strategy for climate change for the Dutch government and holds a strategic position at the NWP Netherlands Water Partnership. Peter organized several successful missions of the Dutch water sector to California. His key ability is to serve as a liaison between private and governmental partnerships and the Dutch – U.S. markets. Peter obtained his master's degree from Wageningen University & Research Centre (WUR) in International Land and Water Management. He studied the transferable volume of water from specific areas in the San Joaquin Valley at the University of Davis.

Appendix B: Who Pays for the Damages?

Who Pays?[1]

The strongest doors and best building materials won't protect a home from invading floodwaters. As much as people try to make their home safe and secure, even a small flood can cost thousands of dollars in cleanup, replacement, and repair costs. And who will pay for the damages? Generally, people pay for the reconstruction of their flood-damaged property in three ways:

1. *Self-Help.* Rebuilding on their own by using savings, borrowed money, assistance from national and local charities, and the help of friends and neighbors, was once common throughout the United States. Today, it survives in many parts of the country for such communal situations as helping a neighbor rebuild a barn destroyed by lightning.

2. *Insurance.* Casualty insurance can provide an excellent and efficient mechanism for recovery, whether the insurance is purchased by the damaged party or made available through special legislation. Examples of legislative-established insurance coverage include Workers Compensation Insurance, whereby the state requires employers to pay premiums to make such insurance available to workers injured on the job. State and Federal Disaster Relief Grants are another form of special legislation established to provide social insurance for disaster victims.

3. *Litigation.* Beyond self-help and insurance, litigation is the only remaining alternative for recovery when a person suffers damage. Successful litigation requires demonstrating that a person, corporation, or agency caused, or somehow is legally culpable for the damage that has taken place.

Sometimes the recovery mechanisms can be linked together. For example, Small Business Disaster Loans are a combination of self-help (via loans) and insurance (via special legislation that both authorizes and subsidizes the loan).

Each of these three mechanisms is characterized by distinct advantages and disadvantages, as well as widely-varying degrees of efficiency and practical effectiveness that vary depending on their application to a particular circumstance.

Self-help worked well in the past and continues to work well for widely-scattered serious loss. For optimal use of this mechanism, the community must be tightly knit and committed to helping each other in times of difficulty. This form of recovery cannot work well if most of the self-helpers are themselves suffering damage. Thus, while this form of assistance can be highly efficient, it will not work when virtually the entire community is damaged.

Insurance can be an extremely efficient mechanism for distributing funds, provided the individuals damaged purchase a sufficient amount of such insurance or have been provided such insurance by operation of law. The downside of insurance is that a person must generally purchase a policy prior to damage. Experience has shown that people will generally not purchase insurance for infrequent events such as floods without government requiring such

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[1] For a more complete discussion of the complex process of funding post- disaster rebuilding, see E.A. Thomas, *Post Disaster Reconstruction: "The Patchwork Quilt" A Creative Strategy for Safe Post-Disaster Rebuilding,* (June 2007), available at http://www.floods.org/PDF/Post_Disaster_Reconstruction_Patchwork_Quilt_ET.pdf

insurance.[2] Even when government acts to require insurance, compliance is an issue.[3]

Litigation, meanwhile, is inefficient. It can take many years and has huge costs that do not go to the damaged party but instead to attorneys, courts, expert witnesses, court recorders, and others. Litigation is also uncertain. The damaged party may not be able to find a culpable entity. Sometimes our system of justice is not quite perfect. And in other cases a deserving, damaged plaintiff will not recover because the defendant has "deep pockets"—the ability to hire clever expert witnesses and/or attorneys. Litigation is also problematic for economically disadvantaged victims who may have difficulty obtaining counsel.

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[2] See "*Flood Insurance Helps Manage Risk of Financial Loss,*" Federal Reserve Bank of Minneapolis, Community Dividend, Fall/Winter 1997 at http://www.minneapolisfed.org/pubs/cd/97f-w/flood-ins.cfm

[3] See e.g. Testimony of J. Robert Hunter, before the Senate Committee on Banking, Housing and Urban Affairs, Regarding Oversight of the National Flood Insurance Program, October 18, 2005. found at: http://www.consumerfed.org/pdfs/Flood_Insurance_Senate_oversight_testimony_101805.pdf

Appendix C: Comprehensive Planning Factors

- The highest level of sustainable protection should be planned for those areas where the potential consequences of flooding are the greatest (areas where the product of flooding probability and consequences are high); and those plans should address the interrelationships among the various elements of existing and proposed flood damage reduction efforts.
- Plans should allow for failure sections of the levee for when design flows are exceeded—some types of agriculture can be compatible with periodic flooding, which has implications for accidental or intentional inundation of agricultural land as a safety valve for developed areas. These failure scenarios would be incorporated into community development and the community's Emergency Action Plans.
- In less populated areas, economically- and environmentally-justified, lower-level flood protection should protect against less severe floods and steps should be taken to minimize the damages and mitigate the impacts from larger floods.
- Once the state has identified those areas where there is dangerous flooding and a probability of failure, but where there are few people and little property, the state and local governments must also plan to limit new development in those areas so that the risk is not increased (by increasing the consequences).
- Plans should account for critical infrastructure locations (keeping them out of high-risk areas) and construction techniques for critical facilities that limit flood damage.
- Comprehensive planning for flood damage reduction should be integrated with basin-scale planning for ecosystem restoration.
- Plans should consider all methods of flood damage reduction including revaluation of the operation of existing infrastructure.
- There must be reasonable rewards and penalties if comprehensive, basin-wide plans are to be completed and implemented on the local and regional level. For instance, if a regional land-use plan were to evolve that adequately considered flood risk, the state might increase funding to cost-sharing mitigation or disaster relief efforts, or fund some of the infrastructure elements that would encourage growth in the agreed-upon growth zones. Likewise, appropriate penalties should apply for plans that are not adopted or implemented. In Florida, the state withholds a percentage of funding to municipalities that do not adopt required plans.
- Plans should have provisions for pre-development risk assessments prior to permit issuance that would ensure that the development community more fully shares the actual cost of developing deep floodplains, both for mitigation and future disaster costs.
- Flood-safe land use regulations and building codes must also be implemented. Plans should include regulations or policies for limiting future hazardous development in deep floodplains. In some areas, this may lead to re-zoning and revisions to building codes to provide for more flood-resistant structures, more appropriate building locations, or more open space (no-build zones). For instance, multistory, multi-unit residential structures with the lower one or two stories used solely for parking, in conjunction with planned Emergency Action Plans could be favored over new, single

family developments. The State of California must insist that communities bring about these kinds of changes and provide them with the information and other resources necessary to do so if long-lasting flood awareness and risk reduction is to be achieved.

- For current development and structures that have already been placed in harm's way, emergency plans to protect life, safety, and long-term building and land-use plans should be addressed. This includes long-term post disaster planning, in addition to the replacement of buildings in a non-disaster context (i.e., similar to the National Flood Insurance Program's substantial improvement regulations).
- Planning for flood risk reduction should require future commitment to adequate budgets for inspection, maintenance, etc. of levees before they are authorized.
- Levee setbacks can reduce risk of structural failure because the levees are less frequently exposed to high-velocity flows and the setbacks reduce water levels and the resultant hydraulic loading on the levees. Properly constructed setback levees will be more sustainable over time.

Appendix D: The Natural and Beneficial Functions of Central Valley Floodplains

Floodplains provide numerous natural and beneficial functions, ranging from supporting endangered species to storing and conveying floodwaters. Infrastructure for flood and other water management has dramatically reduced the extent—and degraded much of the functionality—of the Central Valley's floodplains, contributing to the decline of numerous species in the Central Valley's rivers and riparian forests as well as in the downstream Sacramento-San Joaquin Delta. State and federal agencies have numerous policies and programs dedicated to reversing these declines. This Appendix briefly reviews the natural and beneficial functions of Central Valley floodplains and describes how floodplain restoration can be consistent with flood-damage reduction objectives. Multipurpose projects that integrate restoration with flood-damage reduction can simultaneously accomplish numerous significant objectives for the state, including reducing flood risks and promoting the recovery of important ecosystems and species.

Naturally-functioning floodplains support high levels of biodiversity and are among the most productive ecosystems in the world. They provide a range of ecosystem services to humans, including storage and conveyance of floodwaters, groundwater recharge, open space, recreational opportunities, and habitat for a diversity of species, many of them of economic importance. Among the world's ecosystem types, Costanza et al[4] ranked floodplains second only to estuaries in terms of the ecosystem services provided to society, with floodwater storage having the greatest relative value. In the Central Valley, the most important ecosystem services provided by floodplains include flood risk reduction and habitat for numerous species, including commercially- and recreationally-valuable species (e.g., chinook salmon and waterfowl) and for endangered species.

Floodplains that can provide significant beneficial functions possess three characteristics: (1) hydrologic connectivity with the river; (2) capacity to interact with a range of river flows; and (3) sufficient geographic extent for the beneficial functions to be measurable and meaningful. Various river flows have significance for floodplain ecosystems. For example, long duration Spring flooding is associated with food-web productivity and high-quality fish habitat, while geomorphically active flows create diverse topographic features that support riparian forest regeneration and associated high levels of biodiversity. Both types of flows are described in more detail below.

Floodplains tend to have greater biological productivity than adjacent main-stem rivers because, compared to water in the river, floodplain water is generally warmer, shallower, and more clear as fine sediments drop out of the slow-moving water. All of these factors promote the growth of aquatic plants, including various forms of algae. In turn, these plants serve as the base of a rich food web that includes zooplankton, insects, fish, and birds. This productivity provides much of the floodplain habitat benefits for native fish, described below, and the productivity can also be exported back to the river and to downstream ecosystems, such as the Sacramento-San Joaquin Delta. The Delta contains several fish species with declining populations, such as the Delta smelt, and food limitation is likely one of the factors contributing to these declines.[5,6] Algae

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[4] Costanza, R., and coauthors, *The value of the world's ecosystem services and natural capital*, Nature 387(6630):253-260, 1997.

[5] Jassby, A. D., and J. E. Cloern, *Organic matter sources and rehabilitation of the Sacramento - San Joaquin Delta (California, USA)*, Aquatic Conservation: Marine and Freshwater Ecosystems 10:323-352, 2000.

provide the most important food source for zooplankton in the Delta[7,8] and these zooplankton are a primary food source for numerous Delta fish species. Consequently, a potential benefit of floodplain restoration is an increase in the food webs that support Delta fish species.[9]

Recent research has demonstrated that floodplains provide the necessary spawning habitat for the Sacramento splittail, an endemic minnow. Splittail can be considered 'obligate floodplain spawners,' meaning they require inundated floodplain habitat to spawn. Recruitment of splittail is strongly correlated with the duration of inundation in the Yolo Bypass; inundation of at least a month appears to be necessary for a strong year class of splittail.[10] Splittail benefit from inundated floodplains in numerous ways. Flooded annual vegetation is their preferred spawning substrate and floodplains provide abundant food resources for adults prior to spawning and for larval fish after hatching. Extensive spawning of splittail has also been observed in floodplains of the Cosumnes River Preserve.[11]

Recent studies have also revealed that juvenile Chinook salmon have faster growth rates on floodplains than in main-stem river channel.[12] Juvenile Chinook can enter and rear on floodplains during their downstream migrations in the winter and early to mid spring. The juveniles have access to a diverse and dense prey base on floodplains—zooplankton density can be 10-100 times greater in a floodplain compared to the river[13]—along with generally more favorable habitat conditions (warmer, slower water, fewer predators). These conditions translate to faster growth compared to juveniles rearing in rivers. Faster growth rates allow juveniles to attain larger sizes when they enter the estuary and ocean, and body size has been found to be positively associated with survival to adulthood for salmonids.[14]

The functions described above—food web productivity and habitat for splittail and salmon—are maximized by floods with relatively low magnitude but long duration that occur in early to mid-Spring. Flooding of short durations does not allow sufficient time for food webs to develop or for

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[6] Schemel, L. E., T. R. Sommer, A. B. Muller-Solger, and W. C. Harrell, *Hydrological variability, water chemistry, and phytoplankton biomass in a large floodplain of the Sacramento River, CA, USA*, Hydrobiologia 513:129-139, 2004.

[7] Muller-Solger, A. B., A. D. Jassby, and D. C. Muller-Navarra, *Nutritional quality of food resources for zooplankton (Daphnia) in a tidal freshwater system (Sacramento-San Joaquin River Delta)*, Limnology and Oceanography 47(5):1468-1476, 2002.

[8] Sobczak, W. V., J. E. Cloern, A. D. Jassby, and A. B. Muller-Solger, *Bioavailability of organic matter in a highly disturbed estuary: the role of detrital and algal resources*, Proceedings of the National Academies of Science 99(12):8101-8105, 2002.

[9] Ahearn, D. S., J. H. Viers, J. F. Mount, and R. A. Dahlgren, *Priming the productivity pump: flood pulse driven trends in suspended algal biomass distribution across a restored floodplain*, Freshwater Biology 51:1417-1433, 2006.

[10] Sommer, T., R. Baxter, and B. Herbold, *Resilience of splittail in the Sacramento-San Joaquin estuary*, Trans. Am. Fish. Soc. 126:961-976, 1997.

[11] Moyle, P. B., R. D. Baxter, T. R. Sommer, T. C. Foin, and S. A. Matern, *Biology and population dynamics of Sacramento splittail (Pogonichthys macrolepidotus) in the San Francisco Estuary: a review*, San Francisco Estuary and Watershed Science 2(2):article 3, 2004.

[12] Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer, *Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival*, Canadian Journal of Fisheries and Aquatic Sciences 58:325-333, 2001.

[13] Grosholz, E., and E. Gallo, *The influence of flood cycle and fish predation on invertebrate production on a restored California floodplain*, Hydrobiologia 568:91-109, 2006.

[14] Unwin, M. J., *Fry-to-adult survival of natural and hatchery-produced Chinook salmon (Oncorhynchus tshawytscha) from a common origin*, Canadian Journal of Fisheries and Aquatic Sciences 54(6):1246-1254, 1997.

splittail to successfully spawn.

Higher magnitude floods move sediment, eroding some parts of the floodplain while depositing sediment in others. Such flows create the necessary conditions for the regeneration of riparian tree species. In the Central Valley, tree species such as cottonwood time their seed release to coincide with the historic peak of snowmelt runoff because these high flows create the necessary conditions for successful germination, growth and survival of seedlings.[15] Riparian forests support high levels of biodiversity and provide essential habitat to a number of endangered species, including the Valley Elderberry Longhorn Beetle and the yellow-billed cuckoo and many other birds.

In summary, Central Valley floodplains are extremely productive habitats that support high levels of biodiversity, provide habitat for endangered species, and produce food for downstream ecosystems, including the Delta. Therefore, floodplain restoration contributes directly to the important state and federal policy goals of restoring the species and ecosystems of the Central Valley and Delta. Achieving these goals will improve the flexibility and predictability of the overall California water management system. Much of the beneficial functions described above can be achieved within multipurpose projects that integrate floodplain restoration with flood-damage reduction. For example, levees that are set back at a distance from the river allow for floodplains to be hydrologically connected to a range of river flows. The expanded floodway also allows the floodplain to convey and store floodwaters, reducing the stage and velocity of flood flows in other locations.

[15] Stella, J. C., J. J. Battles, B. K. Orr, and J. R. McBride, *Synchrony of seed dispersal, hydrology and local climate in a semi-arid river reach in California*, Ecosystems 9(7):1200-1214, 2006.

The Web Site of The Sacramento Bee

This story is taken from Sacbee / News.

Levee report shocks city

Feds plan tough restrictions that could halt building in Natomas and require flood insurance.

By Mary Lynne Vellinga And Matt Weiser - mlvellinga@sacbee.com
Published 12:18 am PST Wednesday, January 16, 2008

After years of post-Hurricane Katrina pressure to improve the nation's defenses against catastrophic flooding, the federal government took a drastic step Tuesday.

The Federal Emergency Management Agency said it would place Sacramento's fast-growing Natomas in a flood hazard zone, essentially halting construction of homes, offices and stores until the levees are improved.

The FEMA announcement sets a long-awaited deadline for homeowners to buy flood insurance before rates rise.

The designation was greeted with anger and shock by Sacramento city officials who have supported bold levee repair plans but oppose restrictions on building.

City leaders questioned the evaluation conducted by the U.S. Army Corps of Engineers. They said they would seek "an act of Congress" to stop the federal action. And they said the new rules could cripple Sacramento's economy.

"I am very frustrated and very angry with the Army Corps of Engineers and FEMA because Sacramento has really become the poster child of what to do right in flood protection," Mayor Heather Fargo said at a hastily called news conference.

Natomas is a major economic driver for the city, which is facing a significant budget crisis. "I'm totally outraged," City Manager Ray Kerridge said Tuesday. "I don't know how the federal government can do this to this city."

North Natomas today accounts for 47 percent of the development in the city of Sacramento.

Fargo said she wasn't sure the city would appeal, but it would seek help from U.S. Rep. Doris Matsui. "The one solution left that I'm aware of is an act of Congress," she said.

Unlike her late husband, however, it doesn't look as if Matsui will lead a charge to make FEMA back off. In the 1980s, U.S. Reps. Robert Matsui and Vic Fazio pushed through legislation that prevented FEMA from slapping building restrictions on much of Sacramento. But that was before Hurricane Katrina destroyed much of New Orleans.

"Public safety is No. 1," Matsui spokeswoman Lauren Smith said Tuesday. She said the congresswoman was "exploring avenues" that would allow critical projects, such as a planned North Natomas fire station, to proceed.

Sacramento is considered the urban area most vulnerable to catastrophic flooding in the nation.

In 1998, after an eight-year building moratorium, the corps said the Natomas levees met its minimal 1-in-100 flood protection standard, or the ability to withstand a flood with a 1 percent chance of striking in any given year.

Then, in July 2006, the corps said the levees didn't meet that standard after all, despite the $57 million in upgrades during the 1990s.

On Tuesday, the corps said Natomas levees aren't strong enough to withstand even a 30-year storm, the type of event that has a 3 percent chance of happening any given year.

Due to the limited time available for this study, the corps closely examined only two Sacramento River levee sections.

The corps found seepage and unstable slopes in both.

"That's enough information right there for us to not certify the levees," said Roger Henderson, assistant geotechnical branch chief for the corps.

In one stretch, three sites were up to 4 inches too short to hold back a 30-year flood.

FEMA proposes remapping the basin as an "AE Zone." That means all new construction or substantial remodeling must be elevated above higher flood levels now thought possible. In Natomas, that could mean buildings must be raised 20 feet – a prohibitively expensive requirement that would create a de facto building moratorium. The decision is likely to become final in December.

City and county officials cannot appeal the AE zone, but they can appeal the elevation, said FEMA spokesman Frank Mansell.

The new Natomas designation also means residents with federally backed mortgages must buy flood insurance. FEMA recommends anyone who does not already have flood insurance buy it now, or face higher rates after December. A policy covering a structure for $250,000 costs $769 per year. After December, it will cost $1,390, Mansell said.

Building in Natomas can proceed as long as a project receives permits by December, when the new maps become effective, officials said.

William Thomas, the city's development director, said the new designation could halt 8,200 housing units in North Natomas that have been approved but haven't received building permits. An additional half-billion dollars in office and retail construction may be affected.

The federal decision could delay public improvements such as a library, a high school and fire station planned for Natomas, Fargo said.

One major project that could be affected is the $1.3 billion expansion of Sacramento International Airport. That project includes a new four-story terminal replacing the Terminal B complex, as well as a hotel and multistory garage.

Sacramento County airport officials said Tuesday they have met with FEMA officials and believe they still will be able to move forward. Airports Director Hardy Acree said his agency is on a fast track to obtain building permits this spring. Construction is scheduled for summer.

Officials at the Sacramento Area Flood Control Agency said Tuesday's announcement won't change their plans for levee upgrades in Natomas. Executive Director Stein Buer said his agency has worked closely with the corps to understand its results and changing standards.

SAFCA hopes to start construction this summer on the first phase of a $400 million levee repair project in Natomas. It is designed to restore 100-year protection by 2010, and achieve 200-year protection by 2012.

But that project has yet to be approved by state and federal officials, and is subject to a lawsuit.

Tuesday's news left some Natomas property owners fuming at the slow progress in achieving flood protection for their area.

David DeLuz said he bought his North Natomas home in 2001 with the understanding that millions of dollars had been spent making the area safe.

DeLuz said homeowners should not have to pay for flood projects needed because of shifting standards and poor planning.

"We've got a situation where property values are going to be affected," DeLuz said. "What's going to happen to the demand for a house that exists in a 30-year floodplain? Homeowners are going to be left holding the bag."

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CESPK-ED-G 11 January 2008

MEMORANDUM FOR RECORD

SUBJECT: Summary of the Natomas Basin 3% Event Screening Level Levee Certification Analysis

1. PURPOSE. This Memorandum for Record summarizes the results and conclusions of a hydrologic, hydraulic and geotechnical engineering screening level analysis of the Natomas basin levee system. The geotechnical analyses were limited to two reaches of levee along the left bank the Sacramento River between the American River and Natomas Cross Canal with known seepage problems and with adequate data and information available to perform a reliable analysis. The hydraulic analyses were limited to the levee reach bounded by the Sacramento River from the Natomas Cross Canal to the confluence of the Sacramento and American Rivers. This screening level analysis was performed to provide an early indication of Sacramento District's (CESPK) ability to support certification of the Natomas basin levee system to a 3% event. Such indication will help the sponsor and the District determine if continued efforts to conduct a full levee system certification would be feasible.

2. REFERENCES:

a. Natomas Basin 3% Event Screening Level Levee Certification Analysis, Hydrologic and Hydraulic Engineering Report, 04 Jan 2008. (Enclosure 1)

b. Natomas Basin 3% Event Certification Geotechnical Memorandum for Record, 10 Jan 2008. (Enclosure 2)

c. ETL 1110-2-570 (Draft), Certification of Levee Systems for the National Flood Insurance Program (NFIP)

3. BACKGROUND. As a result of Sacramento District's decertification of the Natomas levee system in 2006, the Federal Emergency Management Agency (FEMA) entered into a remapping effort for the area. Discussions between the local agencies and FEMA indicated the Natomas area being mapped into one of two potential flood hazard zones; an AR zone which is a less restrictive rating where residential and commercial construction activities may continue with minor elevation restrictions, and an AE zone which is a more restrictive flood hazard zone with construction elevation requirements tied to a base flood elevation (33 feet, NGVD-29, in the case of Natomas). Mandatory flood insurance is also a requirement of both the AR and AE flood hazard zones.

In order to obtain an AR flood hazard zone rating, the FEMA regulations specifically required Federal Agency certification that the flood defense system would pass a 3% annual chance flood event (ACFE). The certification, if successfully performed, would allow FEMA to remap the Natomas basin as an AR flood hazard zone and the more stringent construction elevation limitations would be lifted. On October 17, 2007, the County and City of Sacramento requested CESPK certify the levee system in order to obtain the AR flood hazard zone designation.

Due to the short timeframe available to do this certification, CESPK in conjunction with the City and County of Sacramento and SAFCA agreed to do an abbreviated geotechnical and hydraulic/hydrologic analysis of limited areas first. It was agreed that to perform a full certification in accordance with USACE levee certification criteria would take significantly longer than desired given the time restrictions in place. Furthermore, it was agreed that if the screening level analysis showed a good probability of the levee system passing, CESPK would then conduct a full and complete certification analysis.

4. METHODOLOGY. The draft ETL 1110-2-570 was the basis for the methodology followed in performing the screening level analysis. Although the ETL outlines certification for the 1% event, it can also be successfully applied for certification to the 3% event in this analysis because certification for any flood event involves the same technical procedures. Per the draft ETL, the levee system under consideration must pass the flood with 90% or 95% assurance, depending upon the amount of existing freeboard. A 95% assurance water surface profile was used for the geotechnical deterministic evaluation of the levee considering under seepage and stability. Additionally, sensitivity analyses using a 50% assurance (i.e. "mean") water surface elevation were also considered in the geotechnical evaluation and were used for comparative purposes only. Use of the 50% or "mean" water surface elevation mimics the traditional approach used for a FEMA based certification.

As noted earlier, this screening analysis was performed on a limited reach of the Sacramento River and did not include an analysis of all the FEMA and draft ETL certification criteria - including erosion, interior drainage, wind-wave run up, etc.

5. DATA. The hydrologic and hydraulic data used in the analysis was originally developed by the USACE Sacramento and San Joaquin Rivers Comprehensive Study. Details regarding the hydrologic and hydraulic inputs, including development of water surface profiles used in the screening analysis, are contained in reference 2.a (Attachment 1). The sources of data for the geotechnical analysis included recent studies performed on the Sacramento River east bank levee for the Natomas Levee Improvement Program (NLIP) by SAFCA and for the Natomas General Reevaluation Report (GRR) by URS for the Corps.

Details regarding the geotechnical data used and the under seepage and stability calculations are contained in reference 2.b (Attachment 2).

6. RESULTS. Tables 1 and 2 below summarize CESPK's analyses. It can be seen that the containment, under seepage and stability criteria for certification to the 3% ACFE were not met for the reaches analyzed. Additionally, sensitivity analyses also revealed that the seepage gradient criteria were not met at Levee Mile 1.33 (River Mile 77.9) even when significantly lower water surface elevations (50% assurance or "mean") were used.

Table 1 - Summary of H&H Screening Analysis

Location		Annual Event Probability	Water Surface Elevation (NAVD 88)*	Top of Levee Elevation (NAVD 88)*	Containment Deficiency (ft)
Levee Mile	River Mile				
3.8	75.5	3% @ 95% assurance	42.6'	42.4'	- 0.2
6.6	72.7	3% @ 95% assurance	41.4'	41.1'	- 0.3
7.1	72.2	3% @ 95% assurance	41.0'	40.9'	- 0.1

* NAVD-88 elevation was obtained by calculating the water-surface elevation in NGVD-29 and then using the computer program "VERTCON" to convert to NAVD-88

Table 2 – Summary of Geotechnical Screening Analysis

Location		Annual Event Probability	Water Surface Elevation (NAVD 88)*	Seepage Gradients (USACE Criteria < 0.5)		Slope Stability (USACE Criteria FS>1.4)
Levee Mile	River Mile			At Levee Toe	At Ditch Bottom	
1.33	77.9	3% @ 95% assurance	43.7'	0.69	1.60	1.284
		3% @ 50% assurance (mean)	41.6'	0.57	1.40	
		> 3% @ 50% assurance (mean)	37.0'	0.32	0.99	
4.11	75.2	3% @ 95% assurance	42.3'	0.69	2.40	Not analyzed

* NAVD-88 elevation was obtained by calculating the water-surface elevation in NGVD-29 and then using the computer program "VERTCON" to convert to NAVD-88

7. QUALITY CONTROL. As part of the USACE commitment to safety and ensuring quality engineering work, both the Hydrologic and Hydraulic Engineering Report, 04 Jan 2008 and the Natomas Basin 3% Event Certification Geotechnical Memorandum for Record, 10 Jan 2008 were reviewed by internal and external technical reviewers. As part of our External Peer Review (EPR) process, the reports were reviewed by Mr. Steve Verigin, PE (GEI Consultants), Mr. Chris Groves, PE (Shannon & Wilson) and Mr. Jeff Bradley, PE (West Consultants, Inc.). All three external reviewers concurred with the applicability and conclusions of the analyses.

8. CONCLUSIONS. Based on the results of the screening level analysis described above, CESPK is unable to certify that the Natomas basin levees can safely pass the 3% ACFE. Because the analyses focused on the weakest link apparent in the system (based on available data), the results are not necessarily characteristic of the Natomas basin levee system as a whole. However, they do provide a clear indication that further analysis for the purpose of 3% event levee certification is unlikely to produce a different outcome. Ongoing efforts by the Corps, SAFCA, and California Department of Water Resources are generating additional information on the Natomas basin levees and taking steps to address the significant known deficiencies.

9. Any questions on the above may be referred to Mr. Roger Henderson, PE, (916) 557-5378, Deputy Chief, Geotechnical & Environmental Engineering Branch.

2 Encls

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Chief, Engineering Division
Sacramento District
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NATOMAS BASIN 3% EVENT SCREENING LEVEL LEVEE CERTIFICATION ANALYSIS

Hydrologic and Hydraulic Engineering Report

4 January 2008

Hydraulic Design Section
Sacramento District
U.S. Army Corps of Engineers

NATOMAS Basin 3% event screening level

LEVEE CERTIFICATION ANALYSIS

Hydrologic and Hydraulic Engineering Report

1. PURPOSE. This report documents the hydrologic and hydraulic engineering inputs, procedures, and results of a screening level certification analysis of the Natomas basin levee system. The analysis was performed on the Sacramento River between the American River and Natomas Cross Canal, a reach containing known freeboard and seepage problems and with adequate data available to perform a reliable analysis. The analysis was performed to provide an early indication of the Corps' ability to certify the Natomas basin levee system to the 3% event. Such indication will help determine if an attempt at a full levee system certification is warranted.

2. REFERENCES

a. ETL 1110-2-570 (Draft), Certification of Levee Systems for the National Flood Insurance Program (NFIP)
b. EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies
c. Natomas Basin 3% Event Certification Geotechnical Analysis, 26 November 2007.
d. Sacramento and San Joaquin River Basins Comprehensive Study, Technical Studies Documentation, December 2002.
e. Sacramento River UNET Model Comparison Draft MFR, 16 February 2006.
f. Lower Feather River Floodplain Mapping Study, 17 February 2005.

3. BACKGROUND. SAFCA, the County of Sacramento, and the City of Sacramento requested the Sacramento District, U.S. Army Corps of Engineers (the Corps) to certify that the levees surrounding the Natomas Basin can safely pass the 3% (i.e. 1 in 33) annual chance flood event. The certification is one of the requirements to map the Natomas basin in a FEMA AR zone. An AR zone is a temporary rating where housing construction and other commercial activities may continue with certain restrictions until the levees are rehabilitated. A recent draft engineering technical letter (ETL 1110-2-570), entitled *Certification of Levee Systems for the National Flood Insurance Program* defines current interim procedures for levee system certification. The USACE policy intent outlined in the ETL is that probability and uncertainty-based analyses be applied to certification determinations, and that only systems shown to possess a strong assurance (i.e. greater than 90% to 95% of the time) of passing a given event, be certified to that event. Notably, the ETL does not allow floodfighting activities to be accounted for as part of the certification determination.

4. SCOPE. The scope of hydrologic and hydraulic engineering efforts for the screening level analysis consisted of development of various water surface (stage) profiles

associated with the 3% chance flow event on the Sacramento River and a containment (i.e. freeboard) analysis using the same profiles. These activities were performed using the best hydrology, hydraulic model, and risk and uncertainty (HEC-FDA) analysis inputs available from existing sources. The profiles were also used for geotechnical analyses performed as part of the screening analysis. The screening analysis did not include an analysis of all the FEMA certification and ETL requirements including erosion and wind-wave. The subject Sacramento River reach was chosen because it appeared to be the critical reach based on our current knowledge of and data availability for the levees in the Natomas basin system.

5. HYDROLOGY. The hydrology data used was developed as part of the Sacramento and San Joaquin Rivers Comprehensive Study (Comp Study). This data consisted of the flow hydrographs computed to represent storms of various sizes centered at the latitude of Sacramento on the Sacramento River. See Reference 2.d for further detail on the Comp Study hydrology. Subsequent to the Comp Study hydrology, a Shanghai centering was developed for the Feather River system. See Reference 2.f for details regarding the development of the Shanghai centering. Following the convention established by the Comp Study, water surface profiles of the Sacramento River were compared using both the Sacramento and Shanghai centerings. The Sacramento centering produced higher water surface elevations for the Sacramento River from the American River to the Natomas Cross Canal and therefore was used for this analysis.

6. HYDRAULICS. The UNET model used was also originally developed as part of the Comp Study, and was later refined based on reviewed and accepted revisions made by MBK Engineers. Reference 2.e documents the comparison of the models and the subsequent changes made. Model runs did not include upstream levee failures, but did allow for overtopping of levees. Profiles generated as part of the Comp Study efforts show no overtopping of levees upstream of Natomas for the 2% chance flood event for the major upstream channels of the flood control system (Sacramento River, Sutter Bypass, Feather River, Yuba River, and Bear River). Therefore, no upstream overtopping is expected for a 3% chance event.

Water surface elevations derived from the UNET model are based on the NGVD 1929 vertical datum. A conversion factor of +2.5' was used to convert to the NAVD 1988 vertical datum using the Corpscon computer program.

7. HEC-FDA ANALYSIS. Inputs for the HEC-FDA (FDA) analysis consisted of stage-frequency and period of record values. Stage-frequency curves were used as opposed to flow-frequency, stage-discharge curves because of the fact that within the Sacramento River system there is not typically a unique set of stages for given discharges at a particular location. Stages at 2 locations (index points at river mile 79 and river mile 68) were extracted for several frequency events from the UNET model runs. The resulting stage-frequency curves used in the FDA analysis are shown in Table 1. 70 years was used as the period of record for both index points analyzed.

Table 1: FDA stage-frequency input

Expected Annual Frequency	Stage (ft)*	
	RM 79	RM 68
0.999	25.50	18.50
0.500	35.46	29.92
0.100	38.70	32.35
0.040	41.71	35.89
0.020	42.47	37.17
0.010	43.99	39.06
0.005	45.31	40.27
0.002	46.60	41.69

*Vertical Datum = NAVD '88

8. 3% EVENT STAGE PROFILES. Various stage profiles were developed for the 3% chance event using the available hydrology data, the existing UNET hydraulic model, and the HEC-FDA results.

a. <u>Expected Profile.</u> The expected 3% chance event stage profile was generated by interpolating between the expected 2% and 4% chance event profiles because hydrology had not been specifically developed for the 3% event. The interpolation was done by first graphically determining the 3% stage using a stage frequency curve for river mile 79. A weighting was then developed comparing the differences in stages for the 3% and 4% events compared to the difference in stages for the 2% and 4% events. The weighting developed at this index point was applied to all other locations to determine the 3% event [3% stage = .447 X (2% stage – 4% stage) + 4% stage]. The 2% and 4% as well as the interpolated 3% profile are shown in Figure 1.

b. <u>90% and 95% Assurance Profiles.</u> The 90% and 95% assurance profiles for the 3% chance event are the 90% and 95% non-exceedence stage profiles for the 3% event. These profiles would not be exceeded in 90% and 95% of the occurrences of a 3% chance flow event. These profiles were developed by following a two-step process. The first step was an iterative process that tested multiple elevations by applying HEC-FDA at two index points previously mentioned to determine which elevations correspond to the 90% and 95% non-exceedence elevations for the 3% event at those locations. The next step generated assurance profiles from these elevations by correlating them to the expected 1% event elevation at each index point and using that correlation to develop the assurance profiles from the 1% event profile. At RM 68, the 90% and 95% assurance elevations for the 3% event differed from the expected 1% elevation by -0.51 feet and 0.14 feet, respectively. At RM 79, the 90% and 95% assurance elevations for the 3% event differed from the expected 1% elevation by -0.24 feet and 0.21 feet, respectively. These differences were applied to the expected 1% event profile to develop two sets of 90% and

95% assurance profiles – one set generated from each index point. These profiles are displayed in Figure 2 and Figure 3 as well as Table 1.

9. CONTAINMENT ANALYSIS. Levee freeboard is the vertical distance from the expected stage profile for a given event to the top of levee elevation. In order to be certified per the ETL for a given flow event, levees must contain the 90% assurance profile for that event if they provide at least 3 feet of freeboard, or must contain the 95% assurance profile if they provide less than 3 feet of freeboard. They must always provide at least 2 feet of freeboard for that flow event. The expected 3% event, the expected 3% event with 2 and 3 feet of freeboard, and the 90% and 95% assurance profiles for the 3% event are all shown in Figure 3 along with the Sacramento River left bank top of levee profile. The top of levee profile was acquired by the California Department of Water Resources relatively recently from ground-based surveys.

As shown in Figure 4, there is at least 2 feet of freeboard along the entire profile. Downstream of about RM 69.9, the left bank levee provides greater than 3 feet of freeboard above the expected 3% event profile, and both of the 90% assurance profiles are contained. Upstream of about RM 69.9, the freeboard above the 3% event profile is less than 3 feet at many locations.

For purposes of the containment and geotechnical analyses, the 95% assurance profile developed from the index point at RM 79 was used for the reach upstream of RM 69, where a break in water surface slope is evident. For downstream of RM 69, the 90% assurance profile (based on the RM 68 index point) is used. Figure 4 shows the combined assurance profile used for the containment analysis that is a combination of profiles for the 2 reaches just described. This profile is not contained below the left bank top of levee profile at river miles 72.2, 72.7 and 75.5. Therefore, the levee in this reach is not certifiable to the 3% chance event per current criteria based on containment (freeboard) deficiencies.

10. SENSITIVITY ANALYSIS. Geotechnical underseepage and stability analyses were conducted using the 3% event with 95% assurance profile (geotechnical analyses were conducted at locations upstream of RM 69). The results of these analyses do not meet minimum criteria for underseepage or stability. To determine the sensitivity of the geotechnical results to water surface inputs, the effects of lower stage profiles were assessed. The geotechnical analyses results also did not meet minimum criteria when the expected 3% event profile was used, and even when an elevation which equates to less than an expected 10% event was used. Additional information on the geotechnical analyses performed as part of the screening analysis can be found in reference 2.c. These results show that requirements to meet 3% chance event levee certification are not close to being met based on serious geotechnical deficiencies that are insensitive to potential uncertainties in associated water surfaces. It is therefore highly unlikely that more refinement of the hydrologic data and/or hydraulic model would provide any chance of certification.

11. Any questions on the above may be referred to Ethan Thompson, P.E. at (916) 557-7142.

Figure 1. Sacramento River Water Surface Profiles RM 61-79

Expected 3% Event Profile

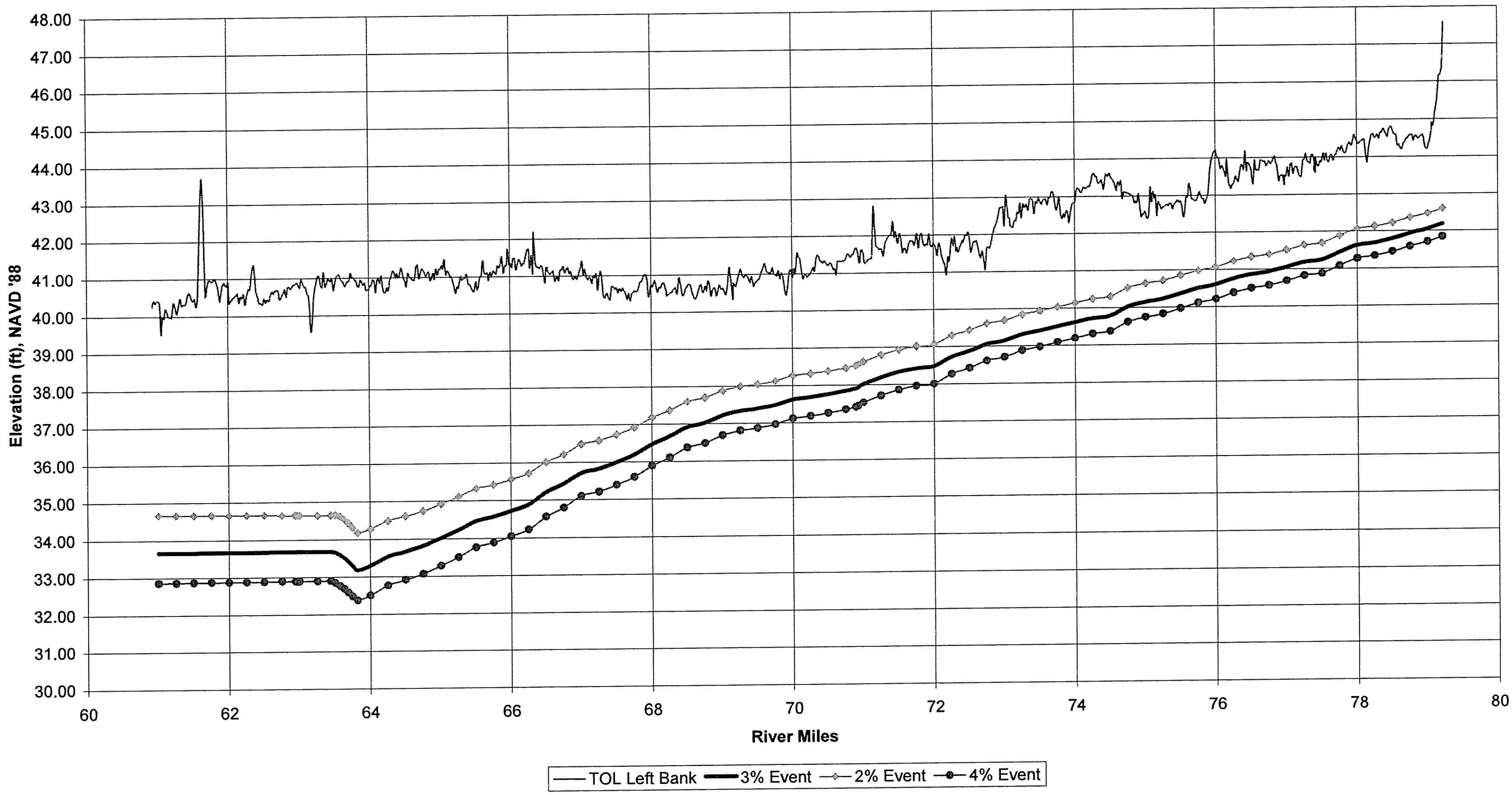

Figure 2. Sacramento River Water Surface Profiles RM 61-79

3% Event Assurance Profiles - Based on RM 79 Index Point

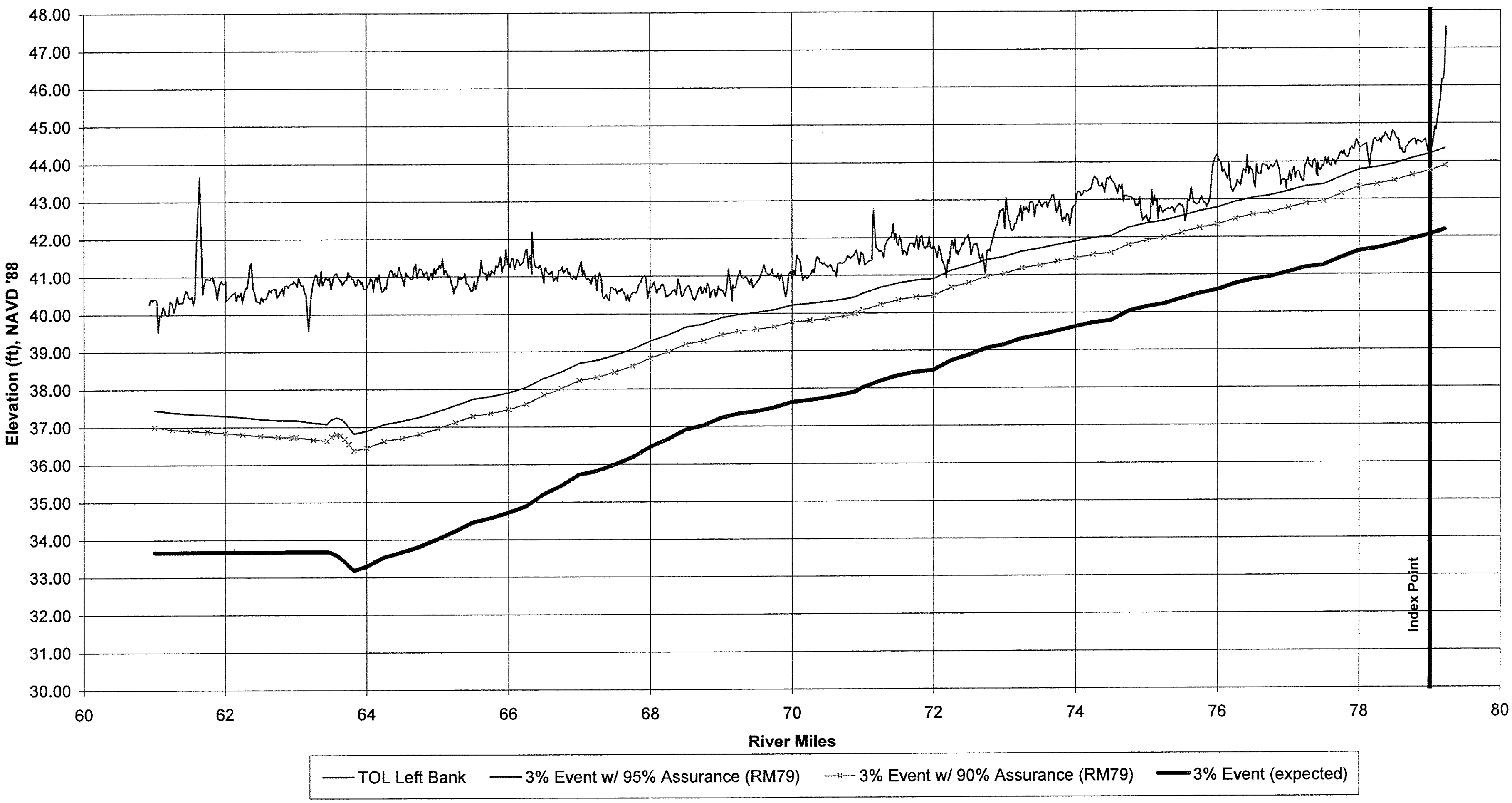

Figure 3. Sacramento River Water Surface Profiles RM 61-79

3% Event Assurance Profiles - Based on RM 68 Index Point

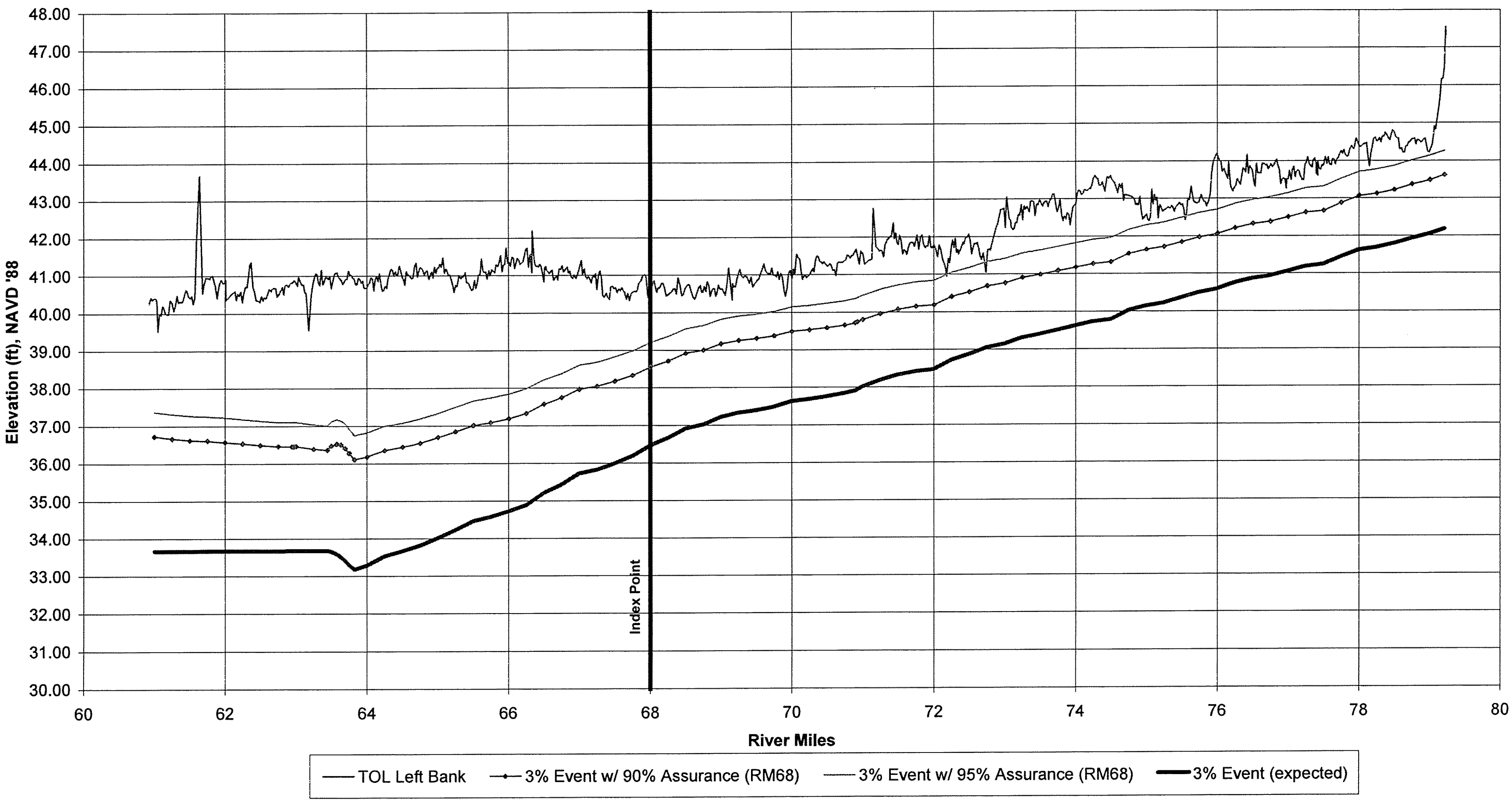

Figure 4. Sacramento River Water Surface Profiles RM 61-79

Containment Analysis

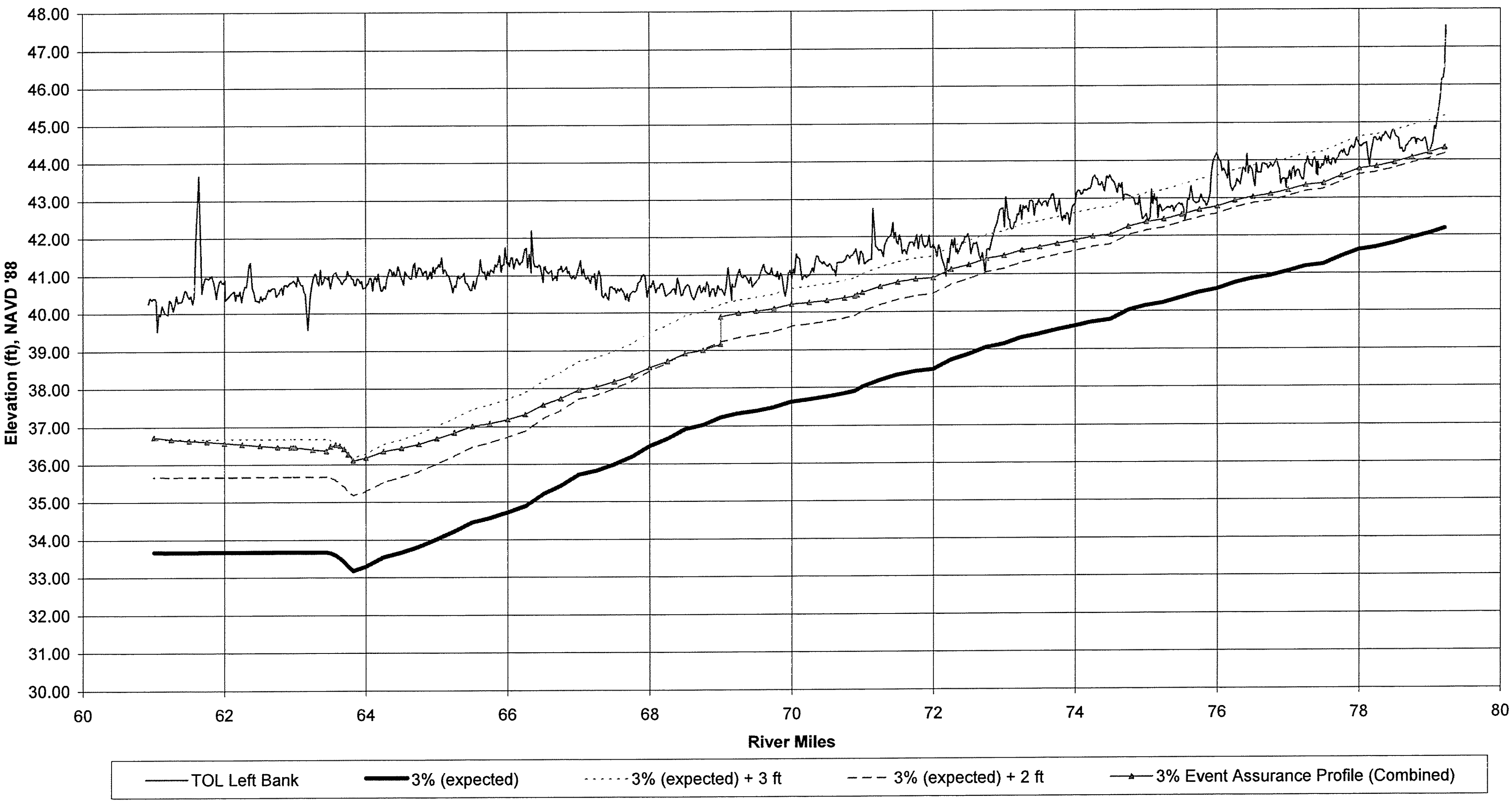

Table 2

				3% Assurance Profiles			
	3% Mean	3% Mean + 2'	3% Mean + 3'	Index PT RM68 (95%)	Index PT RM68 (90%)	Index PT RM79 (95%)	Index PT RM79 (90%)
River Miles	Elev (ft) NAVD '88	Elev (ft) NAVD '88	Elev (ft) NAVD '88	Elev (ft) NAVD '88	Elev (ft) NAVD '88	Elev (ft) NAVD '88	Elev (ft) NAVD '88
79.21	42.18	44.18	45.18	44.26	43.61	44.34	43.89
79	42.05	44.05	45.05	44.13	43.48	44.20	43.75
78.75	41.93	43.93	44.93	44.01	43.36	44.08	43.63
78.5	41.80	43.80	44.80	43.87	43.22	43.94	43.49
78.25	41.69	43.69	44.69	43.77	43.12	43.84	43.39
78	41.63	43.63	44.63	43.71	43.06	43.78	43.33
77.75	41.44	43.44	44.44	43.52	42.87	43.60	43.15
77.5	41.24	43.24	44.24	43.32	42.67	43.39	42.94
77.25	41.19	43.19	44.19	43.27	42.62	43.34	42.89
77	41.06	43.06	44.06	43.14	42.49	43.22	42.77
76.75	40.94	42.94	43.94	43.03	42.38	43.10	42.65
76.5	40.87	42.87	43.87	42.97	42.32	43.04	42.59
76.25	40.75	42.75	43.75	42.86	42.21	42.94	42.49
76	40.59	42.59	43.59	42.71	42.06	42.78	42.33
75.75	40.50	42.50	43.50	42.62	41.97	42.70	42.25
75.5	40.36	42.36	43.36	42.49	41.84	42.57	42.12
75.25	40.23	42.23	43.23	42.37	41.72	42.44	41.99
75	40.15	42.15	43.15	42.30	41.65	42.37	41.92
74.75	40.02	42.02	43.02	42.18	41.53	42.25	41.80
74.5	39.79	41.79	42.79	41.96	41.31	42.04	41.59
74.25	39.72	41.72	42.72	41.92	41.27	41.99	41.54
74	39.62	41.62	42.62	41.82	41.17	41.89	41.44
73.75	39.51	41.51	42.51	41.73	41.08	41.80	41.35
73.5	39.40	41.40	42.40	41.64	40.99	41.71	41.26
73.25	39.31	41.31	42.31	41.56	40.91	41.63	41.18
73	39.14	41.14	42.14	41.41	40.76	41.49	41.04
72.75	39.05	41.05	42.05	41.34	40.69	41.41	40.96
72.5	38.87	40.87	41.87	41.18	40.53	41.25	40.80
72.25	38.73	40.73	41.73	41.05	40.40	41.13	40.68
72	38.48	40.48	41.48	40.83	40.18	40.90	40.45
71.75	38.43	40.43	41.43	40.80	40.15	40.87	40.42
71.5	38.33	40.33	41.33	40.72	40.07	40.79	40.34
71.25	38.19	40.19	41.19	40.60	39.95	40.68	40.23
71	38.01	40.01	41.01	40.45	39.80	40.52	40.07
70.926	37.93	39.93	40.93	40.38	39.73	40.46	40.01
70.893	37.90	39.90	40.90	40.36	39.71	40.43	39.98
70.75	37.84	39.84	40.84	40.30	39.65	40.37	39.92
70.5	37.76	39.76	40.76	40.23	39.58	40.31	39.86
70.25	37.69	39.69	40.69	40.18	39.53	40.26	39.81
70	37.63	39.63	40.63	40.14	39.49	40.22	39.77
69.75	37.48	39.48	40.48	40.02	39.37	40.10	39.65
69.5	37.40	39.40	40.40	39.95	39.30	40.03	39.58
69.25	37.33	39.33	40.33	39.91	39.26	39.98	39.53
69	37.22	39.22	40.22	39.82	39.17	39.89	39.44
68.75	37.02	39.02	40.02	39.65	39.00	39.72	39.27

68.5	36.92	38.92	39.92	39.57	38.92	39.64	39.19
68.25	36.67	38.67	39.67	39.36	38.71	39.44	38.99
68	36.46	38.46	39.46	39.20	38.55	39.27	38.82
67.75	36.19	38.19	39.19	38.98	38.33	39.06	38.61
67.5	35.99	37.99	38.99	38.83	38.18	38.90	38.45
67.25	35.82	37.82	38.82	38.69	38.04	38.76	38.31
67	35.72	37.72	38.72	38.61	37.96	38.68	38.23
66.75	35.43	37.43	38.43	38.39	37.74	38.46	38.01
66.5	35.21	37.21	38.21	38.22	37.57	38.29	37.84
66.25	34.89	36.89	37.89	37.97	37.32	38.05	37.60
66	34.72	36.72	37.72	37.84	37.19	37.91	37.46
65.75	34.57	36.57	37.57	37.74	37.09	37.81	37.36
65.5	34.46	36.46	37.46	37.66	37.01	37.73	37.28
65.25	34.22	36.22	37.22	37.50	36.85	37.57	37.12
65	34.01	36.01	37.01	37.34	36.69	37.41	36.96
64.75	33.81	35.81	36.81	37.19	36.54	37.26	36.81
64.5	33.66	35.66	36.66	37.08	36.43	37.16	36.71
64.25	33.54	35.54	36.54	37.00	36.35	37.07	36.62
64	33.29	35.29	36.29	36.82	36.17	36.90	36.45
63.82	33.18	35.18	36.18	36.75	36.10	36.82	36.37
63.75	33.29	35.29	36.29	36.92	36.27	36.99	36.54
63.69	33.41	35.41	36.41	37.06	36.41	37.13	36.68
63.63	33.51	35.51	36.51	37.15	36.50	37.22	36.77
63.57	33.59	35.59	36.59	37.17	36.52	37.25	36.80
63.5	33.65	35.65	36.65	37.13	36.48	37.20	36.75
63.44	33.68	35.68	36.68	37.01	36.36	37.08	36.63
63.25	33.67	35.67	36.67	37.04	36.39	37.11	36.66
63	33.68	35.68	36.68	37.11	36.46	37.18	36.73
62.973	33.68	35.68	36.68	37.11	36.46	37.18	36.73
62.971	33.68	35.68	36.68	37.11	36.46	37.18	36.73
62.943	33.68	35.68	36.68	37.11	36.46	37.18	36.73
62.941	33.68	35.68	36.68	37.11	36.46	37.18	36.73
62.75	33.67	35.67	36.67	37.11	36.46	37.18	36.73
62.5	33.67	35.67	36.67	37.14	36.49	37.22	36.77
62.25	33.67	35.67	36.67	37.19	36.54	37.26	36.81
62	33.67	35.67	36.67	37.22	36.57	37.30	36.85
61.75	33.67	35.67	36.67	37.26	36.61	37.33	36.88
61.5	33.67	35.67	36.67	37.28	36.63	37.35	36.90
61.25	33.67	35.67	36.67	37.32	36.67	37.39	36.94
61	33.67	35.67	36.67	37.38	36.73	37.45	37.00

NATOMAS BASIN
RECLAMATION DISTRICT 1000

3% Flood Event
Levee
Geotechnical Analysis

10 January 2008

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NATOMAS BASIN

3% Flood Event

Geotechnical Analysis

1. INTRODUCTION

In October of 2007 SAFCA, the County of Sacramento, and the City of Sacramento requested that Sacramento District of the USACE (the Corps) certify that the levees surrounding the Natomas Basin, Reclamation District 1000, can safely pass the 3% (i.e. 1 in 33) annual chance exceedance flood event. This certification is one of the requirements of CFR 44 65.14 to map R.D. 1000 in a FEMA AR zone. This allows restricted development until the levee hazard can be reduced. A recent draft engineering technical letter (ETL 1110-2-570), entitled *Certification of Levee Systems for the National Flood Insurance Program* defines current interim procedures for levee system certification. The procedures have been written to certify levees for the 1% percent annual chance exceedance event. We are applying the same procedures to evaluate the 3% event. These procedures are a probability and uncertainty-based analyses to determine water surface elevations and only systems possessing a minimum 90% reliability, can be certified for that event. Geotechnical analysis is made using deterministic methods. (It is important to note that ETL 1110-2-570 does not allow flood-fighting activities or events on other parts of the system to be accounted for as part of the certification determination. Also this assurance is only for containment; it does not include the probability of failure by any other mode or combined probability of all failure modes.)

This report presents the results of the geotechnical analysis for the Natomas Levee System (RD 1000), considering the water elevation corresponding to a 3% flood event with a 95% Conditional Non-Exceedance Probability (CNP). The 3% flood event water elevations were obtained from hydraulic analysis summarized in the 23 November 2007 MEMORANDUM FOR RECORD, SUBJECT: Natomas Basin 3% Event Levee Certification, Screening Level Analysis, Hydraulic Report. Elevations are all reported in North American Vertical Datum (NAVD) 88.

The primary goal of this analysis is to determine if the critical levee sections meet minimum geotechnical design criteria required by the Corps of Engineers with respect to underseepage and slope stability at the 3% flood event water surface. The following criteria apply:

Underseepage Gradient should be less than 0.5 at the landside toe (maximum gradient is 0.8 at the toe of a landside seepage berm if applicable) for the selected water elevation (ETL 1110-2-569);

Stability Factor of Safety of the landside levee slope considering steady state conditions under the selected water elevation should be greater than 1.4. (EM 1110-2-1902)

The existing conditions were evaluated considering the geotechnical information provided by subsurface investigations performed in the past, supplemented by recent studies developed for Natomas GRR by URS for the Corps of Engineers and by Kleinfelder for SAFCA's Natomas

Levee Improvement Program. The following tasks were performed for this study:

- Examination of criteria for certification of levees.
- Review of existing sources of information.
- Evaluation of each existing levee unit including design features and subsurface conditions to determine most critical areas for analysis.
- Geotechnical analysis for critical levee reaches.

Geotechnical analyses were performed in accordance with the Corps of Engineers design guidance. Underseepage and landside slope stability considering a steady state conditions with the water at the 3% flood event at 95% CNP were evaluated.

2. SOURCES OF INFORMATION

The primary sources of information for the subsurface conditions of the existing levee are as follows:

a. URS "Natomas GRR Investigation" Draft Evaluation Report, Sacramento East Levee, 2007
b. "Geotechnical Data Report, Sacramento River East Levee, Natomas Basin Evaluation, Reclamation District 1000, Sacramento and Sutter Co. California", Kleinfelder, 3 January 2007.
c. "Geotechnical Data Report, Natomas Cross Canal South Levee, Natomas Basin Evaluation, Reclamation District 1000, Sacramento and Sutter Co. California", Kleinfelder, 4 January 2007.
d. "Alternatives Analysis Report for Seepage Mitigation, Sacramento River East Levee, Natomas Basin Evaluation, Reclamation District 1000, Sacramento and Sutter Co. California", Kleinfelder, 25 September 2006.
e. "Natomas Levee Evaluation Study", Prepared for SAFCA by MBK Engineers, Kleinfelder, and others, July 14, 2006.
f. "Alternatives Analyses Report for Seepage/Stability Mitigation, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sutter Co. California", Kleinfelder, 29 April 2006.
g. "Natomas General Evaluation Report, American River Watershed Project (Common Features), California", URS for USACE-SPK, 29 November 2005.
h. "Geotechnical Report, American River Watershed, Implementation of WRDA 99 Common Features, Natomas Cross Canal Levee", USACE-SPK-ED-GS, May 2002.
i. "American River Watershed Project (Common Features), California, Sacramento River Levee and Berm, Sacramento, CA", URS for USACE-SPK, 6 December 2002
j. "Natomas Basin 3% Event Levee Certification, Screening Level Analysis, Hydraulic Report ", USAED Sacramento. 23 November 2007

The references used for the geotechnical analyses are as follows:

k. EM 1110-2-1913 "Design and Construction of Levee" (2000)
l. EM 1110-2-1902 "Slope Stability" (2003)
m. EM 21110-2-1901 "Seepage Analysis and Control for Dams"
n. Recommendation for Seepage Design Criteria, Evaluation and Design Practices, Final Report of the 2003 CESPK Levee Task Force
o. SOP EDG-03 Technical Product Review Policies and Procedures- Geotechnical Levee Practice
p. ETL 1110-2-569 "Design Guidance for Levee Underseepage"

The references used for levee mapping and certification are as follows:

q. 44 CFR 65.10, "Mapping for areas protected by levee systems."
r. 44 CFR 65.14, "Remapping of areas for which local flood protection systems no longer provide base flood protection."
s. ETL 1110-2-570 "Guidance of Levee Certification for the National Flood Insurance Program – FEMA Map Modernization Program Issues" (draft 2007)

3. DESCRIPTION OF THE LEVEE SYSTEM

3.1 General Description.

The Natomas flood protection system consists of 42.61 miles of levees divided into 4 major units as follows: (1) Levee Unit 1, 18.6 miles long, located along the east bank of the Sacramento River; (2) Levee Unit 2 , 2.33 miles long, located along the north bank of the American River; (3) Levee Unit 3, 17.30 miles long, located along the west bank of the Natomas East Main Drainage Canal and Pleasant Grove Creek Canal; and (4) Levee Unit 4, 4.38 miles long, located along the south bank of the Natomas Cross Canal. The Natomas Levee (Reclamation District 1000) is shown in Figure 1.

3.2 Levee Unit 1 Sacramento River

Levee Unit 1 is located along the east bank of the Sacramento River between the Natomas Cross Canal on the north end and American River at the south end. The levee in this unit was constructed in the early 1900s by excavating a core trench and depositing the excavated material on both sides of the trench to form starter levees, then filling the space between the starter levees with hydraulic deposited sand fill and finally topping off the levee with sand fill. The sand extends in some locations deeper in the center of the levee. The existing levee embankment has slopes generally of 1(V) on 2(H) on the landside and 1(V) on 3(H) on the waterside, except in the area where encroachments on the levee right of way included fill over the levee waterside slope. The levee height varies between 19 and 22 feet, with the crest between elevation 43 and 38.5 feet, NAVD 88. The Garden Highway runs along the levee crest. Between Natomas Cross

Canal (Levee Mile 0.0) and Powerline Road (Levee Mile 12.03) the levee embankment has a more recently constructed 10 foot wide landside berm extended to about half of the levee height (Figure 2). The berm was constructed over a drainage layer that was extended as a chimney drain on the levee slope, to prevent internal erosion due to the water seepage through the levee embankment. Filter fabric was placed between the drainage layer and the levee fill. A cut-off wall was recently constructed in the levee between Power Line Road (Levee Mile 12.03) and the south end at American River (Levee Mile 18.60) to prevent seepage and internal erosion caused by seepage through the levee (Figure 3). The wall was constructed in two different phases and the depth varies between 25 and 45 feet. The wall was constructed to penetrate into the upermost impervious clay layer of the foundation, but not the lower impervious clay layer. It was constructed to prevent seepage through the levee embankment and to increase the seepage path. A 5-foot deep unlined irrigation ditch has been constructed 10 feet from the landside toe between levee miles 0.0 and 12.03 (Powerline Rd). A second 3-foot deep unlined irrigation ditch between levee miles 12.03 to the end of the levee unit was excavated 5 feet from the landside levee toe. Encroachments on the waterside levee slope include but are not limited to houses constructed on the riverbank, fences along the levee crest on the shoulder of the highway, power poles in the levee landside and waterside slopes, and utility lines including pressurized pipes for the irrigation crossing the levees. The riverbank is covered by heavy vegetation that extends on the levee slope, in some places up to the levee crest. The heavy vegetation includes large diameter trees with deep root systems. Access to the waterside levee toe for inspection is sometimes denied by the owners of the riverbank. Encroachment on the landside slope includes fences, power poles, utilities and in some place downstream of Power Line Road orchards planted on the levee slope. The landside slope is also covered by scattered brush and old big diameter trees. Typical cross section of the levee with stability berm north of the Power Line Road is shown on Figure 2. Figure 3 shows a typical cross section of the levee south of the Power Line Road, with a cut-off wall.

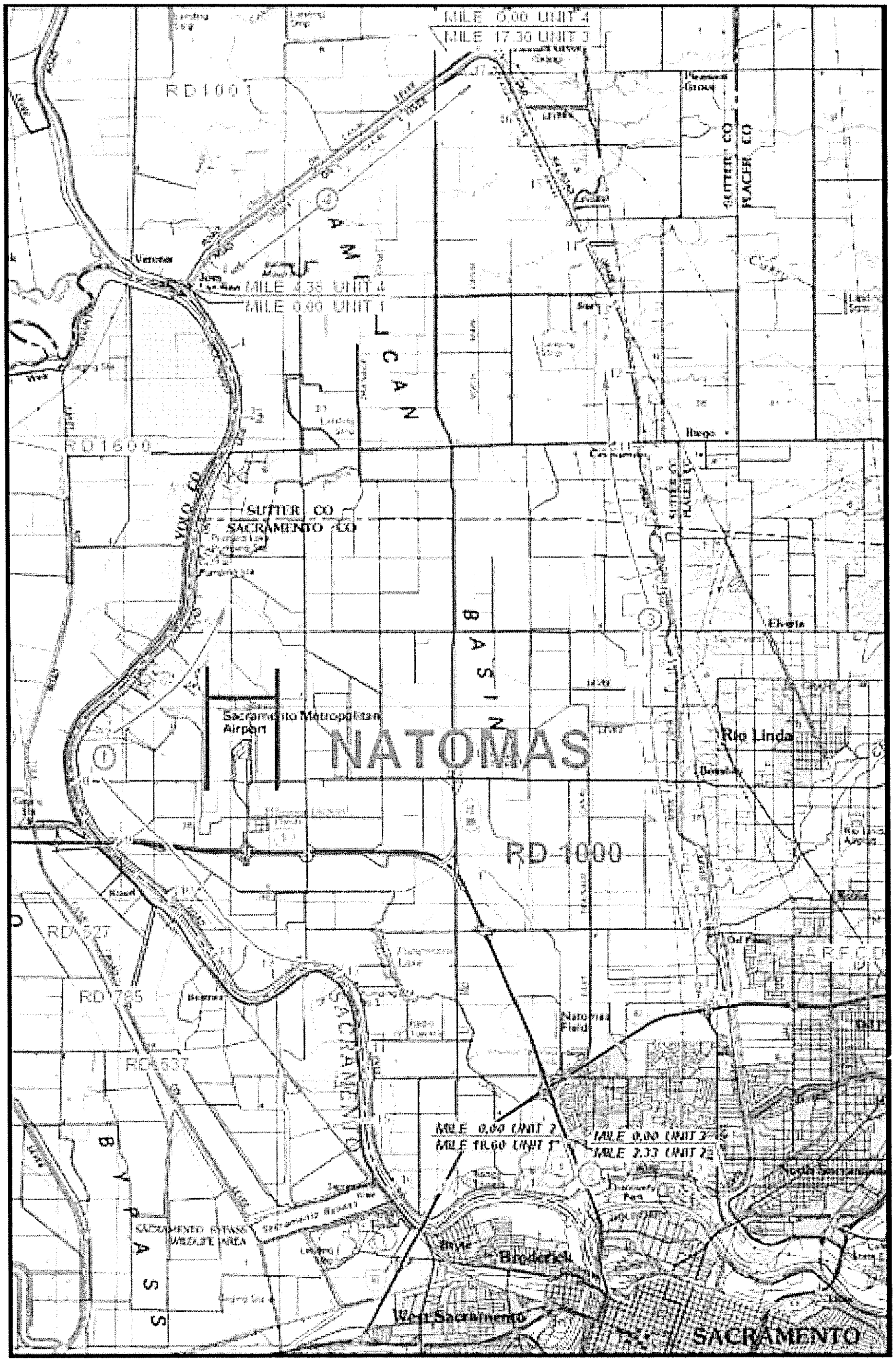


Figure 1 Natomas Basin Levees RD 1000

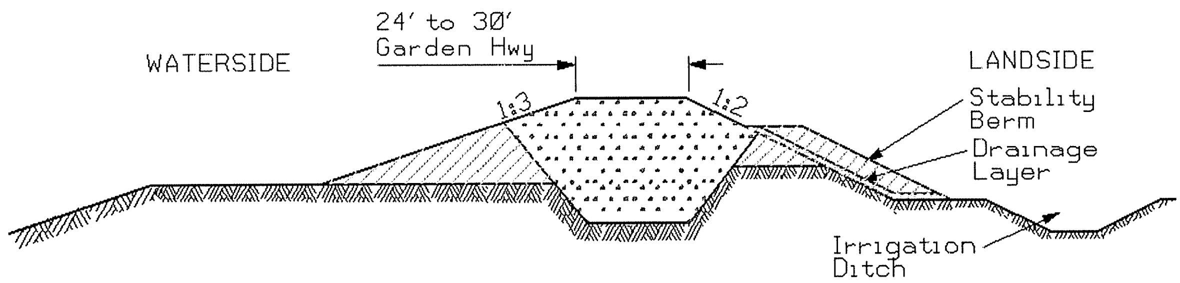


Figure 2 – Unit 1 Typical Cross Section North of Power Line Road

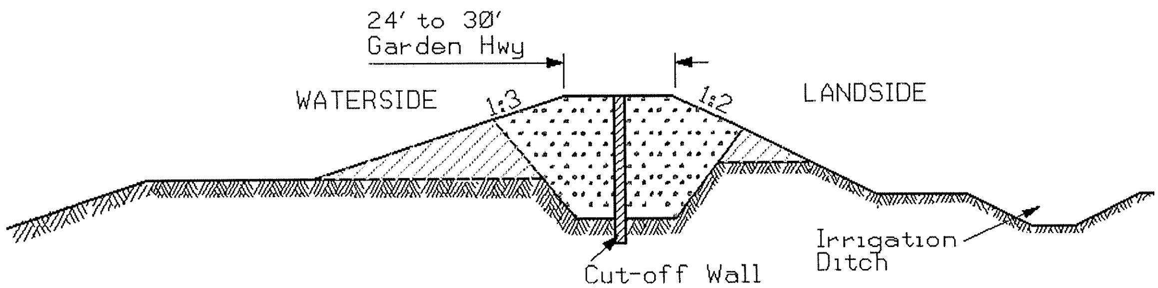


Figure 3 – Unit 1 Typical Cross Section South of Power Line Road

3.3 Levee Unit 2, American River

Levee Unit 2 is located along the north bank of the American River between the Sacramento River on the west end and Natomas East Main Drainage Canal on the east end. It is 2.33 miles long. The levee crest is typically 45 feet wide to accommodate Garden Highway. The levee height varies between 19 and 20.5 feet with the side slopes of 1(V) on 3(H) on the waterside and 1(V) to 1.5 to 2 (H) on the landside. The levee embankment was constructed of impervious clay material. The levee has a canal near the waterside toe which is an extension of the Natomas East Main Drainage Canal and an irrigation ditch 4 to 6 feet deep along the landside toe from the Garden Highway ramp to Azusa Street where the Garden Highway ramps off. The levee crown width is reduced to 20 feet where the Garden Highway ramps off. A typical cross section for Levee Unit 2 is shown on Figure 4.

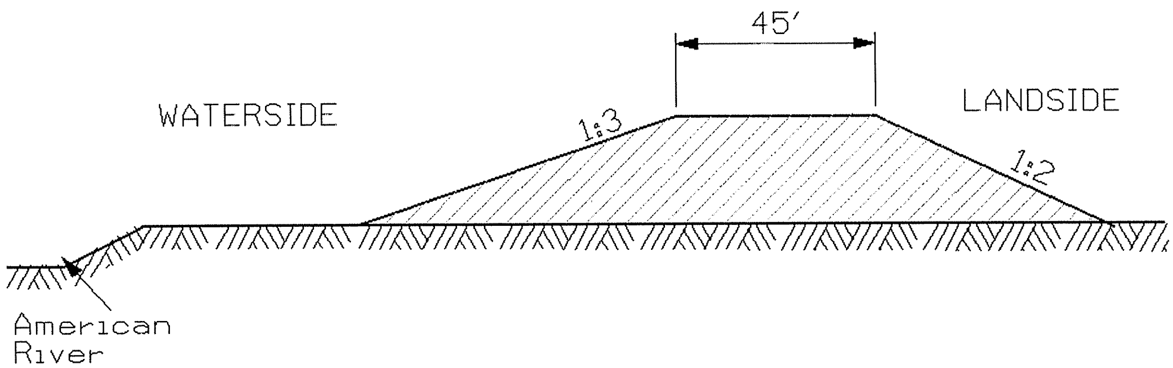


Figure 4 – Unit 2 Typical Cross Section

3.4 Levee Unit 3 Natomas Main Drain Canal and Pleasant Grove Creek Canal

The 17.3 miles long levee is located along the west bank of the Natomas East Main Drain Canal, continuing along the west bank of the Pleasant Grove Creek Canal, between the American River on the south end and Natomas Cross Canal on the north end. The levee embankment crown width varies between 22 and 55 feet with a landside slope of 1(V) on 2(H) and waterside slope of 1(V) on 3(H). The levee height varies between less than 5 feet to 20 feet. The levee embankment was constructed of impervious material. Figure 5 shows a typical cross section of the Levee Unit 3. A reach of this unit between Sankey Road and Riego Road ground surface is of sufficient height to not require a levee for low flow events.

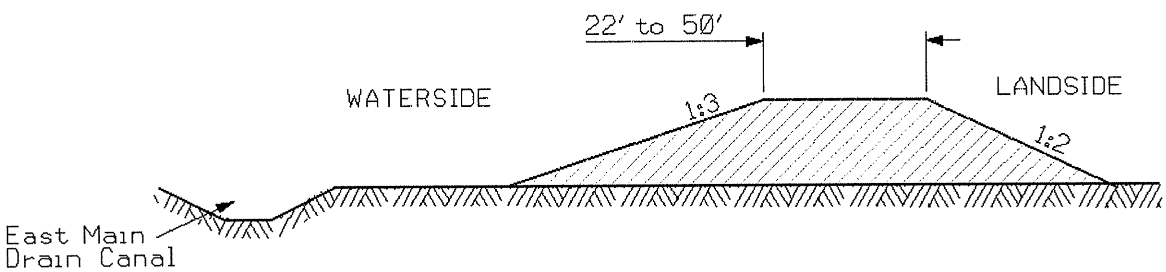


Figure 5 – Unit 3 Typical Cross Section

3.5 Levee Unit 4, Natomas Cross Canal.

The 4.38 miles long levee is located along the south bank of the Natomas Cross Canal between the Pleasant Grove Creek Canal on the east end and Sacramento River on the west end. The levee height varies between 12 and 25 feet, with the crown width varying between 23 and 50 feet. The levee has side slopes of 1(V) on 2(H) on the landside and 1(V) on 3(H) on the waterside. The levee was constructed of silts and clays of low to medium plasticity. Berms located along three reaches of the levee (from mile 0.13 to 2.23, from mile 3.11 to 3.52 and from mile3.71 to 4.39) are 10 to 15 feet high with a width varying between 15 and 20 feet. The berms were constructed with a chimney drain to prevent internal erosion due to seepage through the embankment and to increase the landside slope stability during high water stages in the canal. A

3-foot deep unlined irrigation ditch is located on a small berm 10 foot from the landside levee toe between miles 0.0 and 0.76. A 10-foot deep unlined irrigation ditch is located 100 feet from the landside levee toe between miles 0.36 and 1.84. A third irrigation ditch, 5 to 10 feet deep, is located 100 to 130 feet from the levee toe between levee miles 2.27 to 4.55. The ditch is concrete lined within the Caltrans Right-of-Way near State Highway 99. There are four (4) pump stations located along the levee. The Odysseus Farms pump station near levee mile 0.76 includes an 18-inch pipe crossing the levee embankment 4 feet below the levee crown and a discharge riser at the landside levee toe. Bennett Pumping Plant near mile 1.1 includes three pipes crossing the levee at 6 to 20 feet below the levee crown. The R.D. 1000 Pump Station near levee mile 1.86 includes an unlined 10-foot deep sump 100 feet from the levee toe and three pipes crossing the levee 5 feet below the levee crest. Natomas Mutual Water Company Northern Pumping Plant near levee mile 2.27 includes five pipes crossing the levee embankment 5 to 10 feet below the levee crest and an 8-foot deep concrete lined sump about 40 feet from the levee toe. A typical levee cross section is shown on Figure 6. An 80 feet deep cut-off wall was recently constructed on the west end of the Natomas Cross Canal levee, from the Sacramento River to the Bennett Pump Station to control the underseepage at this area. The wall will be extended along the entire Natomas Cross Canal by the end of 2009.

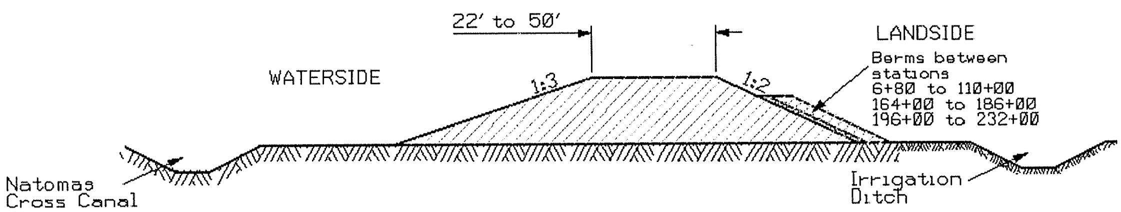


Figure 6 – Unit 4 Typical Cross Section

4. FOUNDATION CONDITIONS

4.1 General

The subsurface conditions along the project are derived from the results of the subsurface investigations performed for the different studies listed in Paragraph 2. The materials encountered during the subsurface exploration consisted primarily of alluvial sand and low plasticity silt and clay in various proportions, with occasional high plasticity clay layers and scattered gravel.

4.2 Geomorphologic Features

A geomorphologic study of the Sacramento River was performed by URS for the Corps of Engineers in 2002 as part of the American River Watershed Project (Common Features) and revised in 2007 for the Natomas GRR. The study includes a geomorphologic map showing the former channels, meanders, oxbows, and current and former point bars as interpreted on the aerial photographs. The geomorphologic map also includes areas of known seepage reported by the landowners or determined by aerial photo survey. It also includes current bank erosion areas.

Several historical river meanders can be seen along the riverbed between Unit 1 levee mile 0.00 and 2.99 at the north side of the area and between levee mile 16.86 and 17.99. Seepage zones were observed in the upper north part of the area, between levee miles 0.0 and 1.98, around mile 5.97, between miles 7.95 and 10.42, around mile 11.63, and between miles 12.69 and 15.15. Extensive seepage associated with sand boils was observed during the high river stages in 1986 and 1997 near mile 4.00, between miles 8.33 and 9.09, at mile 11.63, and between miles, 16.59 to 16.80, where the impervious blanket is thin and the underlying sandy aquifer is close to the surface. However, seepage was not reported between levee mile 16.86 and 17.99.

Bank erosion is manifested along the Sacramento River between Unit 1 levee miles 0.0 and 2.75, miles 4.17 and 6.25, miles 9.00 and 10.61, miles 11.93 and 12.69, miles 14.96 and 16.29, and miles 16.86 and 18.56, close to the confluence with the American River.

4.3 Geotechnical Conditions - Levee Unit 1 East Bank Sacramento River

The foundation soils consist generally of three layers: an upper relatively impermeable alluvium layer of silts and clays overlying an intermediate pervious layer of sand and silty sand, which in turns overlies a lower impermeable silt and clay deposit. The elevations and depth of these strata are highly variable as is expected in such a floodplain deposit environment. The thickness of the upper silt and clay alluvium varies from a few feet at levee mile 6.80 to as much as 40 feet at levee mile 5.15. Its elevation also varies from being exposed at the surface at levee mile 10.00 to being under 15 feet of sand cover at levee mile 6.00. The upper silt and clay layer is underlain by a silty sand to sand layer varying in thickness from 15 feet at levee mile 2.20 to 70 feet at levee mile 9.32. In the southern part of the levee unit, south of levee mile 9.00 the lower 15 feet becomes gravelly sand and gravel. Near Pritchard Lake Pump Plant the sand layer was deep extending to more than 80 feet below the ground surface. The intermediate sand layer was underlain by a silty clay and fat clay layer containing occasional thin layers or lenses of sand.

Ground water levels were measured in piezometers installed along the levee. From the piezometer measurements it can be seen that the ground water level decreases during the summer. In general the ground water varied from 2 to 18 feet below the ground surface, depending upon the season.

As stated previously the levee was constructed by hydraulically depositing sand in a core trench excavated in the natural ground, to the top of the levee. Consequently loose hydraulic placed sand can be found at a depth below the natural ground surface. A 10-foot wide landside berm was constructed in the 1990s between levee mile 0.0 (at the Natomas Cross Canal) and 12.3 (at Power Line Road). The berm was constructed with a drainage layer to half of the levee height to intercept seepage and increase the levee landside slope stability. A seepage cut-off wall no deeper than 40 feet was constructed between levee mile 12.3 (Power Line Road) and the end of the Unit 1 at levee mile 18.8.

Irrigation ditches were excavated along the levee landside toe. The location of the irrigation ditches vary from the landside levee toe to about 60 feet landward of the toe. The ditches are typically unlined and vary in depth from 3 to 6 feet.

5. GEOTECHNICAL ANALYSES

5.1 General.

Previously there have been studies of the Natomas Basin. These studies have primarily concentrated on the conditions along the Sacramento River, Unit 1 of the Natomas levee system. Two studies recently completed, one performed by Kleinfelder for SAFCA and the other by URS for the Corps of Engineers indicate that most of Unit 1 have exit gradients higher than the maximum allowed and slope stability with factors of safety less than the minimum allowed for the 1% expected flood frequency considering only the 50% Conditional Non-Exceedance Probability (CNP). For those studies Unit 1 was divided into several reaches where levee construction and foundation conditions are similar. Kleinfelder's designated Reaches 1 and 2 were found to be the most critical. URS study found similar conditions. Areas with undesirable results for Levee Unit 1 on the left bank of Sacramento River are shown on Figure 18. Therefore, based upon the results of geotechnical analyses performed by Kleinfelder for SAFCA and by URS for the Corps of Engineers these two reaches in Unit 1 levee along the east bank of the Sacramento River were chosen to be first examined for this analysis. If these reaches met criteria then it is likely the entire system would be sufficient to pass the 3% event. The water elevations used for the geotechnical analyses correspond to the 3% expected flood frequency considering 95% Conditional Non-Exceedance Probability (Assurance). The expected 3% at 95% assurance profile differs at most by 0.2 ft from the mean 1% profile. The results have been compared with the geotechnical analyses performed previously.

5.2 Selected Cross Sections

This geotechnical analysis was performed on cross sections found critical by previous analyses performed by URS and Kleinfelder, where the subsurface investigation shows unfavorable conditions which could lead to failures due to piping or slope stability. Previous seepage and stability analyses show high gradients and lower factors of safety. The selected cross sections are in the upper reach of the Sacramento River East levee (Unit 1), at miles 1.33 and 4.11, where previous analyses performed by Kleinfelder and URS for a mean water elevation corresponding to the 100 and 200 year flood events show excessively high gradients at the levee toe or at the bottom of the irrigation ditch located 10 to 70 feet from the levee toe. The geomorphologic study reveals the levee constructed at these locations is on an overbank deposit of sand, silt and clay deposited during past high-stage water flow, overtopping channel banks. (See Figure 8) A 5 to 6 feet deep irrigation ditch was excavated along the landside levee toe, 10 feet from the toe of the berm at LM 1.33 and 60 feet from the berm toe at LM 4.11. Recent borings performed in 2007 by URS on the crest of the levee and both waterside and landside of the levee embankment at mile 1.33 show the foundation materials consisting of a 24-foot thick sand layer underlying 17-foot thick natural clay blanket. The blanket thickness is reduced by the ditch excavated close to the levee toe. The geotechnical analysis was performed using the foundation and embankment material properties (strength and permeabilities) as determined by URS by the recent explorations performed at the site. Same permeabilities were used also by Kleinfelder in their seepage analyses. Figure 7 illustrates the foundation soils and the levee geometry used at levee mile 1.33.

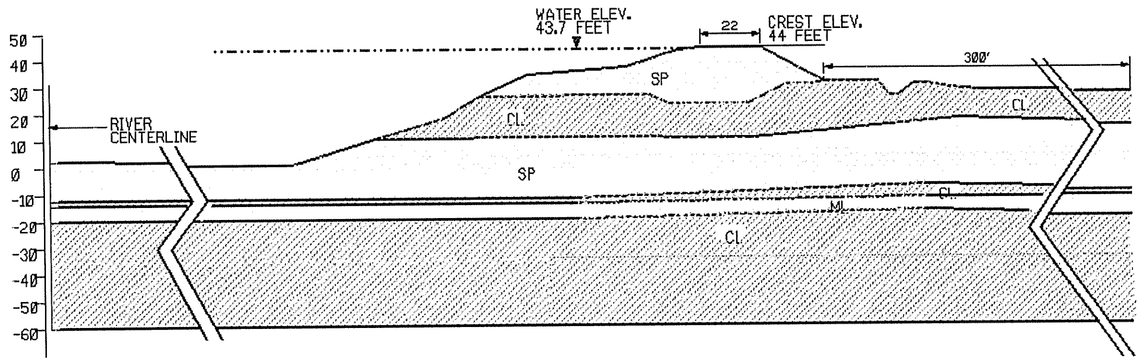


Figure 7 – Levee mile 1.33

Explorations performed recently by URS at levee mile 4.11 show the foundation soil consisting of an approximately 13 feet thick impervious blanket overlaying a layer of sandy silt/silty sand followed by the permeable aquifer of sand and gravel. The impervious blanket was excavated for

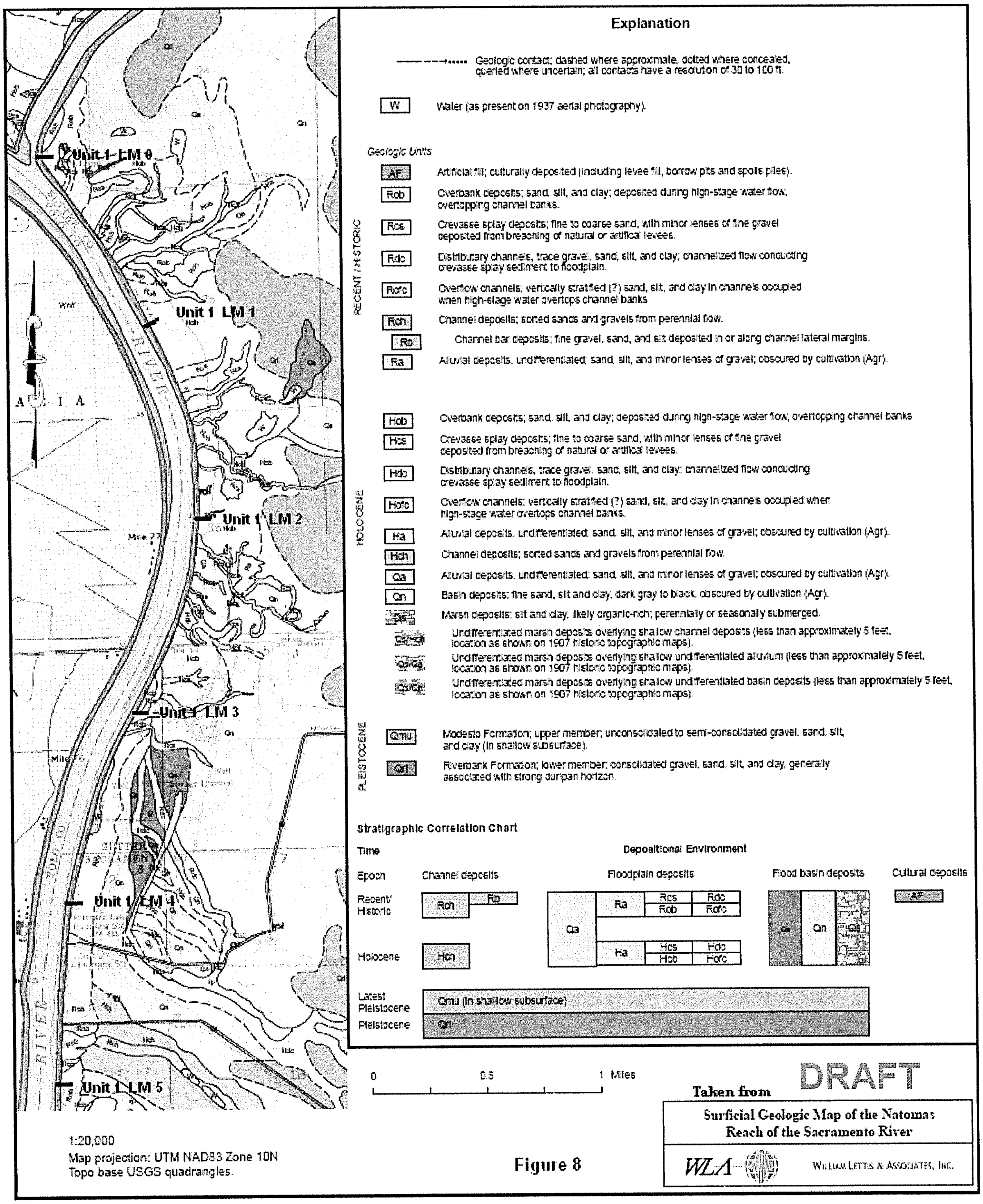

Unit 1 LM 0
Unit 1 LM 1
Unit 1 LM 2
Unit 1 LM 3
Unit 1 LM 4
Unit 1 LM 5
Explanation
Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; all contacts have a resolution of 30 to 100 ft.
W Water (as present on 1937 aerial photography).
Geologic Units
RECENT / HISTORIC
AF Artificial fill; culturally deposited (including levee fill, borrow pits and spoils piles).
Rob Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
Rcs Crevasse splay deposits; fine to coarse sand, with minor lenses of fine gravel deposited from breaching of natural or artificial levees.
Rdc Distributary channels, trace gravel, sand, silt, and clay; channelized flow conducting crevasse splay sediment to floodplain.
Rofc Overflow channels; vertically stratified (?) sand, silt, and clay in channels occupied when high-stage water overtops channel banks
Rch Channel deposits; sorted sands and gravels from perennial flow.
Rb Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins.
Ra Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; obscured by cultivation (Agr).
HOLOCENE
Hob Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks
Hcs Crevasse splay deposits; fine to coarse sand, with minor lenses of fine gravel deposited from breaching of natural or artificial levees.
Hdc Distributary channels, trace gravel, sand, silt, and clay; channelized flow conducting crevasse splay sediment to floodplain.
Hofc Overflow channels; vertically stratified (?) sand, silt, and clay in channels occupied when high-stage water overtops channel banks.
Ha Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; obscured by cultivation (Agr).
Hch Channel deposits; sorted sands and gravels from perennial flow.
Qa Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; obscured by cultivation (Agr).
Qn Basin deposits; fine sand, silt and clay, dark gray to black, obscured by cultivation (Agr).
Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged.
Undifferentiated marsh deposits overlying shallow channel deposits (less than approximately 5 feet, location as shown on 1907 historic topographic maps).
Undifferentiated marsh deposits overlying shallow undifferentiated alluvium (less than approximately 5 feet, location as shown on 1907 historic topographic maps).
Undifferentiated marsh deposits overlying shallow undifferentiated basin deposits (less than approximately 5 feet, location as shown on 1907 historic topographic maps).
PLEISTOCENE
Qmu Modesto Formation; upper member; unconsolidated to semi-consolidated gravel, sand, silt, and clay (in shallow subsurface).
Qrl Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay, generally associated with strong duripan horizon.
Stratigraphic Correlation Chart
Time
Depositional Environment
Epoch
Channel deposits
Floodplain deposits
Flood basin deposits
Cultural deposits
Recent/ Historic
Holocene
Latest Pleistocene
Pleistocene
Qmu (in shallow subsurface)
0
0.5
1 Miles
DRAFT
Taken from
Surficial Geologic Map of the Natomas Reach of the Sacramento River
WLA
William Letts & Associates, Inc.
1:20,000
Map projection: UTM NAD83 Zone 10N
Topo base USGS quadrangles.

Figure 8

the construction of levee. The levee constructed of dredged sand from the river. Figure 9 shows the levee and the foundation soils.

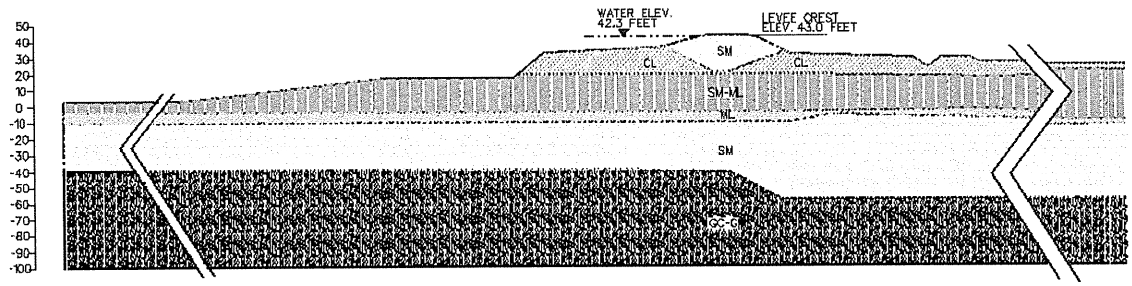


Figure 9 – Levee mile 4.11

5.3 Underseepage Analysis

The underseepage analysis was performed using SEEP2D finite element program developed as part of the GMS version 6. The phreatic line obtained by the finite element method for the 3% flood water elevation was used in the stability analysis. Corps of Engineers design criteria requires the exit gradient does not exceed 0.5 at the landside toe of the levee.

5.3.1 Methodology and Assumptions

Two-dimensional, steady state seepage modeling using SEEP2D was conducted to estimate the position of the free surface to be used in stability analysis and to determine the hydraulic gradient at the toe of the levee and at the bottom of the irrigation ditch. Permeabilities used in the analysis were obtained from the recent URS evaluation report prepared for the Natomas GRR which are similar with permeabilities provided by Kleinfelder in their levee evaluation.

5.3.1.1 An unconfined model was used for the seepage analyses. The seepage analyses were performed by saturated/unsaturated flow modeling where the flow in both saturated and unsaturated zone is modeled. The hydraulic conductivity in the unsaturated zone is reduced using the linear frontal method. The analysis used the water elevation provided by the hydraulic analyses. Additional analyses were performed for other water elevations to determine the maximum water elevation to obtain a hydraulic gradient less than 0.5 at the bottom of the irrigation ditch.

5.3.1.2 Boundary Conditions. The model was extended to the middle of the river on the waterside and 400 feet landside of the toe of the levee. The following boundary conditions have been assigned.

(1) Head Boundary Condition was assumed for all nodes where the flow enters or exits the system, such as the nodes along the waterside slope up to the assumed water elevation.

(2) Exit Face Boundary Condition was assumed for nodes along the face where the free surface is likely to exit the model including the nodes along the sloped natural ground landside of the levee toe and in the ditch excavated landside of the levee.

(3) The model was extended to the center of the river assuming a no flow boundary on the vertical face of the center of the river.

5.3.2 Material properties

The material properties used in the analyses are shown in Table 1. The permeabilities used in the seepage analyses are provided by URS in their recent report and are the same as those used by Kleinfelder in their analyses. For all materials the model assumed minimum pressure head $h_0 = -1$ and minimum relative conductivity $kr_0 = 0.001$. The ratio of horizontal to vertical conductivity is assumed to be 4:1.

Table 1 – Hydraulic Conductivity

Material	Permeability	
	K_h (ft/day)	K_v (ft/day)
Sandy levee Embankment	56	14
Clay Blanket	0.028	0.007
Foundation Sandy Silt	0.56	0.14
Foundation Silty Sand	11.2	2.8
Foundation Sand	56	14
Foundation Gravel	280	280

5.3.3 Selected Sections for Analysis

5.3.3.1. Levee Mile 1.33 (Station 70+00). The levee crest is at elevation 44 feet and is constructed of sandy soil. The levee slope is 1(V) on 3(H) on the waterside and steeper, close to 1(V) on 2(H) on the landside. The berm on the landside slope was neglected since the permeability of the drain rock was much higher than the permeability of the levee. The maximum height of the levee at this location is 13 feet. The crest width of the levee is 24.5 feet, with Garden Highway located on the levee crest. The foundation consists of a thick layer of sand covered by an impervious clay blanket. The sandy aquifer underlain a thin layer of silt followed by clay soil. The riverbank has been eroded and the sandy layer is now exposed directly to the river. The irrigation ditch excavated 10 feet from the levee toe reduces the blanket thickness by 7 feet. The blanket thickness at the landside toe of the levee is 18.3 feet and reduced to 11 feet at the bottom of the ditch. The water elevation provided by the hydraulic analysis for this levee mile is at 43.7 feet, 0.3 feet below the levee crest. Additional analysis was performed for lower water elevations to determine the variation of the gradient with the river stage.

5.3.3.2 Levee mile 4.11 (Station 217+00). The levee crest is at elevation 43 feet with the water elevation provided by the hydraulic analysis at 41.9 feet. The 11-foot high levee constructed of dredged sand has a 27 feet wide crest with 1(V) on 3(H) waterside slope and 1(V) on 2(H) landside slope. Garden Highway is located along the levee crest. The foundation soil consists of an impervious clay blanket followed by a thick layer of sandy silt, overlaying a thin layer of clay covering more sand and gravel extending below elevation -100 feet. The impervious blanket is 12.7 feet at the levee toe and reduced to 6 feet at the bottom of the irrigation ditch excavated 60 feet from the levee toe.

5.3.4 Seepage Analyses Results

The hydraulic gradients obtained by the seepage analyses are shown in Table 2.

Table 2 Hydraulic Gradients Obtained by Seepage Analyses – Sacramento River

Unit 1 Levee Mile	Water Elev. (ft) (1)	Top of Levee Elev. (ft) (2)	CNP (3)	Toe of Levee		Bottom of Ditch		Author
				Excess head (4)	Calculated Gradient (5)	Excess head (4)	Calculated Gradient (5)	
1.33	43.70	44	95% (8)	12.65	0.69	17.60	1.60	USACE 07
	43.45		50% (7)		0.84	-	2.00	URS 07
	43.45		50% (7)		0.65	-	-	KA (6) 06
	41.60		50% (8)	10.46	0.57	15.40	1.40	USACE 07
	37.00		<50% (8)	5.92	0.32	10.89	0.99	USACE 07
4.11	42.3	43	95% (8)	8.73	0.69	14.63	2.40	USACE 07
	41.9		50% (7)		0.83		2.0	URS 07
	41.8		50% (7)		0.58	-	-	KA (6) 06

(1) Elev NAVD 88 in Feet
(2) Crest of Levee from surveys conducted by PSOMAS in 2007 for SAFCA in Feet
(3) Conditional Non-Exceedance Probability (Assurance)
(4) Excess Head from Seep 2D/GMS in Feet
(5) Gradient = Excess Head / Blanket thickness
(6) KA- Kleinfelder Assoc.
(7) 1% Frequency Flood Event
(8) 3% Frequency Flood Event

The blanket thickness at mile 1.33 is 18.3 feet at the levee toe and 11 feet at the toe of the irrigation ditch. The blanket thickness at levee mile 4.11 at the levee toe is 12.6 feet and at the bottom of the ditch 6.1 feet.

Seepage analyses performed by URS and Kleinfelder at the levee mile 1.33 considering the water elevation corresponding to 100 year flood (elevation 43.45 feet) with 50% Conditional Non-Exceedance Probability (CNP) show the gradient at the levee toe of 0.84 and 0.65 respectively. The seepage analyses at levee mile 4.11 performed by URS and Kleinfelder for the same flood frequency of 100-year with 50% CNP (flood water elevation 41.9 feet) show gradients of 0.83 by and 0.52 respectively. The gradients obtained by URS at the bottom of the ditch are 1.08 at levee mile 1.33and 2.00 at levee mile 4.11. Kleinfelder did not consider the existing ditch at the levee toe.

The following figures 10 through 13 illustrate the results of the seepage analyses and the boundary conditions.

If one were to plot the exit gradients from the various studies versus the water surface elevations at Levee Mile 1.33, one could get a rough estimate that the water level must be less than 40 feet for the exit gradient at the toe of the levee to meet the design criteria, while the elevation would need to be below elevation 35 feet for the bottom of the ditch to meet the design exit gradient (See Figure 14). The water surface elevation for the 3% event with 50% Conditional Non-Exceedance Probability (CNP) at Levee Mile 1.33 was found to be 41.6 feet. Thus the site does not meet current design criteria for the 3% event at the mean water surface as well as the mean water surface exceeds elevation 40. There is insufficient data from analysis to make a similar comparison at Levee Mile 4.33.

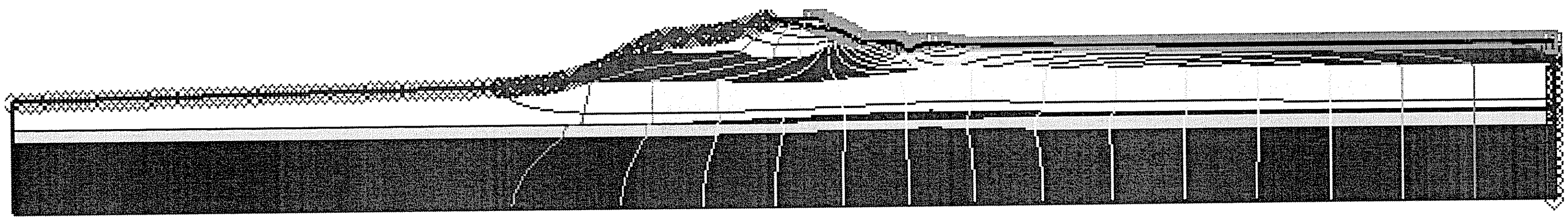


Figure 10 Levee Unit 1 Mile 1.33, Water Elevation 43.7 feet

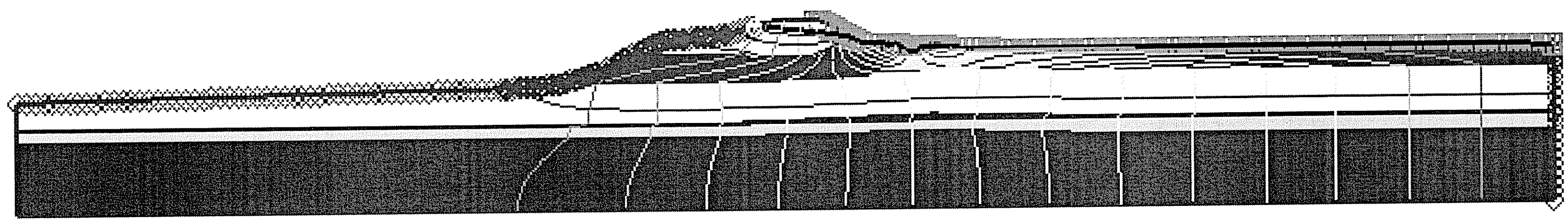


Figure 11 Levee Unit 1 Mile 1.33, Water Elevation 41.6 feet

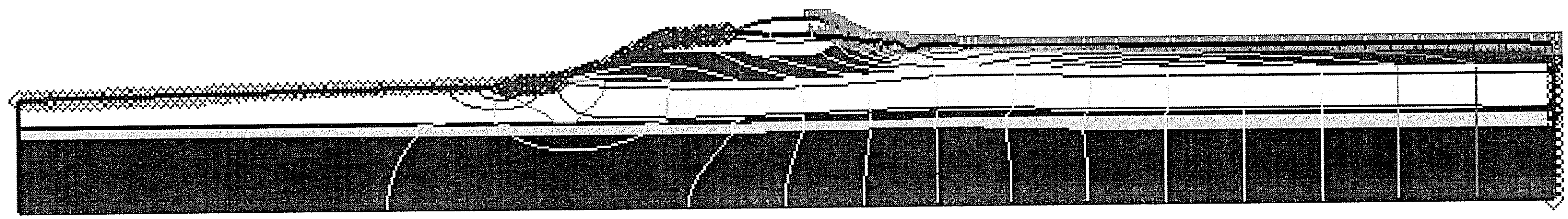


Figure 12 Levee Unit 1 Mile 1.33, Water Elevation 37.0 feet

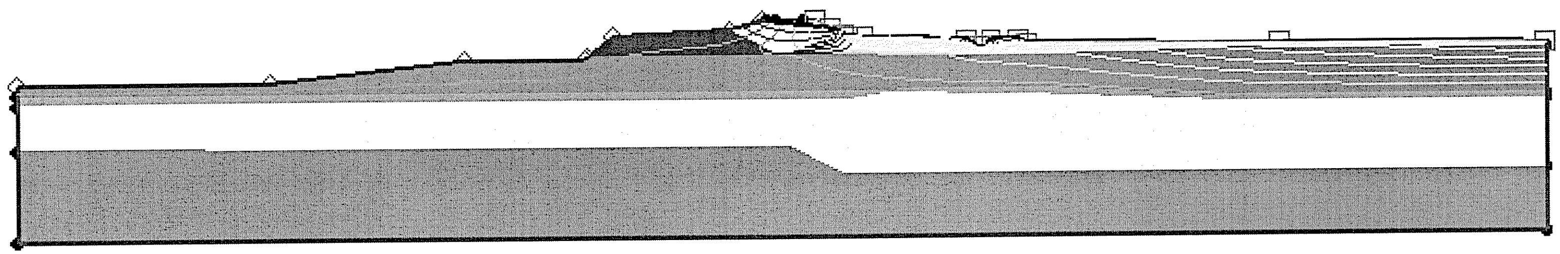
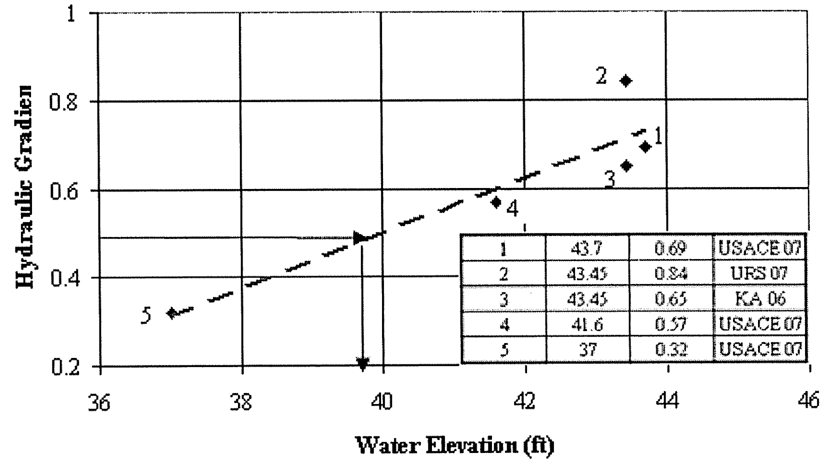


Figure 13 Levee Unit 1Mile 4.11, Water Elevation 42.3 feet

Unit 1 Levee Mile 1.33 Toe of Levee



Unit 1 Levee Mile 1.33 Bottom of Ditch

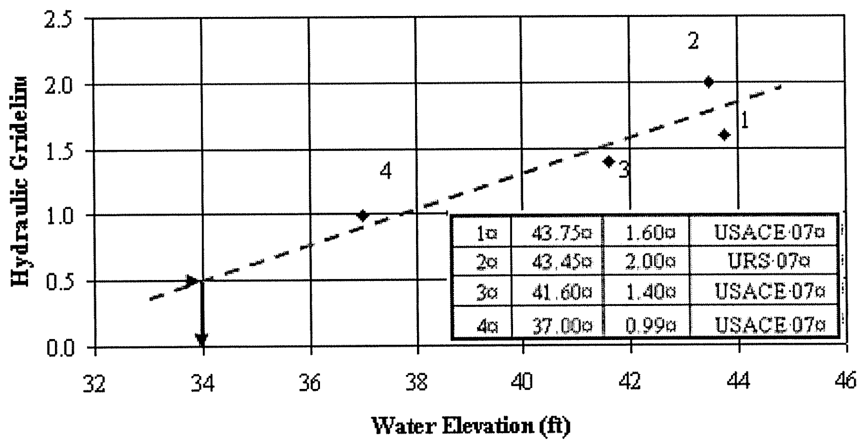


Figure 14 Levee Unit 1Mile 1.33, Maximum Water Elevation to Meet Corps Criteria

5.4 Slope Stability Analysis

Stability analyses were performed on the cross section at LM 1.33 on Unit 1 Sacramento River East Bank Levee using the phreatic line obtained by the previously described seepage analysis for water surface elevation 43.7 feet NGFD 88.

5.4.1. Case Analyzed and Method used for Analyses.

The section analyzed was performed for the steady state seepage for the landside slope of the levee. Rapid drawdown was not analyzed. The levee is constructed of sandy material that provides sufficient drainage during a rapid drawdown of the river. The landside stability berm was considered in the analysis. The phreatic surface developed for the steady state condition was determined by the SEEP2D finite element computer program. The stability analysis was performed using the limit equilibrium computer program "UTEXAS3" assuming circular failure surfaces. The analysis consisted of running a search routine to identify the critical failure surface using the Spencer's Method.

5.4.2 Soil Strength Parameters.

Soil Strength Parameters used in the stability analyses were the drained soil parameters as determined in the URS "Natomas GRR Investigation" Draft Evaluation Report, Sacramento East Levee, 2007. A summary of the soil strength parameters is presented in Table 3.

Table 3 – Soil Strength Parameters used in Stability Analysis.(1)

Soil Type	Unit Weight (pcf)		Effective Strength Parameters	
	Moist	**Sat.**	**Friction Angle Φ(deg.)**	**Cohesion (psf)**
Levee Fill (Sand)	115	135	35	0
Foundation Clay	N/A	125	29	0
Berm (silt)	110	N/A	31	0
Foundation Sand	N/A	115	35	0
Drain Rock	135	N/A	40	0

(1) The parameters used are identical to those used by URS for their analyses.

5.4.3 Results of Stability Analysis.

The Sacramento River East Levee mile 1.32 was analyzed for steady state condition considering the phreatic line developed by the 3% flood elevation. The factor of safety obtained by the stability analysis and the critical failure surface are shown on Figure 15.

NO.	DESCRIPTION	UNIT WEIGHT	[1] SHEAR STRENGTH	PORE PRESSURE
1	levee sand moist	115	Cohesion: 0.0 Friction angle: 35	None
2	drain rock	135	Cohesion: 0.0 Friction angle: 40	None
3	berm silt	110	Cohesion: 0.0 Friction angle: 31	None
4	levee sand saturated	135	Cohesion: 0.0 Friction angle: 35	Piezometric Line no. 1
5	foundation clay	125	Cohesion: 0.0 Friction angle: 29	Piezometric Line no. 1
6	foundation sand sat	135	Cohesion: 0.0 Friction angle: 35	Piezometric Line no. 1

[1] These are the same strengths used by URS & Kleinfelder in their stability analysis.

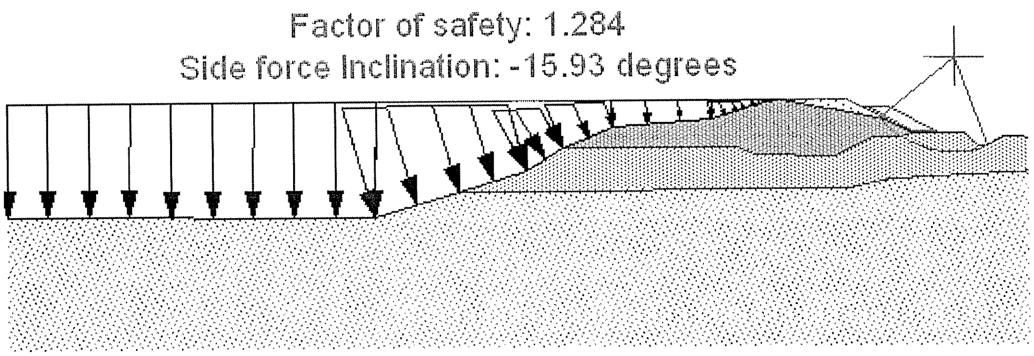


Figure 15 – Levee Unit 1 Sacramento River East Levee Mile 1.33

As seen on Figure 13 the factor of safety for steady state condition is 1.28, which is less than the minimum factor of safety of 1.4 required by Corps design criteria.
Considering the irrigation ditch backfilled with the material similar to the adjacent soil, the factor of safety increases to Fs = 1.59 as shown on Figure 16 below.

NO.	DESCRIPTION	UNIT WEIGHT	(1) SHEAR STRENGTH	PORE PRESSURE
1	levee sand moist	115	Cohesion: 0.0 Friction angle: 35	None
2	drain rock	135	Cohesion: 0.0 Friction angle: 40	None
3	berm silt	110	Cohesion: 0.0 Friction angle: 31	None
4	levee sand saturated	135	Cohesion: 0.0 Friction angle: 35	Piezometric Line no. 1
5	foundation clay	125	Cohesion: 0.0 Friction angle: 29	Piezometric Line no. 1
6	foundation sand sat	135	Cohesion: 0.0 Friction angle: 35	Piezometric Line no. 1

(1) These are the same strengths used by URS & Kleinfelder in their stability analysis.

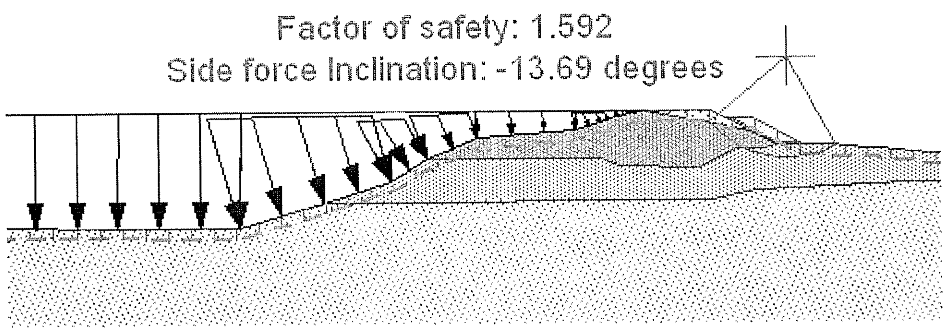


Figure 16 – Levee Unit 1 Sacramento River East Levee Mile 1.32 – Ditch Backfilled

The gradients at the levee toe and at the ditch invert (at the bottom of the irrigation ditch excavated between 10 and 60 feet from the landside levee toe) are greater than the maximum 0.5 exit gradient required by the Corps. The landside steady state stability factor of safety of 1.28 is less than the minimum acceptable factor of safety of 1.4.

6. CONCLUSIONS OF THE GEOTECHNICAL ANALYSIS

The Natomas Levees do not meet current Corps design criteria for seepage and stability for the 3% flood frequency considering 95% Conditional Non-Exceedance Probability. This is further substantiated by the studies analyses performed by URS, and Kleinfelder. For water elevations at the 3% flood frequency or lower exit gradients are higher than the maximum allowed and the stability factors of safety are lower than the minimum allowed along the Levee Unit 1 on the left bank of Sacramento River. Results are shown on the Figure 18.

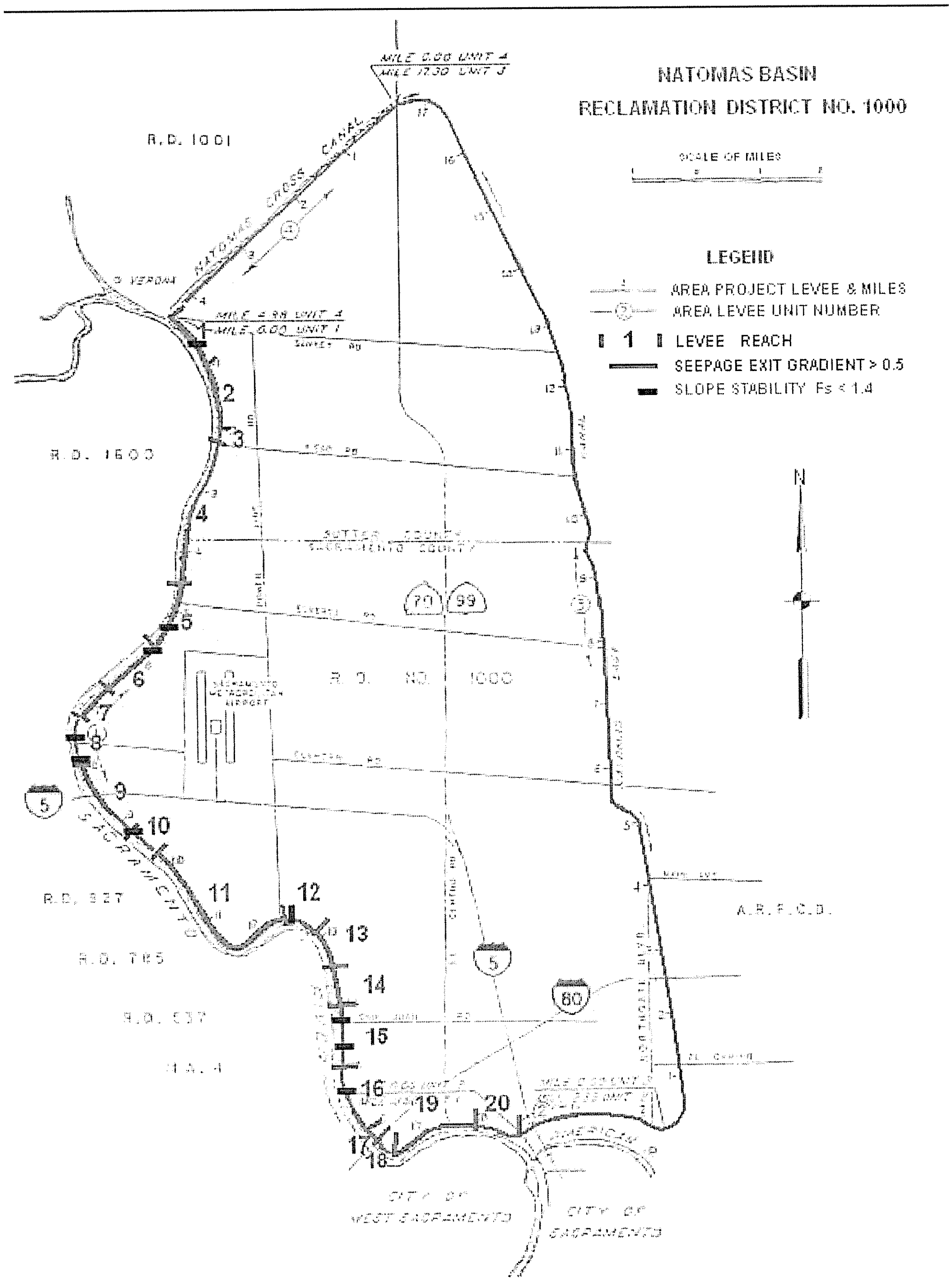


Figure 18 – Levee Unit 1 Sacramento River East Levee – Critical Reaches